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## **Viewpoint – Brazil's Madeira River Dams: A Setback for Environmental Policy in Amazonian Development**

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**ABSTRACT:** Decisions on hydroelectric dam construction will be critical in shaping the future of Amazonia, where planned dams would convert most tributaries into chains of reservoirs. The Santo Antônio and Jirau dams, now nearing completion on the Madeira River, have created dangerous precedents in a trend towards weakening environmental protection in Brazil. Political appointees have overruled the technical staff of the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA), which is responsible for evaluating the environmental impact study (EIA) and for licensing dams. Installation licences were granted without satisfying many of the 'conditions' that had been established as prerequisites. This feature and several others of the licensing process for the Madeira River dams have now been repeated in licensing the controversial Belo Monte Dam on the Xingu River. Brazil plans to build 30 large dams in its Amazon region in a decade, and others are to be financed and built by Brazil in Peru, Bolivia, Ecuador and Guyana. These plans affect virtually all water resources in an area larger than Western Europe. The Madeira River dams indicate the need to reform the decision-making process in Brazil.

**KEYWORDS:** Hydropower, hydroelectric dams, environmental impact, energy policy, Amazonia

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### **INTRODUCTION**

Brazil's energy-expansion plan for 2011-2020 calls for 30 additional large dams in the Legal Amazon region, or one new dam every four months (Brazil, MME, 2011: 285). The 2010 Brazil-Peru accord calls for five dams in Peruvian Amazonia to be financed by Brazil's National Bank for Economic and Social Development (BNDES), largely for export of electricity to Brazil (see Finer and Jenkins, 2012). BNDES funding is also planned for many additional dams in Peru, Bolivia, Ecuador and Guyana (Fearnside, 2014). These plans have the potential to affect aquatic ecosystems in virtually all of the river basins in Amazonia. They also affect road infrastructure, population movements and deforestation throughout the region, which is larger than Western Europe. Brazil's Court of Electoral Accounts (TCE) has released data indicating that in the 2002-2012 period the four largest contributors to political campaigns were construction firms that build infrastructure such as dams (Gama, 2013). The political and financial force behind this development can affect environmental policies.

Much has changed in Brazil's decision making in the years since 1986 when major infrastructure projects such as highways and dams were first required to have an Environmental Impact Study (EIA) and a Report of Impacts on the Environment (RIMA), which are jointly known as the EIA/RIMA. The decision-making system is a key factor determining environmental problems and their management throughout the world, and the impact of the decisions made is especially great where ecosystems are still relatively unaffected by 'development', as in Brazil's Amazon region. Tropical dams throughout the world are known for their particularly severe impacts (WCD, 2000; Moore et al., 2010).

The EIA/RIMA is seen by development project proponents as an impediment to implementing needed public works, pitting the proponents against the Ministry of the Environment (MMA), which is

legally responsible for supervising and approving the reports. Pressures within the government are commonplace for abbreviating the reporting process and for approval of projects despite either inadequate reports or disproportionately large impacts, or both (e.g. O Globo, 2007).

Environmental licensing for dams in Brazil proceeds through a series of stages (World Bank, 2008). First an inventory study is prepared for the river basin. Then a viability study is prepared for each dam, followed by the EIA/RIMA. Once the initial EIA/RIMA documents are approved, public hearings are held in the affected areas, modifications are made in the documents, and the final EIA/RIMA is approved. Then a preliminary licence must be granted before the contracts are let out for bidding by construction firms. An installation licence must then be obtained before construction work can begin, and an operating licence must be obtained before a dam can generate power. In practice, as the project advances through these stages and large amounts of money (and political capital) are invested in the scheme, it becomes increasingly improbable that any major changes would be made, especially a 'no-project' option. In fact, a 1992 law allows judges to overrule any restraining orders (such as those based on violations of the environmental licensing regulations) if halting a project would cause "grave damage to the public economy" (Law No. 8437 of 30 June 1992). This law has been repeatedly used to justify ignoring objections to dams regardless of the impacts and the documentation of irregularities (e.g. Fearnside and Barbosa, 1996).

The Madeira River (Figure 1) is the site of two dams that are currently under construction and that have resulted in intense controversy in Brazil regarding the EIA/RIMA: Santo Antônio with 3150 MW of installed capacity, and Jirau with 3750 MW. In 2005 the EIA/RIMA reports were submitted to the Brazilian Institute for Environment and Renewable Natural Resources (IBAMA), the agency under the Ministry of the Environment responsible for licensing (FURNAS et al., 2005a,b).<sup>1</sup> In 2006, nationalisation of Brazilian gas operations in Bolivia by President Evo Morales, combined with cutbacks in gas deliveries from Bolivia, led to heightened pressure on the Ministry of the Environment to approve the Madeira dams, regardless of unresolved problems.

The purpose of this paper is to extract lessons for the decision-making process that can be applied to strengthening environmental decision making throughout Brazil.

### PLANS FOR THE MADEIRA RIVER DAMS

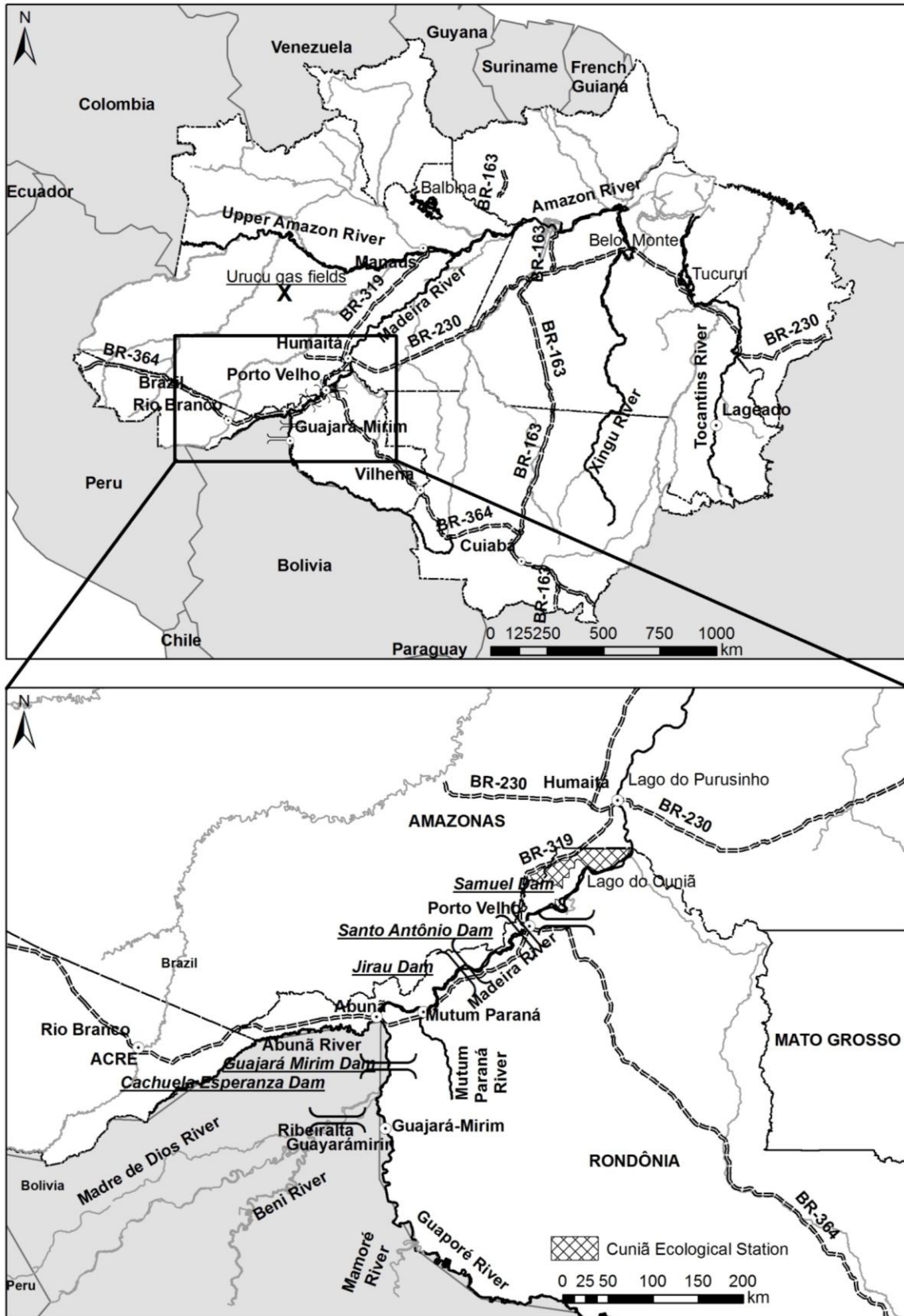
The plans for dams on the Madeira River have evolved over time and have undergone sharp changes in their priority. In Brazil's '2010 Plan', released in 1987, a single large dam was indicated in the 254-km stretch of river now occupied by the Santo Antônio and Jirau reservoirs (Brazil, ELETROBRÁS, 1987; see Fearnside, 1995). The original mega dam was divided into two in order to reduce the area to be flooded and, especially, to avoid the diplomatic complications of flooding in Bolivia. However, the question of impacts on Bolivia is still an important part of the debate on the dams.

The Santo Antônio Dam is located just above Porto Velho (capital of the state of Rondônia) on the outskirts of the city, while the Jirau Dam is 117 km further upstream, approximately midway between Porto Velho and Abunã, a town at the border between Brazil and Bolivia (see Figure 1). Advantages of the dams include their small reservoir size as compared to the installed capacity: Santo Antônio Reservoir would have  $0.11 \text{ km}^2 \text{ MW}^{-1}$  and Jirau  $0.10 \text{ km}^2 \text{ MW}^{-1}$ . These values compare very well with those for 'traditional' Amazonian dams such as Balbina, Samuel, Curuá-Una and Tucuruí. The Belo

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<sup>1</sup> The EIA/RIMA viability study and other government and technical documents cited in this paper are available at [http://philip.inpa.gov.br/publ\\_livres/Dossie/Mad/BARRAGENS%20DO%20RIO%20MADEIRA.htm](http://philip.inpa.gov.br/publ_livres/Dossie/Mad/BARRAGENS%20DO%20RIO%20MADEIRA.htm)

Figure 1. Locations mentioned in the text.



Monte Dam, now under construction on the Xingu River, is also a run-of-river dam with a small reservoir relative to installed capacity, but a favourable ratio of area to capacity there depends on the fiction that only one dam would be built (Fearnside, 1996, 2006a). Unlike Belo Monte, in the case of the Santo Antônio and Jirau dams no upstream storage of water in additional dams is needed to justify the planned installed capacity. The very high streamflow of the Madeira River, combined with the small volumes of the proposed reservoirs, results in unusually fast turnover time, implying better water quality than in existing Amazonian reservoirs. These positive features have been frequently presented as though they mean that the impact of the dams would be minimal. Unfortunately, the dams have major environmental impacts.

The Madeira River dams have bulb turbines, which can be operated without the large head of traditional high dams using Kaplan or Francis turbines. The run-of-river technology with bulb turbines represents an improvement, but it is hardly the benign, almost impact-free, technology suggested by project proponents. Documents and presentations on the dams have widely used a photograph of a power plant on Europe's Danube River with no perceptible reservoir or river fall (e.g. ARCADIS Tetraplan et al., 2005: 116; PCE et al., 2005, Vol. 2: II-84). This is misleading, as the 55-m high wall erected at Santo Antônio and the 65-m structure at Jirau are similar in height to other dams in the Amazon region.

The EIA/RIMA and viability studies for Santo Antônio and Jirau were done simultaneously, with both being completed in 2005 as joint documents for the two dams. The logical sequence of events would require the viability study to be completed before the environmental studies because one must know the technical characteristics of a proposed dam in order to properly evaluate the impacts that it will have. An important change in the plans over the course of the studies was the decision in 2004 that the Jirau Reservoir would be operated with a variable water level averaging 88 m above mean sea level (msl) but ranging from 82.5 to 90.4 m. This was in order to avoid flooding in Bolivia but, as will be explained later, this change does not guarantee that flooding will not occur in that neighbouring country.

Adhering to the variable water level plan in Jirau increases the cost of generation by 12%, which would represent a significant amount in the company's balance sheets. The cost of generation would increase from US\$22.76/MWh at the constant water level of 90 m above msl to US\$25.50/MWh with the variable water level (PCE et al., 2004: Tomo 1, Vol. 1: 1.1). Therefore, the temptation to raise the water level will be a constant presence. In addition, the variable water-level plan only prevents the reservoir itself from entering Bolivia, not the backwater stretch (a backwater is the raising of the water level in the section of the river above a reservoir because of the accumulation of sediments). In 2007, the IBAMA technical staff posed a series of questions to the proponents (Brazil, IBAMA, 2007a,b,c), and in their reply the proponents stated that water levels in the Jirau Reservoir would be managed such that not only the reservoir proper but also the backwater would be prevented from entering Bolivia (FURNAS and CNO, 2007). However, the presumption appears to be that there simply will be no backwater stretch, meaning that there would be no accumulation of sediments at the upper end of the Jirau Reservoir that would raise water levels upstream of the reservoir proper. No information is given on how much further the water level would have to be lowered to avoid effects from a backwater stretch, or by how much this would further reduce revenue. In addition to the history of similar actions on reservoir water levels not conforming to announced promises (Fearnside, 2006a), factors suggesting that the reservoir water levels might not be lowered as much as this statement implies include the possibility that permission could be obtained from Bolivia to allow flooding land in that country (e.g. Época, 2008).

## SUMMARY OF IMPACTS

The Madeira River dams are expected to have severe environmental and social impacts, not only in Brazil but also in Bolivia and Peru (e.g. Switkes, 2008; Fearnside, 2013a). Impacts in Bolivia include flooding due to the Jirau Reservoir's backwater stretch where sediments that accumulate at the upper end of the reservoir raise water levels in the river stretch immediately upstream of the reservoir proper (Fearnside, 2006b). Both aquatic and terrestrial ecosystems are eliminated in the area flooded by the reservoirs. Human populations living along the river are also displaced, with social impacts that are already obvious. A particularly severe social impact is the blockage of migration of the 'giant catfish' of the Madeira River, especially *Brachyplatystoma rouxeauxii* and *B. vaillantii* that sustain fisherfolk in Bolivia and Peru as well as in Brazil (Barthem and Goulding, 1997; Fearnside, 2009). Fisheries will also be affected by alteration of peak floods that supply nutrients to flood plain lakes downstream of the dams. The gold-mining boom in the 1980s left many tons of mercury deposited in sediments; with the advent of the dams, the sediments in the tributaries are expected to become anoxic, causing mercury in these sediments to be transformed into the highly toxic methyl form (Forsberg and Kemenes, 2006). Greenhouse-gas emissions, while lower than in traditional storage reservoirs, are not zero: high methane flux has already been measured from the water surface in the tributaries at Santo Antônio (Hällqvist, 2012: 25), and high methane concentration in the water has been found downstream of the Santo Antônio Dam (Grandin, 2012). Carbon credit under the Clean Development Mechanism was approved for Jirau on 17 May 2013 and for Santo Antonio on 26 November 2013. Because these dams would have been built anyway, this further increases impact on global warming by permitting emissions in the countries that buy the credit (Fearnside, 2013b). Deforestation has been stimulated by populations displaced by the dams and by migrants attracted to the area (Escada et al., 2013). The dams are an essential part of a planned expansion of waterways or *hidrovias* to transport soybean from rainforest areas that would become economically attractive for this crop, including areas to be opened by over 4000 km of waterways in Bolivia (e.g. Vera-Díaz et al., 2007). Although the inventory of the Madeira River that proposed these dams highlights the financial returns from this soy expansion as a benefit of the dams (PCE et al., 2002: 6.22), the inventory, the viability study and the EIA do not consider the implied increase in deforestation to be an impact of the dams (PCE et al., 2004; FURNAS et al., 2005b). The dams also require building a 2450-km transmission line. In a review of the legal aspects of licensing the Madeira dams, Sotelino (2013: 62) points out the requirement of avoiding 'segmenting' the interdependent parts of large projects for licensing purposes; he concludes that "[h]ow exactly Odebrecht and Furnas managed to avoid the requirement for an EIA with regard to the transmission lines remains a mystery".

## BENEFITS OF THE MADEIRA DAMS

The Madeira dams would supply power to Rondônia and Acre. These two states constituted an 'isolated system' that received power from diesel generation (in addition to the Samuel Dam). The diesel generation in these two states represented 23% of the Account for Fuel Consumption (CCC), which was a subsidy for fossil-fuel purchase by isolated systems that was paid for by rate surcharges throughout Brazil (Brazil, ELETROBRÁS, 2006). It should be remembered that the plan at the time that the licensing of the Madeira dams was underway called for linking Rondônia with the national grid well before the Madeira dams were to come on line, thereby ending the area's status as an 'isolated system'. However, delays in building the transmission line resulted in some generation of power beginning before its completion.

Another benefit listed (Brazil, ELETROBRÁS, 2006) was to remove the city of Manaus from the CCC; Manaus represented 44% of the CCC. Obtaining this benefit from the Madeira dams implies building a transmission line from Porto Velho to Manaus (850 km). However, Manaus now has power from natural gas piped from the Urucu gas fields and a transmission line from the Tucuruí Dam, both completed in

2013. On 26 July 2012, the Minister of Mines and Energy announced that the CCC would be eliminated in all of Brazil, thus removing at the stroke of a pen this argument for the transmission lines and dams now under construction that had, in part, been justified by their role in reducing the CCC. The transmission line from the Madeira dams to Manaus was not included in either the viability studies or the EIA/RIMA for the Madeira dams. It should be remembered that the BR-319 Highway that once linked Manaus to Porto Velho has been impassable since 1988. A proposed reconstruction of this highway has not yet had an EIA/RIMA approved, although the process, now in its third revision, continues to proceed. Reopening the highway would cause severe impacts on deforestation in central and northern Amazonia (Fearnside and Graça, 2006). Assuming that the highway will not be reopened in the coming years due to these concerns, a transmission line that would be presumably built along the highway route implies stimulating the highway reconstruction and contributing to the associated impacts.

More controversial is the fate of power to be transmitted to the national grid in south-central Brazil. In addition to use by residential consumers and by the full range of commercial and manufacturing users, it also supplies an expanding sector of 'energy-intensive' industries, including aluminium smelting. In 2008, Brazil exported 7.8% of its electricity in the form of electro-intensive commodities, and the percentage is increasing (Bermann, 2012).

### ENVIRONMENTAL LICENSING

The licensing process for the Madeira River dams provides an illustration of the susceptibility of the system to political pressure and establishes precedents that weaken safeguards for future dams. Some of these are already evident in the licensing of the controversial Belo Monte Dam on the Xingu River (Fearnside, 2012).

The Public Ministry in Porto Velho undertook a separate review of the EIA/RIMA for the Madeira River dams, together with the supplementary questions and responses (COBRAPE, 2006). The Public Ministry, which was created by Brazil's 1988 Constitution as an agency under the Ministry of Justice, is less subject to political pressures than are agencies such as IBAMA. The Public Ministry has had an important role in the licensing process for Amazonian projects since the 1988 Constitution (see Eve et al., 2000). Under increasing pressure, IBAMA approved the EIA/RIMA for the Madeira dams in September 2006, allowing public hearings to be held (International Rivers, 2012).

In January 2007, President Luiz Inácio Lula da Silva (known as President 'Lula') announced the Program for the Acceleration of Growth (PAC), which consisted of a list of major infrastructure projects, the Madeira dams being the highest of these high priorities (Kepp, 2007). During 2007, several non-infrastructure projects related to health and education were added to the PAC, but the environment has been notably missing from the planned activities. More importantly, efforts to abbreviate the environmental review process have been a major part of the push to build the infrastructure projects, especially the Madeira dams (e.g. Switkes, 2008).

On 21 March 2007, as part of the process to grant the preliminary licence, the technical staff in IBAMA's licensing department submitted a 221-page technical opinion opposing approval of the preliminary licence (Deberdt et al., 2007). The document was only made public on 23 April, after the Minister of the Environment had already caved in to presidential pressure to force approval of the dams (Peixoto, 2007; Switkes, 2008). Many of the points raised had been derived from the independent assessment commissioned by the Public Ministry in Rondônia (COBRAPE, 2006). The head of the licensing department was immediately replaced, reportedly as a signal of the government's displeasure with the position of the technical staff (Faleiros, 2007). Even though his dispatch had "declined to accept" the list of questions, he had called for further studies rather than immediately authorising the granting of the preliminary licence (Kunz Júnior, 2007). The technical opinion by the staff of the licensing department had requested that a new EIA/RIMA be done. The staff then submitted a series of



40 questions to be answered by the proponents (Brazil, IBAMA, 2007a,b,c). An editorial in the *Estado de São Paulo* newspaper labelled the IBAMA staff as engaging in "childish pranks" (*molecagem*) in handling such an important project by asking questions that "clearly showed that they intended to reject the license" (OESP, 2007).

The Ministry of Mines and Energy (MME) contracted consultants to contribute opinions on key areas of the questioning: sediments, mercury and fish; 'technical notes' by the consultants were delivered to IBAMA on 24 April 2007 (most are reproduced in FURNAS and CNO, 2007). The proponent companies delivered a 316-page response to the IBAMA questions on 11 April 2007 (FURNAS and CNO, 2007). In most cases, the replies either refused to answer on the grounds that IBAMA was asking for information beyond those corresponding to normal procedures, or replied to the effect that IBAMA concerns were unfounded. Much of the lengthy reply consisted of copying sections of the EIA/RIMA (compare PCE et al., 2005; FURNAS and CNO, 2007) and sometimes adding corroboration from the hired consultants (e.g. FURNAS and CNO, 2007: Annexes I-V). Most significant, however, are several changes in the plans that were quietly made, thereby allowing some of the questions to be answered to the effect that no problem existed. Most important were changes to 1) adopt a 'guide curve' strategy for managing the water level in the Jirau Reservoir that would supposedly avoid a backwater formation that would cause floods in Bolivia (FURNAS and CNO, 2007: Estudos Sedimentológicos, p. 6.32), and 2) removing the remains of the coffer dams that had previously been planned to be left in place as sediment-retention walls (coffer dams are temporary dikes used to keep the river from entering the construction site)(FURNAS and CNO, 2007). The official scenario in which all sediments will be naturally flushed from the reservoirs has been strongly contested (Fearnside, 2013c).

The licensing case for the Madeira dams triggered the dividing of IBAMA into two agencies, paralysing much of its activity. Immediately after a meeting during which President Lula pressured Minister of the Environment Marina Silva to accelerate approval of the dam, the minister announced that IBAMA would be split into two agencies, the Chico Mendes Institute for Biodiversity (ICMBio), which would handle protected areas, and IBAMA, which would handle the remainder of the old IBAMA's functions, including licensing infrastructure projects. The split was allegedly part of an agreement with President Lula to accelerate the approval of the Madeira dams (e.g. Alencar, 2007; Domingos, 2007; Switkes, 2007). On 30 April, the head of IBAMA's licensing department was changed again. Beginning on 14 May a large part of the IBAMA staff throughout the country went on strike in an attempt to block the split. The splitting of IBAMA was approved by the National Congress and on 28 August 2007 it was signed into law; the strike ended shortly thereafter. Although the Madeira dams apparently triggered the splitting of IBAMA, this is something that had been under consideration for a long time as a means of reorganising the Ministry of the Environment such that the Minister would have more power over the functions of the agency. IBAMA had a much larger budget than the remainder of MMA, and in many ways it had more real power than the ministry itself. Splitting the agency has the effect of restoring the balance between the tail and the dog. However, the way that the split was forced upon the agency as a means of approving the Madeira dams had grave consequences in demoralising the agency's technical staff.

The approval of the Madeira River dams involved an extraordinary series of behind the scenes changes of personnel in the regulatory agencies, removing any individuals in positions of authority who questioned the project or offered support to those who did. The 'president' of IBAMA was removed and the Minister of the Environment's former chief-of-staff was appointed as interim 'president' on 3 May 2007. Dam critics claim the change was made to 'guarantee' approval of the preliminary licence (Switkes, 2008). However, when he later announced the approval of the licence, he denied that he had been coerced by any political pressure (Craide, 2007).

The head of IBAMA's licensing department was changed again just before the preliminary licence was approved on 9 July 2007, and the same person was subsequently promoted to head IBAMA as a whole prior to approval of the installation licence on 13 August 2008 (see International Rivers, 2012).

Five days earlier the technical staff had submitted a formal opinion opposing approval of the installation licence due to the 33 conditions associated with the preliminary licence not having been met (Brazil, IBAMA, 2008). The pattern of replacing the head of IBAMA with a person willing to override the agency's technical staff was repeated soon after in licensing the controversial Belo Monte Dam (Fearnside, 2012). Since this pattern is capable of securing approval of any project regardless of impacts, it has severe implications for the many dams that have been announced for construction over the coming decade in Brazilian Amazonia.

The present paradigm for infrastructure decisions is still one based on political fiat, where the environmental reports that are prepared thereafter merely serve to legalise a decision that has already been made (e.g. Fearnside and Laurance, 2012). The case of the Madeira River dams provides a concrete example. Major development projects, such as hydroelectric dams, invariably have large impacts and usually (but not always) large benefits. Rational decisions require that the costs and benefits of all options be fairly and thoroughly assessed and compared before a decision is made. This must include environmental and social as well as financial considerations. Decision-making practices are evolving towards this ideal, but have a very long way to go before such a basic logical sequence becomes the norm in practice. The test of the system comes when the stakes are high, as in the case of the Madeira River dams. Although a mere tributary to the Amazon, the Madeira is one of the world's largest rivers. The average streamflow at the Jirau Dam site (17,686 m<sup>3</sup>/s) is 24% greater than that of the Yangtze River at the Three Gorges Dam in China, which has the world's largest installed capacity. The two dams under construction on the Madeira River (Santo Antônio and Jirau) will have a combined installed capacity of 6900 MW, while a third dam (Guajará-Mirim, also known as Cachoeira Riberão) would add another 3000 MW, and a fourth dam, Cachuela Esperanza, on the Beni River (a tributary of the Madeira in Bolivia) would add 600 MW (and possibly as much as 800 MW; HRW, 2008), mostly for export to Brazil by the Brazilian companies that expect to build the dam with financing from Brazil's National Bank for Economic and Social Development (BNDES).

### ENERGY POLICY AND DEVELOPMENT DECISIONS

The spectre of a large-scale blackout (*apagão*) has been constantly raised as the justification for the extraordinary priority attached to the Madeira dams. However, Brazil has many options other than dams, fossil fuels and nuclear power (e.g. Moreira, 2012). Options include both ways of using less electricity and ways to generate power from alternative sources such as wind and the sun.

The Brazilian government plans expect a 5% growth in gross domestic product (GDP) to be sustained over at least a decade (Brazil, ELETROBRÁS, 2006). This is far greater than the current growth rate: Brazil's GDP increased at annual rates of around 3.3% for most of the past decade – a rate viewed as insufficient by the government. The assumption that GDP growth can be sustained at 5% per annum includes the assumption that Brazil will continue to export ever-greater quantities of electricity-intensive products, such as aluminium, and that high levels of inefficiency and waste will continue. Growing at 5% per year may be possible for a few years, but when extrapolated for a decade or more, the implication of astronomical demand for electricity is a simple consequence of the mathematics of exponential growth. Limits are bound to be encountered, such as the social and environmental impacts of damming virtually all of the rivers in Amazonia. It would be better to face these limits before they are reached.

The use to be made of the power has not been the subject of open debate in Brazil. Aluminium smelting for export is one of the most extreme cases, providing only 2.7 jobs per GWh of electricity consumed (Bermann and Martins, 2000). Aluminium ingots essentially represent electricity in a form that can be loaded on a ship and taken away. Aluminium factories such as those in Barcarena, Pará, have direct transmission lines to Tucuruí and to the future Belo Monte Dam (Fearnside, 1999, 2001, 2006a). The Interconnected National System (SIN) to which these dams and the Madeira dams

contribute supply power to smelters in Sorocaba (São Paulo), Volta Redonda (Rio de Janeiro) and elsewhere.

An emblematic example of opportunities to reduce electricity consumption is the electric showers used for bathing in Brazil. These are an extremely inefficient way of heating water, since the second law of thermodynamics results in energy being lost at each transformation between, for example, Bolivian gas and a showerhead in São Paulo. According to Brazil's National Plan for Climate Change, electric showers consume 5% of all of the electricity in the country (Brazil, CIMC, 2008: 58). This is much more than what the Madeira dams will produce. Water for showers can be heated with solar water heaters with no need for electricity.

Decision making is done in an information vacuum with respect to social and environmental impacts. The dams are announced in development plans long before impact studies are initiated, let alone completed. Rather than contributing to making a wise initial decision, the most that subsequent studies contribute are suggestions for minimising impacts. The environmental studies themselves give little idea of the true impact of the dams due to inherent bias in the reporting system. The firms that pay for the impact studies are the same as those that expect to subsequently win the contracts for constructing the dams. This creates a built-in conflict of interest, where emphasis of positive features and minimization of negative ones can be expected. This has been a perennial problem since the beginning of the EIA/RIMA in Brazil in 1986, and still awaits solution.

One of the ironies of the licensing system is that the content of the impact studies and required hearings has very little effect on decisions regarding licensing the projects. At the end, those writing the reports and speaking at the hearings can say anything they like and the infrastructure projects go ahead just the same. The only fact that matters is that the various steps in the process have been carried out, such as submission of the EIA/RIMA, response to queries from IBAMA, and hearings with affected populations. The content is secondary.

That political decisions can effectively override virtually any environmental or social concern will hardly be news to those familiar with development in the Amazon. Brazil needs a functioning environmental decision-making system that is capable of analysing and fairly judging the wide range of impacts and benefits associated with such projects. The system must deliver decisions that are neither hurried to skip needed stages nor paralysed to the point where no infrastructure can be built no matter how great the benefits are relative to the impacts.

Projects vary widely in their impacts and benefits. One extreme occurs when impacts (without omissions) are huge and benefits (deflated for exaggerations) are minimal. Examples include the Balbina Dam and the BR-319 Highway (Fearnside, 1989; Fearnside and Graça, 2006). Others have real benefits in addition to substantial impacts, such as the Tucuruí Dam and the BR-163 Highway (Fearnside, 1999, 2001, 2007). Issues raised by these cases vary considerably, but one common feature is the separation of the actual decision on project construction from the formal process of evaluating environmental impacts and even from evaluating purely financial costs and benefits.

The important question is how the system can be changed. Needed changes include assuring the independence of those who make licensing decisions. The example of the Madeira dams highlights questions of how decisions are made and the relative weight of political versus technical considerations.

## CONCLUSIONS

The environmental and social impacts of hydroelectric dams on the Madeira River are substantial, including population displacement, deforestation, loss of livelihoods from fisheries in Brazil, Bolivia and Peru, flooding a backwater stretch in Bolivia in addition to the flooding from the reservoir proper in

Brazil, greenhouse gas emissions, mercury methylation, and downstream impacts on fish reproduction and riverside residents from changes in flood regimes and sediment movements.

The impacts of the Madeira River dams should have been better studied before the decision was made to build the Santo Antônio and Jirau dams. A rational decision on any infrastructure project requires that the impacts and benefits be first evaluated and compared before the decision is made in fact. The paradigm of decisions by fiat must be broken if the history of the Madeira dams is not to be repeated many times over in the coming decades. The approval of the Madeira dams by means of political pressure and replacement of key licensing officials establishes a dangerous precedent. Decisions need to follow a logical sequence of steps. One must weigh all costs and benefits and include alternatives distinct from the immediate proposal, such as energy conservation and changing policies that encourage and subsidise aluminium and other energy-intensive industries. Unfortunately, a public discussion of energy policy has scarcely begun in Brazil.

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