Hydropower and the Environment:

Present Context and Guidelines for Future Action

IEA Technical Report

VOLUME I

Summary and Recommendations

IEA Hydropower Agreement

CANADA CHINA FINLAND FRANCE JAPAN NORWAY SPAIN SWEDEN UNITED KINGDOM

OVERVIEW OF THE IEA IMPLEMENTING AGREEMENT FOR HYDROPOWER TECHNOLOGIES AND PROGRAMMES

The Hydropower Implementing Agreement is a collaborative programme among nine countries: Canada, China, Finland, France, Japan, Norway, Spain, Sweden and the United Kingdom. These countries are represented by various organizations including electric utilities, government departments and regulatory organizations, electricity research organizations, and universities. The overall objective is to improve both technical and institutional aspects of the existing hydropower industry, and to increase the future deployment of hydropower in an environmentally and socially responsible manner.

HYDROPOWER

Hydropower is the only renewable energy technology which is presently commercially viable on a large scale. It has four major advantages: it is renewable, it produces negligible amounts of greenhouse gases, it is the least costly way of storing large amounts of electricity, and it can easily adjust the amount of electricity produced to the amount demanded by consumers. Hydropower accounts for about 17% of global generating capacity, and about 20% of the energy produced each year.

ACTIVITIES

Four tasks are operational, they are: 1. upgrading of hydropower installations, 2. small scale hydropower, 3. environmental and social impacts of hydropower, and 4. training in hydropower. Most tasks have taken about five years to complete, they started in March 1994 and the results will be available in May 2000. To date, the work and publications of the Agreement have been aimed at professionals in the respective fields.

UPGRADING

The upgrading of existing hydropower installations is by far the lowest cost renewable energy available today. It can sometimes provide additional energy at less than one tenth the cost of a new project. One task force of the Agreement is studying certain technical issues related to upgrading projects.

SMALL SCALE HYDROPOWER

Advances in fully automated hydropower installations and reductions in manufacturing costs have made small scale hydropower increasingly attractive. The small scale hydropower task force will provide supporting information to facilitate the development of new projects.

ENVIRONMENTAL AND SOCIAL ISSUES

For some hydropower projects the environmental and social impacts have been the subject of vigorous debate. There is a need to communicate objective information to the public, so that countries can make good decisions with respect to hydropower projects. The environmental task force will provide such information on possible social and environmental impacts and on mitigation measures.

TRAINING

The availability of well-trained personnel is a key requirement in the hydropower sector. The training task force is concentrating on training in operations and maintenance, and planning of hydro power projects.

INTERNATIONAL ENERGY AGENCY

IMPLEMENTING AGREEMENT FOR
HYDROPOWER TECHNOLOGIES
AND PROGRAMMES

ANNEX III

HYDROPOWER AND THE ENVIRONMENT:

PRESENT CONTEXT AND GUIDELINES FOR FUTURE ACTION

**Subtask 5
Report**

VOLUME I:

**Summary and
Recommendations**

May 2000

TECHNICAL REPORTS IN THIS SERIES

Hydropower Upgrading Task Force (Annex 1)
Guidelines on Methodology for Hydroelectric Turbine Upgrading by Runner Replacement – 1998 (available to non-participants at a cost of U.S. $1,000 per copy)

Guidelines on Methodology for the Upgrading of Hydroelectric Generators – to be completed in May 2000

Guidelines on Methodology for the Upgrading of Hydropower Control Systems – to be completed in 2000

Small-scale Hydropower Task Force (Annex 2)
Small-scale Hydro Assessment Methodologies – to be completed in May 2000 (available to non-participants on request)

Research and Development Priorities for Small-scale Hydro Projects – to be completed in May 2000 (available to non-participants on request)

Financing Options for Small-scale Hydro Projects – to be completed in May 2000 (available to non-participants on request)

Global database on small hydro sites available on the Internet at: www.small-hydro.com

Environment Task Force (Annex 3)
Survey on Positive and Negative Environmental and Social Impacts and the Effects of Mitigation Measures on Hydropower Development – 2000 (available to non-participants on request)

A Comparison of the Environmental Impacts of Hydropower with those of Other Generation Technologies – 2000 (available to non-participants on request)

Legal Frameworks, Licensing Procedures, and Guidelines for Environmental Impact Assessments of Hydropower Developments – 2000 (available to non-participants on request)

Hydropower and the Environment: Present Context and Guidelines for Future Action
Volume 1: Summary and Recommendations
Volume 2 : Main Report
Volume 3 : Appendices
– 2000 (available to non-participants on request)

Hydropower and the Environment: Effectiveness of Mitigation Measures – 2000 (available to non-participants on request)

Education and Training Task Force (Annex 5)
All of the following reports are available on the Internet at www.annexv.iea.org (some reports may consist of more than one volume)

Summary of Results of the Survey of Current Education and Training Practices in Operation and Maintenance – 1998 (available to non-participants on request)

Development of Recommendations and Methods for Education and Training in Hydropower Operation and Maintenance – 2000 (available to non-participants on request)

Survey of Current Education and Training Practice in Hydropower Planning – 1998 (available to non-participants on request)

Structuring of Education and Training Programmes in Hydropower Planning, and Recommendations on Teaching Material and Reference Literature - 2000 (available to non-participants on request)

Guidelines for Creation of Digital Lectures – 2000 (available to non-participants on request)

Evaluation of Tests – Internet-based Distance Learning – 2000 (available to non-participants on request)

Brochure
A brochure is available for the general public. Entitled “Hydropower – a Key to Prosperity in the Growing World”, it can be found on the Internet (www.usbr.gov/power/data/data.htm) or be obtained from the Secretary. (address on the inside back cover)

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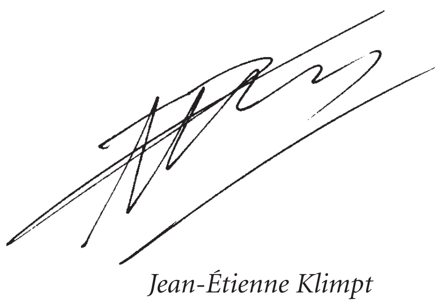
Montréal, 1 April 2000



Jean-Étienne Klimpt
Canadian Representative,
Annex III Subtask 5 Leader

PREFACE

The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organization for Economic Cooperation and Development (OECD). The IEA carries out a comprehensive program of energy cooperation among twenty-four of the OECD'S twenty-nine member countries[1]. The basic aims of the IEA, which are embodied in the *Agreement on an International Energy Programme*, are the following:

- cooperation among IEA participating countries to reduce excessive dependence on oil through energy conservation, development of alternative energy sources and energy research and development
- an information system on the international oil market as well as consultation with oil companies
- cooperation with oil-producing and other oil-consuming countries with a view to supporting stable international energy trade, as well as the rational management and use of world energy resources in the interest of all countries
- a plan to prepare participating countries against the risk of a major disruption of oil supplies and to share available oil in case of an emergency.

As part of the implementation of the IEA's comprehensive program of energy cooperation, ten member countries of the IEA agreed in 1995 to cooperate in a five-year research program focused on hydropower. The contents of this particular program were set out in the *Implementing Agreement for Hydropower Technologies and Programmes.* The *Implementing Agreement* proposed that four distinct Task Forces be set up to address the various outstanding issues pertaining to hydropower. Designated as the *Annexes*, these Task Forces aim to address the following topics:

- Annex I:
  Upgrading of Existing Hydropower Facilities
- Annex II:
  Small-Scale Hydropower
- Annex III:
  Hydropower and the Environment
- Annex V:
  Education and Training

The present report is one of the outcomes of work carried out within the scope of *Annex III*, concerning Hydropower and the Environment. Seven member countries were active participants in this work. These countries are Canada, Finland, Italy[2], Japan, Norway, Spain and Sweden.

The linkage between hydropower and the environment is of particular interest at the present time. In the short term, hydropower represents the only large-scale renewable alternative to fossil fuel generation, particularly in developing countries. It provides approximately 19% of the electricity produced worldwide, and only one-third of its economically feasible potential has been developed to date. Future hydropower development will need to conform to demanding social and environmental standards in order to ensure that it is fully sustainable, and future water resource development projects will be faced with increased demands by different users. The increase in environmental awareness which has occurred during the past two decades has led to a heightened concern to minimize negative effects of hydro projects on the ecosystem and on the social fabric of local communities.

1 IEA participating countries are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway (by special agreement), Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

2 Italy withdrew from Annex III in 1997.

The objectives set-out for the *Annex III* Task Force were to produce a set of international recommendations and criteria in view of improving the environmental management of hydropower. These objectives extended to developing the information base required for making environmental comparisons between hydropower and other forms of electricity production.

The *Annex III* Task Force is composed of several working groups, called Subtasks. The efforts of these Subtask working groups are summarised below:

- *Subtask 1* carried out an international survey on the management of the environmental impacts of hydropower;

- *Subtask 2* prepared the database required to integrate the results of the survey;

- *Subtask 3* proceeded with the comparison of the environmental impacts of electricity generating options;

- *Subtask 4* studied the legal and regulatory processes associated with hydropower;

- *Subtask 5* provided the synthesis of the Annex III work and presented the International Recommendations on Hydroelectricity and the Environment;

- *Subtask 6* analysed environmental impacts and mitigation measures associated with hydropower.

This report is the final product of *Subtask 5*. It summarises and reflects the work achieved by the other Subtasks. The report draws from expertise, reviews and comments originating from both within and without the *Annex III* Task Force. The intent of the Task Force is to provide up-to-date knowledge, guidance and references on the best available environmental practices in the hydropower sector. The information presented in the report is based on actual case studies, as well as on the experience of technical and environmental professionals who are actively involved in the hydropower sector.

The intended audience for this report is composed of professionals and policy makers involved in the development, the operation or the regulation of power generation and supply. The report is also destined to other interested parties, such as government agencies, utilities, bilateral and multilateral organisations, non-governmental organisations (NGOs), academic institutions or others.

The information contained in the report is presented in three volumes:

Volume I:
Summary and Recommendations

Volume II:
Main Report

Volume III:
Appendices

SUMMARY AND RECOMMENDATIONS

INTRODUCTION

This report summarises the findings of Annex III work[3] , and presents recommendations on improving environmental practices for existing and future hydropower plants.

These recommendations focus on *best practices* rather than *minimum practices*, and as such set high standards of environmental management. The practices recommended are based on a critical review of past experience by environmental practitioners who work in assessing and managing the environmental impacts of hydropower[4].

Given the site and project-specific nature of hydropower project impacts[5], not all of these recommendations apply to all types of hydropower projects: for example, a run-of-river project is not concerned by recommendations regarding reservoir management.

The review of best practices in the hydropower sector reveals that hydropower projects can be truly sustainable when they "internalise" (or fully account for) their social and environmental costs. This is a significant challenge in an era of competitive electricity markets: if other competing power generation options - coal, oil, gas, etc. - do not in turn "internalise" their own impacts, then there is no level playing field. In such a case, imposing extensive environmental requirements *on hydropower only* is equivalent to subsidising air pollution and greenhouse gas emissions. Indeed, this gives a competitive advantage to other options, which are, today, mostly thermal generators. Environmental responsibilities must apply evenly to all players in the power sector.

Public pressures and expectations regarding the environmental and social performance of hydropower tend to increase over time. Throughout the world, several projects have recently been the subject of disputes and sharp resistance. This has led in certain cases to the cancellation of major hydropower projects.

It is clear that poorly designed and managed projects are likely to have adverse consequences on local communities and the environment and to adversely affect the reputation of concerned governments, financing agencies and the hydropower industry as a whole. In short, it is in the common interest to ensure that the necessary means are taken to design, build and operate the best projects. In view of the above, what are the conditions to be met or the guidelines to be followed in order to design a good hydroelectric project? What constitutes an acceptable project from an environmental and social standpoint?

The reader should keep in mind that this report is on hydropower per se, excluding the impacts of other possible dam uses such as irrigation, flood control or water supply. This is important in view of the fact that a relatively small proportion of large dams throughout the world (20%) are used for the production of electricity, while a much larger proportion of dams (48%) are built for irrigation purposes only[6]. The proportion of dams used for the production of electricity throughout the world is even lower if one includes smaller dams: out of the 75,000 dams over 6 ft (1.83 metres) tall in the U.S.A., only 2.9% are for hydroelectricity[7].

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3 See IEA Hydropower Agreement. Annex III. Subtask III/5: *Hydropower and the Environment: Present Context and Guidelines for Future Action,* Vol. II: Main Report & Vol. III: Appendices

4 See IEA Hydropower Agreement. Annex III. Subtask III/1: *Hydropower and the Environment: Survey on Environmental Impacts of Hydropower and Mitigation Measures.*

5 See IEA Hydropower Agreement. Annex III. Subtask III/6: *Hydropower and the Environment: Effectiveness of Mitigation Measures.*

6 Lecornu, J. 1998. *"Dams and Water Management"*. Conférence Internationale Eau et Développement Durable, Paris. (http://genepi.louis-jean.com/cigb/article-barrages-an.html)

7 U.S. Army Corps of Engineers. *National Inventory of Dams.* Quoted in: *Dam Removal Success Stories.* 1999. p.ix. By American Rivers, Friends of the Earth, & Trout Unlimited.

Moreover, the specific impacts of irrigation dams are frequently quite different from those of hydropower dams[8]. Unlike irrigation, hydroelectricity is a non-consumptive use of available water resources: there is no loss of water as it runs through a hydropower plant.

Because of the focus of the report on hydropower and the environment, wider issues associated with multi-purpose water resource management and the resolution of water use conflicts have not been addressed as such[9].

The present report is written from the perspective of hydropower professionals and practitioners from a selection of OECD countries. Because of the nature of the experience of the contributors to the report, the impacts of large plants have been emphasised to a greater degree than those of smaller hydropower plants.

The next section provides a summary of lessons learned, as presented in the Annex III Technical Report.

LESSONS LEARNED

■ Recent Trends in Hydropower Development [10]

The main trends identified for large hydropower projects are:

- full integration of environmental assessment (EA) into the hydropower planning process
- the recognised need for transparency over project costs, dam safety and environmental and social impacts
- increased public interest and scrutiny of large dam projects
- increased public consultation in identifying and screening projects
- growing recognition that hydropower may be a major instrument in the fight against climate change
- developing hydropower within the context of integrated water resource planning
- increased awareness that environmental sustainability and high discount rates are in conflict
- increased private sector financing and, as a consequence, increased emphasis on cutting costs and duration of design and construction, and on reducing financial risks
- increasing difficulty for hydropower to compete against thermal generation in countries with abundant coal and gas supplies
- an increased awareness and understanding of complex technical, environmental and social issues which are inherent to large dam projects; and the realisation that the development of large dam projects requires trade-offs between potential benefits and potential losses
- a holistic approach with increased application of multi-criteria ranking models and quantification of secondary and external costs and benefits to select the most attractive hydropower projects and alternatives
- a number of technological developments which make the planning and construction of large dam projects more efficient
- increased need for safety inspection and environmental management of existing dam projects
- increased interest in modernisation and upgrading of existing hydropower schemes.

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8 Goodland, Robert. 1999. *"What Factors Dictate the Future Role of Hydro in the Power Sector Mix? Environmental Sustainability in Hydro Projects."* Presented to Annex III, Madrid Technical Seminar. Hydropower and the Environment. Euroforum, Madrid March 15-17, 1999. 24p. + annexes.

9 The World Commission on Dams (www.dams.org) is reviewing the development effectiveness of large dams in general, integrating the multiple uses of dams in its studies.

10 For a full discussion of this issue, see Vol. II: Main Report, Ch.2: *"Trends in Hydropower Development"*. IEA. May 2000. *Hydropower and the Environment: Present Context and Guidelines for Future Action.*

These trends occur in a context of global restructuring of the electricity sector, with increased competition between electricity producers. The privatisation of certain state monopolies in the power sector has led to the creation of new multinational corporations operating in many energy sectors. This new competitive context for electricity production will certainly favour power generation options which minimise both capital investment and the time required to bring production online. The environmental consequences of such a shift towards market-based power generation will depend on what power source the new electricity production options will displace.

Electricity restructuring poses considerable challenges to the environmental regulatory agencies, as well as to operators seeking prudent environmental stewardship: in some regions of the world, electricity markets may favour "cleaner" generation options when compared to existing power generation "mixes", but in other areas of the world, markets may favour more polluting (and less costly) options. In addition, the implementation of energy efficiency programs or of technology development programs in the power sector might require government support to compensate for the inadequacies of existing market mechanisms.

Comparative Environmental Analysis of Power Generation Options [11]

There is a pressing need to compare the relative environmental costs and benefits of the various sources of power generation. Indeed, the demand for power continues to increase worldwide and, in turn, the power industry continues to generate significant ecological and social impacts throughout the world. For a discussion of the comparative generic impacts associated with major power generation options (including hydropower), the reader may refer to Chapter 3 of the Main Report.

Most major human endeavours cause environmental and social impacts, and power generation projects are no exception. However, unlike many other economic activities, power can be produced from a variety of primary energy sources and conversion technologies. Electricity may be generated from the following sources:

Thermal processes based on:

- the combustion of fossil fuels such as coal, oil or natural gas;
- the combustion of biomass: peat, wood, waste and biogas;
- fission reactions in nuclear power plants.

Renewable processes, such as:

- wind, using wind turbines;
- flowing water, with hydropower plants;
- sunlight, with photovoltaic (PV) panels;
- ocean tides, and tidal power plants;
- steam, originating from geothermal emissions.

Chemical processes such as:

- electric batteries, used in cars or portable appliances;
- fuel cells, which transform without combustion streams of oxygen and hydrogen into electricity[12]. These are used in space stations and are under development for terrestrial applications.

The wide variety of primary energy sources and conversion technologies which are available to produce electricity raises difficult questions when trying to compare their relative environmental merits.

Even if some electricity production can be avoided through energy efficiency programs for instance, such programs cannot fill all electricity capacity requirements and also have their own environmental impacts which must be accounted for.

11 For a full discussion of this issue, see Vol. II: Main Report, Ch.3: *"Comparative Environmental Analysis of Power Generation Options"*. IEA. May 2000. *Hydropower and the Environment: Present Context and Guidelines for Future Action.*

12 Emitting GHG when hydrogen is extracted from fossil fuels, such as natural gas or gasoline.

The comparison of power generation options from an environmental perspective must take into account two major aspects: the comprehensiveness of the analysis, and the ancillary services provided by the various electricity generation technologies.

Comprehensiveness

A cursory evaluation of impacts tends to focus only on the impacts of the power plant, thereby omitting the inevitable impacts upstream and downstream of the production cycle. The impact of an oil-based thermal power plant must include the impacts associated with oil extraction, oil transportation and storage, etc., as these activities are unavoidable steps in the process of producing electricity from oil. The same applies to gas or coal based electricity production. The impacts of a photovoltaic plant must include those of the chemicals that enter into the PV cell's manufacture[13].

In short, the life-cycle of the production process must be considered when comparing the environmental impacts of electricity options.

Ancillary Service

Although electricity may be produced from a dozen or more primary energy sources and many more conversion technologies, the end result is not the same. All these processes produce electricity, but the ancillary services they provide are not identical, in terms of conversion efficiency, flexibility of production, or capacity to follow demand.

For example, car batteries provide electricity instantly at the turn of a key, but it is inconceivable to provide electricity for a city based on batteries. Therefore the electric battery is well suited for certain applications – instant, low-voltage power – but unsuited for large-scale supply. Another example is photovoltaic or wind power: both are relatively low impact sources, but only produce electricity during daylight or when the wind blows; these are intermittent, variable sources of generation which cannot produce electricity on demand. The service they provide is therefore much more limited than other options.

The examples above illustrate how ancillary services rendered by electricity production options may vary. Some options offer limited services, other options provide many.

When comparing the environmental impacts of power generation options, it is essential to take into account the kind of ancillary services the option provides.

A simple analogy is the environmental comparison between a bus and a car. A bus generates much more pollution than a car. This being true, should we replace buses by cars? The level of service provided by a bus (moving 40 people) is higher than that of a car (moving 4 people). Which mode of transportation has the greatest environmental impact? Based on the service provided by the technology, the private automobile has much larger environmental impacts than the bus[14, 15].

It is interesting to note that technology is not the only aspect to consider when assessing environmental impacts: management is just as important, as an empty bus moving through a city (good technology and poor management of public transit routes) provides no service, and therefore has a much higher environmental impact than the private automobile.

In summary, the exceptional ancillary services provided by hydropower – reliability, power on demand, electricity available in a few minutes from a cold start, energy storage in reservoirs, etc. – makes hydropower a possible producer of base load, of peak load, of voltage and frequency regulation, of energy storage and of other services. These ancillary services are not always available with other power generation options. They must therefore be considered and integrated into the comparative environmental analysis of electricity production options.

13 IEA. 1998. *Benign Energy? The Environmental Implications of Renewables.* OECD/IEA. Paris.

14 However, the automobile offers other services that buses cannot provide, such as flexibility of destination and schedule.

15 Environmental assessments carried out for transportation projects frequently compare various transportation systems (car, bus, rail, air, etc.) on a relative basis such as impact per passenger/km (e.g., pollution or accidents per passenger/km) in order to make fair comparisons between the various options. The same logic must apply to the comparison of power generation systems (e.g., impacts per kWh).

Comparative Life-cycle Environmental Performance of Hydropower

The comparison of the relative environmental performance of power generation systems on the basis of *life-cycle analysis* (LCA) does not eliminate the need for value judgements and arbitration. This is due to the fact that many impacts are impossible to compare directly (e.g., local land use issues for hydropower versus the management of radioactive wastes for nuclear power, or versus the management of global and regional atmospheric issues for coal, oil and natural gas based power). Another constraint of life-cycle analysis is that it cannot easily account for "non-quantifiable" or "qualitative" impacts, such as landscape, social, or biodiversity issues.

Carrying out life-cycle assessments according to decreasing levels of impacts (e.g., global, regional and local) may be a good way to define priorities. Modifications to a global biochemical cycle (such as the carbon cycle) will ultimately produce significant changes at all levels (global, regional and local). Global climate change is likely to be the source of major impacts on biodiversity and human health. Carrying out life-cycle assessments on the basis of such levels of priority would clearly favour any renewable energy source over the various forms of fossil fuel power generation.

To conclude on the comparative life-cycle environmental performance of hydropower, it is important to note that most comparisons of systems are unfair to hydropower for the following reasons:

- the multipurpose character of many reservoirs increase their environmental impacts, while the related benefits are often neglected; social concerns are extremely variable from one project to another

- the reliability that hydropower provides the electricity network is often forgotten

- since "best available technology" is not an appropriate concept for hydropower, comparisons tend to compare statistics of old hydropower projects with new recent thermal power projects.

However, despite this "structural" negative bias, hydropower still comes out ahead of other electricity systems in most life-cycle comparisons. (See Table 1: Synthesis of Environmental Parameters for Electricity Options.)

Table 1: **Synthesis of Environmental Parameters for Electricity Options**

Electricity Generation Options (classified by level of service)	**Energy Payback Ratio**	**Greenhouse Gas Emissions** (kt eq.CO_2/TWh)	**Land Requirements** (km^2/TWh/y)	**SO_2 Emissions** (t SO_2/TWh)	**NO_x Emissions** (t NO_x/TWh)	**NMVOC Emissions** (t/TWh)	**Particulate Matter Emissions** (t/TWh)	**Mercury Emissions** (kg Hg/TWh)
Options capable of meeting base load and peak load								
Hydropower with reservoir	48 – 260	2 – 48	2 – 152 projects designed for energy production	5 – 60	3 – 42		5	0,07 methylmercury in reservoirs
Diesel		555 – 883		84 – 1 550	316+ – 12 300	1 570	122 – 213+	
Base load options with limited flexibility								
Hydropower run-of-river	30 – 267	1 – 18	0,1	1 – 25	1 – 68		1 – 5	
Bituminous coal: modern plant	7 – 20	790 – 1 182	4	700 – 32 321+	700 – 5 273+	18 – 29	30 – 663+	1 – 360
Lignite: old plant		1 147 – 1 272+		600 – 31 941+	704 – 4 146+		100 – 618	2 – 42
Heavy oil without scrubbing	21	686 – 726+		8 013 – 9 595+	1 386+	22+		2 – 13
Nuclear	5 – 107	2 – 59	0,5	3 – 50	2 – 100		2	
Natural gas combined-cycle turbines	14	389 – 511		4 – 15 000+	13+ – 1 500	72 – 164	1 – 10+	0,3 – 1
Large fuel cell (natural gas to hydrogen conversion)		290+ – 520+		6	0,3+ – 144	65	2 – 6+	
Biomass: energy plantation	3 – 5	17 – 118	533 – 2 200	26 – 160	1 110 – 2 540	89+	190 – 212	0,5 – 2
Biomass: forestry waste combustion	27	15 – 101	0,9+	12 – 140	701 – 1 950		217 – 320	
Intermittent options that need a backup production (such as hydro with reservoir or oil-fired turbines)								
Wind power	5 – 39	7 – 124	24 – 117	21 – 87	14 – 50		5 – 35	
Solar photovoltaic	1 – 14	13 – 731	27 – 45	24 – 490	16 – 340	70	12 – 190	

Source: IEA. May 2000. *Hydropower and the Environment: Present Context and Guidelines for Future Action.* Vol. II: Main Report, Ch.3: *"Comparative Environmental Analysis of Power Generation Options".*

Environmental and Social Impacts of Hydropower: State of Knowledge and Challenges [16]

As for all other major power generation options, hydropower is the source of both significant and unavoidable environmental and social impacts. The most important unavoidable impacts of hydropower are generally related to the flooding of land in the impoundment zone upstream of a dam and to changes to water flows and water levels downstream of a dam. The nature and severity of such impacts are highly site specific and tend to vary in scale according to the size and type of projects.

The section that follows briefly discusses the state of knowledge with respect to the avoidance or mitigation of social and environmental impacts of hydropower. It presents a summary overview of the challenges that still confront hydropower designers, builders and operators.

Socioeconomic Impacts of Hydropower

The management of socioeconomic impacts and benefits constitutes one of the major challenges associated with hydropower projects, particularly in countries affected by political instability, competing water needs, and a scarcity of resources. Several hydroelectric projects still await completion or have been abandoned because of controversies related to socioeconomic concerns, such as:

- poorly managed involuntary displacement and loss of livelihoods for populations living within or downstream of the impoundment zone

- loss of means to support traditional ways of life, particularly in the case of culturally vulnerable indigenous or ethnic/religious minority groups that are largely dependent on locally available land and natural resources

- higher incidences of waterborne or behavioural diseases, particularly among vulnerable communities

- low regional economic development returns and inadequate redistribution of project benefits to affected communities.

For current planning and management practices for each of these issues, the reader may refer to Vol III, Appendix F of the present report. Even if substantial progress has been made in planning for and managing these concerns, there still remain problems to be addressed. These problems are briefly summarised hereafter.

Succeeding in improving livelihoods following resettlement

Reservoir impoundment and construction works may involve both displacing people and/or jeopardising their livelihoods. Managing such a process therefore requires both the resettlement of displaced communities and their socioeconomic rehabilitation (e.g., the rebuilding of displaced people's livelihoods through community development). To be successful in such an undertaking, the objective for proponents must be to ensure that hydropower projects result in improved standards of living for affected people. Moreover, proponents must count on effective legislative and institutional management, which pose the following challenges:

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16 For a full discussion of this issue, see IEA. May 2000. *Hydropower and the Environment: Present Context and Guidelines for Future Action.* Vol. III: Appendices:

- *Appendix D: "Physical and Chemical Environment"*
- *Appendix E: "The Flora and the Fauna"*
- *Appendix F: "Socioeconomic Environment"*

and

IEA. May 2000. Annex III - Subtask III/6, *Hydropower and the Environment: Effectiveness of Mitigation Measures.*

- how to foster the adoption of appropriate regulatory frameworks for resettlement and rehabilitation (R&R) in countries where local traditions and sociopolitical contexts are not adapted to such undertakings

- how to build institutional capacities for R&R (institutionalised project-planning processes, reinforced land management capabilities, increased public participation in the decision-making process) in a context of scarcity of human and financial resources

- how to provide necessary land-based and non-based income restoration programs for R&R in a context of scarcity of available land and financial resources

- how to ensure the design and implementation of long-term integrated community development programs in a context of political instability or neglect.

Minimising Impacts on Culturally Vulnerable Communities

Hydropower projects in indigenous or traditional resource based areas can have far-reaching cultural and social effects at the community level. The extent of such impacts is difficult to ascertain, considering the number of outside influences to which communities often are already subjected. Nevertheless, communities often perceive such projects as being destructive or a threat to their culture.

To successfully minimise impacts on such communities, the objective for proponents should be to ensure that hydropower projects provide sufficient time and resources to adapt to changing conditions, as well as alternative means to support traditional ways of life where required. There are several challenges to reach such an objective, including:

- how to provide culturally vulnerable communities with sufficient time and resources to adapt to changing conditions, when both available time and resources are limited

- how to ensure long-term financial support of economic activities and community services that are adapted to local cultures, without causing long-term dependence on outside sources of funding.

Improving Public Health

Higher incidences of waterborne diseases due to modifications to hydrological systems and higher incidences of behavioural diseases due to population displacement are possible consequences of the presence of a man-made reservoir, particularly in tropical or subtropical environments. To successfully minimise such impacts, the objective for proponents should be to ensure that hydropower projects result in improved health conditions for affected people. This poses certain difficulties, such as:

- how to build the required regional and local institutional capacities for an effective public health systems in a context of scarcity of resources and possible lack of government infrastructure.

Sharing of Development Benefits

Hydropower projects, like many other infrastructure projects, sometimes result in an inadequate redistribution of project benefits to locally affected communities. To successfully optimise local development benefits, and even more so in less developed countries where local populations may be more economically vulnerable, the objective for proponents should be to ensure that affected communities become project beneficiaries. However, the lack of political will and competition for resources are frequently an obstacle to reach such an objective. This poses certain difficulties, such as:

- how to ensure an equitable distribution of long-term development benefits and costs between affected populations and project beneficiaries, in a context of competing needs, limited political will and often insufficient resources.

Environmental Impacts of Hydropower

The understanding and management of environmental impacts associated with hydropower projects has progressed considerably over the last twenty years, as a result of studies, of monitoring, of follow-up, and of increased regulatory requirements. Experience gained worldwide in terms of improved project planning and design, as well as in the development of comprehensive environmental mitigation programs, have helped avoid or reduce the severity of a large number of impacts typically associated with hydropower.

For a comprehensive overview of current environmental knowledge and management practices, the reader may refer to Vol III, Appendices D, E and F of this report. Even if substantial progress has been made in designing hydropower projects and managing their environmental impacts, challenges still remain to be addressed. The main ones are briefly presented hereafter.

- *Integrating the preservation of biodiversity and productivity in project design:* The need to preserve biodiversity and productivity, and to minimise the loss of ecologically valuable habitats through the restoration or improvement of other habitats poses new challenges to hydropower project designers. Issues to be addressed include the conservation of rare or protected species, maintaining aquatic continuums, minimising habitat fragmentation and identifying better biophysical indicators.

- *Optimising flow regimes downstream of a reservoir:* Optimising flow regimes downstream of a reservoir poses complex technical and political problems. It is the subject of ongoing research. Such optimisation must take into account water uses upstream and downstream of the dam, power generation requirements and the needs of aquatic or riverine habitats. Optimisation is particularly challenging when communities rely on subsistence fishing or seasonal flooding of fields downstream of a reservoir.

- *Improving fish passages for valuable migratory species at hydropower dam sites:* Improvements in turbine, spillway, and overflow design have proven to be highly successful in minimising fish mortality and injury. Existing fishways and fish ladders installed at hydropower dams are in some cases rather ineffective. Designing effective fishways or fish ladders for migratory or anadromous species still pose complex problems and is also the subject of ongoing research.

- *Improving sedimentation management in reservoirs:* In general, large dams and reservoirs are designed for an operating life of about 100 years, but about 10% of hydropower reservoirs face sedimentation problems. Periodic flushing can prolong the life of a reservoir, but many dams are not equipped for this. In certain cases, severe reservoir sedimentation leads to sediment deficits and increased river bank and river bed erosion in downstream rivers and estuaries. Avoiding the siting of dams in areas characterised by high erosion rates, and the planting and conservation of forested areas in upstream catchment areas can also reduce sedimentation in reservoirs, but is not always easy to sustain on a long-term basis.

- *Limiting water quality problems through good site selection:* When a reservoir is located in dense forest areas, particularly in tropical regions, a very large amount of biomass and soils may be submerged. In certain conditions, this may lead to oxygen depletion and to anoxic conditions in the reservoir. This in turn can result in the formation of toxic substances such as hydrogen sulphide (H_2S) or heavy metals in the anoxic layer of the reservoir, to fish deaths when toxic substances rise to the surface, to increased water acidity levels, and to problems in the downstream area (bad odour, methane emissions, toxicity) which may restrict water uses. Even if pre-impoundment forest clearing and water storage management measures (such as selective multi-level intakes) can reduce such problems, further consideration must be given to reservoir water quality management at the early design stage of a project through good site selection, the use of better predictive modelling and more widespread reservoir water quality monitoring.

- *Managing reservoir eutrophication and water contamination problems during operation:* During the operation phase, water quality problems in reservoirs are caused primarily by the inflow of organic material and nutrients and/or toxic substances due to untreated domestic sewage and runoff from agricultural or industrial uses, or due to activities in the reservoir itself, such as aquaculture. Such inflows may lead to eutrophication which can make water unsuitable for recreation purposes or as drinking water and to the proliferation of aquatic weeds. Establishing effective multi-stakeholder watershed management in the catchment area and downstream of the reservoir, enforcing sound land use management policies and building sewage treatment systems are effective means to reduce such problems in reservoirs, but are not easy to implement and sustain on a long-term basis.

Ethical Considerations [17]

Over the past two decades, the role played by large-scale hydropower projects in global development, particularly in the developing world, has been increasingly questioned. In a context of mounting uncertainties about the availability and quality of water resources in many regions of the globe, using water (viewed as a common good) to produce energy must be justified not only on the basis of national or local economic benefits in general, but also on the basis of the quantity and quality of expected benefits for a wide variety of regional and local stakeholders (local communities, regional or international environmental resource-based interest groups, etc.).

These stakeholders express a wide diversity of viewpoints. In many cases, stakeholders do not share similar values, codes of conduct or interests. Conflicts may arise when the concerns of certain groups are ignored or rejected, particularly when they involve fundamental issues of allocation and control over resources and of distribution of wealth. In most societies, resolving ethical dilemmas surrounding such issues (e.g., establishing a consensus in regards to what is acceptable) often requires prolonged and difficult discussions to identify widely accepted moral, social, economic and environmental trade-offs.

In view of the above, what are the main ethical dilemmas that may be associated with hydropower development? Such dilemmas generally fall into one of four categories.

- *The conservation of natural resources versus the satisfaction of essential human needs:* Opponents claim that major hydropower projects are unacceptably disruptive to the balance of natural and man-made components of river systems and incompatible with the need to conserve or restore biodiversity in valued watersheds. Proponents claim that widespread access to electricity plays a key role in promoting development (lessening such ills as harvesting wood for household or industrial needs, for example), and that all sources of power generation entail short- or medium-term loans on natural capital as well as certain irreversible ecosystem impacts.

- *The increased production of wealth in order to support growing needs versus the fair distribution of accumulated wealth:* Opponents claim that major hydropower projects lead to reduced levels of social justice because they subsidise urban, industrial or agribusiness interests to the detriment of locally affected rural populations. Proponents claim that such projects are required in order to support the development of modern industries and services and thereby generate sufficiently important surpluses to be able to assist poor rural populations.

- *The rights of small numbers of locally affected populations versus the rights of larger numbers of potential beneficiaries:* Opponents claim that large water resource development and hydropower projects frequently violate the rights of locally affected populations and unnecessarily displace and lower the standards of many people in poor rural areas. Proponents claim that the number of people benefiting economically and socially from such projects is much greater than those whose lives may be disrupted and that the large majority of hydropower projects yield a variety of benefits that far exceed their costs, including the costs of adequate measures to mitigate their adverse environmental and social impacts.

17 For a full discussion of this issue, see Vol. II: Main Report, Ch.5: *"Ethical Considerations"*. IEA. May 2000. *Hydropower and the Environment: Present Context and Guidelines for Future Action.*

- *The standards of international donor and lending agencies versus the standards of less developed beneficiary countries:* Opponents claim that internationally funded water resource development and hydropower projects do not always apply the same stringent environmental and social standards in less economically developed beneficiary countries as those that would be required in more economically advanced countries. They advocate the prior development of appropriate political processes and institutional frameworks in order to democratise and decentralise the decision-making process for water resource and land-use management. Proponents claim that international environmental and social standards are now increasingly applied to all development projects, even if they must be adapted to a certain extent to local cultural, political, institutional and regulatory realities and contexts.

In order to confront these dilemmas in a responsible fashion, what are the main ethical *principles* or *rules of conduct* that should be applied to future hydropower development projects? The five following ethical principles are generally recognised as being applicable to most development projects.

- *Stewardship:* Proponents of hydropower projects should demonstrate their willingness to act as stewards of the watersheds where they intervene, by properly managing available environmental resources in a sustainable way. They must therefore be prepared to contribute to a system of checks and balances – such as community-based monitoring and follow-up committees. They must also periodically validate the soundness of resource management measures.

- *Participatory Decision-Making:* The most equitable solutions generally arise from discussions that give everyone a chance to be heard. A participatory process can also ensure that important factors which might otherwise be overlooked are fully taken into account. Finally, it can strengthen the moral authority and legitimacy of the resulting decision. Participatory processes do present challenges of their own. The question of who is a legitimate representative of a group or a stakeholder and hence entitled to participate is not always an easy one. Some important interests, for example those of society as a whole, may not even be represented by a spokesperson at the table. Some participants, including the promoter, may have strategies of all sorts that result in the choice of an alternative selected in advance. Just because an interested party participates in the process does not of itself produce an optimal result. Whatever the merits or disadvantages of participatory decision-making may be, the fact is that in many countries citizens have increasingly challenged the power and authority bestowed on their elected officials and the bureaucracy. Value systems have evolved, and those who are governed want to participate more fully in decisions made by those who govern.

- *Precautionary approach and control:* To build trust and credibility, proponents and regulators of hydropower projects must adopt a responsible and cautious decision-making attitude based on the study of the foreseeable consequences of their actions. This requires that in-depth assessments be carried out to determine the possibility of irreversible impacts on water quality and life-sustaining systems, on the health and safety of local populations, on the ability of displaced communities to restore or improve their standard of living, and so forth.

- *Fairness and justice:* Supporting sustainable development requires that one act with respect for human dignity and for the right of every human being to develop his or her potential. This means that the benefits and drawbacks of a project that involves the use of limited collective resources must be fairly distributed among beneficiaries and impacted populations, as well as between existing and future generations. Those who benefit from a project must also assume its risks as well as its environmental and social costs. Fairness means that affected populations who do not directly benefit from a project should receive sufficient indirect benefits to be fully compensated for their losses.

- *Optimality:* When the use of a limited collective resource is at stake, optimality refers to the selection of the best available project option on the basis of the factors deemed important by concerned stakeholders. The search for an optimal solution involves a difficult process of balancing pros and cons and identifying trade-offs which, to be credible, must be based on open, inclusive and transparent public discussions. Such a process tends to generate the trust that will be needed subsequently to implement the project in a peaceful social climate.

In view of the above, the social acceptability of future hydropower projects requires that:

- project goals be clearly stated in relative terms (by comparing project benefits and costs to those of other alternatives, including the "no go" option)

- they result in net social development gains in terms of the multiple use of available resources (e.g., improved access to water, irrigation, public health, community services, power, etc.)

- they are the result of a fair, open, inclusive and transparent participatory process

- they include accountability guarantees such as grievance committees to respond to unpredictable or unforeseen issues, as well as funding for as long as there are risks to manage

- affected communities become project beneficiaries, through revenue or equity sharing, for example.

Legal and Regulatory Frameworks and Decision-making Issues [18]

The last outstanding environmental issue related to hydropower involves the environmental decision-making process. In most countries, this process is closely linked to legal and regulatory frameworks, and to the environmental assessment and licensing processes in particular. Environmental assessment (EA) is both a management tool and an indispensable aid for decision-making. Its purpose is to help elected officials and project proponents make well-founded decisions, to give clearance or not to a project once its environmental impacts are fully known, and to improve the project design itself. Indeed, EA is not an aim in itself, but an instrument to be used by decision makers to carry out their duties in accordance with relevant legal and regulatory frameworks.

As noted previously, ethical dilemmas frame hydropower development issues. Thus, to be of any use, an assessment of environmental approval processes for hydropower projects must take into account ethical considerations. From a legal perspective, the ultimate goal is to reconcile the three basic requirements (promoting human rights, protecting the environment, and ensuring everyone's right to economic development) that frame hydropower development. The reconciliation of each of these requirements can be pursued by applying a holistic approach. As our review of literature has shown, a holistic approach can prove effective in reconciling the conflicting views of protagonists involved in the environmental approval process by balancing the different concerns of local populations, of groups that promote environmental conservation, and of project proponents.

Chapter 6 of the Main Report outlines and discusses environmental approval processes in the specific context of future hydropower projects. In the future, decision-making processes should not only aim at reconciling stakeholders' perspectives, but must also be efficient and effective for stakeholders and for society at large. An **efficient** process is one that minimises the resources required – time, money, expertise – to achieve a decision. An **effective** environmental process is one in which the relevant environmental and social impacts of a project are correctly and rigorously identified, assessed, and fully taken into account.

Since the Seventies, most countries have created legal and regulatory frameworks to protect their environment, including environmental assessment and licensing processes. They have used these tools to ensure that large infrastructure projects do not cause unacceptable adverse environmental impacts. The appropriateness or importance of such tools is not questioned here. Rather, it is our belief that we have learned from past experiences and can draw certain conclusions and recommendations from these experiences to improve on past practices.

18 For a full discussion of this issue, see Vol. II: Main Report, Ch.6: *"Legal and Regulatory Framework"*. IEA. May 2000. *Hydropower and the Environment: Present Context and Guidelines for Future Action.*

In light of the present analysis of the effectiveness and efficiency of regulatory processes that apply to hydropower projects, there is growing concern that environmental approval and licensing processes have become overly rigid and cumbersome in many OECD member countries in particular. In certain cases, such processes impose costs on society and project proponents that are not commensurate with the benefits gained or impacts avoided. Such costs include, among others, excessive information requests, unnecessary operational restrictions and unreasonable delays to project implementation schedules. Such costs may even lead to the cancellation of beneficial projects.

Around the world, the demand for reliable power supplies is steadily increasing. Electricity prices have recently been following upward trends in a number of countries. In part, this reflects insufficient new investments in power generation for a number of years. Because hydropower projects are more affected by uncertainty, including market and regulatory uncertainty, there are fewer new hydropower projects being developed throughout the world. This is regretful in view of the fact that many countries still have abundant hydroelectric resources to develop, combined with increasing needs.

Unduly restraining hydropower development may not be desirable because hydropower may, in many cases, be more environmentally benign than other traditional sources of power. Nonetheless, policy errors are still being made when allocating power generation resources. Investments in power generation currently being planned are, in many parts of the world, mostly thermal electric, which produces greenhouse gases and other air, water and land pollution. Hence, by discouraging investment in hydropower projects, decision makers may inadvertently encourage power generation investments that might be more damaging to the environment than hydropower.

Regulatory reform is required to address certain imbalances and to avoid a poor allocation of resources for power generation. Project proponents, along with governments and non-governmental organisations, share responsibilities with regards to the development and implementation of legal and regulatory frameworks governing hydropower development, including environmental assessment and licensing processes. In our summary and recommendations, we discuss how these various stakeholders could contribute to improve these aspects.

RECOMMENDATIONS

Based on the above, there are five areas which pose significant challenges to the hydropower sector. These are:

- **Energy policy framework**
- **Decision-making process**
- **The comparison of hydropower project alternatives**
- **Improving environmental management of hydropower plants**
- **Sharing benefits with local communities**

Recommendations and guidelines are proposed for each of these topics. These recommendations, as well as their associated criteria and guidelines, apply to a very broad range of projects. Obviously, all project-related impacts cannot be avoided or mitigated. For this reason, environmental impact assessments, as well as corresponding mitigation, enhancement, compensation, monitoring and follow-up programs, remain essential project planning tools. These recommendations, criteria and guidelines should thus be seen as a guide for planners and operators.

RECOMMENDATION # 1

Energy Policy Framework

Energy is a fundamental sector of a nation's economy. In the same way as countries have health or education policies, a clear view of the energy priorities of a country is required in order to clarify the development context. Such an energy policy may be market-based and competitive – allowing market forces to freely allocate resources – or, at the other extreme, it may be centralised and restrictive, leaving governments to decide what investments should be made in terms of energy development. The point here is not to discuss the relative merit of any single type of policy. Indeed, each nation's energy context is unique, and requires specific approaches at various stages of economic development.

What is recommended here is that each country should clearly set out its energy policy, or at least its energy development strategy, so that the rules are known to all, and that arbitrary decisions are minimised: this is particularly important for hydropower development which requires a long lead-time and expensive engineering / environmental studies prior to producing electricity.

In the coming decades, most future power generation capacity will be privately financed. Private investment seeks the highest return on capital while minimising risks. For the hydropower industry, it is imperative to reduce existing uncertainties regarding changing environmental regulations and open-ended licensing procedures in order to attract investment capital.

Therefore, governments have a significant responsibility with respect to the clarification and simplification of environmental and licensing procedures, as well as to the harmonisation of overlapping agency regulations that apply to hydropower projects[19]. One avenue is to have governments clearly define their energy development strategies in general, and state their positions regarding hydropower development in particular. Such an approach would allow investors to know whether hydropower development is encouraged or not in a given country or jurisdiction, and under what conditions.

RECOMMENDATION # 1

Energy Policy Framework

Nations should develop energy policies which clearly set out objectives regarding the development of power generation options, including hydropower.

- National energy policies should compare electricity generation options fairly, by "internalising" or fully accounting for environmental and social costs.
- Comparison of power generation options should be based on a life-cycle analysis, by assessing impacts on the basis of the services provided by each technology.
- The social, environmental and economic trade-offs required to establish a national energy policy should be supported by public debates and be the result of a consensual approach.

19 Regulations that apply to waterways, land use, fisheries, navigation, recreation, habitat protection, etc.

Energy policies must fully integrate environmental and social considerations. Available tools for integrating such considerations into energy policy decision-making include life-cycle analysis (LCA) for the comparison of power generation options, as well as strategic or sectoral environmental assessment (SEA) which can be combined, if necessary, with hydropower master planning. The main reason for using such tools is to establish a level playing field between power generation options, by "internalising" (or accounting for) the environmental and social costs of each option. Recommendation #1 addresses this issue.

This recommendation is based upon the premise that clear and transparent power supply and transmission strategies should be put forward by governments, industry and civil society in order to avoid the re-questioning of power generation options at the onset of projects. Governments should develop energy strategies in concert with concerned parties so that a general consensus exists prior to project-specific investments.

Energy strategies should be based on political, economic, environmental and social criteria as well as on the principles of sustainable development. The comparison of energy options should take into account the level of energy services, the multiple uses of available resources, the pooling of regional means of power supply and transmission, the life-cycle assessment of energy options, as well as energy efficiency alternatives.

GUIDELINES FOR ENERGY POLICY-MAKING

Countries should consider strategic environmental assessment (SEA) as a planning tool at the national energy policy level

An SEA at the national or regional policy-making stage helps integrate environmental and public concerns into energy policy-making, in order to reconcile development, environmental protection and community rights. One important objective of an SEA for energy policy would be to reduce uncertainties regarding the potential development of hydropower resources by, for example, defining river reaches which should be available for development and, conversely, those reaches protected from water resource development.

Apply the precautionary principle at the national policy level

Decision makers should consider global issues such as ozone depletion, global warming, acid rain precipitations, loss of biodiversity, as important issues when establishing national policies for energy, water and land use. These issues should be addressed and dealt with at the policy level even if scientific uncertainties remain in explaining certain aspects of these phenomena.

RECOMMENDATION # 2

Decision-making Process

The second outstanding issue concerns the environmental decision-making process, e.g., the EA process and the regulatory and legal framework that applies to hydropower development. A decision-making process must be efficient and effective for both the project proponent and society at large. The second recommendation presented below proposes guidelines which address these concerns.

RECOMMENDATION # 2

Decision-making Process

Stakeholders should establish an equitable, credible and effective environmental assessment process that considers the interests of people and the environment within a predictable and reasonable schedule.

This recommendation is based on the premise that stakeholders must be treated in an equitable manner. Therefore, the assessment and licensing of hydropower projects should be based on a credible and effective decision-making process, with established rules and clear responsibilities for all stakeholders.

The decision-making process must help identify and reject the worst project alternatives, in order to retain the best alternative. The process should ensure that the environmental reviews and approvals required for each project are completed within a reasonable time schedule. Thus, the process should be directed towards decision-making at the earliest stages of project planning, so that stakeholders know as soon as possible if the project is good enough to be implemented.

This is particularly important in a context of global restructuring of the electricity sector, with increased competition between electricity producers. Unreasonably long environmental assessment and licensing processes for hydropower projects translate into a competitive disadvantage for hydropower producers compared to other forms of power generation, including, for example coal-fired power plants.

Time delays generate significant costs for all participants in a hydropower project: Delays can lead to significant social and economic costs for concerned communities. When a hydropower project is announced in an area and then postponed for regulatory and administrative reasons, uncertainty may set in. Such uncertainty may subsequently lead to the freezing of local investments as communities, governments, businesses, and individuals refrain from committing resources in an area that might be flooded in the future. Although this is true for any type of reservoir impoundment project, whether it is delayed or not, additional delays simply compound the problem.

Governments can also incur costs when decisions regarding hydropower projects are unnecessarily delayed: loss of revenue from delayed investments, direct costs due to lengthy procedures, etc. Similarly, as project proponents are likely to lose money and investment opportunities if a project is delayed, they often prefer to know as early as possible in the design process whether a project is acceptable or not in order to minimise such losses.

The key then, is to improve the decision-making process for hydropower assessment and licensing in such a way as to effectively protect the environment and local communities without unfairly burdening project proponents with procedural uncertainties and unreasonable delays.

The second recommendation presented above is supported by the following proposed Guidelines for Decision-Making.

GUIDELINES FOR DECISION-MAKING	P	C	O	R
Bilateral and multilateral institutions should increase their support for EA institutional strengthening and capacity building In addition to national regulatory and legal frameworks for EA, qualified human resources are required to establish a credible and efficient environmental management culture. International institutions already provide such services. These must be encouraged, particularly in countries where needs are greatest.	●			
Countries without a compulsory EA process should develop and adopt one All countries should enact laws that make EA mandatory for large infrastructure or energy projects. It should be easier to encourage countries to enact a legislative framework by pointing to the international treaties that they have signed. Laws and regulations must be implemented, and countries should have the appropriate resources to carry out the assessments.	●			
Countries that have not yet adopted an EA policy should review the past experience of both developing and developed countries in EA implementation. The aim here is to adopt pragmatic approaches so as to avoid major errors of the past. Sharing past experiences in implementing EA is a possible route for countries which share similar socioeconomic conditions. Some developing countries have had over a decade or more of practical experience in EA implementation, which could provide useful lessons for other countries with less experience in such matters.	●			
Develop an international procedure for the environmental management of existing dams, reservoirs and hydroelectric power stations. The ISO (International Standards Organisation) or the IEC (International Electrotechnical Commission) could serve as focal organisations to develop such a procedure. Such an international standard of management could help avoid many conflicts regarding competing water uses. It would also provide a common framework for dam management whatever the institutional context.			●	
The power sector should implement recognised environmental management systems (EMS). ISO 14001 is an example of a recognised international standard in environmental management that pursues continuous improvements in environmental performance. The environmental management system (EMS) selected could be certified or registered by international organisations.	●	●	●	●

LEGEND:
P: Planning – **C**: Construction – **O**: Operation – **R**: Refurbishment

GUIDELINES FOR DECISION-MAKING	P	C	O	R
The power sector should adopt and enforce codes of conduct regarding human rights and environmental protection These codes are important to ensure that EAs are adequately conducted and human rights respected across the power industry, particularly in regions where minimum standards are non-existent or inadequately enforced. The codes should provide guidance in environmental management, public participation, and conflict resolution.	●	●	●	●
EA processes should address both the adverse impacts and the benefits of a hydropower project, in a balanced analysis. Trade-offs between social, environmental and economic goals are inevitable in a development process. EA as a decision-making tool should reflect this. The focus of the EA process must be on assessing possible trade-offs, and proposing concrete solutions such as mitigation, enhancement and compensation measures.	●			
Quality of work is the foremost criterion for EA studies, which must be based on recognised scientific methods and factual information As long as a systematic and scientific methodology is applied to EA studies, it matters little who is responsible for conducting the studies. When scientific uncertainties remain, they should be stated in the reports and adequately explained, letting decision makers arbitrate such issues.	●	●	●	●
On issues that raise the most concerns, consult recognised experts Under certain circumstances, such as scientific uncertainty or polarisation of a debate, it may be desirable to consult with experts who are deemed acceptable by most parties to present an external perspective regarding a specific issue.	●	●	●	●
Environmental assessment at the project level must concentrate on project issues – e.g., selection of alternatives, assessment of impacts, mitigation, etc.– and not on policy issues – e.g., a nation's energy, water or land-use policy Project level EA cannot substitute for a legislative assembly and democratic debate on policy issues. Policy issues must be debated at the national level using tools such as SEA, Regional Environmental Assessment, etc.	●			
Focus hydropower project assessment on key issues through project scoping The EA process must focus on issues that are truly important for a given project. Project scoping helps identify the main issues to be assessed at the onset of the EA process. Scoping should reduce the length of the assessment process by avoiding the study of trivial concerns. Selection of the key issues must be undertaken on the basis of public participation and of established science, integrating past experience from follow-up studies. When adequately implemented, this requirement should help avoid the production of unnecessarily "encyclopaedic" environmental impact assessment reports.	●			

GUIDELINES FOR DECISION-MAKING	P	C	O	R
Design each stage of the EA and licensing processes for hydropower with a view to reducing delays Delays mean uncertainty, and uncertainty means added costs and a competitive disadvantage for hydropower project proponents. In a competitive energy market, the EA process for a hydropower project should not take longer than the EA process required for any other type of power generation option. EA processes must be decision-oriented and carried out within a reasonable time-frame. Mandatory deadlines throughout the EA process are excellent ways to limit uncertainty and unreasonable delays for all stakeholders.	●			
When more than one EA process applies, the EA must be consolidated into a single procedure in order to avoid the duplication or overlapping of efforts In some countries, EAs may be conducted by two or more levels of government. As countries form regional alliances, the issue of EA may even be addressed at the regional, national or even supranational level. Decisions by one level of government often are non-binding for other levels of government. Timing of the various assessments often do not coincide, increasing uncertainty and delays in decision-making. A unified EA process means one set of guidelines, one single panel and, ultimately, one decision and one set of conditions.	●			
Encourage public participation in the EA of power projects Proponents and governments should solicit public participation from the onset so that the scope and scale of the studies can be determined with the help of concerned communities and environmental groups. In addition, when the findings of the various studies are obtained, they should be made readily available to the public. Finally, the public should be involved in developing mitigation, enhancement and compensation measures from the onset of the project and throughout the EA process, with the assistance of appropriate tools and available technology.	●		●	
Adopt a code of basic procedural rights for public meetings or hearings to ensure that all stakeholders are treated fairly and that their roles are clearly set out Stakeholders in a debate must be treated in a manner that allows for arguments and counter-arguments to be exposed and debated openly. Procedures should allow for any stakeholder – including project proponents, opponents, government representatives and the public – to be challenged on their arguments, in order to allow the general public to build an informed opinion about a project.	●			

Comparison of Hydropower Project Alternatives

If the decision is taken at the policy level to develop hydropower, then criteria must be available for both government agencies and developers to provide for *an effective comparison of hydropower project alternatives.* Such criteria are required in order to eliminate bad hydropower projects from the very onset of project planning.

Engineers and economists can apply readily available tools to quickly assess the technical and economic merits of project alternatives, and to prioritise such alternatives. Similar tools should be developed to prioritise alternatives from an environmental and social perspective at the preliminary design stage, when only limited field data is available.

The traditional process of identifying the best project alternatives mostly on the basis of technical and economic considerations and *subsequently* undertaking an environmental impact assessment (EIA) for the selected project is ineffective and a waste of resources, for a number of reasons.

- A good project from a business and technical perspective might be a poor project from an environmental or social viewpoint. Engineers must be aware of the social and environmental consequences of their choices when they design project alternatives.
- Hydropower project planning requires considerable resources. Once these resources are set in motion, it becomes harder for both proponents and opponents to modify or reverse the process.
- Mitigation of social and environmental impacts carries significant costs. Project planners try to minimise such costs and therefore have an incentive to know which project involves the least impacts.
- It is very time-consuming to select project alternatives without taking into account environmental considerations, then prepare the EIA, then defend the selected project, then modify or abandon the proposed project to minimise environmental damages. An alternative process in which the worst environmental alternatives are quickly abandoned should reduce the time required to prepare the EIAs. It should also limit the risk of project cancellation or of having to undertake major changes to project design following the EIA.

Recommendation # 3 proposes 10 specific social and environmental criteria to compare and select the best project alternatives, in parallel with economic and technical analyses.

RECOMMENDATION # 3

Comparison of Hydropower Project Alternatives

Project designers should apply environmental and social criteria when comparing project alternatives, in order to eliminate unacceptable alternatives early in the planning process.

A Proposal

The best way to manage impacts is to avoid them in the first place. This third recommendation proposes a list of ten environmental and social criteria to rapidly assess the comparative merits of various project alternatives, helping eliminate those options which present unacceptable impacts. These criteria are presented below.

Project alternatives vary in terms of river basins, dam sites, operation levels, plant factors, and other considerations, including "no-go" options. Since environmental, social and political issues may be as constraining as technical or economic concerns, these alternatives should be presented and discussed with stakeholders as early as possible in order to incorporate in the planning process the social, political and economic dimensions surrounding the potential projects.

The engineering process for selecting preliminary alternatives requires that rapid assessments and decisions be made with minimum fieldwork. It is therefore important to develop tools, such as the ten criteria below, to quickly assess the *relative merits* of project alternatives on environmental and social grounds. Such tools can provide a timely input to the iterative process leading to the selection of project alternatives. These criteria may also be useful for regulators when assessing hydropower alternatives.

Such comparisons must also take into account the level of service provided by each project alternative. This screening process should not replace the detailed inventories which might be required at a later stage of an EA.

There is no order or priority in the checklist presented below.

CHECKLIST of 10 Screening Criteria to Compare Project Alternatives	**COMMENTS**	**EXAMPLES**
Prioritise alternatives on already developed river basins	In several countries, sites with a high potential are often already developed. However, the potential of such sites is not always completely exploited. Therefore, before developing new sites on wild rivers, the residual potential of regulated rivers should be analysed, especially because such rivers often offer less impacting project alternatives. However, the addition of new installations on regulated rivers can lead to cumulative impacts and harm the remaining habitats in a river basin. Proper care should be taken to ensure the preservation of portions of river basins in order to satisfy the needs of existing species.	Several hydropower producers optimise existing hydropower plants and the use of watersheds by upgrading plants or increasing energy production of existing plants through river diversions. (Source: Hydro-Québec)
Prioritise alternatives that minimise the area flooded per unit of energy (GWh) produced See: Vol. II, Chapter 1, Sec 1.2.4 Small, Mini and Micro Projects. *The Large Dam Versus Small Dam Debate*, p.21	It is generally recognised that the environmental impacts increase as the area flooded increases. The selected site and project design should thus tend towards minimising the flooded area *per unit of energy produced* (km^2/GWh), since impact avoidance is always more effective than applying mitigation measures.	During the design phase of the Sainte-Marguerite-3 project in Québec, Canada, the flooded area was reduced by 20% (from 315 to 253 km^2) for a 4% reduction in energy (from 2.9 to 2.8 TWh). (Source: Hydro-Québec)

SCREENING CRITERIA	COMMENTS	EXAMPLES
Prioritise alternatives that do not pose significant threats to vulnerable social groups See: Vol. III. APPENDIX F: SOCIOECONOMIC ENVIRONMENT, Sec. 3.6 Impacts on Vulnerable Minority Groups	1. Prioritise project alternatives that do not affect vulnerable social groups. 2. Project alternatives that affect vulnerable social groups may be acceptable if they include a comprehensive social/cultural enhancement program to manage and monitor the risks. Such programs must be planned and implemented jointly with the concerned communities. Prioritise project alternatives that offer the best possibilities of protecting human rights, enhancing local cultures and developing economic partnerships. 3. Avoid project alternatives that present significant threats to vulnerable social groups that cannot be adequately mitigated.	Project alternatives that are negotiated with, and accepted by, vulnerable social groups minimise adverse social and political impacts.
Prioritise alternatives that minimise public health risks See: Vol. III. APPENDIX F: SOCIOECONOMIC ENVIRONMENT, Sec. 3.1 Impacts on Human Health	1. Prioritise project alternatives that enhance public health or that avoid public health risks. 2. Project alternatives posing potential public health risks may be acceptable if they include a comprehensive public health program to manage and monitor such risks. Prioritise project alternatives that offer the best possibilities of improving local health conditions. 3. Avoid project alternatives that present significant public health risks beyond the institutional capacity required to properly manage them.	In tropical countries, a project alternative which minimises breeding areas for malaria-transmitting mosquitoes should be prioritised. Properly selecting the maximum reservoir level and maximum drawdown can help avoid the formation of seasonal stagnant water pools.
Prioritise alternatives that minimise population displacement See: Vol. III. APPENDIX F: SOCIOECONOMIC ENVIRONMENT, Sec. 4. Resettlement.	1. Prioritise project alternatives that avoid displacing people. 2. Project alternatives that involve population displacement in numbers manageable with the available resources may be acceptable if a comprehensive resettlement and rehabilitation plan is developed and implemented. Prioritise project alternatives that offer the best possibilities of improving local living standards in the short and long run. 3. Project alternatives that involve population displacement must be avoided when the number of people displaced goes beyond the institutional capacity to properly manage resettlement and rehabilitation.	In Java, one design alternative for the Saguling reservoir required displacing thousands of people. Lowering the maximum design level of the reservoir by a few metres reduced resettlement significantly. (Source: PLN) In Finland, the headwater level was lowered by one metre from the preliminary plan of the Kokkosniva Project to save the Suvanto village from being flooded. (Source: Kemijoki Oy)

SCREENING CRITERIA	COMMENTS	EXAMPLES
Prioritise alternatives that avoid designated natural and human heritage sites See: Vol. III. APPENDIX E: THE FLORA AND FAUNA, Sec. 4 Biological Heritage. *Protected Areas.* And: Vol. III. APPENDIX F: SOCIOECONOMIC ENVIRONMENT, Sec. 5.5 Impacts on human heritage and landscapes.	Protected natural and heritage sites are by definition exceptional. Selected alternatives should avoid development in these sites.	In the Aurland II L Project in Norway, transmission line routes were set up in order to avoid valued recreation areas. (Source: Annex III, ST1 report) In the Kurkiaska Project in Finland, the proposed power plant was relocated away from the scenic Porttikoski canyon and cannot now be seen from the river. (Source: Kemijoki Oy)
Prioritise alternatives that avoid the disappearance of known rare, threatened, or vulnerable species and their habitats See: Vol. III. APPENDIX E: THE FLORA AND FAUNA, Sec. 4. Biological Heritage. *Protected Areas.*	In a context of preservation of biodiversity, the rare, threatened or vulnerable species are the object of close attention. The development of hydroelectric projects should not compromise the survival of such species, should avoid as much as possible the habitats which support them and allow for their preservation in the long term.	In the Okumino Project in Japan, the development of a daily pumped storage plant threatened some endangered species and protected areas. All technical facilities were therefore constructed underground so as not to affect rare plants. (Source: Annex III, ST1 report)
Prioritise alternatives that minimise development in high quality habitats See: Vol. III. APPENDIX E: THE FLORA AND FAUNA, Sec. 4. Biological Heritage.	Habitats are not of equal quality, some are poorer, others richer. In richer habitats, rates of reproduction are usually much higher than death rates. As these habitats support large numbers of individuals from various species, they should be protected as much as possible.	In the upgrading project of Rivière-des-Prairies in Québec, Canada, one of the key environmental issues was the expected negative impact on fish spawning. Creation of new spawning grounds was implemented and successful. (Source: Annex III, ST1 report)

SCREENING CRITERIA	COMMENTS	EXAMPLES
Prioritise alternatives that will maintain an ecological flow [20] See: Vol. III. APPENDIX D: PHYSICAL AND CHEMICAL ENVIRONMENT Sec. 2: Impact of Streamflow Control on Hydrologic Regime And: Vol. III. APPENDIX F: SOCIOECONOMIC ENVIRONMENT, Sec. 1.3 Changes to Downstream Land Uses	The development of a hydropower project on a river can modify the downstream flow regime in different ways, by reducing, increasing or regulating the flow. Because ecological and biological processes are tightly linked to the flow regime and because local populations often rely on the river flow for many uses, alternatives with characteristics that keep the river as close as possible to the natural regime should be prioritised.	The dam in the Hunderfossen HPP in Norway became a barrier to migratory and spawning trout. The fish ladder was unsuccessful, as reduced river flow limited fish migration. Trout restocking turned out to be less successful than expected. An increase in the minimum flow downstream, at certain times to trigger migration, improved the situation. (Source: Annex III, ST1 report)
Prioritise alternatives with lower sedimentation risks See: Vol. III. APPENDIX D: PHYSICAL AND CHEMICAL ENVIRONMENT Sec. 4 Erosion and Sedimentation in Reservoirs, Downstream and in Rivers with Modified Regimes	Hydraulic changes resulting from dams and reservoirs on a river system may increase the process of sedimentation. This process is variable depending on the sediment load of the river, the residence time of the water, the reservoir configuration, watershed management, etc. Sites/options with characteristics that minimise this process should thus be prioritised.	A rubber weir for automatic sediment flushing was built in a river in Japan, and the mitigation measure has been shown to be successful. (Source: Annex III, ST1 report) The 300 MW Fortuna HPP in Panamá has a 10 km^2 reservoir surrounded by a 160 km^2 natural reserve, covering the upstream watershed. This limits erosion risks and sedimentation. (Source: Hydro-Québec)

20 See Vol. III: Appendices. Appendix A: Glossary

Improving Environmental Management of Hydropower Plants

Once a hydropower project has been selected, a significant number of environmental and social considerations must be addressed. Many hydropower projects around the world already "internalise" (or fully account for) such requirements, while many others do not.

Recommendation #4 proposes 13 guidelines to improve environmental practices for project construction and operation.

RECOMMENDATION # 4

Improving Environmental Management of Hydropower Plants

Project design and operation should be optimised by ensuring the proper management of environmental and social issues throughout the project cycle.

This recommendation is based on the premise that hydropower projects must be harmoniously integrated into their surroundings and communities.

Choosing the right site to build a hydropower project is the first step towards a good project. But once the site has been identified, the project may still have to undergo a series of design changes that take into account environmental and social concerns. Hydropower projects do have impacts, regardless of the selected site. On the basis of the "polluter-payer principle", these impacts must be properly mitigated or compensated for. Communities must also be fully informed and consulted regarding such matters and the multiple uses of available water resources must be considered.

It is thus important to invest the required resources to be able to manage the environmental and social issues throughout the project cycle. Responsibilities must be clearly identified at each step to ensure that commitments are fulfilled throughout the project life.

This fourth recommendation includes a series of guidelines to help decision-makers to optimise the design and operation of projects. These guidelines are presented below.

GUIDELINES FOR HYDROPOWER PLANT OPTIMISATION	P	C	O	R	D
Mitigate water quality problems Water residence time is one of the most significant environmental variables that affect water quality and related problems such as anoxia, etc. Other problems related to water residence time can also be observed in reservoirs and downstream, in particular waterborne diseases such as malaria. Project design and operation must take these aspects into consideration in order to minimise as much as possible negative effects on water quality.	●	●	●	●	●
Facilitate upstream and downstream fish passage for migratory species Aquatic fauna and fish in particular sometimes travel long distances to provide for their needs. Physical structures and especially dams constitute barriers to such migrations. The selection of the dam site (sites with thresholds or falls for example) and design of mitigation measures (fish ladders, elevators, etc.) must be examined carefully in order to minimise this type of impact.	●	●	●	●	●
Plan and carry out monitoring and environmental follow-up programs Such programs are essential components of any hydroelectric project. Certain residual impacts remain and must be addressed by specific monitoring or follow-up programs. A proper environmental follow-up program requires the collection of a time-series of data both before and after the implementation of the project. Monitoring represents an essential activity to ensure the application and effectiveness of mitigation measures. Project monitoring should be periodically verified by carrying out environmental audits.	●	●	●	●	●
Design and implement power plant flow rules that take into account the needs of communities and the environment both upstream and downstream of the project Operating rules for hydropower facilities are conceived in order to supply a specific energy service. However, these rules must also take into account impacts on fish and other species, as well as other needs and multiple uses of water such as irrigation, fishing, navigation, recreation, water supply, etc.	●	●	●	●	
Plan construction activities to minimise adverse effects during the critical phases of species' life cycles At certain phases of their life cycles, species are more sensitive to disturbances, for instance at the time of reproduction. In order to protect those critical phases and the habitats of concerned species, it is important to minimise activities that may compromise the survival of such populations.	●	●		●	●
If necessary, implement a reservoir logging program taking into account the various uses of the reservoir Although it is generally expensive, logging of selected areas of a future reservoir may be required for environmental, technical or economic reasons, such as the recovery of commercial wood. Logging may also generate considerable benefits for future reservoir navigation and fisheries. However, standing logs in a reservoir can also constitute good habitats for fish and benthic fauna. The logging program must therefore be adapted to the various uses of the reservoir.	●	●	●		

LEGEND: **P**: Planning – **C**: Construction – **O**: Operation – **R**: Refurbishment – **D**: Decommissioning

GUIDELINES FOR HYDROPOWER PLANT OPTIMISATION	P	C	O	R	D
Evaluate the effectiveness of mitigation measures The effectiveness of many mitigation measures is well known. However some measures, for a variety of reasons, may require a specific follow-up program. This is particularly the case for experimental measures for which there is little or no experience available from other projects.		●	●		●
Use the lessons learned from past hydropower projects in EAs carried out for new projects Lessons are not always learned. The experience gained in one project is not always integrated into EAs carried out for subsequent projects. This is true for proponents, governments and NGOs alike. A systematic review of lessons learned should help minimise the resources required for future studies and avoid past mistakes.	●				
Strengthen countermeasures against earthquakes in zones of strong seismicity Projects in zones of strong seismicity should be designed with appropriate criteria in order to reduce risks such as dam failure. It is also necessary to implement monitoring and contingency plans for downstream communities.	●			●	●
Plan measures to avoid or control reservoir sedimentation In certain river basins, sedimentation is an important issue because of the high sediment load carried by rivers. This problem should be correctly evaluated at the planning stage in order to design appropriate mitigation measures, such as river basin afforestation programs.	●		●	●	
Compensate the loss of biological production on a regional scale Hydropower projects modify existing habitats. Lakes, rivers and various humid and terrestrial habitats are replaced by the aquatic habitats of reservoirs. Although local losses cannot always be avoided, such losses can be compensated for on a river basin or regional scale, by protecting or managing similar habitats nearby.	●		●		
Consider human health and safety issues in any Environmental Management System (EMS) Hydropower projects may affect human health and safety. Environmental Management Systems should therefore address potential adverse health impacts such as water-related diseases (malaria or presence of heavy metals), and safety issues such as downstream water releases.			●		
Assess the environmental impact of decommissioning a power plant Decommissioning a hydropower plant may have significant environmental and social consequences. If decommissioning involves emptying a reservoir, there is a risk that a balanced and productive reservoir ecosystem will disappear, and that the human activities surrounding the reservoir will be significantly affected by its removal. Such impacts must be assessed prior to taking a decision.					●

Sharing Benefits with Local Communities

Beyond the project planning and design process discussed above, an important issue associated with hydropower projects is that of ensuring social justice through the *fair distribution of project costs and benefits* among local communities, society at large, project proponents and governments. In several cases, local communities have incurred most of the social costs of hydropower projects (in the form of involuntary population displacement, for instance), whereas most of the benefits have gone to other external constituencies: agricultural concerns, industries, urban communities, national or regional power supply and distribution systems, etc.

RECOMMENDATION # 5

Sharing Benefits with Local Communities

Local communities should benefit from a project, both in the short term and in the long term.

This recommendation considers that local communities are key players in hydropower projects because they are most directly affected by a project. Proponents must seek community involvement and partnership throughout the project cycle. Community support is most effective and legitimate when it involves broad constituencies including government agencies, non-governmental organisations, academic institutions, and other members of civil society.

Moreover, early community involvement is preferable, since project design is less likely to undergo major changes to suit the biophysical and socio-economic environment at a latter stage of project planning. The development of short term as well as of long term community benefits must be a foremost project goal and the only way to achieve such a goal is through a participatory planning process.

Community benefits do not necessarily mean monetary benefits, or might not even have to constitute monetary benefits at all. Improved access, improved infrastructure, support for health and education programs, legal title to land, are all important benefits that may be derived from a hydropower project. What constitutes a benefit, however, must be defined by locally affected communities on the basis of a participatory process.

What is meant by “affected communities” may vary greatly from one project to another. At the minimum, this term refers to people and communities who lose their livelihood, or their property, or access to resources that are essential for their livelihood, due to reservoir impoundment, construction works or downstream water flow changes.

However, defining who is affected by a project is a difficult exercise: Who decides? To what extent is a community “affected”? Beyond the minimal definition proposed above, there are many people and communities who may be affected to a certain extent by a project, whether positively or not. There are no simple answers, except to say that establishing who is affected by a project is often a negotiated exercise that is carried out between those who legitimately believe they are negatively affected by a project and those who represent the project proponent and/or relevant public authorities.

The following guidelines ensure a fair allocation of project benefits, while limiting adverse consequences for locally affected communities. These guidelines are based upon the implementation of a participatory approach with local communities.

GUIDELINES REGARDING BENEFITS TO LOCAL PEOPLE	P	C	O	R
Inform and consult local communities at all stages of project planning and implementation Every project raises questions and in certain cases sharp disputes. Public consultation is required to address the concerns of affected stakeholders. Consultations must be carried out as early as possible in order to ensure that the project incorporates communities' needs. Study results must be presented on a regular basis, to ensure transparency.	●	●	●	●
Cooperate with social and economic development agencies Many measures to mitigate and compensate socioeconomic impacts are dependent upon regional and national policies and programs which come under the responsibility of government agencies. Project proponents must therefore cooperate with such agencies in order to assess potential impacts and design appropriate mitigation, enhancement and compensation measures. The main areas to consider are: multiple reservoir and river uses, regional economic development, land-use planning, education and training, land expropriation, transportation and public health.	●	●	●	●
Design and implement monetary transfer mechanisms to local and regional institutions A regular revenue stream from the power plant operations allows for the implementation of regional infrastructure development and land-use planning initiatives, including watershed management or reforestation. Examples of such transfer mechanisms are: a regional tax corresponding to a percentage of the power plant's income, establishment of trust funds for environmental and economic development, or an equity share of local institutions in the ownership of the power station. Such transfer mechanisms must also apply to other types of power generation, such as coal, gas, nuclear or wind power.	●	●	●	●
Optimise local and regional economic spin-offs The onset of a project in a given area represents a potential source of employment opportunities. Throughout the project's life cycle, it is advisable to optimise the use of local and regional resources so that local communities benefit from the project. However, the qualifications of local labour do not always correspond to proponents' needs. In such cases, it may be advisable to provide technical training in such fields as environmental or social monitoring, natural resource management, etc.	●	●	●	●

LEGEND:
P: Planning – **C**: Construction – **O**: Operation – **R**: Refurbishment

GUIDELINES REGARDING BENEFITS TO LOCAL PEOPLE	P	C	O	R
Facilitate the involvement of affected people in the design and implementation of mitigation, enhancement and compensation measures The purpose of mitigation measures is to effectively minimise impacts that are often borne by local communities. In order to select and implement measures correctly, the participation of the concerned communities should be promoted, given their particular knowledge of the area and of local needs.	●	●	●	●
Ensure that vulnerable social groups benefit from the project Hydropower projects sometimes affect the lives of vulnerable social or ethnic/religious minority groups. It must be ensured that less privileged social groups, and not just dominant social groups, benefit from the project.	●	●	●	●
Plan and implement resettlement and rehabilitation programs for communities that are displaced or otherwise affected by the project Even when the best alternative is selected, involuntary population displacement is sometimes inevitable. The impacts of such activities are very complex, involve many stakeholders and cannot be dealt with within a short time-frame. The objectives of resettlement and rehabilitation programs must be to ensure the short- and long-term improvement of local standards of living by designing and implementing appropriate development opportunities for both displaced and “host” communities.	●	●	●	
Plan and manage public health programs A new hydropower project often leads to socioeconomic changes that may affect public health. Changes in living standards, in the quality of access to water, in the incidence of waterborne diseases such as malaria, are examples of changes that must be addressed. Programmes must be designed to ensure that local public health conditions are enhanced by the project.	●	●	●	
Integrate local ecological knowledge into project planning Beyond the studies which are required for any project, local knowledge can also be a source of relevant and useful information. It is thus necessary to ensure that this type of knowledge is taken into consideration in project planning.	●			●
During the planning and design phases, show openness in resolving local problems which existed prior to the proposed project The announcement of a new project often triggers the public re-emergence of unsettled problems from the past. These issues are often linked to previous projects carried out many years earlier. This is particularly true in the case of the upgrading of existing installations. These problems should be addressed even if they might not be directly related to the new project, as the project might help solve past grievances.	●			●
Support reservoir fisheries and other community uses of the reservoir Hydroelectric installations often include a large reservoir. Reservoirs might sustain significant local fisheries or other uses and may even be the subject of specific enhancement measures in order to increase their potential. In several countries, this aspect can be quite important for the local economy. It is thus advisable to support this kind of initiative, within reasonable limits.			●	

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