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Pittock, J. 2010. *Viewpoint* – Better management of hydropower in an era of climate change. Water Alternatives 3(2): 444-452

Volume 3 | Issue 2

Viewpoint – Better Management of Hydropower in an Era of Climate Change

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ABSTRACT: Ten years ago the World Commission on Dams (WCD) report established new standards for the sustainable development of water infrastructure, but the hopes many of us had then for a new era of more thoughtful development have been attenuated by the resilience of the hydraulic bureaucracy and the emergence of new influences on the hydropower debate. Particularly important is the impact of climate change as a driver of government policies in favour of hydropower, water storage and inter-basin water transfers. As a former Director of Freshwater for WWF International and now as a researcher on the water-energy nexus, I spent much of the past decade seeking to influence the direction of water infrastructure development, and in this viewpoint I have been asked to reflect on the changes that have occurred, and the opportunities in an era of climate change to reduce the environmental and social impacts of hydropower development while maximising the benefits. Better outcomes are more likely with a renewed focus on limiting the perverse impacts of climate change policies, implementing standards for certification of more sustainable hydropower, building capacities within developing countries, and enhancing management of existing dams.

KEYWORDS: Dams, hydropower, biodiversity, climate change, standards

DAMS AND BIODIVERSITY

Dams and other water infrastructure significantly impact on freshwater ecosystems by changing the quantity, quality and timing of water flows, creating barriers to movement of wildlife, sediment and nutrients, and inundating particular habitats (WCD, 2000). The expansion of hydropower dams creates conflicts with international agreements, which have national land and water management implications, to significantly reduce the loss of biodiversity (Pittock et al., 2008). The cumulative global impact of water infrastructure on freshwater ecosystems continues to grow in severity despite the recommendations of the WCD to address existing and planned dams. For instance, global overviews of dam-based impacts on large river systems show that over half (172 out of 292) are now affected by dams (Nilsson et al., 2005) and many of the world's remaining free-flowing rivers are at imminent risk of fragmentation (WWF, 2006). Fragmentation of bio-diverse and previously little-impacted river systems is now underway, such as with the planned construction of up to 19 main stem dams on the Mekong river (Molle et al., 2009; Osborne, 2009). The Millennium Ecosystem Assessment (MEA, 2005) summarises extensive losses of wetlands (including rivers) globally and describes freshwater ecosystems as being over-used and under-represented in protected areas, and having the highest portion of species threatened with extinction. Primary direct drivers of degradation and loss are described as infrastructure development, land conversion, water withdrawal, pollution, over-harvesting and over-exploitation, the introduction of invasive alien species, and global climate change. These drivers are synergistic, for example, climate change is increasing demand for low-carbon-energy sources and greater water storage leading to construction of more infrastructure and water withdrawals (Pittock et al., 2008). Consequently, this paper focuses on four linked influences on the global hydropower industry that have strengthened since the WCD report in 2000: 1) the growing importance of climate change policies, 2) changing role of countries with emerging economies, 3) ongoing debate on sustainability standards, and 4) emerging role of old dams.

CLIMATE CHANGE POLICIES

In the past decade, growing concern about the climate impacts of greenhouse gas emissions has prompted many governments to adopt policies in favour of low-carbon- energy sources (Pittock et al., 2008). In particular, countries with emerging economies and rapidly rising energy demands are looking to expand their own hydropower production or import hydropower from neighbouring states, as many of these countries have developed relatively low portions of their own economically feasible hydropower potential (GoB, 2008; GoC, 2007; GoI, 2008). However, the potential for deleterious environmental impacts from such climate mitigation measures is illustrated by the global coincidence of river basins with greatest fish biodiversity with those regions with the greatest hydroelectric power development that is yet to be exploited (IUCN et al., 2003), namely South America at 67%, Africa at 93%, and Asia at 78% (Journal of Hydropower & Dams, 2002). The hydropower industry, with targeted advocacy, has skilfully manoeuvred international policy makers into favouring further expansion of hydropower, for example, by categorising hydropower as an energy source with low greenhouse gas emissions under the Kyoto Protocol's Clean Development Mechanism (CDM) (CDM Executive Board, 2009a). This low emission status is contested, as all energy production emits some level of greenhouse gases, including in the production of construction materials, such as concrete in dams; in a transition phase, such as emissions from deforestation of an area to be inundated when a reservoir fills; or in daily operation, including the release of methane and carbon dioxide from decomposition of inundated organic matter (Fearnside, 2004; Harvey, 2006; IHA, 2010; Pacca, 2007; Rosa et al., 2006; Weisser, 2007).

The CDM grants Certified Emission Reduction (carbon credit) certificates (CERs) to registered hydropower projects in developing countries with a power density of greater than four Watts per square metre of inundated lands, and, provides additional income for such projects (CDM Executive Board, 2009a; UNFCCC, 2009). As of April 2008, registration was sought for 828 hydropower project, 26% of all CDM projects (Pottinger, 2008). Most of these projects are located in China, India, and Brazil, and the main purchasers of CERs are the United Kingdom, Netherlands, Germany, and Japan. CDM hydropower projects are meant to demonstrate adherence to the WCD's recommendations but critics contend that there is no convincing case of WCD-compliance by any CDM hydropower project (Haya, 2007). All CDM dam projects are supposed to demonstrate 'additionality', that is that they are only financially viable with the additional income provided by CERs, yet this is hard to prove and questionable in many instances (Haya, 2007). The CDM Executive Board say they have tightened additionality, validation and verification processes (CDM Executive Board, 2009b; de Boer, 2009), yet there is no evidence of any improvement in outcomes (Wara and Victor, 2008). Clearly, the CDM is providing incentives for hydropower projects with few environmental constraints. Similar criticisms of lack of transparent adherence to the WCD strategic priorities have been levelled at the European Union's Linking Directive for the admission of CDM CERs from hydropower projects into the EU's emission trading scheme (EU, 2008). As most hydropower projects will impact on biodiversity the CDM is in conflict with the objectives and decisions of other international environmental agreements, such as the Convention on Biological Diversity and Ramsar Convention on Wetlands. The CDM is scheduled to expire with the Kyoto Protocol in 2012, providing a key opportunity to ensure that any replacement of carbon market mechanisms include more holistic and effective safeguards.

Like governments, non-government environment organisations with a broad mission to promote sustainability find themselves in a dilemma between balancing their desire to protect freshwater ecosystems and the rights of peoples in poorer nations to equitable development, and also the need to propose credible means of meeting the needs of people for energy without exacerbating climate change. WWF, a non-government organisation (NGO) campaigning on climate change, that has policies in favour of protection of forest and freshwater ecosystems, and against the use of nuclear and fossil fuels, responded with a comprehensive energy policy that proposed limited expansion of hydropower (WWF, 2007). WWF's 2007 policy proposes hydropower development of up to 30% of economically feasible potential by nation or river basin, to maintain ecologically significant river reaches within basins as free-flowing, such as main stems, while enabling developing nations to access local energy sources. WWF noted that of 2,270 Gigawatts (GW) of economically feasible large hydropower potential globally 740 GW (33%) had been developed, 445 GW were planned (20%) and 120 GW were under construction (5%), and developments had not yet been proposed for the remaining sites (or they were reserved from development). WWF estimated that 250 GW of large hydropower sites "could be developed with relatively low impacts", plus an additional 20 GW for medium, 100 GW from small, and 30 GW from re-powering hydropower plants (WWF, 2007). This pragmatic policy has helped to open dialogue on sustainable energy policy with different stakeholders, such as the International Hydropower Association, but it has not been adopted by governments as yet. While it is possible to propose such limits the challenge, discussed below, is to influence decision-makers to apply them.

Climate change policies are altering the application of most energy technologies. In the case of hydropower, pumped storage schemes are taking on a new role, and one that has greater flexibility in providing economic benefits while limiting impacts compared to conventional hydropower. The growth of intermittent electricity production from wind and solar generators brings with it a need for large-scale energy storage systems for energy management, frequency control and provision of reserve on power grids, and while a number of technologies could potentially meet this need, pumped storage hydropower is the most widely adopted technology to date (Miller and Winters, 2009; Schaber et al., 2004). Pumped storage hydropower uses excess, or cheap (non-peak) electricity to pump water from a lower reservoir to an upper reservoir. When required, the water flow is then reversed to generate electricity with an energy efficiency of 70-85% (Boyle, 1996; Miller and Winters, 2009; Sorensen, 1979). Globally, there are 127 GW of installed pumped hydro capacity representing about 3% of generation capacity in over 100 power stations (Baker, 2008; ESA, 2009). While currently the majority of these pumped storage plants enable coal-fired and nuclear-power stations to generate power more consistently, such large energy storage is needed to back up increased production from variable renewable electricity. Industry reports suggest that the pumped storage market will expand 60% in the next four years, with an estimated installed capacity of 203 GW by 2014 (Ingram, 2009). Socially and environmentally, pumped storage hydropower projects have not been systematically assessed but are expected to have lesser impacts since projects can be constructed off-river and using existing storages; off-river pumped storage reservoirs require relatively little land; and the water is largely recycled so consumption is low. Using existing dams for pumped storage may result in political opportunities and funding for retrofitting devices and new operating rules that reduce previous ecological and social impacts. Planned expansion of pumped storage hydropower schemes is currently focused in developed nations, China and India.

In countries like China, to manage variability induced by climate change more multi-purpose water infrastructure schemes are being proposed to increase water storage and supply, and supposedly to manage floods, as well as generating power (GoC, 2007). Driven by climate-change policies, further technological changes to use of hydropower can be expected, such as the development of hydrokinetic (in river) electricity generators (Bodin, 2010), which will raise new questions on how to maximise the benefits while minimising adverse social and environmental impacts. This illustrates the importance of the preparation and adoption of sustainability standards for hydropower developments (discussed below) that are sufficiently broad and flexible to manage changing hydropower technologies.

COUNTRIES WITH EMERGING ECONOMIES

The past decade has also seen a shift in dominance from multilateral and developed country hydropower service suppliers to developing country proponents, who now construct the majority of the world's hydropower projects. In the past, opponents of hydropower development in developing countries would seek to block developments by campaigning against developed country financiers, suppliers and export-credit guarantee agencies. Since China self-financed the Three Gorges dam development, restricting international finance has become a less and less successful strategy for project opponents. Indeed, many developing countries are now exporting their hydropower development expertise as part of aid and trade agreements (Bosshard, 2010). Self-financing may also explain why institutions like the World Bank, which had contemplated more balanced policies with hydropower development at the time of the WCD, and then reiterated a so-called "high risk, high reward" policy to finance water infrastructure (World Bank, 2004). International financial institutions need developing country customers, and if these countries can largely fund their own hydropower projects then increasingly they can attract additional foreign loans and credit guarantees on their terms. Under these circumstances, those who seek to minimise the social and environmental impacts of hydropower must find new ways to constructively influence the development and operations of the sector.

As the growth in new hydropower projects has moved to countries with emerging economies, many of the solutions for less-damaging infrastructure development must largely be found in these nations by strengthening the capacities and standards of their government, industry, academic and non-government sectors. Although hydraulic bureaucracies (Molle et al., 2010) prevail in promoting large-scale water resources development, in a number of developing nations there are moves towards more considered approaches. Subsequent to its rejection of the WCD guidelines in 2000, China is the most interesting example of a government considering the mistakes of developed nations in overdeveloping their rivers. In recent years, Chinese ministers have proposed setting upper limits on development, including of hydropower, to sustain the freshwater environment to help implement the government's policy of building "harmonious co-existence between man and nature" (Shucheng, 2006). Consequently, the Ministry for Water Resources announced it would limit hydropower to 60% of potentially feasible developments, and withdrawals to 30% available water resources by 2030 in the Yangtze River Basin Master Plan that is currently in preparation (China Daily, 2009). This contrasts with the policy of India to fully exploit its hydropower potential (GoI, 1998) backed up by large targets in its climate-change policy (GoI, 2008). Approvals for a number of proposed hydropower projects have been refused by the Government of China and stronger environmental impact assessment procedures adopted (Bezlova, 2009; Xinhua, 2009b), including an interest in applying environmental standards to the growing number of Chinese hydropower projects in other countries (Bosshard, 2010). Further, the Government of China has begun promoting mitigation measures, such as large-scale environmental flow projects on six rivers and lakes (Shucheng, 2006), and has a major programme to renovate the 37,000 reservoirs (more than 40 percent of the country's total) that have "potential dangers" (Hu Yinan, 2008; Xinhua, 2009a). While these measures are currently a modest influence on the expansion of the hydropower sector in the world's largest dam-building nation, they illustrate the potential to support institutions to adopt more holistic practices to mitigate the worst impacts of hydropower development in developing countries. In this context, the efforts by institutions like The Nature Conservancy and World Bank to develop practical, technical guidance on better environmental practices for the development and operations of dams (Hirji and Davis, 2009; Krchnak et al., 2009) are a positive means of redefining professional practices and informing decision-makers. Yet I believe that more precise standards are also required for the myriad of financiers, government officials, politicians and hydropower industry officials involved in funding, regulating, constructing and operating hydropower systems.

SUSTAINABILITY STANDARDS

The tokenistic citation and lack of application of the WCD guidelines in the assessment of CDM project applications to date, and similar approaches to the purchase of CERs by EU organisations (EU, 2008), highlight the limits of the application of the WCD recommendations. The practical use of the WCD recommendations is curtailed by their rejection by some of the largest dam-building nations, particularly China, and acceptance of only the strategic priorities by institutions like the World Bank (Fujikura and Nakayama, 2009), since political acceptance is equally or more important for implementation than technical proficiency. The WCD recommendations were framed as principles rather than operational standards, and their use as global criteria versus tools for national scale application is disputed (Fujikura and Nakayama, 2009). Having worked with commercial financiers considering their internal screening policies on water infrastructure projects I came to appreciate that more practical, global operational guidance is required that may be overseen by decision-makers who do not necessarily have a professional background in relevant disciplines. Regional hydropower standards have been developed in Europe and North America but these have not been developed with the involvement of wider stakeholders and considering the broader range of issues that global application requires.

For these reasons I supported the establishment of (but have not subsequently participated in) the global Hydropower Sustainability Assessment Forum and its work, currently in progress, to attempt to gain cross-stakeholder consensus on a hydropower sustainability protocol (HSAF, 2009; Locher et al., this volume). The Forum is far from a perfect process in being tightly held by a nervous industry and under-resourced. The International Hydropower Association membership lacks consensus as to the ultimate destination of the processes, whether as a voluntary tool as currently agreed, or whether after a new stage of development a more credible third-party certification process is adopted. There are many issues where stakeholder consensus is difficult, including standards for gaining public acceptance and free, prior, informed consent. The Draft Protocol is more readily implemented compared to the WCD's strategic priorities and guidelines, but has been criticised (Bosshard, this volume). Some of the reviews appear contradictory, for example, in criticising length, complexity and fragmentation while calling for "more substantive guidance about existing progressive practice" (Foran, 2010). The substantial criticism that the Draft Protocol is based on "highly relativist methodology" (Foran, 2010), that is inevitable when it is not possible to quantify all performance attributes and value judgements are required, should be addressed by developing an independent assessment process.

From an environmental perspective, mechanisms for implementing assessments earlier in time and at a river basin or regional scale are critical to minimising impacts (well articulated by The Nature Conservancy in unpublished work). Such strategic assessments are essential to better inform decisions on whether hydropower projects are needed, and if so, how they can be developed to maximise economic, social and environmental outcomes within a river basin or region at a time when there are more alternative options. However, industry disputes its responsibility for this work by arguing that this is a task for governments. The HSAF's Draft Protocol section on strategic assessments (HSAF, 2009) addresses the question of how a proposed dam relates to such strategic assessments, but does not proactively propose such broad-scale planning. Outside the Forum process, WWF, the Asian Development Bank and Mekong River Commission are attempting to develop a basin-wide protocol in the Mekong region, "Environmental Criteria for Sustainable Hydropower Development" (King et al., 2007). This is intended to be applied to multiple hydropower projects such as a cascade or at upstream basin or sub-basin planning levels and will hopefully demonstrate how to more effectively implement strategic assessments in other regions.

If the HSAF process fails to reach consensus on sustainability standards then the hydropower sector will continue to be dogged by disputes over its development plans, increasing risks to the industry's social license to operate and in some instances, to finance for projects. The HSAF has the possibility of delivering standards supported by a broad range of stakeholders, as it comprises respected NGOs like

Transparency International, Oxfam, The Nature Conservancy and WWF, as well as industry and government institutions, including from China (although some NGOs are critical that "dam affected peoples" are under-represented in the Forum; see Bosshard, this volume). The currently agreed HSAF process only proposes to produce a voluntary sustainability protocol and has not yet agreed to a credible process for its application. The HSAF participants should have the courage to take another step and agree to an independent, third-party certification system that could see the protocol applied in a rigorous and trustworthy manner. Independent certification would largely address the criticism that the Draft Protocol is overly reliant on an interpretivist method (Foran, 2010). Certification would offer greater certainty for all stakeholders, especially the hydropower industry, as similar mechanisms have in other sectors, such as the Marine and Forest Stewardship Councils, and the Roundtable on Sustainable Palm Oil. All manner of key stakeholders external to the industry are looking for a decision-making framework that they can trust: financiers, carbon-credit institutions, government officials, suppliers, and green-energy retailers. This can only come from a certification scheme supported by credible social and environmental NGOs. Not every NGO globally would endorse such an agreement on hydropower standards, (as indicated by Bosshard, this volume) yet those organisations could play an important external role in holding such a system accountable.

MANAGING OLD DAMS

A further challenge and opportunity that has been largely overlooked in the decade since the WCD report is the recommended strategic priority to address existing dams (WCD, 2000). The world's aging dam stock provides problems in the loss of capacity, safety risks, costs of remediation, and opportunities to optimise benefits (USACE, 2009; Xinhua, 2009a). Many governments regulate hydropower dams as if they are permanent structures, when history tells us that societal changes often make such infrastructure redundant, and structurally major repairs or removal are inevitable. At the same time, many older dams have the potential to be re-powered to produce more electricity from the same structures. For instance, an assessment of four old dams in Brazil concluded that re-powering could increase energy production at each dam by 46 to 205% (WWF, 2004). Further, many existing storages could be re-engineered as pumped-storage projects. Re-operated old dams can also provide environmental flows to restore downstream ecosystems and enhance livelihoods (Krchnak et al., 2009; Postel and Richter, 2003). These challenges can only be systematically addressed and the benefits realised if there is better regulation of dams, such as the periodic relicensing procedure applied by the Federal Energy Regulatory Commission to non-Federal Government-owned hydropower projects in the USA (FERC, 2009b). Such a regulatory system in reassessing the performance of water infrastructure every 30-50 years provides benefits for all stakeholders, as illustrated by the partial removal and the re-operation of a hydropower dam cascade on the Penobscot river in the USA to provide the dam owners with greater certainty, generate a similar amount of electricity, while restoring access to migratory fish to the greater part of the river basin (FERC, 2009a; PRRT, 2009; Gosnell and Kelly, this issue). Illustrating the range of opportunities to maximise benefits by re-operating existing dams, another opportunity is to restore flood plains and use multi-purpose reservoirs – which are kept partially empty to store flood waters – as run-of-river dams to produce more electricity and restore degraded freshwater ecosystems (Opperman et al., 2009).

CONCLUSIONS

The World Commission on Dams' 2000 report was a great step forward in identifying issues that the hydropower sector needs to address to ensure projects are justified and well-managed while minimising social and environmental impacts. Unfortunately, the absence of more measurable and operational standards and lack of support from a small number of critical governments and other institutions have undermined the practical implementation of its recommendations (Fujikura and

Nakayama, 2009). Subsequent years have seen changes in the nature of the hydropower sector, with the dominant influence moving to countries with emerging economies, and with climate-change policies rejuvenating development plans. The application of hydropower as an energy technology will continue to change, as evidenced by the expansion of pumped-storage and growing challenges and opportunities in managing old dams. Hopes for optimising the use of hydropower while eliminating unacceptable social and environmental impacts lie in a) more rigorous climate-change policies that limit the perverse impacts of incentives for hydropower; b) building on the WCD recommendations to adopt more practical, consensus-based multi-stakeholder sustainability standards to guide decision-makers; c) working within those developing nations that are the current focus of hydropower development to build capacities and greater professional and governance standards to better regulate hydropower development and operations; and d) establishing regulatory systems for making better use of existing dams.

ACKNOWLEDGEMENTS

Insightful comments on a draft of this article from S. Dovers, D. Harrison, J. Dore and four reviewers were greatly appreciated. This paper was prepared in a personal capacity and does not necessarily reflect the policies of WWF.

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