HYDROPOWER AND THE ENVIRONMENT:
Towards better decision-making

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Abstract

Global energy needs are rising rapidly, as are greenhouse gas emissions from the energy sector. Hydropower may seem an obvious choice for the provision of clean, low cost electricity, yet the negative environmental impacts of hydropower schemes, especially large ones, often hit the headlines. Many new hydropower plants currently under construction or planned pose a particular threat to the environmental integrity of some of the world's most ecologically diverse river basins. This in turn has social impacts such as a decline in important freshwater fisheries. Yet, other energy options face their own environmental problems. The search for sustainable energy solutions is thus a complex task. In view of a huge technical and economic potential of hydropower, this paper explores to what extent hydropower and the protection of freshwater ecosystems can be compatible. The paper discusses how better decision-making (according to the recommendations of the World Commission on Dams), more discriminate site selection and more effective mitigation measures could significantly reduce the environmental impacts of hydropower. It also argues that some sites and rivers should be kept free of hydropower development to avoid major losses of biodiversity.

Keywords: ecosystem impacts, World Commission on Dams, mitigation measures

1 Introduction

The world faces a huge challenge to supply the energy needs of a growing population, as well as to keep climate change in check by reducing greenhouse gas emissions. Hydropower is one of a number of options for meeting this challenge. It already supplies 19% of global energy needs but there remains a vast unexploited potential, in particular in developing countries. According to the World Energy Council (WEC), two-thirds of the economically feasible hydropower potential remains undeveloped. The WEC estimates that in order to exploit this potential, 20,000 new hydropower plants with a total of capacity of 1400 GW would have to be built[1], at a cost of US $1500 billion (WEC, 2004).

While this technical and economic potential is undeniably attractive, the big question is how much of this potential can be exploited without causing widespread environmental damage. The drive for more hydropower comes at a time when many freshwater ecosystems are already in crisis, partially due to the development of dams and related activities such as water withdrawals for irrigation. According to the United Nations, 60% of the world's 227 largest rivers are already severely fragmented by dams, diversions and canals, leading to the degradation of ecosystems (UN, 2003). A particular problem is the cumulative impacts of several dams on the same river. A recent report by WWF (2004) identified 20 rivers where ecosystems are at risk from large numbers of dams planned or under construction, including the Yangtze in China, La Plata in South America and the Tigris/Euphrates in the Middle East.

[1] This assumes an average plant capacity of 50 MW to 100 MW. The WEC suggests that large plants of the size of Three Gorges would not be the norm.

Ecosystem impacts are often very closely linked to social impacts. Freshwater ecosystems provide humankind with essential services, including water supply and purification, fisheries, flood control and floodplain fertility. Although freshwater ecosystems occupy less than 1% of the earth's surface, they deliver goods and services of enormous global value, adding up to trillions of dollars annually. When these services are lost, it is often the poor who are most affected.

While hydropower plants are implicated in this ecosystem degradation, other energy options, in particular coal and nuclear power, also have significant negative environmental impacts. Even new renewable energy sources such as windpower face opposition in some places. The search for sustainable energy solutions is a complex challenge which requires new approaches. This paper explores to what extent hydropower has a place in a sustainable energy future and discusses approaches to reducing the environmental impacts of hydropower.

2 Improving decision-making

The environmental damage caused by hydropower schemes has become increasingly apparent over the last decade or so. Damage has been caused by both large scale and small (<10 MW) hydropower schemes, as impacts are not necessarily size related. According to the World Commission on Dams (WCD), in the case of large dams the damage has often been unnecessary and mitigation measures have frequently been ineffective (WCD, 2000). This has been due to the lack of attention to anticipating and avoiding such impacts, the poor quality and uncertainty of predictions, the difficulty of coping with all impacts, and the only partial implementation and success of mitigation measures. While many of the more recent hydro schemes have learnt from the mistakes of the past and the quality of environmental assessment and mitigation measures is slowly getting better, there is still plenty of scope for improvement.

Arguably, the environmental and social impacts of many technically and economically feasible hydro sites are so unacceptable that these sites should never be developed. However, there are other sites where impacts can be managed through good design and effective mitigation measures. The WCD produced recommendations which should ensure that decision-making results in a more balanced outcome, giving equal weight to environmental and social factors as to economic and financial factors. However, they are yet to be applied in a consistent manner.

In terms of reducing the ecosystem impacts of hydropower plants, the following steps of the WCD framework are particularly important:

- Comprehensive needs and options assessments
- A river basin approach to site selection
- Effective mitigation measures

These will be further discussed in the following sections.

3 Needs and options assessment

In a world of growing energy demand, the need for a new hydropower plant may be seen as given. However, electricity systems are often incredibly inefficient, with large transmission losses (e.g. 25% in Turkey) and very high end-use inefficiencies in all sectors. Some argue that reducing energy demand through energy efficiency is not an option for developing countries. However, the issue is not necessarily one of reducing absolute demand but of limiting increases in demand. Government and utility policies for meeting water and energy needs thus need to tackle demand and supply issues in an integrated fashion. While hydropower plants (and other supply options) can play a role in meeting needs, they should not be given the go ahead without effective policies and programmes in place that address end-use efficiency. It makes neither environmental nor economic sense to give the go-ahead to a hydropower plant when half of the energy gets wasted in inefficient applications. Furthermore, refurbishment of existing plants can often yield considerable extra capacity and should be prioritised.

In terms of options assessment, a key recommendation of the WCD was to give social and environmental aspects the same significance as technical, economic and financial factors. This is particularly crucial when dealing with the issue of providing energy to the world’s poorest communities. Four out of five people without access to electricity live in rural areas, mainly in South Asia and sub-saharan Africa. By destroying wetland ecosystems, hydropower can also seriously threaten the quality and security of drinking water. Furthermore, the impacts of large hydropower dams on fisheries and agriculture downstream can be severe, often directly threatening the livelihoods of the poorest communities. In most cases their needs would be best served through decentralised energy systems, as the investment needed for large power plants and associated electricity transmission grids is simply unaffordable for most countries. Smaller scale hydropower and other renewable sources such as biomass, solar and wind are among the best options for alleviating energy poverty and this needs to be given greater recognition in options assessments.

4 A river basin approach to site selection

The single most important factor in reducing the environmental (and social) impacts of hydropower is good site selection. As pointed out above, environmental mitigation measures have often proved ineffective. The best option is thus as much as possible to avoid negative impacts from the outset. This can often be achieved through selecting a better site and/or a different type of scheme (e.g. run-of-the-river scheme vs a large storage reservoir). Ledec and Quintero (2004) have developed some useful indicators for rating and ranking proposed new hydroelectric projects, with 13 factors including reservoir surface area, water retention, biomass flooded and number of downstream tributaries.

It is the downstream impacts, as well as the cumulative impacts of several dams in the same river system, that are often given inadequate attention in decision-making. In WWF's view, the key to good site selection is thus decision-making within the framework of Integrated River Basin Management (IRBM). IRBM is the process of coordinating conservation, management and development of water, land and related resources across sectors within a given river basin. The aim of IRBM is to sustain and improve livelihoods and preserve biodiversity by conserving the ecosystems that support both. This requires an integrated, holistic and strategic approach (WWF, 2003). Like the WCD, IRBM emphasizes stakeholder involvement. In the European Union, IRBM has become a legal requirement through the Water Framework Directive and some very useful lessons are being learnt which can be applied elsewhere.

5 Effective mitigation measures

While better decision-making as discussed above should ensure that only the best hydropower sites are selected, mitigation measures are still needed for those sites. While, as discussed above, the experience with mitigation measures has been somewhat mixed, certain measures, when well implemented, can go a long way to reducing impacts. In this section we discuss three types of measures particularly important for the conservation of freshwater ecosystems.

5.1 Environmental flows

Changes to river flows are one of the key consequences of the construction of dams. Maximising the electricity output of a hydropower plant according to demand can have serious consequences both for ecosystems and other users, as flow conditions downstream of the dam are altered. However, in many cases it is possible to adjust the operational regime of a dam to better meet a variety of needs. So-called 'environmental flows' provide critical contributions to river health, economic development and poverty alleviation (IUCN, 2003). Environmental flows are not natural flows but aim to find a balance for meeting a variety of water needs, including those of ecosystems and downstream communities. According to Postel (2003), 230 rivers world-wide now have some kind of flow restoration scheme in place.

To demonstrate that environmental flows are not just a costly 'luxury' for rich developed nations, WWF has been working with the Zambian Ministry of Water and Energy Development and the Zambian Electricity Supply Company to introduce environmental flows at the Itezhi-tezhi dam, upstream of the Kafue flats wetland. The Kafue flats are a vast, open floodplain in the Zambezi basin and part of the area has been designated as a Ramsar site, a wetland of international importance. The construction of two major dams on the river (Kafue Gorge hydropower plant and Itezhi-tezhi storage reservoir) has disrupted the natural hydrological system, with adverse impacts on the habitat and breeding cycles of many species. Lower fishery yields and reduced availability of grazing land as a result of the altered flooding regime have affected human communities.

The project includes the re-establishment of a hydro-meterological monitoring network (which had fallen into disrepair), as well as computer modeling to simulate different water management scenarios. A new operational regime for the dam is being implemented, aimed at bringing benefits for people and for wildlife. WWF has facilitated the project and provided some financial support and many local stakeholders were involved in its design. The aim is to embed the new operational rules into the operating license for the dam to ensure consistent implementation of the agreement.

5.2 Compensatory measures

Habitat loss from dams can either be direct (i.e. the area flooded) or indirect (loss of downstream wetlands). Where no direct mitigation, for example through environmental flows, is possible, compensatory measures should be considered. This could involve purchasing suitable land and managing it for environmental protection purposes. Often, compensation involves areas next to or near the impoundment that have been impacted by other human activities (e.g. agriculture), with a focus on restoration or rehabilitation, especially of native vegetation. For example, in Brazil, the Peti hydro project (originally commissioned in 1946) is now surrounded by a 606 ha nature reserve where the native forest has been rehabilitated. CEMIG, the operator, has also established on environmental research centre and native species re-introduction programme.

In developing countries, the setting aside of land in a conservation area as a compensation measure can be difficult to implement due to the continuing demands for agricultural areas and sources of income for local residents. In these instances, a more successful approach has been to introduce various programmes to enable the residents to utilize the resources in a more sustainable way. It also has to be recognised that habitat restoration does not entirely compensate for the loss of natural areas, as it is very difficult (in particular in the case of wetlands) to achieve similar biodiversity values. Nevertheless, the approach can be beneficial in the case of existing dams where areas are already degraded. Reforestation in particular can have additional benefits in terms of reducing erosion and hence reservoir sedimentation.

5.3 No-go rivers

In many countries, river fragmentation by dams means that there are few rivers left in their natural state. This has resulted in an enormous loss in wetlands and other freshwater ecosystems. WWF believes that governments should designate some of the remaining unregulated rivers in areas of high conservation value as “no-go” areas for hydropower schemes. For example, in Iceland, where the Kárahnjúkar hydropower plant will cause considerable damage to two glacial rivers, WWF is urging the Icelandic government to afford protection to a third glacial river, Jökulsá á Fjöllum, including its designation as a Ramsar site. In Brazil, WWF is campaigning to get the Purus and Negro rivers in the Amazon basin declared as “free flowing” rivers. While this approach does not entirely compensate for losses elsewhere, it at least affords protection to some high value areas.

6 Improving implementation: hydropower certification schemes

One of the problems with mitigation measures is that they are often poorly implemented. Obviously, a well enforced licensing system should ensure that mitigation measures are applied. In the case of existing hydropower plants, especially where no relicensing systems exists, one option can be a certification scheme, such as the ‘naturemade’ green electricity label in Switzerland (www.naturemade.ch). This renewable energy label includes the accreditation of new and existing hydropower plants under certain conditions and consumers can choose to buy ‘green’ electricity at a premium price. The scheme is supported by WWF, other environmental as well as consumer associations and a number of electricity companies. To achieve the highest standard, the ‘naturemade star’ label, hydro plants have to meet strict environmental conditions. These include environmental flows, sediment flushing, fish ladders and protective measures for wetland habitats. Additionally, operators have to pay a percentage of their income into a fund for environmental improvement measures, including habitat recreation. Allocation of the fund is jointly decided by the plant operator, local authorities and environmental organisations. Fourteen Swiss electricity suppliers have gained certification under this label. Key to the credibility of this scheme is its independent statute with board membership from industry, consumer and environmental organisations. In the United States, the Low

Impact Hydropower Institute has a similar approach (www.lowimpacthydro.org).

In principle, such a certification system could be developed at a global level, either for hydropower plants or dams more broadly. A global certification system is for example in existence for forestry products, administered by the Forestry Stewardship Council. Such certification systems are expensive and time-consuming to set up, so this approach would need to be given careful thought.

7 Conclusions

Meeting the challenge of satisfying global energy needs while reducing greenhouse gas emissions and protecting freshwater ecosystems requires new approaches. Decisions about hydropower plants should no longer be made in isolation as they are part of a suite of solutions for meeting energy needs. Comprehensive needs and options assessments are thus a must, with environmental and social factors given equal weighting to economic and financial ones. Where hydropower plants emerge as the best solution, mitigation measures need to be designed carefully and compensatory measures such as the designation of 'no go' rivers need to be considered. Hydropower does have a role in a sustainable energy future but its potential should not be developed at the expense of freshwater ecosystems. WWF is calling on governments and developers to ensure a better balance between economic, social and environmental considerations when it comes to decision-making on hydropower and to follow the recommendations of the World Commission on Dams.

References

Dyson, M., Berkamp, G., Scanlon, J. (eds) (2003) *Flow – the Essentials of Environmental Flows*. IUCN, Gland and Cambridge.

Ledec, G. and Quintero, J.D. (2004) *Good dams and bad dams: environmental criteria for hydroelectric project site selection*. Paper presented at the ICOLD Environmental Symposium, Seoul, June 2004.

Postel, S. and Richter, B. (2003) *Rivers for Life – Managing Water for People and Nature*. Island Press, Washington.

United Nations (2003) *Water for People, Water for Life – the United Nations World Water Development Report*. United Nations.

World Commission on Dams (2000*) Dams and Development: A New Framework for Decision-Making*. www.dams.org.

World Energy Council (2004) *Survey of energy resources: hydropower*. http://www.worldenergy.org/wec-geis/publications/reports/ser/hydro/hydro.asp

WWF (2003) *Managing Rivers wisely*.
http://www.panda.org/about_wwf/what_we_do/freshwater/what_we_do/river_basins/index.cfm.

WWF (2004) *Rivers at Risk: dams and the future of freshwater ecosystems*. http://www.panda.org/downloads/freshwater/riversatriskfullreport.pdf