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THE JIRAU DAM'S CDM PROPOSAL: COMMENTS ON THE PROJECT DESIGN DOCUMENT

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THE JIRAU DAM

Two dams, Santo Antônio and Jirau, are nearing completion on the Madeira River, a major Amazon tributary that drains parts of Brazil, Bolivia and Peru. Both dams have applications pending for carbon credit under the Kyoto Protocol's Clean Development Mechanism (CDM). The Jirau Dam, located in Brazil's state of Rondônia near the border with Bolivia, is being built by the French multinational GDF Suez together with Energia Sustentável do Brasil S.A (a consortium with the Suez group made up of Eletrosul, Chesf and Camargo Correa). Commercial energy production is expected to begin in by the end of 2012, with the full 3750 MW of installed capacity coming on line by 2014. The Project Design Document (PDD) for the carbon credit proposal (Energia Sustentável do Brasil S.A. & GDF Suez Energy Latin America Participações Ltda., 2012) is similar to other CDM proposals for dams and serves as a warning both of the defects of this project and of the inadvisability of carbon credit for hydroelectric dams in general.

ENVIRONMENTAL AND SOCIAL IMPACTS

The PDD states that "The Brazilian Energy Research Company (EPE), part of the Ministry of Mines and Energy (MME), …. Considers economic and social as well as environmental aspects … . In this context, EPE also considers Brazil's insertion in international agreements … . This view implies that all external costs and benefits are adequately assessed to identify most beneficial projects and to maximize their socio-economic benefits and minimize their impacts" (p. 5). The irony of this portrayal would be hard to exaggerate, given the enormous accumulation of criticism from civil society of the EPE plans, and of the Madeira River dams in particular, based on their socio-economic and environmental impacts (see for example: Amigos da Terra-Amazônia Brasileira & International Rivers Network, 2006; Monteiro, 2011, 2012; Ortiz *et al*., 2007; Switkes, 2008). A 2010 letter to the president of GDF Suez from 16 environmental groups (Amigos da Terra-Amazônia Brasileira *et al*., 2010) describes multiple deficiencies in dealing with environmental and social impacts at Jirau. These problems led to GDF Suez being elected a 2010 finalist for the "public eye award" that is given annually to the world's most irresponsible company (http://www.publiceye.ch/en/).

The PDD asserts that "… the Jirau HPP [hydropower plant project] is being developed according to the best technical and environmental practices and standards" (p. 5). The local people and the civil society groups mentioned above would contest this claim. As the *Folha de São Paulo* described it, the licensing process was a "collection of errors" (Angelo, 2011). Jirau's environmental impact study (EIA) was done jointly with the neighboring Santo Antônio Dam (FURNAS, CNO & Leme Engenharia, 2005). The preliminary license was only granted after a sudden replacement of the head of the licensing department of the federal environment agency (IBAMA) and later the same person was promoted to head the agency as a whole just before approving the installation license, again overriding the agency's technical staff (see International Rivers, 2012 for names and dates). The demoralization of Brazil's environmental licensing system may prove to be one of the greatest impacts of the Madeira River dams.

All CDM projects must contribute to "sustainable development" (Kyoto Protocol, Article 12, Paragraph 2). Sustainable development is generally considered to have three pillars: social, environmental and economic. The PDD stresses the social benefits of jobs provided by the construction project, pointing out that "more than 70% of workers are hired locally" (p. 6). However, this apparently must mean that workers "hired locally" include migrant laborers who have traveled from other parts of Brazil to the construction site of their own accord before being hired. The social problems caused by massive migration to the construction site and surrounding area would better be described as an impact than as a benefit of the project (e.g., de Almeida, 2009; Instituto Pólis, 2006).

An indication that conditions at the construction site are less than ideal is given by persistent labor unrest at Jirau, including two major incidents of criminal arson (e.g., Romero, 2012). The conditions at the construction site contrast with the PDD's description of the "eco-friendly district" built by the company at Novo Mutum Paraná for the engineers (p. 6). Although labor discontent is a common phenomenon, the uprisings at Jirau stand out among all of the hundreds of construction sites that have been established under the Program for the Acceleration of Growth (PAC), and they have shocked the government.

One of the major impacts not mentioned in the PDD is blockage of fish migration. The only aspect of this mentioned is that the turbines used kill less descending fish larvae than would other types of turbines (p. 5). Readers of the PDD will have no idea of the dam's major expected impact (together with the Santo Antônio Dam) in wiping out the fishery of the giant Madeira River catfish (*Brachyplatatystoma rouxeauxii* and *Brachyplatystoma platynemum*), not only in the Brazilian portion of the Madeira but also in Peru and Bolivia (e.g., Barthem & Goulding, 1997; Fearnside, 2006; 2009a,b). These catfish have, until now, been a major source of income and food for the local people in the Madeira Basin in these three countries, and the dam projects do not even admit, let alone compensate for, the loss of livelihoods.

Flooding in Bolivia is not mentioned as an impact. The PDD states that water levels at Abunã are to "follow their natural seasonal variation" (p. 8), as required by a 2006 decision of Brazil's National Water Agency (ANA) (ANA resolution 555/2006). The claim that no flooding would occur in Bolivia has been contested multiple times (Fearnside, 2006, 2007; Molina Carpio, 2006; Molina Carpio *et al*., 2008). The issue is a delicate one diplomatically because Abunã lies at the upper end of the Jirau reservoir exactly on the border with Bolivia. Sedimentation and consequent raising of water levels in the "backwater stretch" is expected to result in flooding in Bolivian territory both along the Madeira River and the Abunã River (a tributary of the Madeira that also forms part of the Brazil-Bolivia border). Impacts of flooding would include effects on a protected area on the Bolivian side of the Madeira above the town of Abunã. Unfortunately, water levels do not respond to government decrees, but rather to physical factors such as the mound of sediment that will form at the upper end of the Jirau reservoir.

The EIA considers the reservoir to be shorter in length at any given water level during the high-water period than during the low-water period (FURNAS, CNO & Leme Engenharia, 2005, Tomo A, p. VII-8). To prevent flooding in Bolivia, the planned operation of the dam in the PDD (p. 9) would keep the water level at the dam at 90 m above sea level for four months (January-April), at 85 m for four months (May, June, November & December), and at 82.5 m for four months (July-October). The calculated effect is only for the length of the reservoir *per se*, not for the backwater stretch. The planned management of the water level will not prevent a mound of sediment from forming at the top of the reservoir and consequent flooding in Bolivia by the water that is held back by this impediment. The Madeira River has one of the highest sediment loads in the world, accounting for about half of all of the sediment in the Amazon River (Meade, 1994).

The water management plan presented in the PDD to avoid flooding in Bolivia (p. 9) has lower water levels in 6 months of the year as compared to the 2005 Environmental Impact Study (EIA) (FURNAS, CNO & Leme Engenharia, 2005, Tomo A, p. VII-13), and there are no months in which the PDD plan calls for higher levels (Table 1). Aside from indicating the inaccuracy of the 2005 claim in the EIA that the plan presented in that document would cause no flooding in Bolivia (FURNAS, CNO & Leme Engenharia, 2005, Tomo A, p. VII-16), the lower levels imply less power generation and an increase in the “additionality” of the carbon claims. More importantly, either one of the operation plans makes clear the very substantial impact on Jirau’s operation from the existence of the international border with Bolivia at the upper end of the reservoir. Operating the reservoir for much of the year at a water level below the “maximum normal” elevation of 90 m implies a substantially lower electricity generation due to the lower head at the dam. This raises the possibility that the company may be expecting that, at some future date, Brazil could reach an agreement with Bolivia to allow the water level to be raised to 90 m (or perhaps even higher) throughout the year. Brazil enjoys considerable leverage in its negotiations with Bolivia over dams, including the terms to be agreed for the planned binational Guajirá-Mirim Dam upstream of Jirau (ARCADIS Tetraplan *et al*., 2005; FURNAS & CNO, 2003). In addition to adding to flooding by the Jirau reservoir, raising the water level beyond that specified in the PDD could make the dam’s carbon credit claims considerably less “additional” than the calculations presented to the CDM imply.

Table 1: Jirau reservoir water management plans

Month	Mean monthly streamflow (m^3/s)	2005 EIA water level (m above msl)	2012 PDD water level (m above msl)	Difference (m)
Jan.	23,900	90	90	0
Feb.	29,100	90	90	0
Mar.	33,600	90	90	0
Apr.	30,200	90	90	0
May	22,700	89.5	85	4.5
Jun.	15,900	87	85	2
Jul.	10,600	85	82.5	2.5
Aug.	6,800	83	82.5	0.5
Sept.	5,600	82.5	82.5	0
Oct.	6.800	83	82.5	0.5
Nov.	10,400	85	85	0
Dec.	10,600	87.5	85	2.5

Various additional impacts of the dam are unmentioned in the PDD, such as mercury methylation in bays along the river edges (Forsberg & Kemenes, 2006) and various social and biodiversity impacts. One unmentioned impact with relevance to greenhouse-gas emissions is the dam's providing a link in a series of planned industrial waterways that would promote the advance of soybeans into rainforest areas in Brazil and especially in Bolivia, thus causing emissions and other impacts from deforestation (Kileen, 2007; Molina Carpio, 2005; Vera-Diaz *et al*., 2007). In addition to future deforestation expected upstream for soy in areas to be served by the waterways, current deforestation rates have skyrocketed in the immediate vicinity of Jirau and the adjacent Santo Antônio Dam: this area was the number-one hotspot of deforestation in Amazonia in December 2010 (Angelo & Magalhães, 2011; Hayashi *et al*., 2011). Ironically, the PDD takes pains to claim that the dam will have no "leakage" causing emissions outside of the project area (p. 59).

GREENHOUSE GAS EMISSIONS

The PDD classifies the dam as only a "minor emissions source" of methane (p. 13), but makes clear that officially the emissions are zero and that no measurements or monitoring are required (p. 58). No technical studies are cited to substantiate the claim that the dam would only be a "minor" source of methane. The claim rests on the loophole in the CDM's regulations classifying dams by power density, or the ratio of installed capacity to reservoir area. Dams with small reservoirs and large installed capacities are allowed to pretend that they have no emissions. In reality, having a small reservoir reduces, but does not eliminate, emissions from the reservoir surface.

The PDD repeatedly cites official documents (e.g., pp. 18-19) referring to hydro as "clean" or as a "non-emitting source" (e.g., Brazil, CIMC, 2008; Brazil, MME, 2011). It should be noted that these documents have been roundly criticized for the assumption that hydroelectricity is clean energy (e.g., Fearnside, 2012a). Although the claim that hydro is clean has been repeated so many times that most people are surprised to learn otherwise, such claims have been scientifically untenable for some decades (see Fearnside, 2011). Multiple studies indicate large emissions in tropical dams (e.g., Abril *et al*., 2005; Fearnside, 2002, 2005a,b; Pueyo & Fearnside, 2012; Kemenes *et al*., 2007, 2011). The high water flow rate through the reservoir at Jirau will result in lower emissions than at other Amazonian dams, but emissions will not be zero.

The question of whether the water in the reservoir will stratify is important to the potential for emissions. The EIA calculates that the water in the reservoir will not be stratified based on the turnover time and on the Froude density equation that relates stratification to water velocity (FURNAS, CNO & Leme Engenharia, 2005, Tomo B, Vol. VII, p. 3.8). The one-dimensional models used in the EIA have been criticized by Forsberg & Kemenes (2006) as inadequate to model stratification in the irregularly-shaped reservoir, and these authors expect stratification along the reservoir's edges. Stratification would occur in the bays and other features where water velocities are much lower than the all-reservoir averages used in the EIA calculations. Stratification with anoxic bottom water can be expected in the flooded mouths of tributaries that enter the reservoir (B.R. Forsberg, pers. comm., 2012). These anoxic areas can be expected to emit methane through the surface, but, unlike reservoirs with more widespread stratification, most of the portion of the dissolved methane that these edge areas produce in their anoxic sediments that does not reach the surface as bubbles will be prevented from reaching the turbines due to the presence of oxygenated water in the main channel where the water is moving faster.

The loophole in the CDM regulations that allows dams with high power densities to claim zero emissions specifies 10 W/m^2 as the limit for this complete exemption (see Fearnside, 2012a). Jirau claims a power density of 18.05 W/m^2, allowing the PDD to conclude that "Therefore, …. project emissions can be neglected" (p. 7). The CDM regulation allows the power density to be calculated not in the normal way as a simple ratio of installed capacity to reservoir area but rather using the "reservoir area increase" as the denominator. This means not counting the natural river bed, which in Amazonian reservoirs is taken to include not only the river channel but also the wide area that is temporarily flooded at the peak of the high-water period. The PDD uses a "reservoir area increase" of 207.74 km^2 (p. 8), rather than the full reservoir area of 361.60 km^2 (p. 9). If the power density were calculated using the full reservoir area and the current configuration of 3750 MW the result would be 10.4 W/m^2, or barely above the 10 W/m^2 cutoff for making use of the loophole for considering the dam's emissions to be zero. If the 3300 MW installed capacity originally planned were used, the power density would have been 9.1 W/m^2, making the project ineligible for claiming zero emissions from the dam. Adding the six extra turbines after the dam location was changed in 2009 gives a double assurance of being able to cash in on the loophole. The CDM regulation's not counting the full reservoir area is apparently based on the mistaken assumption that the water over the natural river bed does not emit methane (see Fearnside, 2012a).

ADDITIONALITY AND CARBON CREDIT

The Kyoto Protocol (Article 12, Paragraph 5) requires that any emissions reductions claimed for CDM credit must be "additional to any that would occur in the absence of the certified project activity", giving rise to the term "additionality" in the jargon for discussing this topic. Establishing additionality requires a hypothetical baseline scenario representing what would have happened without the mitigation project, and demonstrating that the project (in this case construction of the dam) would not have taken place without CDM funding. The simple fact that the Jirau dam is already under construction is solid evidence that it is not additional. However, CDM regulations allow projects to calculate an internal rate of return (IRR) and compare it to a "benchmark" IRR value in order to establish that CDM funds are needed to make the dam profitable. The IRR is meant to represent the highest discount rate at which an investment of capital would be considered profitable. There are many possible adjustments to the values used, with major implications for investment decisions.

One of the questions to be answered by the PDD concerns public funding, which would reduce the cost and investor risk in the project. Under the item "Public funding of project activity" the PDD says simply "There is no public funding from Annex I parties available for the project". However, the question this answers is not restricted to Annex I parties (countries with emissions caps under the Kyoto Protocol). The question regarding public funding is asked because the CDM "additionality tool" requires reporting as revenue "subsidies/fiscal incentives, ODA [overseas development assistance], etc., when applicable" (p. 36). The response in the PDD fails to mention the massive subsidy in public funding that Jirau receives from a non-Annex I party, namely Brazil. Counting these subsidies as revenue would be likely to make the project fall into the "financially attractive" category, making it ineligible for CDM funding.

Project proponents are free to search the literature for an IRR value to use as a "benchmark". Obviously, there is an inherent interest in picking a high value so that the dam project will be classified as unprofitable when compared to the benchmark, thus making it "additional" and eligible for CDM credit. The values appear to be essentially picked out of a hat: the Jirau CDM project uses a benchmark IRR of 15.67% (p. 35), while the CDM projects for the Teles Pires and Santo Antônio Dams, which were prepared by a different consulting firm, used 10.35% as the benchmark, this being calculated by applying the Weighted Average Cost of Capital (WACC) for the power generation sector in Brazil in 2007 (Ecopart, 2011; Santo Antônio Energia S.A., 2012). The 15.67% benchmark for Jirau is calculated in the PDD based on various correction factors (p. 35). The principal justification given for this benchmark is not the rationale behind the long list of corrections applied but rather citation of confirmation from an almost identical value in a report by the World Bank (2008) that refers to Brazil's National Agency for Electrical Energy (ANEEL) as having said [without referencing any document] that "investors are prepared to invest in electricity generation only when rates of return are approximately 15%" (p. 34). This figure is repeatedly referred to as a World Bank estimate, and the "prestige and experience" of the Bank are extolled to bolster its credibility (p. 34). Nevertheless, the origin of the number is an unreferenced statement by someone from ANEEL.

The basic fact remains that the dam is under construction. The firms would not abandon the project in the absence of CDM funds. Even straining to make the dam look unprofitable, the PDD calculates an IRR of 9.7% after taxes and in real terms (i.e., after discounting inflation) under the project's actual loan terms from BNDES (i.e., not under a hypothetical scenario), and without CDM credit (p. 53). This is not a bad deal as compared to most investments and is almost as high as the 10.35% IRR benchmark that was used for the neighboring Santo Antônio Dam's CDM proposal (Santo Antônio Energia S.A., 2012), despite all of the ways that this benchmark was inflated (see International Rivers, 2012; Fearnside, 2012b). While an IRR of 9.7% was calculated for the case without CDM credit, the case with credit would raise the return to 16.7%/year (p. 53). The difference would represent a huge windfall profit for GDF Suez and could hardly be considered a wise use of mitigation funds.

The PDD states that "the electricity displacement will occur at the system's margin, i.e., mainly fossil fuelled thermal plant generation will be substituted" (p. 15). What, one might ask, is the place of the dozens of other dams that Brazil plans to build over the next decade? The "margin" appears to have shifted to hydro, so that one dam is really displacing another rather than "primarily" fossil fuel. Of course Brazil's future priorities regarding its energy matrix could be different than they are today: this dam could just as well be displacing a future energy-efficiency program or a wind, solar or tidal energy source instead, in which case the justification for claiming carbon credit for Jirau would evaporate even if the dam really were additional.

CDM regulations permit using an IRR benchmark calculated from a scenario without government subsidies or other favorable regulations that are designed to reduce emissions. The question of whether the subsidies the dam receives are motivated by climate concerns is therefore critical. Hydro receives favorable financing terms from BNDES, including both lower interest rates (partly from a 2007 change in BNDES policy to offer large hydro projects rates calculated from a "basic spread" of only 0.5%, versus 1.8% for fossil fuels: p. 47) and a provision in effect since 2006 for a 20-year amortization period, as compared to 14 years for gas-fired power plants (p. 48). It is ironic that the 0.5% "basic spread" value charged to large hydro is much lower than the 0.9% charged to wind power (p. 47), raising doubt as to whether the generous concession to hydro is really motivated by climate-mitigation concerns.

Brazil's offering of more favorable loan terms from its National Bank for Economic and Social Development (BNDES) to hydro as opposed to gas-fueled power plants (pp. 45-47) is not motivated by concern for global warming alone. In 2006 the Evo Morales government took over Petrobrás facilities in Bolivia and sent shock waves through the Brazilian government (*Folha de São Paulo*, 2006). Brazil imported 50% of its gas from Bolivia in 2006, a percentage the country has now managed to reduce to 36% (Ordoñez, 2012). The Bolivian crisis motivated Brazil to institute a strong program to promote domestic energy production through hydro development for a reason that is independent of any alleged benefit of hydropower for climate change. Of course additional factors could also be favoring dam projects since the construction industry represents one of the largest sources of contributions to political campaigns (Scofield Jr., 2011). Brazil is currently engaged in a massive effort to build dams, with an average of one large dam to be completed in the country's Legal Amazon region every four months for the next decade (Brazil, MME, 2011, p. 285). The portrayal of the government's subsidy for this as a selfless contribution to global efforts to combat climate change stretches the limits of credibility. In other words, the applicability of the CDM regulation allowing a benchmark IRR value to be used based on a hypothetical scenario without the subsidies from "E-policies" is open to question.

After the various adjustments to represent the hypothetical scenario without government "E-policy" subsidies, the PDD arrived at an equity internal rate of return of 6.8% for the project in the "base case"[i.e., in the configuration announced at the time of the bidding] and 7.5% in the "optimized" configuration [i.e., with more turbines and at a more favorable location subsequently approved]; both are only about half the value of the

15.7% IRR benchmark in real terms, post-tax (p. 35), which is inflated by various correction factors to compensate for alleged risks (p. 35).

I repeat: the dam is under construction. This is the physical manifestation of the basic fact that the dam would be built anyway and is not "additional". The arguments over IRRs to justify the opposite conclusion are a mere smokescreen, whether or not these arguments are judged to conform to CDM rules. The CDM rules themselves are in urgent need of reform.

HOT AIR AND CLIMATE CHANGE

The amount of "hot air" (carbon credit granted without a real climate benefit) to be generated by the project is staggering. As an annual average, emissions reductions claimed are 6,180,620 t CO_2e/year, equivalent to 1.69 million t C/year. Over the seven-year project they will total 43.3 million tons of CO_2e or11.8 million tons of carbon, which is approximately the annual emission of the city of São Paulo. This amount of carbon will be emitted somewhere else in the world in the countries that purchase the certified emissions reductions (CERs). Since the dam would have been built anyway, no real mitigation takes place to offset the emissions authorized by the credits.

CER revenues are expected to average R$250 million per year (at the exchange rate on the project start date: 22 July 2008), or US$158 million per year (p. 52). Over 7 years US$ 1.11 billion will be siphoned off from real mitigation. When the world becomes serious about containing global warming the measures needed will be very expensive, and we cannot afford to waste money intended for this purpose.

The initial paragraphs of the PDD describe GDF Suez as dedicated to "responsible growth" and "respecting the environment" (p. 3). Unfortunately, in addition to the many other impacts of the dam, the Jirau CDM project would represent a blow to global efforts to contain climate change. The contrast between these impacts and the platitudinous "greenwashing" of company statements dramatizes the need for basic reorientation, not only of the companies but also of the Brazilian designated national authority (DNA) for the Clean Development Mechanism, the CDM executive board, and the United Nations Framework Convention on Climate Change as a whole. Unfortunately, the problems of the Jirau CDM proposal are, in essence, common to vast numbers of other carbon proposals for dams. The take-home lesson is that funds for mitigating global warming should be used for other types of projects – not dams.

LITERATURE CITED

Abril, G., F. Guérin, S. Richard, R. Delmas, C. Galy-Lacaux, P. Gosse, A. Tremblay, L. Varfalvy, M.A. dos Santos & B. Matvienko. 2005. Carbon dioxide and methane emissions and the carbon budget of a 10-years old tropical reservoir (Petit-Saut, French Guiana). *Global Biogeochemical Cycles* 19: GB 4007, doi: 10.1029/2005GB002457

Amigos da Terra-Amazônia Brasileira & 15 other groups. 2010. Re: Responsabilidade corporativa da GDF Suez pelos impactos sociais e ambientais e riscos associados resultantes da construção da usina hidrelétrica de Jirau no Rio Madeira, na

Amazônia brasileira. Letter to Gérard Mestrallet, president of GDF Suez. Available at: http://www.amazonia.org.br/arquivos/341098.pdf

Amigos da Terra-Amazônia Brasileira & International Rivers Network. 2006. *Estudos Não Confiáveis: 30 Falhas No Eia-Rima do Rio Madeira.* Amigos da Terra-Amazônia Brasileira, São Paulo, Brazil. 17 pp. Available at: www.irn.org/pdf/madeira/AmazonStudy2006.pdf

Angelo, C. 2011. Processo de licenciamento para a obra foi coletânea de erros. *Folha de São Paulo*, 23 March 2011, p. B-6.

Angelo, C. & J. C. Magalhães. 2011. Hidrelétricas do rio Madeira fazem desmatamento voltar a crescer. *Folha de São Paulo*, 23 Feb. 2011. Available at: http://www1.folha.uol.com.br/ambiente/879988-hidreletricas-do-rio-madeira-fazem-desmatamento-voltar-a-crescer.shtml

ARCADIS Tetraplan, FURNAS & CNO. 2005. *Complexo Hidrelétrico do Rio Madeira: Avaliação Ambiental Estratégica. Relatório Final.* ARCADIS Tetraplan, FURNAS Centrais Elétricas, S.A. and Construtora Noberto Odebrecht, S.A. (CNO), Rio de Janeiro, Brazil. 169 pp + annexes.

Barthem, R. & M. Goulding. 1997. *The Catfish Connection: Ecology, Migration, and Conservation of Amazon Predators*. Columbia University Press, New York, U.S.A. 184 pp.

Brazil, CIMC (Comitê Interministerial sobre Mudança do Clima). 2008. *Plano Nacional sobre Mudança do Clima – PNMC -- Brasil.* Ministério do Meio Ambiente, Brasília, DF, Brazil. 129 pp. Available at: http://www.mma.gov.br/estruturas/smcq_climaticas/_publicacao/141_publicacao07122009030757.pdf

Brazil, MME (Ministério de Minas e Energia). 2011. Plano Decenal de Expansão de Energia 2020. MME, Empresa de Pesquisa Energética (EPE). Brasília, DF, Brazil. 2 vols. Available at: http://www.epe.gov.br/PDEE/20111229_1.pdf

Brazil, PR (Presidência da República). 2011. Eixo Energia. Available at: http://www.brasil.gov.br%2Fpac%2Frelatorios%2F2011-pac-2%2F1o-balanco%2Feixo-energia%2Fat_download%2Ffile&ei=xSRIT-yfLcLm0QGJz_n9DQ&usg=AFQjCNFDXgdru2ZOVOly-0m4xASkEAegJg&cad=rja

de Almeida, A.W.B. (ed.) 2009. *Conflitos Sociais no Complexo Madeira*. Universidade Estadual do Amazonas Edições, Manaus, Amazonas, Brazil. 391 pp.

Ecopart (Ecopart Assessoria em Negócios Empresariais Ltda.). 2011. Project design document form (CDM PDD) - Version 03. Available at: http://cdm.unfccc.int/filestorage/G/Y/E/GYE0D3RQV8K9I4S1WCO2JTFHANLU7M/Teles_Pires_PDD_24012012.pdf?t=NUx8bHp4NjY2fDCy286b2TU-8uLt2EV00sA6

Energia Sustentável do Brasil S.A. & GDF Suez Energy Latin America Participações Ltda. 2012. *Jirau Hydro Power Plant. Project Design Document (PDD)* (18 April 2012) Project Design Document Form for CDM Project Activities (F-CDM-PDD) Version 04-0. 94 pp. Available at: http://cdm.unfccc.int/Projects/Validation/DB/M4OO2XA6U9D8X8CASOJDWPFTIZ2Z3H/view.html

Fearnside, P.M. 2002. Greenhouse gas emissions from a hydroelectric reservoir (Brazil's Tucuruí Dam) and the energy policy implications. *Water, Air and Soil Pollution* 133(1-4): 69-96.

Fearnside, P.M. 2004. Greenhouse gas emissions from hydroelectric dams: Controversies provide a springboard for rethinking a supposedly “clean” energy source. *Climatic Change* 66(2-1): 1-8. doi: 0.1023/B:CLIM.0000043174.02841.23

Fearnside, P.M. 2005a. Brazil's Samuel Dam: Lessons for hydroelectric development policy and the environment in Amazonia. *Environmental Management* 35(1): 1-19.

Fearnside, P.M. 2005b. Do hydroelectric dams mitigate global warming? The case of Brazil's Curuá-Una Dam. *Mitigation and Adaptation Strategies for Global Change* 10(4): 675-691.

Fearnside, P.M. 2006. Pareceres dos consultores sobre o Estudo de Impacto Ambiental do Projeto para aproveitamento hidrelétrico de Santo Antônio e Jirau, Rio Madeira-RO. Parecer Técnico sobre ecossistemas. Parte B, Volume 1, Parecer 8, pp. 1-15. In: *Pareceres Técnicos dos Especialistas Setoriais—Aspectos Físicos/Bióticos. Relatório de Análise do Conteúdo dos Estudos de Impacto Ambiental (EIA) e do Relatório de Impacto Ambiental (RIMA) dos Aproveitamentos Hidrelétricos de Santo Antônio e Jirau no, Rio Madeira, Estado de Rondônia.* Ministério Público do Estado de Rondônia, Porto Velho, Rondônia. 2 Vols. Available at: http://www.mp.ro.gov.br/web/guest/Interesse-Publico/Hidreletrica-Madeira

Fearnside, P.M. 2007. Impacto ambiental [das hidrelétricas do rio Madeira] *Folha de São Paulo Online* 21 February 2007 (letter) *http://www1.folha.uol.com.br/folha/paineldoleitor/ult3751u282.shtml*

Fearnside, P.M. 2009a. Recursos pesqueiros. pp. 38-39. In: A.L. Val & G.M. dos Santos (eds.) *Grupo de Estudos Estratégicos Amazônicos (GEEA) Tomo II*, Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, Amazonas, Brazil. 148 pp. Available at: http://philip.inpa.gov.br/publ_livres/2009/Fearnside-GEEA-Recursos pesqueiros.pdf

Fearnside, P.M. 2009b. Impactos de presas hidroeléctricas en la Amazonía. In: *Memoria "Evaluación de Impactos Ambientales de grandes hidroeléctricas en regiones tropicales: El caso del río Madera" 19 y 20 de Maio de 2009*, WWF-Bolivia, La Paz, Bolivia (CD-ROM). Available at:

http://philip.inpa.gov.br/publ_livres/2009/Hidroelectricas%20Rio%20Madera-Philip-Fearnside.pdf

Fearnside, P.M. 2011. Desafios para midiatização da ciência na Amazônia: O exemplo da hidrelétrica de Belo Monte como fonte de gases de efeito estufa. In: A. Fausto Neto & A. Ventura (eds.) *A Midiatização da Ciência*, UNISINOS, São Leopoldo, RS, Brazil. Available at: http://philip.inpa.gov.br/publ_livres/2011/Philip_Fearnside_Belo Monte UNISINOS_proofs.pdf

Fearnside, P.M. 2012a. Carbon credit for hydroelectric dams as a source of greenhouse-gas emissions: The example of Brazil's Teles Pires Dam. *Mitigation and Adaptation Strategies for Global Change* doi: 10.1007/s11027-012-9382-6. (online-first version published 6 May 2012 http://www.springerlink.com/content/c105v17021045048/fulltext.pdf)

Fearnside, P.M. 2012b. Philip Fearnside Comments to PJCERS on the Santo Antônio Hydropower Project (Brazil) Submission to the Perry Johnson Registrars Carbon Emissions Services. Available at: http://www.internationalrivers.org/en/node/7295

Fearnside, P.M. & S. Pueyo. 2012. Underestimating greenhouse-gas emissions from tropical dams. *Nature Climate Change* 2(6): 382–384. doi:10.1038/nclimate1540

Folha de São Paulo. 2006. Bolívia ocupa Petrobras e nacionaliza exploração de petróleo e gás. *Folha de São Paulo*. 1 May 2006. http://www1.folha.uol.com.br/folha/mundo/ult94u95508.shtml

Forsberg, B.R. & A. Kemenes. 2006. Parecer Técnico sobre Estudos Hidrobiogeoquímicos, com atenção específica à dinâmica do Mercúrio (Hg). Parte B, Vol. I, Parecer 2, pp. 1-32. In: *Pareceres Técnicos dos Especialistas Setoriais—Aspectos Físicos/Bióticos. Relatório de Análise do Conteúdo dos Estudos de Impacto Ambiental (EIA) e do Relatório de Impacto Ambiental (RIMA) dos Aproveitamentos Hidrelétricos de Santo Antônio e Jirau no, Rio Madeira, Estado de Rondônia.* Ministério Público do Estado de Rondônia, Porto Velho, Rondônia. 2 Vols. Available at: http://www.mp.ro.gov.br/web/guest/Interesse-Publico/Hidreletrica-Madeira

FURNAS & CNO. 2003. Complexo do Rio Madeira, 1º Seminário Internacional de Cofinanciamento BNDES/CAF, Brasília, DF. FURNAS Centrais Elétricas S.A. & Construtora Noberto Odebrecht, S.A. (CNO). Rio de Janeiro, Brazil. Available at: http://www.bndes.gov.br/conhecimento/seminario/caf_20.pdf

FURNAS, CNO & Leme Engenharia 2005. *EIA- Estudo de Impacto Ambiental Aproveitamentos Hidrelétricos Santo Antônio e Jirau, Rio Madeira-RO. 6315-RT-G90-001*. FURNAS Centrais Elétricas S.A, Construtora Noberto Odebrecht, S.A. (CNO) & Leme Engenharia. Rio de Janeiro, Brazil. 8 Vols. Irregular Pagination. Available at: http://www.amazonia.org.br/arquivos/195010.zip

Hayashi, S., C. Souza Jr., M. Sales & A. Veríssimo. 2011. Transparência Florestal da Amazônia Legal Dezembro de 2010 e Janeiro de 2011. Instituto do Homem e Meio Ambiente da Amazônia (IMAZON), Belém, Pará, Brazil. 22 pp. Available at: http://www.imazon.org.br/publicacoes/transparencia-florestal/transparencia-florestal-amazonia-legal/boletim-transparencia-florestal-da-amazonia-legal-dezembro-de-2010-e-janeiro-de-2011/at_download/file

Instituto Pólis. 2006. *Parecer sobre o Papel do Município de Porto Velho Frente aos Impactos Urbanos e o Estudo de Impacto Ambiental do Projeto das Usinas Hidrelétricas do Rio Madeira.* Instituto Pólis, São Paulo, SP, Brazil. 89 pp.

International Rivers. 2012. Comments on the Santo Antônio Hydropower Project Submitted to the Perry Johnson Registrars Carbon Emissions Services. International Rivers, Berkeley, California, U.S.A. 12 pp. Available at: http://www.internationalrivers.org/pt-br/node/3052

Kemenes, A., B.R. Forsberg & J.M. Melack. 2007. Methane release below a tropical hydroelectric dam. *Geophysical Research Letters* 34: L12809. doi: 10.1029/2007GL029479. 55

Kemenes, A., B.R. Forsberg & J.M. Melack. 2011. CO_2 emissions from a tropical hydroelectric reservoir (Balbina, Brazil). *Journal of Geophysical Research* 116, G03004, doi: 10.1029/2010JG001465

Kileen, T.J. 2007. *A Perfect Storm in the Amazon Wilderness: Development and Conservation in the Context of the Initiative for the Integration of the Regional Infrastructure of South America (IIRSA)*. Conservation International, Arlington, Virginia, U.S.A.

Meade, R.H. 1994. Suspended sediments of the modern Amazon and Orinoco Rivers. *Quaternary International* 21: 29-39.

Molina Carpio, J. 2005. El megaproyecto hidroeléctrico y de navegación del Río Madera. pp. 101-116 In: *Geopolítica de los Recursos Naturales e Acuerdos Comerciales em Sudamerica*. Foro Boliviano sobre Medio Ambiente y Desarrollo (FOBOMADE), La Paz, Bolivia. 149 pp. Available at: http://www.fobomade.org.bo/publicaciones/docs/8.pdf

Molina Carpio, J. 2006. *Análisis de los Estudios de Impacto Ambiental del Complejo Hidroeléctrico del Rio Madera: Hidrología y Sedimentos*. La Paz, Bolivia. 45 pp. Available at: http://www.institutomadeiravivo.org/wp-content/plugins/riomadeiravivo/publicacoes/analisis_madera_.pdf

Molina Carpio, J., F. Ledesma & P. Vauchel. 2008. Estudio del río Madera: Remanso hidráulico y sedimentación. pp. 96- 191 In: A.M. Arnez, E.M. Patana, L.F.N. Garzon, J. Molina Carpio, F. Ledezma, P. Vauchel & R. Canese (eds.) *Bajo el Caudal: El Impacto de las Represas del Rio Madera en Bolivia.* Foro Boliviano sobre Medio Ambiente y Desarrollo (FOBOMADE), La Paz, Bolivia. 192 pp. Available at: http://www.fobomade.org.bo/documentos/libro_represas%20.pdf

Monteiro, T. 2011**.** *As Hidrelétricas do Madeira: as lições não aprendidas que se repetem em Belo Monte. Observatório de Investimentos na Amazônia*. Instituto de Estudos Socioeconômicos (INESC), Brasília, DF, Brazil. 43 pp. Available at: http://observatorio.inesc.org.br/visualizar_estudos.php?id=47

Monteiro, T. 2012. Santo Antônio e Jirau: Hidrelétricas Malditas. http://telmadmonteiro.blogspot.com.br/2012/03/santo-antonio-e-jirau-hidreleletricas.html\

Ordoñez, R. 2012. Brasil depende menos do gás boliviano. *O Globo*. 3 May 2012. Available at: http://clippingmp.planejamento.gov.br/cadastros/noticias/2012/5/3/brasil-depende-menos-do-gas-boliviano

Ortiz, L., G. Switkes, I. Ferreira, R. Verdum & G. Pimentel. 2007. *O Maior Tributário do Rio Amazonas Ameaçado: Hidrelétricas no Rio Madeira*. Amigos da Terra-Brasil, Porto Alegre, RS, Brazil. 22 pp. Available at: http://www.riosvivos.org.br/dowloads/rio_madeira_portugues.pdf

Romero, S. 2012.Amid Brazil's rush to develop, workers resist. *New York Times*, 5 May 2012. http://www.nytimes.com/2012/05/06/world/americas/brazils-rush-to-develop-hydroelectric-power-brings-unrest.html?hpw#

Santo Antônio Energia S.A. 2012. Santo Antonio Hydropower Project. PDD version: 01.1 (27/10/2011) Clean Development Mechanism Project Design Document Form (CDM-PDD) Version 03. 53 pp. Available at: http://cdm.unfccc.int/Projects/Validation/DB/S253ZCTBJU9LJ3VF72CS1J8SHY02PP/view.html

Scofield Jr., G. 2011. Empreiteiras recebem R$ 8,5 por cada real doado a campanha de políticos. *O Globo*. 7 May 2011. Available at: http://oglobo.globo.com/economia/empreiteiras-recebem-85-por-cada-real-doado-campanha-de-politicos-2773154#ixzz1vFriSQgF

Switkes, G. (ed.). 2008. *Águas Turvas: Alertas sobre as Conseqüências de Barrar o Maior Afluente do Amazonas*. International Rivers, São Paulo, SP, Brazil. 237 pp. Available at: http://www.internationalrivers.org/am%C3%A9rica-latina/os-rios-da-amaz%C3%B4nia/rio-madeira/%C3%A1guas-turvas-alertas-sobre-conseq%C3%BC%C3%AAncias-de-barrar-o- Partial English translation available at: http://www.internationalrivers.org/en/latin-america/amazon-basin/madeira-river/introduction-and-article-the-madeira-hydroelectric-and-hidr

Vera-Diaz, M.C., J. Reid, B. Soares-Filho, R. Kaufmann & L. Fleck. 2007. *Effects of Energy and Transportation Projects on Soybean Expansion in the Madeira River Basin*. CSF Series number 7. Conservation Strategy Fund, Lagoa Santa, Minas Gerais, Brazil. 26 pp. Available at: http://conservation-strategy.org/sites/default/files/field-file/Madeira_soy_final_draft2.pdf

World Bank. 2008. *Environmental Licensing for Hydroelectric Projects in Brazil: A Contribution to the Debate, Volume I, Summary Report*. Available at:

http://siteresources.worldbank.org/EXTWAT/Resources/4602122-1214578930250/Summary_Report.pdf