International
Hydropower Association

Sustainability Guidelines

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1 Introduction

Nearly one-third of the world's population has no access to electricity. Without concerted action at least 3.5 billion people, nearly 50% of the global community, will face water scarcity by 2025. At the same time the world's energy systems, substantially based on fossil fuels, account for a significant proportion of the greenhouse gas emissions that are leading to climate change and global warming.

Hydropower is a major renewable energy resource that can play an increasingly important role in enabling communities around the world to meet sustainability objectives. As a high quality, reliable and flexible energy source it has a pivotal role in integrated energy systems. This flexibility, through energy storage in reservoirs, is increasingly being seen as a means of expanding the effective contribution of other less reliable and more dilute renewable energy sources, such as wind and solar energy. The multiple-use benefits of hydropower, particularly in relation to the availability, reliability and quality of fresh water supplies, can also contribute to a fundamental sustainability goal – the alleviation of poverty.

1.1 Purpose of these guidelines

The International Hydropower Association (IHA) has produced these guidelines to promote greater consideration of environmental, social and economic aspects in the sustainability assessment of new hydro projects and the management and operation of existing power schemes. Thorough sustainability assessments should ensure that detrimental social and environmental impacts are avoided, mitigated or compensated and positive outcomes are maximised. Of necessity, the principles are generic since each particular power scheme and development project will have its own unique set of circumstances influenced by scale, geographic location, social, legal and political constructs. The guidelines will need to be adapted to the specific context of each particular project.

The principles outlined in this document span the following six elements. Supporting comment provides further guidance where necessary:

- IHA policy
- The role of governments
- Decision making processes
- Hydropower - environmental aspects of sustainability
- Hydropower - social aspects of sustainability
- Hydropower - economic aspects of sustainability

The principles have been drafted to assist hydropower developers and operators with the evaluation and management of often competing environmental, social and economic issues that arise in the assessment, operation and management of hydropower projects.

2 IHA Policy

2.1 IHA commitment to sustainable development

The International Hydropower Association (IHA) regards sustainable development as a fundamental component of social responsibility, sound business practice and natural resource management.

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Report of the World Commission on Environment and Development, 1987). Sustainable development requires the integration of three components – economic development, social development and environmental protection – as interdependent, mutually reinforcing pillars. Eradicating poverty, changing unsustainable patterns of production and consumption, and protecting and managing the natural resource base underpinning economic and social development are overarching objectives of, and essential requirements for sustainable development.

The World Commission on *Dams report, Dams and Development, a new framework for decision-making*, was published in 2000. While there is disagreement on some aspects relating to its detailed recommendations, there is clear acceptance of the Core Values listed in the Report:

- equity,
- efficiency,
- participatory decision-making,
- sustainability, and
- accountability.

In addition, there is broad agreement on the objectives of the Report's Strategic Priorities. The IHA Sustainability Guidelines provide a framework for good practice which is in accordance with these values.

IHA recognises that sustainable development is the collective responsibility of government, business, civil society, consumers and individuals. It is committed to working cooperatively with these sectors in achieving sustainable outcomes.

2.2 Further promoted values

As part of its commitment to sustainable development, IHA supports the values of eco-efficiency and a precautionary approach to environmental management.

2.2.1 Eco-efficiency

IHA also supports the opportunities to create more value with less environmental impact through the concept of eco-efficiency.

Eco-efficiency is founded on the idea that becoming more efficient makes good business sense and is concerned with three broad objectives:

- Reducing the consumption of resources
- Reducing the impact on nature
- Increasing product or service value

IHA believes evaluation of power generation options should be based, where feasible, on life-cycle analysis of alternative technologies with a precautionary approach to scientific uncertainties.

2.2.2 Precautionary approach

A precautionary approach is one of the underlying values guiding efforts to achieve more sustainable outcomes for new and existing developments.

In the application of this approach, public and private decisions should be guided by:

- evaluation to avoid, wherever practicable, serious or irreversible damage to the environment;
- consideration of the need for electricity and a reliable water supply to alleviate poverty and enhance living standards; and
- an assessment of the risks associated with various options.

IHA supports the application of a precautionary approach at the national and/or regional policy level. Decision makers should consider global issues, such as global warming, acid rain, and loss of biodiversity, when establishing national and/or regional policies for energy, water and land use. These issues should be addressed and dealt with at the national and/or regional policy level prior to the assessment of specific projects.

3 The Role of Governments

3.1 Governments and sustainability

Good governance within each country and good governance at the international level are also essential sustainable development prerequisites. At the domestic level, sound environmental, social and economic policies, together with democratic institutions responsive to the needs of people, the rule of law, anti-corruption measures, gender equity and an enabling environment for investment are the basis for sustainable development (WSSD Plan of Implementation, 2002).

Sustainability is based on due considerations given to interrelationships and integration of competing needs. Therefore, it's of prime importance that the national and/or regional policy context takes into account cross-sectorial issues, for example through integrated water resources management.

3.2 National and regional energy policies

The social, environmental and economic trade-offs required to establish national and regional development plans are the responsibility of governments.

IHA encourages countries to have in place national and/or regional energy policies. Each jurisdiction should clearly set out its energy development strategy so that the rules are known to all and arbitrary decisions are minimised.

National and/or regional energy policies should include a Strategic Assessment (SA) process that includes assessment of cumulative impacts, determination of land use and environmental priorities, as well as goals for poverty alleviation and economic growth. The policies should be framed in the context of the global need to reduce greenhouse emissions. They should also incorporate the three elements of sustainability -- economic, social and environmental -- in energy planning.

A Strategic Assessment process allows the high level identification of environmental, social and economic concerns and the resolution of competing needs. This process is a mechanism by which sustainable development and global trends concerning environmental goals can be reconciled with the management and conservation of natural resources. It should be a participatory, streamlined process, focused on major issues, using common sense and readily available information, and with short and definite time limits for its completion.

One important objective of an SA for energy policy would be to reduce uncertainties for developers by prioritising project options. Governments should give guidance on which social costs should be borne by developers and which should be the government's responsibility. Guidance can also be given in relation to priority areas or regions by, for example, defining river reaches which should be available for hydropower development and, conversely, those reaches protected from water resource development.

IHA also supports resolution of issues between nations where river basins cross national boundaries. This should be achieved through collaborative decision-making, under a framework of shared water management policy. Coordination of river basin research and policy development can be facilitated by multi-lateral agencies. An example of such an agency is the Mekong River Commission.

3.3 Reducing the carbon intensity of energy production

Greenhouse emissions have to be considered in energy policy planning.

According to the Intergovernment Panel on Climate Change (IPCC), emissions of greenhouse gases (such as carbon dioxide, methane and nitrous oxide) continue to alter the earth's atmosphere in ways that are expected to affect the climate. The warmest year on record was 1998. There is no longer any reasonable doubt that greenhouse emissions are playing a key role in the increase, and acceleration, of global warming.

Against this background a continuing escalation in fossil fuel use will only make global warming worse. There is a growing international effort therefore to find alternative solutions that are less carbon intensive, but at the same time meet the energy needs of the developed and developing world.

Development of renewable energy resources is part of the solution to this problem. In this context hydro-electricity has a role to play. Use of water for electricity generation is essentially a non-consumptive use of a natural resource. It also produces very few greenhouse gas emissions when compared with alternative methods of electricity generation. Estimates of "gross" emissions from boreal reservoirs are 60 times lower than emissions from coal-fired plants and 30 times lower than emissions from efficient natural gas plants. (Gagnon, 2002). These differences are even greater when more appropriate "net" emissions are used. While more research is needed, present indications point to very low "net" emissions with nearly all carbon being transported by rivers, with or without dams, exiting to the atmosphere rather than accumulating in ocean sediments.

4 Decision Making Processes

4.1 Evaluation of alternative energy options

IHA believes that broad energy option assessment should be the responsibility of national and/or regional governments as part of their energy development strategy.

Governments and, where applicable, project proponents should apply sustainability criteria when comparing project alternatives in order to focus on options that maximise environmental, social and economic benefits and, conversely, eliminate unacceptable alternatives early in the planning process.

Each option is different and it is not always possible to directly compare one alternative with another. It is nevertheless important that relevant comparisons are made in relation to the basic sustainability of a project. It should also be realized that an infinite variety of options is never available and fundamental factors such as affordability, resource availability and scale of requirements define the possible options that need to be assessed.

The sustainability of an option is relevant to the environmental assessment and regulatory approval processes. Proponents need to demonstrate that their recommended option is sustainable and of net benefit to the community. To facilitate this, early engagement with relevant stakeholders on the comparative benefits of feasible options is recommended.

Table 1 below lists key criteria for assessing sustainability between various energy options.

Table 1 Key criteria that should be used in comparing various energy options

KEY CRITERIA	DISCUSSION
1. *Assess the options in terms of need against supply-side and demand-side efficiency measures.*	Ideally, this process should be carried out by governments. Assessments need to consider existing supply-side and demand-side efficiency standards in the affected region, the economic feasibility and practicability of alternative efficiency options and the delivery of equivalent benefits.
2. *Assess the options in terms of resource depletion.*	This is a question of inter-generational equity. Projects that consume finite resources can be transferring costs to future generations. Projects using abundant resources are preferable to those depleting scarce resources. Renewable energy options do not directly consume finite resources.
3. *Assess the options in terms of energy payback ratio.*	Energy payback is the ratio of energy produced during the normal life span of a project divided by the energy required to build, maintain and fuel the generation equipment. Renewable sources have most of their energy inputs during the construction phase, whereas fossil fuel systems continue to consume energy through extraction, transportation and processing.
4. *Assess the option in terms of economic viability over the life of the facility.*	The economic feasibility and viability of each option needs to be considered over the projected life of the facility. Electricity generation is a long-term business, with most hydro facilities being considered viable for at least 40 years. With refurbishment they have a longer life than many alternatives such as coal, nuclear or gas generation.
5. *Assess the option in terms of the availability and cost of resources over the projected life of the facility.*	The availability and cost of fossil fuels may change over the operating life of a power station with availability decreasing and cost increasing. With hydropower, drought can impact on the ability to generate power although water use is basically non-consumptive.
6. *Assess the options in terms of appropriateness of the technology, levels of efficiency and service required.*	Projects should use appropriate and proven technology to cost effectively maximise the benefits to be derived from use of a resource. Comparisons should be made on the efficiency of conversion and the flexibility and reliability of the product provided. The comparison should take account of the level of service required (e.g., some electric systems may require peak load capacity while others may seek stable base load). Hydro-electric systems generally rate highly level of service provided. They are very efficient, have relatively low maintenance costs and can provide a flexible and reliable product that supports other less flexible systems in the overall energy mix.

KEY CRITERIA	DISCUSSION
7. *Assess the options in terms of additional or multiple use benefits.*	The creation of reservoirs for hydropower projects provides opportunities for multiple-use benefits rarely associated with other forms of electricity production. Examples include drinking water supply and sanitation, water for business and industry, water for sustainable food production (both in-reservoir and via irrigation), flood mitigation, water-based transport, and recreation and tourist opportunities.
8. *Assess the options in terms of poverty reduction through flow on benefits to local communities via employment, skills development and technology transfer.*	Many energy development projects provide jobs for the local population. Direct and indirect employment opportunities, both during construction and for the life of the project, as well as expansion of the local skills base, capacity building and the benefits of technology transfer should all be assessed when evaluating options.
9. *Assess the options in terms of carbon intensity and greenhouse gas emissions.*	In general terms hydro-electric schemes and other renewable energy projects have low carbon intensity and low levels of greenhouse gas emissions. This compares, for example, with coal-fired systems that emit approximately 1000 tonnes of CO_2 per GWh produced.
10. *Assess the options in terms of land area affected (environmental footprint) and associated aquatic and terrestrial ecological impact.*	The relatively dilute nature of renewable resources often means that these types of projects have a large environmental footprint per unit of energy produced. Run-of-river and mini-hydro projects usually have relatively small environmental footprints. Projects that are spread over large areas of land often have limited or easily mitigated environmental effects. Wind farms, for example, have limited impact on other land use activities. Some fossil fuel-based projects can have a very large footprint, for example, the area affected by air emissions. The impact of the environmental footprint needs to be assessed in relation to the associated aquatic and terrestrial ecological impacts and the degree to which they can be mitigated and/or compensated.
11. *Assess the options in terms of waste products (emissions or discharges to air, water and land).*	Waste products are a major sustainability issue for fossil fuel and nuclear projects. Negative health effects can result from particulate and other emissions to air. Disposal of waste to tailings dams and radio-active waste repositories represents an inter-generational transfer of cost and environmental liability.

4.2 Alternative hydropower options

If the decision is taken to develop hydropower, then sustainability criteria must be available for both government agencies and developers to provide an effective comparison of hydropower project alternatives. Such criteria are required in order to eliminate unsustainable hydropower projects early in the project planning phase.

Table 2 below focuses on hydro-electric alternatives and their prioritisation based on sustainability criteria.

Table 2 Key criteria that should be used in comparing hydro-electric project alternatives

KEY CRITERIA	DISCUSSION
1. *Prioritise upgrading of existing facilities.*	Although hydro-electricity is an essentially efficient form of electricity generation, refurbishment and modification of operational regimes, particularly of older power stations, can often result in significant additional energy generation.
2. *Prioritise alternatives that have multiple-use benefits.*	Hydro-electric projects normally have a variety of other uses and benefits. These can include irrigation, water supply, fishing, flood mitigation, water-based transport, tourism and recreation. The value of these additional benefits should be considered when comparing project alternatives. The value should be discounted against any loss of benefits (including environmental costs) associated with the project.
3. *Prioritise alternatives on already developed river basins.*	The potential of sites on already developed rivers is not always fully realised. While consideration of cumulative and other environmental impacts is necessary it is often preferable to develop new hydro-electric projects on already regulated river systems.
4. *Prioritise alternatives that minimise the area flooded per unit of energy (GWh) produced.*	Increasing the area flooded generally increases environmental impacts. Impact avoidance is more effective than mitigation so the selected site and project design should tend towards minimising the flooded area per unit of energy produced (square kilometres per gigawatt hour)
5. *Prioritise alternatives that maximise opportunities for, and do not pose significant unsolvable threats to, vulnerable social groups.*	Where vulnerable social groups will be affected, projects should include comprehensive social and cultural enhancement programs. Projects that present significant threats to vulnerable social groups should be avoided if the threats cannot be mitigated.
6. *Prioritise alternatives that enhance public health and / or minimise public health risks.*	Hydropower developments can often provide significant new public health benefits to previously poorly developed areas. Projects can also pose risks, such as increases in waterborne diseases and a temporary rise of mercury levels in fish. Where these risks exist they need to be managed and monitored with an appropriate public health plan.

KEY CRITERIA	DISCUSSION
7. *Prioritise alternatives that minimise population displacement.*	Where population displacement is necessary, comprehensive resettlement and rehabilitation plans need to be developed and implemented in consultation with the affected population. Opportunities to modify scheme design to reduce population displacement need to be carefully examined. An example could be lowering the full supply level of a proposed reservoir.
8. *Prioritise alternatives that avoid exceptional natural and human heritage sites.*	Developers should make every effort to avoid, or reduce to a minimum, alterations to sites of exceptional national and international value.
9. *Prioritise alternatives that have lower impacts on rare, vulnerable or threatened species, maximise habitat restoration and protect high quality habitats.*	Potential impacts on rare, vulnerable or threatened species should be carefully assessed as part of the decision-making process. Consideration of the creation of alternative habitats or the protection of adjacent areas should be considered as part of any mitigation program. Habitats are of varying quality and priority should be given to protecting or restoring higher quality habitats. Significant damage to areas of high conservation value (including critical habitat for endangered species) should be avoided when adequate mitigation or compensation is not feasible.
10. *Prioritise alternatives that can achieve or complement community-supported objectives in downstream areas.*	Regulation of a river, or its diversion, creates environmental change in the downstream reaches. Environmental flow regimes should be developed on the basis of community-supported objectives.
11. *Prioritise alternatives that have associated catchment management benefits and lower sedimentation and erosion risks.*	Sites and options should be assessed for sedimentation and erosion risks, both within the reservoir and downstream. Catchment management strategies can reduce sediment load entering reservoirs. Developers need to assess the need for the creation of catchment reserves or other management strategies to reduce erosion and sediment transport. Where appropriate, support should be given for conservation areas in catchments. Construction programs should be geared to ensuring minimum disturbance and appropriate rehabilitation of disturbed sites.

4.3 Environmental Assessment (EA) Principles

Environmental assessments (also known as environmental impact assessments or environmental impact statements – EIAs and EISs) are conducted to inform decision makers of positive and negative effects of a project and associated mitigation measures.

IHA's policy position is that Environmental Assessments (EAs) should be applied at the project level.

EAs should take account of higher-level national and/or regional policies and strategic assessments, including assessments already completed for the relevant river basin(s). Initial screening should be conducted to determine if a project is likely to have significant effects on the environment by virtue of its nature, size or location.

EAs should be conducted for all hydro-electric projects that have the potential for significant impacts on the environment. EAs should be based on good science and factual information. They should be relevant to the scale and nature of the project in question and factor in existing information.

IHA members should apply appropriate procedures or codes of practice regarding stakeholder participation and environmental protection.

Stakeholders should be given opportunities to participate in decision-making processes. Their roles, and rights to access information, should be documented in language relevant to their needs.

IHA supports transparency of process and co-ordination between the different sectors involved - government, developer and community interests. It recommends developers consult with local and national resource agencies at the earliest opportunity to assist in the determination of the environmental issues to be addressed, the studies required, and to clarify the timelines that apply.

Regulatory authorities should have specified and reasonable timelines for their assessment and approval processes.

IHA recognises the following stages of environmental assessment.

Initial Screening

Aim: to establish the types and scale of project risk and opportunity, and ensure consistency with environmental and other relevant policies.

Scoping

Aim: to determine the type, level and guidelines for environmental assessment based on regulatory requirements and community input. The guidelines should define key project level environmental issues to be addressed. These in turn should be relevant to the project and appropriate to the scale and type of risk involved.

Conduct Environmental Studies

Aim: to address the key issues outlined in the guidelines supplied by regulatory agencies, and to present the decision making authority with the relevant environmental information covering project, construction, commissioning and management.

Appraisal

Aim: for the decision-making authority to consider the quality of information supplied by the proponent and determine conditions of development approval/license.

Implementation (construction and operation)

Aim: to manage environmental issues during construction and operation in accordance with agreed conditions.

Monitoring

Aim: to measure predicted impacts and the effectiveness of mitigation measures through adherence to commitments in specified management plans, licence conditions, and voluntary agreements.

IHA acknowledges that an EA for a large infrastructure project, such as a hydro-electric power scheme, takes place in a broad political, social and economic context. It is one step in a wider decision making process, and is generally written to provide authorities with the following information.

- A full description of the project;
- A statement of objectives, including clear targets and proposed indicators of success;
- A description of the existing environment in the area where the project is to be developed;
- Project justification, including evaluation of project alternatives;
- Economic, social and environmental considerations, including the consequences of not undertaking the project;
- Any mitigation measures that will be implemented to minimise environmental harm and / or enhance the environment; and
- A description of the stakeholder communication / consultation process.

IHA supports post-construction auditing to measure performance against objectives, targets and proposed indicators of success detailed in the project EA.

A key element for public acceptance can be the negotiation of an agreement between the proponent and the local community on the nature and scope of the collaboration required to conduct the EA.

IHA encourages bilateral and multilateral development agencies to support institutional strengthening and capacity building for impact assessment in developing countries.

4.4 Safety

The first priority for dam designers, builders, owners and operators is dam safety and the protection of life, property and the environment from the consequences of dam failure.

Dam safety is factored into all phases of the planning, design, construction and operation of a hydropower development. Potential dam and reservoir sites need to be thoroughly assessed from a safety perspective. Comprehensive dam safety risk assessments are completed for selected sites in any proposed schemes.

Design and construction practices need to ensure that defined safety requirements, as identified in the risk assessment and agreed with appropriate regulatory authorities, are met. Changes in flood frequency lead to changes in land-use activities and population distribution. These changes should be included in any risk assessment.

All operating dams should have a dam safety management plan. This should define the scale, frequency and nature of monitoring requirements, including types of instrumentation required. Levels of expertise needed to implement the plan should also be specified.

Identification of potential problems during dam monitoring needs to be followed-up in a timely manner with detailed investigations and, where required, the rectification of the problem.

Dam safety programs need to include emergency response plans. These need to be developed in conjunction with relevant regulatory authorities and stakeholders – particularly downstream residents. They should clearly specify responsibilities for action and be supported by appropriate awareness and training programs.

Effective dam safety programs will ensure the community is not exposed to unacceptable risks and that the long-term value of the dam and its associated infrastructure is preserved.

Safety planning can often be integrated within a formalised environmental management system.

4.5 Management of existing hydropower schemes

IHA encourages its members to ensure appropriate management of environmental and social issues throughout the life of the project.

4.5.1 Legal & institutional arrangements

Operators of hydro-electric schemes should ensure that they have processes in place to ensure compliance with all relevant laws, policies, permits, agreements and codes of practice for the jurisdictions in which they operate.

These may include, but are not limited to:

- Electricity supply industry legislation;
- Water management legislation and policies, including licences, water management plans and water quality standards;
- Environment protection legislation and associated regulatory standards and permits;
- Conservation and threatened species legislation;
- Cultural heritage and indigenous rights legislation;
- Resettlement and compensation regulations and/or agreements;
- Occupational health and safety legislation;
- National, regional and local government policies;
- International agreements and protocols;
- Corporate law requiring financial and environmental reporting;
- Relevant international laws, conventions and protocols; and
- Voluntary commitments and signed agreements.

Hydro-power operators should undertake an analysis of legal risks with the aim of developing appropriate response strategies, identifying activities that need to be managed, and determining priorities.

For a power scheme operator, complex jurisdictional issues can be difficult to manage. Decisions on how water is allocated for urban water supplies, industry, irrigation for agriculture and power generation, not to mention the maintenance of environmental flows, becomes a competitive task when the resource is finite and there are multiple interests. Conflicts can occur, and unless the legal and administrative framework for resolving these competing needs is adequate the power scheme operator is left in an untenable situation.

Investors in major long-term projects such as hydro-power developments need a reasonable degree of certainty regarding the on-going viability of their investments. Adjustments to operations may be required as new information becomes available and the results of monitoring programs are assessed. If governments introduce new environmental or resource usage objectives they should consider the impacts on the economic viability of hydro-electric power schemes, as well as other economic and social implications, and compensate accordingly.

4.5.2 Environmental management systems

One approach to continual improvement of operational practices is through a formal environmental management system (EMS).

IHA believes hydro-power operators, as well as manufacturers of hydro-electric equipment, should adopt internationally recognised environmental management systems (such as ISO 14001). The implementation of these systems is enhanced where:

- there is a corporate environmental ethos where environmental excellence and business excellence are twin goals;
- senior management leadership and commitment drives environmental understanding throughout the organisation;
- there is a corporate commitment to continuously improve environmental management systems, operating practices as well as training and awareness raising in the workforce;
- employees work to a common environmental or "sustainability" goal;
- there is a clear line of accountability and responsibility for environmental impacts; and
- there is corporate recognition of employees initiating environmental improvements.

The components of an environmental management system are summarised as follows:

- Management Commitment;
- Environmental Policy;
- Environmental Aspects and Impacts;
- Objectives and Targets;
- Roles and Responsibilities;
- Planning and Programs;
- Regulatory Compliance;
- Document Control;
- Operational and Emergency Procedures;
- Training;
- Monitoring and Measuring; and
- Review (including environmental audits) and Improvement.

Hydropower operators should also consider incorporating their EMS as part of a broader sustainability management and public reporting program. Open and continuous stakeholder consultation enhances longer-term relationships with the local community, regulators, and shareholders.

5 Hydropower - Environmental Aspects of Sustainability

Over the past decade, there have been substantial improvements in our understanding of the impacts of dams on riverine environments, and particularly those associated with hydropower developments. In line with this increased knowledge base, the management of environmental issues arising from hydropower is undergoing rapid improvement. Targeted studies and monitoring programs have identified viable mitigation options and provided long-term assessments of their effectiveness. Increased legislative and regulatory mechanisms have also driven these improvements. Changes in the approach to project planning and design have resulted in the maximisation of positive outcomes and the reduction in severity or avoidance of impacts.

5.1 Optimising Environmental Outcomes for hydropower schemes

Table 3 Optimising environmental outcomes for hydropower schemes

Issue for Management Consideration	Mitigation Options/Strategies
1. Water quality *Changes in water quality are likely to occur within and downstream of the development as a result of impoundment. The residence time of water within a reservoir is a major influence on the scale of these changes, along with bathymetry, climate and catchment activities. Major issues include reduced oxygenation, temperature, stratification potential, pollutant inflow, propensity for disease proliferation, nutrient capture, algal bloom potential and the release of toxicants from inundated sediments.* *Many water quality problems relate to activities within the catchment beyond the control of the proponent.*	Adequate data collection and an EIA process that identifies potential problems prior to dam design are critical. Design and operational systems that minimise as much as possible the negative impacts within the storage and downstream; examples include multi-level off-takes, air injection facilities, aerating turbines, and destratification capability. While removal of vegetation from proposed impoundments is expensive, the potential benefits for water quality means that at least some removal should be considered. Working with local communities and regulatory authorities in improving catchment management practices can have significant water quality benefits for hydro reservoirs.
2. Sediment transport and erosion *The creation of a reservoir changes the hydraulic and sediment transport characteristics of the river, causing increased potential sedimentation within the storage and depriving the river downstream of material. Sedimentation is an important sustainability issue for some reservoirs and may reduce the long-term viability of developments. Reduction in the sediment load to the river downstream can change geomorphic processes (eg. erosion and river form modification).*	Development proposals need to be considered within the context of existing catchment activities, especially those contributing to sediment inflow to the storage. Reducing reservoir sedimentation through cooperation with local communities and regulatory authorities in improving catchment management practices is an option. Specific actions, such as terracing or reforestation, may need to be considered. In some cases sediment by-passes, flushing systems or dredging should be investigated. Operational or physical mitigation measures to reduce erosion of downstream should be considered for both proposed and existing developments and appropriate objectives set.

Issue for Management Consideration	Mitigation Options/Strategies
3. Downstream hydrology and environmental flows *Changes to downstream hydrology impact on river hydraulics, instream and streamside habitat, and can affect local biodiversity. Operating rules should not only consider the requirements for power supply, but also be formulated, where necessary and practicable, to reduce downstream impacts on aquatic species and human activities.*	Operating schedules should, where necessary and practicable, incorporate environmental water release patterns (including environmental flows) within the operational framework for the supply of power. Downstream regulating ponds and other engineering solutions may provide cost-effective alternatives to environmental flow releases directly from power stations. It is important that the environmental objectives of any flow release are identified in a clear and transparent manner. These releases need to be developed within the context of environmental sustainability and also take into account local and regional socio-economic factors. It is desirable that the environmental flow objectives be agreed with local communities.
4. Rare and endangered species *The loss of rare and threatened species may be a significant issue arising from dam construction. This can be caused by the loss or changes to habitat during construction disturbance, or from reservoir creation, altered downstream flow patterns, or the mixing of aquatic faunas in inter-basin water transfers.* *Hydropower developments modify existing terrestrial and aquatic habitats, and when significant changes cannot be avoided, mechanisms to protect remaining habitats at the local and regional scale should be considered in a compensatory manner.*	Plans to manage this issue need to be developed prior to construction and options for mitigation identified and assessed. Habitats of critical importance should be identified (within a wider regional context) and impacts to these avoided or minimised as much as possible during the design phase. Targeted management plans need to be developed for species of conservation significance. Translocations or habitat rehabilitation may be options, along with identification of suitable habitat for 'reserve' management.
5. Passage of fish species *Many fish species require passage along the length of rivers during at least short periods of their life-cycle. In many places the migration of fish is an annual event and dams and other instream structures constitute major barriers to their movement. In some cases the long-term sustainability of fish populations depend on this migration and in developing countries local economies can be heavily reliant on this as a source of income.*	The passage of fish is an issue that must be considered during the design and planning stage of proposed developments (dam site selection) and adequate consideration should be given to appropriate mechanisms for their transfer (eg. fish ladders, mechanical elevators, guidance devices and translocation programs). Large-scale downstream migration of some species may require mitigation measures to reduce mortality by passage through turbines. Appropriate and feasible options for facilitating passage are also an issue for existing developments.

Issue for Management Consideration	Mitigation Options/Stategies
6. Pest species within the reservoir (flora & fauna) *In some regions a significant long-term issue with reservoirs, irrespective of their use, is the introduction of exotic or native pest species. The change in environment caused by storage creation often results in advantageous colonisation by species that are suited to the new conditions, and these are likely to result in additional biological impacts. In some instances, proliferation may interfere with power generation (eg. clogging of intake structures) or downstream water use through changes in the quality of discharge water (eg algal bloom toxins, deoxygenated water).*	Identifying the risk of infestation prior to development should also help identify potential options for future management or mitigation. Shorter residence time of water is one viable mechanism for reducing risk. Downstream water uses must also be considered when examining potential options for control.
7. Health issues *The changes brought about by hydropower developments have the capacity to affect human health. Issues relating to the transmission of disease, human health risks associated with flow regulation downstream and the consumption of contaminated food sources (eg, raised mercury levels in fish) need to be considered. The potential health benefits of the development should also be identified.*	Public health and emergency response plans should be developed in conjunction with local authorities. These plans, and their associated monitoring programs, should be relevant to the levels of risk and uncertainty. The health benefits due to improved water supply, economic improvements and flood control should be recognised. Proper reservoir management can be highly effective in eliminating mosquito-borne illnesses such as malaria.
8. Construction activities *Construction needs to be carried out so as to minimise impacts on the terrestrial and aquatic environment.* *Where a new development is planned, there are a range of activities that can result in environmental impacts, both terrestrial and aquatic. Noise and dust may also be issues where the development is close to human habitation.*	These issues should be adequately addressed during the EA stage and plans developed to manage these issues. Plans to manage specific issues may be required; e.g., rehabilitation of borrow pits, management of construction site drainage, storage and handling of chemicals. Similar plans to manage disturbance to terrestrial and aquatic fauna may also be required.
9. Environmental management systems *It is recommended that all hydropower schemes implement an independently audited environmental management system.*	An environmental management system should allow for effective management of the range of environmental issues associated with the on-going operation of the hydropower scheme. The associated monitoring programs and environmental plans should ensure a program of continuous improvement in environmental management over the life of the project.

6 Hydropower – Social Aspects of Sustainability

Hydropower schemes have the ability to significantly reduce poverty and enhance quality of life in the communities they serve. Access to electricity promotes new economic activity, empowers women by reducing domestic and repetitive chores such as firewood collection, improves health and education services, and provides a cleaner and healthier home environment. Hydropower infrastructure, such as reservoirs, also provides multiple-use benefits, particularly through increased availability, reliability and quality of fresh water supplies and reduced flood risks.

Local communities are impacted by the change associated with new hydro projects. To be sustainable these schemes need to recognize entitlements and share benefits with directly affected people. The goal should be to ensure that all individuals and communities affected by developments gain sustainable benefits.

6.1 Managing social impacts

There are various issues that require management to ensure that change affecting communities and individuals is effectively managed during the planning, construction and operation of hydropower facilities. Possible social impacts that require consideration are identified below.

1. Changes to resource use and biodiversity in the area of the proposed project and the impacts this may have on the local community.
2. Distribution of benefits among affected parties.
3. Effectiveness and on-going performance of compensatory and benefits programmes.
4. Public health issues that can result from the modification of hydrological systems, especially in tropical and sub-tropical areas, where water-borne diseases can be a significant issue. In some reservoirs, a further concern is the management of the temporary rise of mercury levels in fish.
5. The impacts of displacement on individuals and communities. These impacts include:
   - the physical loss of homes and lands;
   - the transition to alternative means of earning a livelihood, particularly for populations that rely heavily on local land and resources for their way of life or that have a traditional existence;
   - disruption of established community networks and loss of cultural identity.

6.2 Outcomes for new developments

When developing hydropower projects, governments and proponents should aim to achieve the following outcomes.

1. Providing affected communities with improved living conditions.
2. Improving public health conditions for impacted communities.
3. Ensuring equitable distribution of the benefits of the project, particularly to affected and vulnerable communities, through processes such as revenue sharing, training programmes and educational outreach.
4. Ensuring that the local knowledge of communities and stakeholders is utilised in project planning.
5. Supporting additional community infrastructure associated with the project, particularly water and electricity connection, where positive benefits to the community will result.

6. Ensuring that displacement is dealt with in a fair and equitable manner. The broad guidelines required to address displacement are:

   - to investigate all possible project alternatives to ensure that displacement is avoided or minimised where feasible;
   - to plan the resettlement thoroughly, where displacement is necessary, ensuring that adequate resources are available to enable the displaced groups to share in the benefits of the project;
   - to ensure adequate and on-going consultation with those groups or individuals that will be displaced, so that they have input into both the planning and the implementation of the resettlement program;
   - to provide displaced groups with sufficient assistance to ensure that their livelihoods are improved or, as a minimum, to ensure that they are re-established at no disadvantage; and
   - to improve standards of living for both the displaced communities as well as the host community, where applicable.

6.3 Strategies to achieve proposed outcomes

To enable the above outcomes to be addressed the following strategies are outlined.

The project proponent should ensure that:

- adequate consultation is undertaken, with relevant local, regional and national agencies consulted, and any legislation, regulations, codes of practice or guidelines of government agencies complied with;
- impacts on the community, stakeholders and the environment are identified and that stakeholders are informed about the project and the implications for them, as well as being regularly consulted throughout the planning and implementation phases;
- stakeholders who may be affected by the project are provided with the opportunity to be represented during the different phases of project development;
- those communities or individuals affected by the project are compensated for impacts caused by the project;
- the proposed project is the best alternative, following the consideration of relevant stakeholders concerns;
- a negotiated and agreed outcome is achieved wherever possible; and
- the community and environmental resources are managed in a sustainable way, and on-going monitoring and liaison with local community groups continues through the life of the project.

Community acceptance of a project, particularly in its early phases, will greatly assist in the successful implementation of that project. To achieve community acceptance, the following should be undertaken by the proponent and / or regulatory authorities.

1. Ensure that benefits and costs of the project, including environmental, social and economic, are clearly identified, documented and disseminated to stakeholders.
2. Identify stakeholders and impacted communities and provide them with the opportunity to have informed input into the decision making process. The community must view the process as being open, fair and inclusive.
3. Affected stakeholders should participate in the development and implementation of mitigation measures, including the formulation of a Resettlement Plan or Policy.

4. A process for addressing future concerns or risks from the project needs to be outlined to stakeholders at the start of the project.

5. Specifically identify any minority and / or vulnerable groups and ensure that they are adequately represented in any consultation process and are not adversely impacted by the project.

6. Communities and / or groups that are impacted by a project should be the first to benefit. These groups should also participate in the identification, planning and distribution of benefits.

7. Communities that will be affected should be compensated for their loss. This will include those persons or groups displaced by associated infrastructure developments, such as roads, those communities both upstream and downstream who experience loss of livelihood, and those who depend on common resources such as forests and agricultural land that might be altered by the project.

8. Where compensation is to be paid, this is undertaken in a timely manner to ensure that the displaced persons are not disadvantaged.

9. Where involuntary displacement is necessary, following consideration of all other alternatives, the same compensation and support standards should apply to all groups whether they have agreed to relocation arrangements or not.

10. All displaced persons should be informed about their rights and options in relation to resettlement.

11. Local and regional resources (particularly labour) should be utilised in the development and operation of the project. Local communities will then more readily see the benefits of the scheme to their community.

12. Social compensation projects (such as new roads) should undergo appropriate environmental assessment.

7 Hydropower - Economic Aspects of Sustainability

There can be no sustainable development without the demonstration of sound and equitable distribution of economic benefits. For this reason economic considerations are a central plank in the decision-making processes associated with hydropower projects. The efficient use of economic resources requires that the best options are selected, that alternatives have been carefully evaluated, and that there are no hidden and unforeseen costs that could emerge in the future. This is the basis for sound economic practice.

All significant hydro costs come at the construction stage. Once constructed, a hydro project is virtually immune from further inflationary pressures and has a very long economic life. Older hydropower stations are often rehabilitated or upgraded, but are seldom decommissioned. Hydropower projects also have favourable energy payback periods (the amount of energy derived from the generating station compared with that put into its construction and operation). In addition they play a pivotal role in integrated energy systems due to their flexibility and reliability. Energy storage associated with hydro schemes is increasingly being seen as a mechanism by which other less reliable and more dilute renewable energy sources (such as wind, wave and solar) can play a larger role in providing electrical power of commercial quality. This high level of service provided by hydropower combined with its multi-purpose character are driving forces for regional development. For these reasons, hydropower projects can be considered as a tool for economic development.

Governments need to ensure that the longer-term and less direct benefits of hydropower projects are not overlooked in the planning process or penalized by short-term financing or tax regime requirements. With new developments, capital and operating costs should be taken into account over the lifetime of a project with a life-cycle assessment of project alternatives forming an integral component of assessment processes. Direct and indirect costs and benefits should be identified, and where possible quantified in monetary terms. The key principles are as follows and require a clear understanding of government and developer responsibilities.

7.1 Institutional framework

Governments need to establish a suitable investment climate and communicate this widely, in the process making known their project priorities. In particular, governments should ensure that:

1. The legislative framework for decision making is one in which an investor can have confidence in terms of clarity, the impartiality of the legal process, and the ability to resolve disputes without undue costs or delay.

2. An efficient institutional framework is in place to ensure that all parties concerned with the development of any project are fully aware of the factors of interest to themselves and that, as far as possible, unnecessary delay and conflict of interest are avoided.

3. In determining project priorities, the long-term interests of the state should be taken into account, in terms of the selection of the preferred project and the finalisation of its ultimate configuration.

4. Economic and financial analysis should take account of the effects of assumed interest rates, and some allowance taken of the needs for price escalation.

5. Wherever possible mechanisms should be implemented to reconcile the gap between short-term price competitiveness and long term wealth creation. Multilateral development banks should be encouraged to play their full part in this process.

7.2 Identifying costs and benefits

Economic sustainability decisions should be based on a comprehensive evaluation of resources affected and project costs and benefits, some of which will be difficult to quantify in precise terms. As far as possible the following elements should be taken into account:

Costs

1. Construction, operations and maintenance costs should be fully detailed, recognising the split between foreign and local currency, financing options and the anticipated exposure that these might give in terms of exchange rate variation.
2. Land acquisition costs should be evaluated in terms of actual economic value of land, as opposed to arbitrary valuations based on little substance.
3. The full capital and recurrent costs of environmental and social mitigation plans should be included.
4. Allowance should be made for the replacement of the main items of equipment after a defined period, and for the rehabilitation of civil works where this becomes necessary.

Benefits

1. Allowance should be made of the accrued benefits at a national or regional level, including any additional taxes, industrial development and improved infrastructure or multiple use benefits that could be attributed to the project.
2. Recognition of savings on greenhouse gas emissions, and improved local air quality, to the extent that this can be quantified.
3. Where feasible, allowance should be made for benefits that accrue to local communities including job creation, local industry, recreation, training, improved health care and sanitation, or environmental benefits.
4. Full quantification of the energy and power benefits (generally measured in terms of the displaced alternative) and ancillary benefits such as spinning reserve, system regulation and improved thermal efficiency.
5. Multi-purpose / multiple use benefits to downstream users and other riparian interests, including irrigation, water supply, flood mitigation, water-based transport, and the improved regulation of other hydropower stations downstream.

7.3 Allocation of benefits

In most countries water resources belong to the State, and this is generally also the case for the land on which the project is built. A hydro project, particularly one with reservoir storage, can affect a large number of people, some of whom are remote from the site itself.

These facts raise some important issues regarding the sharing of benefits arising from a project. The most fundamental point is that some of the benefit must accrue, either directly or indirectly, to the State.
For internal projects supplying domestic electricity demand, this might take the form of stable energy prices and other benefits to the utility in the form of ancillary services; but for an export project where power is being used in another country, a more explicit system of payment is needed.

The principal stakeholders in any project are the developer, the electricity user/supplier (if different), governments, financing agencies, communities and individuals directly affected by the scheme (for example, traditional resource users). These stakeholders should be identified early in the planning and development approval process and their legitimate interests acknowledged and taken into account in the financial and economic evaluation processes.

The above objectives imply the need for the following:

- Balanced commercial agreements in the case of privately funded projects
- Reasonable returns on equity, consistent with the risk profile and international norms
- Transparency in procurement processes
- Directly negotiated contracts to be subject to independent audit
- Ongoing auditing/monitoring of economic performance against projected benefits.

8 IHA Member Commitment to Sustainability

Hydro-electricity, provided that it is developed and operated in a sustainable manner, will play an important role in addressing some of the major global challenges of the twenty first century.

One of these challenges is to alleviate poverty and increase living standards through the provision of affordable access to water, electricity and basic services. This is a necessary step towards achieving more equity between different socio-economic groups within nations, and between developed and developing nations.

Another major challenge is global warming. This is the world's most pressing environmental issue and requires the increasing development of less carbon intensive methods of energy production.

On both counts hydro-electricity is making, and will continue to make, a significant contribution.

IHA members are operators and developers of hydro-electric projects. They are committed, through their membership of IHA, to the underlying principles of sustainability outlined in this document.

Acknowledgements

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