THE FUTURE OF BIG DAMS

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1. Introduction

This paper shows how to achieve sustainability of big dams. The paper focuses on hydroelectricity dams. Irrigation dams are mentioned, although much of what is proposed for hydrodams applies to all dams, such as for flood control, water supply and navigation. The raging international controversy for and against big dams has led to a decline in big dam building, to an increase in coal-fired electricity, and to a decrease in irrigation per capita. Developing countries are the main places dams are contemplated and are the focus of this paper.

Proponents of dams and other renewable energy sources are losing the fight to promote them. Sustainability will be strongly promoted by phasing out of the big impact forms of energy production, and phasing into the low impact forms of energy. This means essentially phasing out of coal and into hydro and other renewables. Hydro is on the cusp between fully renewable and clearly non-renewable. Hydros have not yet become fully environmentally sustainable. Some of the recent controversial dams and debates over dams are given in Tables 1 and 2.

S. No.	Country	Description
1	**Thailand**	**Thailand's** 576 MW ($352 M) **Nam Choan** was indefinitely postponed by the Royal Thai cabinet in 1982 because the 140 square km reservoir would flood 4% of the 4,800 square km Thung Hai Wildlife Sanctuary. This sanctuary was (and is even more since) being actively logged and poached which the project could

		have halted. This is an example of many, that hydro projects are indeed dropped on environmental grounds.
2	**Sweden**	**Sweden** has banned further hydroprojects on half of its rivers; New government may rescind this decision partly because of availability of Finland's nuclear energy.
3	**Norway**	**Norway** until recently was 100% hydro-based, which was then considered good and sustainable. Norway has now postponed all new hydros because of excess capacity and opposition.
4	**Slovakia**	**Slovakia** is defying the EC and the EC-appointed tribunal looking into the Danube's **Gabcikovo** Dam which is alleged to have lowered the water table in Hungary's prime agricultural area (yields dropped 30%) by 6m in the lower central part of Hungary's Szigetkoz wetland. Most Danube fish are reported to have since declined; work was halted for a period in mid-construction. International Court of Justice found both parties guilty in 1997.
5	**USA**	**USA:** New York State (NY Power Authority) canceled their 20-year $12.6 bn contract to buy 1000 MW of Quebec's **James Bay** power, reportedly for environmental (and social) reasons, in 1992. Demand reduction in New York played a role too, but is now much more exploited than previously, so there will be decreasing scope for more demand side management. HydroQuebec indefinitely postponed Great Whale hydro 1994.
6	**India**	**India** requested the World Bank on 31 March 1993 to cancel the outstanding $170 M **Sardar Sarovar** (Narmada) loan, partly because contractual agreement schedule was unlikely to be met on time. This was the world's most intense dam controversy for years on environmental and social impacts as amplified by Morse & Berger (1992).
7	**Nepal**	**Nepal's** 401 MW **Arun** hydro (43 ha reservoir; little resettlement), twice entered Nepal's Supreme Court in 1994 because of opposition related to the 122 km access road, and transparency; petition lodged with World Bank's Inspection Panel in 1994; project dropped in 1995 largely because of financial risk although environment was criticized by opponents.
8	**China**	**China's** 18,200 MW **Three Gorges**, the largest in the world, had US support withdrawn in 1993 & US Ex-Im Bank withdrew 1994. Contracts signed in 1977 with Asea Brown Boveri, General Electric/Alsthom, Kvaerner, Voith, Siemens,); Japan & Germany (Hermes-Buergschaften Ex-Im Bank) involved as of 1997.
9	**Chile**	**Chile's** 400 MW, **Pangue** hydrodam, the first of five (see below) planned for the BioBio river ($150 million, approved 1992, completed 1997), litigated in Chile's Supreme Court in 1993, partly because the EA failed to address downstream impacts. An independent review commissioned by IFC, led by Jay Hair former President of IUCN-World Conservation Union, is said to damn both

		the project process and IFC; World Bank Group President Wolfensohn (6 Feb.97) threatens to declare default to Finance Minister Aninat. 11 March 1997: Chile severs ties with IFC by prepaying IFC's loan and obtaining cheaper money from the Dresdner Bank, with fewer environmental conditions.
10	**Chile**	**Chile's** 570 MW **Ralco** dam on the Biobio river has become a test of Amerindian rights, as well as divergent views between those vulnerable ethnic minorities preferring traditional living, and those preferring economic development at the risk of assimilation. The 1000 acre, $500 million reservoir planned by Spanish private corporation ENDESA would displace 500 Pehuenche Amerindians, a sub-group of the Mapuche ethnicity who have been beleaguered since the Spanish conquistadors. The Government claims that the Electric Service Law takes precedence over the 1992 Indian Rights Law that prohibits sale of Indian lands without unanimous consent of the community involved. The director of the National Environmental Commission was fired in 1997 after a report finding against the project. In 1998 President Frei dismissed three members of the National Indigenous Peoples Board when it appeared they would vote against the project. The fired director, Domingo Namuncura, pointed out that the lands offered to the Amerindians are too infertile to support their traditional wheat and potato crops. Demonstrations, country-wide road blockades, and a 3-day Indian protest march could halt the project. Will oustees be penalized for the greater good of the nation?
11	**Malaysia**	**Malaysia's** 2,400MW **Bakun** dam was cancelled in 1997 breaking ABB's $5 bn. contract when agreement on financial risk allocation (cost over-runs) could not be reached. Vulnerable ethnic minority oustees (9,000) rejected resettlement arrangements; the EA was declared illegal (and secret).

Table 1: Examples of Controversial Dams

PROPONENTS CLAIMS	OPPONENTS CLAIMS
It is possible to mitigate hydro's impacts significantly, given political will	Historically, hydro's known impacts have not always been mitigated in practice, even when well known, such as involuntary resettlement.
Developing countries need large power projects; many small power projects (deforestation, old diesels) can be environmentally and economically worse than the best hydro	Developing countries are better served by less lumpy power investments than big hydro
The impacts of hydro's alternatives (coal, nuclear) cannot be mitigated	Lumpy power projects demote Demand Side Management, so small coal and gas turbines make DSM more likely

Hydro generates much less greenhouse gas compared with coal alternatives	GHG reduction by hydro is unlikely to be the least cost; transport sector improvements are more likely to be less cost
Gas is best reserved for transport fuels or for chemical feedstock; costly for base load	Use natural gas for the next decade or so or until other renewables become competitive
Many countries still have good hydro sites left; the best hydro sites should promote local development, to export electricity to neighbors, to postpone coal or nuclear alternatives, to benefit the country by attracting energy intensive industries.	Practically all good hydro sites have already been developed, especially in Europe and USA
The worst hydro sites should not be built: tropical, many oustees and species, large reservoir areas, shallow, etc.	The main really good hydro sites are non-tropical (that is, mountainous), no biomass or resettlement, no fish or no endemics, high head, deep reservoirs
Government regulation is needed; enforcement possible	Government regulation unlikely and enforcement may be weakening
Privatization needs government regulation	Private sector less regulable by government
Public and private power projects should follow least cost	Private sector less likely to follow least cost; prefers to externalize all it can
Electricity sales help the country irrespective of the use to which the power is put, such as exports or for the already electrified elites.	More electricity for elites not needed. Electricity for basic needs, health, education and for the poor is not best met from big hydro feeding the national grid.
Must not let water "waste to sea" unharnessed.	Water to sea not wasted, but used by ecosystems.
Need large scale for urban, industries and surpluses, especially as their capability to pay is greater.	Poor and rural benefit less, if at all, from large scale. Priorities should be poor before industries
Subsidies to rich can be cut; pricing can help poor.	Subsidizes the rich; decreases equity.
Foreign contractors create jobs and transfer technology	Too dependent on foreign exchange and contractors
Poor countries lack capacity to build large dams; low maintenance cost and simplification of operations suitable for LDCs.	Indigenous, smaller often more appropriate for LDCs to begin with; big hydro has huge capital costs
Big/small not substitutable	Small/medium hydro can partly substitute for big, and with more equitable goals

Table 2: The Big Dams Debate

This paper begins by considering environmental sustainability and dams. We then consider the most recent progress with big dams, namely increased transparency and participation. The paper then outlines how to select the next least-bad dam through environmental least-cost ranking. Then the worst impact of big dams, involuntary resettlement, is also outlined. The paper concludes with sections on irrigation dams, greenhouse gas, and speculation on the future of dams.

2. Environmental Sustainability in Hydro Dams

The starting point is the solar-powered hydrological cycle which is the quintessence of sustainability. Water flow is a renewable resource. The cycle must be harnessed so that the project continues to generate benefits (such as power, fish; in multipurpose dams irrigation, flood control, navigation, water supply) for a long period, certainly decades, preferably a hundred years or more. In the narrow sense, sustainability means the hydro's lifetime should be as long as possible. In the broad sense, sustainability means environmental and social damage has been prevented or offset such that net residual impacts are insignificant. In addition, sustainability requires that the environmental and social costs are low and do not increase, especially not for future generations, such as climate change (the intergenerational equity component of sustainability). Sustainability is NOT only a continuation of power output. A modest fraction of power sales allocated to social and environmental needs ensures their acceptability. The concept of environmental sustainability is summarized in general Table 3. Sustainable dams also include the following specific characteristics.

S. No.	Description
1	Increase transparency and participation
2	Achieve demand side management before adding new capacity
3	Follow least-cost ranking
4	Improve involuntary resettlement
5	Internalize greenhouse gas emission damage costs
6	Promote capacity strengthening to implement mitigation
7	Balance rural *versus* urban supply
8	Balance small, medium and big projects
9	Balance storage dams *versus* run-of-river
10	Balance hydro with other renewables

Table 3. Characteristics for Sustainability of Dams

Involuntary Resettlement (includes affected people): The number of oustees is zero or low (e.g. Nepal's Arun reservoir); those relocated are promptly better off after their move. To be no worse off means stagnation, so cannot be called development. Of course, "no worse off" would be much better than historic achievements. Diseases cannot be allowed to increase. Brazil and China call for fractions of power sales be allocated to oustees. The policy of China and of the International Commission on Large Dams is to ensure oustees are better off, not "no worse off". Impact on affected people should be made acceptable.

Sedimentation: The reservoir generation capacity will not be curtailed; certainly for longer than the amortization of the loan. Opponents claim that 50 years of power is too brief a benefit to outweigh the environmental costs. Early designs need to calculate the ratio of live to dead storage to aid in dam selection. Catchment protection should be an integral component to all relevant hydroprojects. Current sediment loadings; expected life of reservoir before sediment starts to curtail generation. Thereafter, if the plant operates as run-of-river, what are the implications? Potential (e.g.: by bottom gates) for de-silting; downstream effects of de-silting. Calculate and monitor erosion processes upstream.

Fish: Fish contribution to nutrition and especially protein must not decline. Unless fish catch increases substantially and permanently, the big new opportunity of the new reservoir will have been wasted. Need to ascertain how many people currently depend for what part of their livelihoods on fish (self-consumption or barter or commercial sales). Non-marketed fish value usually exceed marketed fish value. Much so-called weekend or recreational fishing forms part of poor household budgets, so must be included. The potential for fish cultivation in the new reservoir or elsewhere should be realized, including the high initial offtake, but then to decrease harvests as productivity stabilizes. Dam operating rules for optimizing fisheries need to be implemented, and costs internalized. Reduction in all fishing, especially subsistence, in downstream areas must be permanently compensated for.

Biodiversity: Species or genetic diversity should not decline due to the project. Sustainability means the project does not cause the extinction of any species. Moreover, migrations (e.g.: seasonal, anadromy, catadromy, potadromy) should not be so impeded as to harm populations. For example, fish breeding or fish passage facilities should be proven in advance. Will wildlife habitat be lost? Are equivalent (or better) compensatory tracts purchasable nearby? Improvements in net biodiversity are not difficult, and should be sought.

Land Preempted: Agricultural production lost; clarify that the net power benefits clearly exceed the net value of lost agricultural production; equivalent areas need to be made available for oustees.

Water Quality: Can acceptable water quality be maintained? Ensure that the reservoir does not impair quality. It does not mean cleaning up dirty water filling the reservoir (e.g.: Zimapan fills from Mexico city's effluent). Can water weeds, decaying vegetation etc. be controlled so that water of acceptable quality will occur downstream? Phosphorus is important, as is organic mercury releases from rotting biomass. Mercury contamination in reservoirs is a relatively recently discovered impact. Mercury seems to arise from its use in recovering gold in the Amazon, from coal-fired thermal generating plants, and traffic in OECD and elsewhere, but is in some soils without such sources. It is accumulated in the organic (methyl mercury) form from sediment, especially in anoxic humus and peats, through algae and insects to fish. Poisonous MeHg accumulates up the food chain to such an extent that carnivorous fish consumption can harm vulnerable humans, such as children and pregnants. The US FDA limit of 1.0 mug/g wet wt is commonly exceeded.

Downstream Hydrology: Harm must be prevented to downstream uses by people (e.g.: irrigation, soil fertility restoration, recession agriculture, washing, cattle watering) and ecosystems (e.g., mangroves, deltaic fish, wetlands, floodplains). The benefits of water regulation downstream: flood control, urban and industrial water supply, multiple use, can be substantial. Temperature control of releases needs to be controlled.

Regional Integration and Esthetics: The project is more sustainable if well integrated into the activities and future of the region; cultural property lost and aesthetics marred

Greenhouse Gas Production: Total Greenhouse gas (from biomass, cement, steel etc.) should not exceed a gas-fired equivalent. Rotting biomass remaining in the reservoir after filling produces estimable amounts of CO_2 and CH_4.

Institutional Capacity Strengthening: Achieving sustainability needs more trained people dedicated to implementing the above priorities. All dams seeking sustainability should invest substantially in capacity strengthening.

Opponents of big dams have been so successful in pointing out inadequacies that hydro development is slowing and coal is burgeoning -- precisely the retrogressive course. Hydro proponents have not been totally successful in persuading opponents that the benefits of big dams clearly outweigh the costs. Hence the controversy over many water development projects.

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