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Environmental and Social Impacts of Hydroelectric Dams in Brazilian Amazonia: Implications for the Aluminum Industry

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Summary. — Aluminum smelting consumes large amounts of electricity and helps drive dam-building worldwide. Brazil plans to build dozens of hydroelectric dams in its Amazon region and in neighboring countries. Benefits are much less than is portrayed, partly because electricity is exported in electro-intensive products such as aluminum, creating little employment in Brazil. Dams perversely affect politics and social policies. Aluminum export offers an example of how a rethinking of energy use needs to be the starting point for revising energy policy. Dam impacts have been systematically underestimated, including population displacement and loss of livelihood (especially fisheries), biodiversity loss, and greenhouse-gas emissions.

Key words — aluminum industry, Amazonia, energy policy, global warming, hydroelectric dams, Brazil

1. INTRODUCTION

Dams have been built on most of the major rivers in industrialized countries, and the combination of decreasing availability of sites with hydroelectric potential in North America and Europe and decreasing tolerance of the public in these areas to accept major impacts has led to a shift of dam building to developing countries (Khagram, 2004). As of 2014 there were 37,641 dams in the world with $\geqslant$15 m height; of the 36,259 of these that had data on use, 8,689 were either wholly or partially for hydropower (ICOLD, 2014). In addition to a surge in dam-building activity in China and in the Himalayan region, construction is increasing and future plans are massive in tropical areas in Latin America, Africa, and Southeast Asia (e.g., Richter *et al.*, 2010; Tollefson, 2011). Aluminum smelting, an activity that consumes large amounts of electricity, has also progressively moved to these locations, including Brazil (Do Rio, 1996). The environmental and social consequences are great wherever large dams are built. Iconic examples include the Narmada Dams in India (Fisher, 1995; Morse, Berger, Gamble, & Brody, 1992), the Three Gorges Dam in China (Dai Qing, 1994; Fearnside, 1988; Fearnside, 1994), and the planned Mekong River Dams in Southeast Asia (Baran, Levin, Nam, Rodríguez-Iturbe, & Ziv, 2012; Grumbine & Xu, 2011). Ignoring or underreporting of large impacts in decision making is by no means restricted to developing countries, as shown by the history of dam building in the United States (Morgan, 1971). Dams have benefits as well as impacts, but it is the large impacts that make consideration of how electricity is used such a vital (and often neglected) aspect of planning and decision making in tropical countries.

Decisions on dam building are not only influenced by the balance (or lack thereof) in reports such as environmental impact studies (EIAs), but also by political processes, including the action of non-governmental organizations ranging from grassroots associations of affected people to international environmental and human-rights organizations. Khagram (2004) reviews the roles of these actors in dam decisions in various developing countries, showing the differences between countries with high degrees of both democracy and social mobilization (India and Brazil), with democracy but low mobilization (South Africa and Lesotho), little democracy but high mobilization (Indonesia), and low levels of both democracy and mobilization (China). The power of the massive financial and political interests surrounding dams, including transnational interests, is evident even where civil society is free and active.

Brazil has embarked on an unprecedented drive to build hydroelectric dams in the Amazon region (Figure 1). Brazil had 15 "large" dams (defined in Brazil as >30 MW installed capacity) in the country's Legal Amazon region with reservoirs filled by May 2015 (Table 1). An additional 37 "large" dams planned or under construction are listed in Table 2, including 13 as-yet unfilled dams that were included in Brazil's 2012–21 Energy Expansion Plan (Brazil, MME, 2012, pp. 77–78). Brazil's economic retraction since that plan has resulted in lengthening time horizons for several of these projects, but the 2014–23 plan still includes 18 Amazonian dams in its 10-year schedule (Brazil, MME, 2014, pp. 80–81). The 51 existing, under-construction and planned dams listed by number in Tables 1 and 2 are mapped in Figure 1. Many others have been inventoried (e.g., Brazil, ANA, (nd [C 2006]), pp. 51–56), including 62 additional dams listed in Brazil's 2010 Plan (Brazil, ELETROBRÁS, 1987; see: Fearnside, 1995). In addition, Brazil plans to build six dams in Peru and one in Bolivia over this period, mainly for exporting electricity to Brazil (Finer & Jenkins, 2012; Wiziack, 2012).

The main argument used to promote hydropower as Brazil's preferred option for electricity production is that dams are (supposedly) the least-expensive option in terms of monetary investment per kWh of generation. However, this argument is open to question because dams almost always cost much more and take longer to build than originally assumed, making them considerably less attractive in financial terms than thought when the decision is made. This is a worldwide

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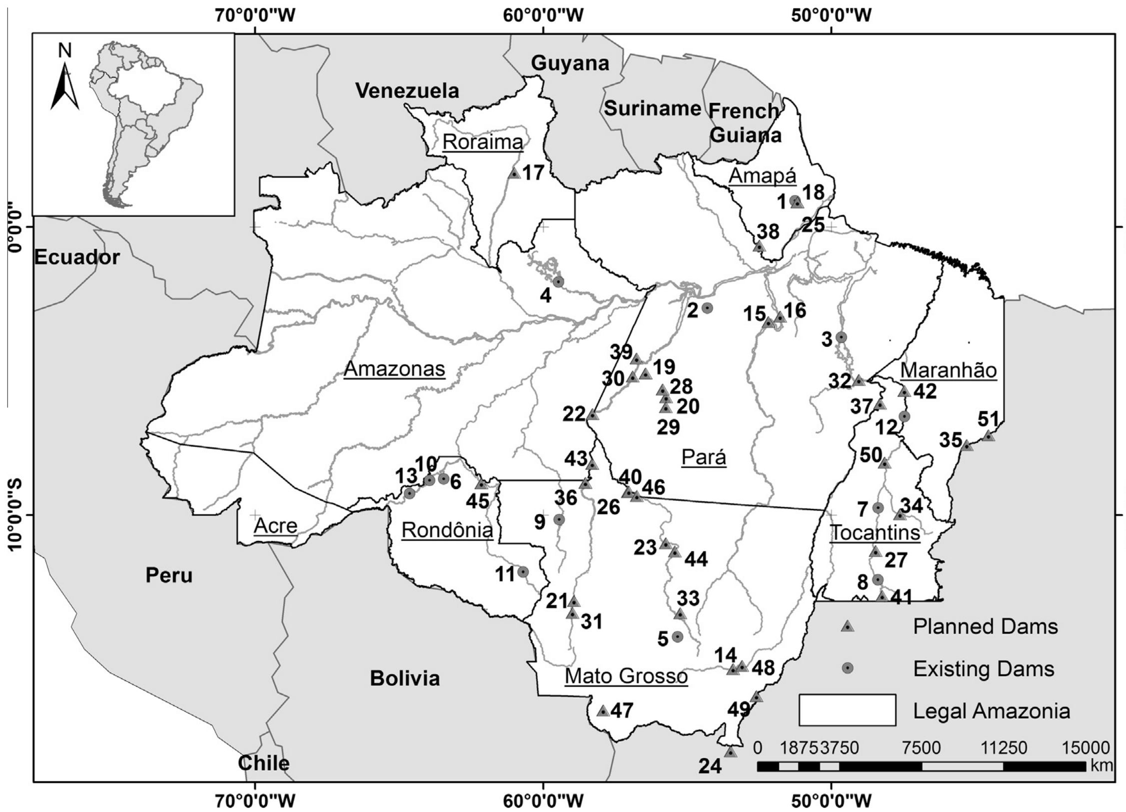

Figure 1. *Existing dams and dams in the planning or construction phases in Brazil's Legal Amazon region. The numbers of the existing dams (dams with their reservoirs filled by February 2014 indicated by circles) correspond to the numbers listed in Table 1, and the numbers of the dams that are planned or under construction (indicated by triangles) correspond to the numbers listed in Table 2. Adapted from: Fearnside (2014c).*

phenomenon, as shown by a recent global review of hundreds of unprofitable hydroelectric projects (Ansar, Flyvbjerg, Budzier, & Lunn, 2014). Most recently in Brazil, the Belo Monte Dam's cost is already double the government's initial estimate (e.g., Veja, 2013). In addition to the high cost of dams in terms of cash outlays, the non-monetary social and environmental costs of this option are tremendous and have little weight in critical decisions on energy options. Many of Brazil's planned dams are in Amazonia because the best sites in other regions of the country have already been dammed.

The present paper examines environmental and social costs and benefits of primary aluminum and reviews impacts of Amazonian dams. The paper is limited to addressing the relation between aluminum and Amazonian dams and their impacts; a reform of energy policy requires addressing many other issues needed to reduce energy consumption and to provide alternative sources of electricity. However, Brazil's energy policy can be broken down and addressed in more manageable parts. A good place to begin is the question of aluminum export. Change is best achieved by focusing attention on one or a few factors (in this case aluminum) and identifying critical points that impede social and environmental objectives from being attained. This is an approach in the field of political ecology.

In a review of the political ecology of large dams, Nüsser (2003) finds that the aluminum industry is "intimately linked to the dambuilding lobby." Questions surrounding Brazil's Amazonian aluminum industry are central to other fields as well. Paul Ciccantell has applied both the social constructionist approach from environmental sociology (Ciccantell, 1999a) and new historical materialism (which combines methods of environmental sociology, sociology of development, and social impact assessment) to interpret the role of these developments in globalization. He finds that "The incorporation of the Amazon via the aluminum industry is a key case of raw materials-based development in the era of globalization" (Ciccantell, 1999b, p. 177). Highly unequal distribution of impacts and benefits of Amazonian aluminum raises issues of environmental justice; concerns of this type have been shown to be important in bringing about change both at individual and societal levels (e.g., Reese & Jacob, 2015).

Aluminum and hydroelectric dams fit into the "resource curse" paradigm that is best known for mining but also applies to other forms of development where capital-intensive industries tap valuable natural resources. The seeming paradox of countries with the greatest mineral wealth having the highest incidences of poverty and the lowest indices of social wellbeing is a well-known and robust generalization; the greater the percentage of a country's gross domestic product that is derived from extracting minerals, the greater its poverty (e.g., Pegg, 2003; Rich, 2013; Ross, 2001; Sachs & Warner, 1995; Weber-Fahr, 2002). Several factors contribute to the explanation of this phenomenon (Collier, 2007, pp. 38–52). One is the "Dutch disease," named after events in the 1960s when the advent of revenue from North Sea gas had the ironic result of worsening employment and general welfare in the Netherlands. This was because the natural-resource revenue caused the country's currency to strengthen, thereby rendering unprofitable the manufacturing and other employment-generating industries that had previously sustained the economy. Another factor is price volatility of extractive commodities, leading to effects that undermine governance and