Rescuing Responsible Hydropower Projects

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Abstract

Given the still-growing use of coal and natural gas in generating electricity in many developing countries, it is necessary to put far more effort into promoting *responsible* large-scale hydropower projects. In contrast to hydro, solar and wind power face physical constraints that greatly limit their potential to replace fossil-fuel sources of power generation. Because designing hydro projects to reduce their socio-economic and environmental damage typically entails greater costs and/or lower capacity, subsidies are needed to increase the number of responsible, economically viable projects. Despite the past abuses, hydro offers low-carbon energy generation, low cost power generation, and important potential for energy storage and peaking supply to supplement intermittent low-carbon sources such as wind and solar. The promotion of responsible hydropower requires greater awareness of the possibilities for responsible projects, greater overall climate funding, better provision for local participation and compensation, changes in the doctrines of additionality, and stronger institutions to identify, design, and broker these projects.

Keywords: additionality, climate finance, hydroelectric dams, Clean Development Mechanism, renewable energy, electricity generation, energy storage

1. Introduction

Anyone concerned with the global climate change must be frightened by the trends in the worldwide expansion of electricity and the fuels that produce it. The transition from fossil fuels to renewable electricity generation is going far too slowly. Environmental sustainability, the 13th Sustainable Development Goal, calls for accepting the Paris Treaty commitment to keep the global temperature rise this century below 2 degrees Celsius above pre-industrial levels, and to strive for keep the rise to 1.5 degrees. Yet, even by 2050, the U.S. Energy Information Administration's reference case projects that the share of coal in electricity generation would be 20 percent, meaning more coal burning than now because of the expected expansion of power generation; the proportion of generation from natural gas would be quite similar (U.S. Energy Information Administration 2019)[1]. Although electricity generation certainly is not the only challenge to decarbonization, it is likely to be the greatest challenge. While hydrocarbons as an end-use sector may increase by roughly 50 percent by 2050, again according the U.S. Energy Information Administration's 2019 reference case, the expansion of electricity is projected to nearly double. Insofar as current energy sources and end uses are more locked-in than are future sources and uses, diverting generating capacity away from adding to power generation is all the more important. In light of the primacy of the challenge to decarbonize electricity, this paper is novel in outlining the essential need for greatly expanded development of responsible hydropower dams, the subsidies needed to finance these dams, and the institutional needs to raise and channel the funds.

<<Figures 1 and 2 about here>>

The most pressing need for greatly expanded renewable-based electricity development is in developing and transitional countries, where the bulk of the 80 percent increase in electricity use by 2050 will occur. Worse yet, it is in these areas where coal plays a particularly destructive role, responsible for conventional pollution as well.

The reference case is so depressing because of the prevalent, unqualified opposition to large-scale hydro projects, which have the greatest potential to make a dent in the continued reliance on fossil fuels. Large-scale hydropower has been so vilified—sometimes for good reason—that they are widely shunned as a tool for replacing fossil fuels. Fletcher (2010, 2) puts it vividly: "Over the past several decades…hydro dams have been subject to scathing critique on

[1] The "reference case" used by the International Energy Administration of the U.S. Department of Energy projects the consequences of assumptions about efficiencies and costs, but does not incorporate projections of levels of subsidy for renewable-resource development.

a variety of grounds, led primarily by grassroots groups of dam-affected peoples and the transnational environmental NGOs, such as International Rivers, that support them…" It is politically correct to proselytize for solar, wind, and small (or micro) hydro, but many "sustainability" pleas for renewable electricity ignore large-scale hydro.

The neglect of hydropower in the decarbonization policy discourse is reinforced by the misperception that the construction of hydropower dams is booming. Zarfl et al. (2015, 161) announced with alarm "A global boom in hydropower dam construction". Their inventory of hydropower dams concluded that "At least 3,700 major dams, each with a capacity of more than 1 MW, are either planned or under construction" (Zarfl et al. 2015, 161). In fact, only 17 percent of these dams were under construction as of 2015 (Zarfl et al. 2015, 165)—and "planned" hardly ensures that a dam would be built. Moreover, the threshold of one megawatt is a full order of magnitude below the generating capacity of dams that are most capable of substantial contributions to reduce carbon emissions and are attractive to international climate finance. And contrary to characterizing hydropower development as a "boom", the *World energy investment 2019* report disclosed that the 2016-2018 investment in hydropower was barely a third of that for solar power, and only 60 percent of the investment in wind power (International Energy Agency 2019, 52).

The answer—though many will not be pleased to hear it—is a massive effort to subsidize hydropower. Yet, not just any hydro projects: those that have been designed to minimize the harm to ecosystems and local people. All of the relevant outcomes—lower carbon emissions, less ecosystem harm, (including less conventional pollution), and less deprivation of impacted populations—provide ample rationale for subsidies to achieve these positive externalities. This plea is based on considerations of what it takes for hydropower projects to be sufficiently benign, how the preconceptions and doctrines increasingly have discouraged climate finance directed to hydropower, and how to gear up to identify, design, and broker responsible hydro projects.

Now that the Clean Development Mechanism, with its highly problematic approach to qualifying hydro projects for subsidies, is making way for new arrangements as part of the implementation of the Paris Treaty, the opportunity for more appropriate eligibility criteria is very promising. The argument here is that the criterion of additionality—the requirement that external funding beyond the government and the developer should be granted only if such funding is needed for the project to proceed (Wara and Victor 2008; Schneider 2009)—can and should be applied to hydropower projects that are designed to minimize environmental and socioeconomic harm at the expense of profitability without subsidies.

2. **Why Even Bother with Hydro?**

Given the righteous opposition to highly damaging large-scale hydropower, why not leap to solar, wind, nuclear, etc.? With declining prices, no impact on downstream fisheries, and the possibility of placing even utility-scale arrays on water and other locations that do not compete with human activity, solar arrays and windfarms have become so alluring that the attraction takes on the aura of a cargo cult. Others hold out nuclear power as the answer. However, the aspiration for any of these as a magic bullet is countered by the reality of the physical and economic constraints that sober assessments clarify.

De Castro et al. (2013), in one of the most careful and comprehensive assessments of the constraints on solar energy, estimate that no more than two to four terawatts of solar energy can ever be harvested annually (compared to the 16 terawatts currently provided by hydrocarbons). The demand for electricity in 2050 is projected by the U.S. Energy Information Administration (2019, 87) reference case to be 44.5 terawatts per year. Capellán-Pérez, De Castro, and Arto

(2017) estimate that an all-solar European Union would require half the land area of these 27 countries. To be sure, estimates of solar potential vary widely, and the de Castro et al. (2013) estimates are certainly lower than most, but the gulf between such estimates and the projected electricity demand make it clear that solar power cannot do the heaviest lifting in the transition away from fossil fuels.

The long-term prospects for *wind power* are limited by geography, wind availability, the availability and cost of land, financial return, and return on the energy required to build and operate. De Castro et al. (2011, 6628) compile previous estimates of the economic/sustainable maximum potential for windfarms, ranging from one to 6.9 terawatts annually. However, taking into account the physics of the wake effect[2], they make a compelling argument that the potential is far less than these estimates. In addition, wind power is also intermittent, and although land can be cultivated among windmills, windfarms may increase the temperature and dryness of the land, reducing agricultural productivity (Gorayeb et al. 2016). Tesemma (2017, 23) concludes that "[t]here is a permanent loss of land of crop production due to the occupation of a number of wind turbines, access roads, and buildings." The de Castro et al. (2011) estimate is that wind power cannot be expected to provide more than one terawatt of electricity capacity.

<<Figure 3 about here>>

Nuclear energy, though finding uses in mobile vehicles such as aircraft carriers, faces obstacles for electricity-grid generation that has led the U.S. Energy Information Administration (2019, 89) to project only a one percent annual growth in nuclear electricity generation, with a 2050 production of less than four TW annually. The largely unresolved waste disposal issues,

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[2] Gans, Miller, and Kleidon (2012, 85) provide the implications of the physics: "accounting for the balance of momentum and kinetic energy is critical to the quantification of large-scale extractability of wind power".

public fears, high costs, population displacement[3], and the environmental and health risks of uranium mining (International Atomic Energy Agency 2005) are formidable limitations.

In contrast to solar and wind, careful basin-by-basin estimates of economically viable hydropower potential, though varying according to assumptions about the break-point price per kilowatt hour, establish a range of roughly nine to 15 TW capacity.[4]

The simple arithmetic is that the equivalent of 9,000 to 15,000 one-gigawatt dams would be needed to reach full economically viable potential. Even this is an underestimate of needs, because more dams would need to replace the dams that have to be replaced over the next thirty years. In short, there is no way of getting around the fact that the expansion of hydropower is essential to supplant fossil fuels for generating electricity.

The greater potential for hydropower is also supplemented by its synergies with solar and wind power. In many contexts, the intermittency of both solar and wind power can be addressed by dams, in particular the pump-storage dams are the most promising complementary generating source—and these require two reservoirs.[5] Another encouraging prospect for utility-scale solar is the placement of floating solar arrays in the reservoirs of hydroelectric dams. Not only does

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[3] The displacement needs include moving people away from the reactors (in India, the area around a nuclear reactor must be cleared for at least a 1.5 km radius [Roshan, Shylamoni, and Acharya n.d.]) and the people in harm's way near the mines.

[4] International Journal on Hydropower & Dams 2013; Zhou et al. 2015. In addition, Gernaat et al. (2017) estimate the economically viable potential at 8.77 TW, but they include only the basins south of 60˚N, excluding high-potential basins such as those in Norway, Sweden, Iceland, and Finland.

[5] Opperman, Grill, and Hartmann (2015, 20) explain that:

> By storing water upstream of turbines—both in traditional reservoirs on rivers and in pumped storage reservoirs…hydropower reservoirs store water as potential energy that can quickly be converted to electrical energy and thus can contribute to load following and peaking, and thus grid stability. Storage in hydropower reservoirs provides the primary means of storing electricity (nearly 100 percent) on the planet and plays an important role in 'firming up' variable sources of energy such as wind and solar.

this avoid displacing people in the placement of the arrays, it also economizes by sharing the transmission lines and reduces the need to displace people occupying transmission tower sites that would not be shared. Cazzaniga et al. (2018, 1731) argue that greater efficiency[6], avoiding the costs of buying or leasing land, and reduced maintenance costs, may make floating arrays more cost-effective than land-based arrays.

3. Obstacles to Responsible Hydro

Breakthrough progress for hydropower faces five problems: 1) the physical harm that has established the negative reputation of hydropower; 2) institutional weaknesses within the countries approached by hydropower developers; 3) risk of lower profitability of relatively benign projects; and 4) the lack of mechanisms to design and gain support for subsidies for responsible projects; 5) the general shortage of climate funding.

However, it is useful first to present the political economy dynamics that underlie all of these problems. One fundamental point is the greater risk to the poor, because of the hilly or mountainous location of most sites typically occupied by economically vulnerable people. Lavers and Dye (2019, 3) note that "dams' river intervention is inherently political, affecting different groups directly through displacement or indirectly through impacts on biophysical systems. This distributional impact is reinforced by questions of who is undertaking dam building and for what purpose. Dams have historically involved trade-offs between those whose livelihoods have been affected, especially through displacement, and those receiving electricity and water benefits...Historically, this has favoured the economically and socially advantaged…"

[6] Floating arrays can be manipulated for greater flexibility in capturing sunlight.

The concerns over the regressive impacts on income distribution meld with environmental concern and indignation over corruption to solidify leftist forces.

The political economy considerations from the perspective of the government involve both money and control. Governments may favor the most profitable, high-capacity hydroelectric dams because the government's share of the revenues would be maximized, and the magnitude of receiving payoffs from rent-seekers may be as well. This would be a disincentive to accepting scaled-back designs that reduce displacement and ecosystem impacts. Domestic developers, or subcontractors to foreign developers, may constitute a strong lobby within the country, arrayed against the solar- and wind-power lobbies. Governments also may take advantage of dam initiatives to assert state control in the area. Blake and Barney (2018, 3) assert "that an important tool of statecraft employed by the Lao People's Revolutionary Party (LPRP) is focused upon controlling and disciplining rural subjects, whose local ecologies and livelihoods have been fractured through poorly mitigated hydropower development." They continue by referring to "the growing number of hydropower resettlement schemes, involving a typical grid layout of residential houses, roads and administrational infrastructure – facilitating state monitoring and regulation of residents' activities" (Blake and Barney 2018, 17). Thus, the area around the dam may be fair game for state initiatives defended as necessary to maximize the utility of the dam, or even to use the dam initiative to expel people from the area, benefit favored groups at the expense of the displaced, and so on.

From an international political economy perspective, liberalization and rise of private finance has expanded the international investment capital available for dams, yet with the attendant decline in the influence of institutions, such as the World Bank, with some potential to discipline governments in their approval of hydroelectric projects. Chinese companies, in particular, have the advantages of ample capital, the reputation for construction speed because of fewer environmental qualms, and the backing of their government motivated to employ their construction firms (Hensengerth 2013; Hwang, Bräutigam, and Wang 2015; Tan-Mullins, Urban, and Mang 2017).

3.1 Problem 1: Harm. The first cause for opposing a transition to renewables is the belief that large-scale hydroelectric dams harm local populations. Numerous dam initiatives have been condemned—often rightfully— because they would displace large numbers of people, severely degrade downstream fisheries, and cause other environmental damage both upstream and downstream. Kuriqi et al. (2019) and Kuriqi et al. (2020) emphasize the complexity of the "water-energy-ecosystem nexus" even for run-of-the-river dams because of the fluctuations in river flow, sensitivity of aquatic life to water quality and sediment load, and many parameters that dam operators must monitor to manage the balance between power generation and aquatic life survival. However, these analyses also imply that careful flow control can minimize adverse consequences.

Even so, the environmental and social risks of hydroelectric dams have long been a *cause celebre* that has mobilized civil society groups all over the world, with protests of varying degrees of confrontation to prevent construction from going forward. Moreover, the delays resulting from resistance to feared projects, even if the projects could overcome the resistance, might increase costs to the point that the projects are unprofitable. Among the very large number of dam initiatives that have been blocked, perhaps forever, are China's Xiaonanhai Dam, the Democratic Republic of the Congo's Grand Inga Dam, and Sudan's Kajbar Dam; other initiatives simply have been abandoned, including Brazil's São Luiz do Tapajós Dam, and

Mexico's La Parota Dam. The economic costs of dams that are stalled or killed after resources have been expended can be very high. Opperman, Hartmann, and Raepple (2015, 8) note that:

> High-profile recent examples of delayed, suspended or cancelled projects—including Myitsone (Myanmar), HidroAysen (Chile), Sao Luis do Tapajos (Brazil) and Belo Monte (Brazil)— provide compelling examples of how incomplete consideration of environmental and social impacts during planning and site selection can lead to significant challenges to developers and investors. The first three of these projects represent an aggregate of US$1.3 billion in stranded investment and 18 GW of undeveloped capacity.

In short, harm is averted—but so is the opportunity to supplant fossil fuels as the inputs for electricity.

3.2 Problem 2: Institutional Weaknesses within Dam-Prospective Countries. Institutional weaknesses undermine the confidence that dams can be responsible, and that cooperation among developers, governments, and the international community can speed the financing of responsible dams. In many lower-income countries the lack of such institutions as effective civil-society monitoring of state performance permits corruption that is responsible for economic waste, the acceptance of problematic designs in exchange for payoffs, and deprivations of local populations suffering from the problematic designs. Both the large-scale contracting opportunities, and the small-scale funds formally earmarked to compensate displaced families, provide ample opportunities for corrupt practices, in countries as disparate as Brazil (Fearnide 2017) and Argentina (Ribeiro 1994), India and Pakistan (Kumar 2020; Sabir, Torre, and Magsi 2017), Ghana (Hausermann 2018) and Ethiopia (Cuesta-Fernández 2015). Projects are approved even if they are unsound economically or structurally, cost overruns raise electricity prices to cover shortfalls, local people are swindled out of their promised compensation, and so on. A history of corruption also increases the likelihood of opposition.

Although these risks facing local people beg for enforceable agreements to reduce the gap between winners and losers, such agreements are often lacking. Community development agreements (CDAs) entail negotiations between developers and communities, often with government involvement, prior to investment (Loutit, Mandelbaum, and Szoke-Burke 2016; Otto 2018). Although CDA negotiations are very common in the mining sector (O'Faircheallaigh 2015), they are often lacking or come very late in the planning of large dams. It is common for developers to approach the government with alluring possibilities of revenues and expanded power capacity; this encourages collusion between the government and the developer to restrict the weight of the various community members, especially those who would be most demanding of the government and the developer.

State institutional weaknesses also contribute to the cynicism toward even well-sited and well-designed dams, due to doubt over the soundness of state oversight of construction and operations, and whether the developers will meet their obligations. Cawley (2019, 1311), after noting that the disastrous collapse of the Xe Pian Xe Namnoy Dam in Laos killed 71 people and displaced over 5,000, further reports that:

> As of May 2019, there are 63 operational dams in Laos, several of which exhibit a lack of oversight comparable to that which led to Xe Pian Xe Namnoy's collapse… [N]one of Xe Pian Xe Namnoy's financiers, sponsors, or builders have been held accountable for the profound consequences of the collapse, thus forcing the local population to bear the steep costs of those harms alone.

3.3 Problem 3: Risk of Lower Profitability of Relatively Benign Projects. The siting and design alternatives that might mitigate these harms often are insufficiently profitable to attract private or public investment. For example, an analysis done by the Natural Heritage Institute (NHI) (2017) provides a solid assessment of alternatives to the Sambor Dam proposal offered by a Chinese firm. The NHI, working with the Cambodian government, developed a least-damaging alternative to the proposal. The NHI proposes that if a dam is to be built—although the Institute recommends against any dam on the grounds of its projection of greater overall costs than benefits—it should permit one channel of the Mekong to flow freely to permit the sediment to flow downstream, adopt less destructive turbines and alternative fish locks, and other modifications. This alternative would, however, generate less electricity, and would not provide the private rate of return that would be attractive to the Chinese firm.

In fact, large-scale hydropower in general is risky from an economic perspective, in light of delays, whether in construction bottlenecks or because of opposition; lower than predicted power generation; or changing economic conditions (World Commission on Dams 2000, chapter 2; Ansar et al. 2014). Some critics argue that other means of generating electricity are economically superior, even leaving aside negative externalities (Ansar et al. 2014). Therefore, with the additional requirement that the designs must minimize damage to people and ecosystems, economic viability is at even greater risk, as these requirements may entail higher costs and may limit revenues due to reduced power generation.

Higher costs may be due to: 1) re-siting requiring higher construction, operating, and maintenance costs; 2) installing mechanisms to increase fish survival; 3) installing channels to permit more nutrient flow-through; 4) providing adequate compensation for displaced people and others (potentially both upstream and downstream) whose livelihoods or health may be damaged;

5) resettling displaced people; or 6) compensating others facing economic or other losses. For example, the developers of the now-operating Xayaburi Dam on the Mekong in Laos spent millions to devise an elaborate system to reduce fish loss and sediment retention (though still too early to assess success), and provided better living conditions for the displaced population than they had before the dam.

Lower revenues may be due to lower power generation resulting from: 1) reducing the height of dams to reduce the area of submerged land for the reservoir; 2) finding a site to reduce the number of displaced people; 3) limiting the dam's width to allow some of the fish and nutrient-rich sediment bypass the dam; 4) using less powerful turbines to allow more fish to survive.

It is true that sometimes a hydroelectric dam can survive strong efforts to mitigate the potential harm that mobilizes communities. For example, the modified design of Ecuador's Baba Dam, facing very stiff community resistance, reduced the dam's height from 54 meters to 20 meters, and reconfigured the dam's structure. The changes reduced the number of displaced people from 778 to 191, and permitted more constant water flow. These changes added to the dam's costs, and reduced the generating capacity from 54 megawatts to 42 megawatts (Hidalgo-Bastidas and Boelens, 2019). Even so, the dam was sufficiently profitable for its construction to proceed. Similarly, Pakistan's Gulpur project also explicitly included considerations of both environmental and social impacts, and the re-siting and redesign both reduced costs and maintained the same 100 MW generating capacity. The financial viability of the project was bolstered by subsidies from the Asian Development Bank, technical assistance from the Australian government, and a loan guarantee from World Bank Group's Multilateral Insurance Guarantee Agency (Brown et al. 2019).

Despite such examples of responsible dams that are still profitable, changing the site and the design from what the developer proposes is likely to reduce the risk-adjusted returns and therefore discourage the investment. It certainly is reasonable to assume that if developers could expect a comparable risk-adjusted profit with a more benign dam, that would be the clear alternative. The problem is that the designs proposed by developers can be expected to build in high revenues and economize on costs. As mentioned above, government policymakers, unless local opposition threatens carrying out the construction and operation, often are disposed to prefer high-capacity dams because these initiatives maximize both energy generation and government revenues, through direct revenue-sharing and taxes. Therefore, although in many instances, design alternatives, as well as decent treatment of displaced people, can reduce the harms (and the opposition), many initiatives would not on their own be profitable to developers if made acceptably responsible. These crucially worthwhile projects must be subsidized.

3.4. Problem 4: Lack of Mechanisms to Design and Gain Support for Subsidies for Responsible Projects. Patel, Shakya, and Rai (2020, 1) pose the dilemma that hydropower, even if responsible, does not gain general acceptance for climate finance subsidies:

> While sustainable hydropower may not broadly meet climate finance criteria, hydropower projects with the necessary characteristics for transition do meet these objectives and should attract climate finance support. Meanwhile, concerns about the social and ecological integrity of hydropower, such as the impact it may have on local communities, provide more reasons for climate finance to incentivise hydropower designs that are socially, environmentally and technically appropriate for future conditions, supporting the shift to accessible, affordable, clean, distributed smart grids.

This problematic status of large-scale hydro's eligibility of climate finance is reflected in the paucity of support from the climate funds. Of all the multilateral and bilateral climate funds, only the GCF and the Clean Tech Fund have shared in the funding of large-scale hydro, and this has amounted to only six projects. For hydro in general, climate finance for hydro projects for 2003-2018 amounted to US$693 million, dwarfed by the total of US$295 billion for solar and wind (Patel, Shakya, and Rai 2020, 16, 19)

Although hydropower finance can be channeled through carbon credit mechanisms, climate bonds, or climate funds, the experience of carbon credits channeled through the Clean Development Mechanism generated cynicism toward the legitimacy of appeals for subsidies that has cast a pall over all channels. When the Clean Development Mechanism (CDM) was in full swing, Haya and Parekh (2011, 3, 5) urged that "[l]arge hydropower should be excluded from the CDM in all countries because it is common practice, unlikely to be additional and additionality testing is inaccurate… Excluding large and some small hydropower projects from the CDM and strengthening WCD compliance evaluations are important steps the European Union could take to strengthen the integrity of its climate change mitigation goals." Bogner and Schneider (2011) similarly concluded that "the CDM is for most projects not an important factor for investment decisions in the medium and large hydropower plants. It appears likely that most projects would have been implemented in any case, i.e. without the CDM".[7]

The cynicism toward the additionality status of large-scale hydro as processed through the CDM had been, in many instances, amply justified. Under the CDM, some of the developers (and perhaps the governments) abused the difficulty of assessing whether subsidies via carbon

[7] Cited in Cames et al. (2016, 112-113).

credits truly met the additionality criterion, by submitting biased or opaque analysis to justify the additionality claim, or registering for CDM after the project had been completed without the subsidy (Haya 2007; Wara and Victor 2008; Schneider 2009; Bogner and Schneider 2011).

We can expect that the cynicism toward the potential for additionality of large hydro will continue in the post-CDM era unless the doctrine of additionality is refined and better mechanisms are developed. The problem is not that a substantial proportion of the initiatives will turn out to lack additionality on closer analysis, but rather that failing a better way to assess additionality, it is not known *ex ante* whether any given initiative will prove to have bona fide additionality. It is not yet clear how, under the Paris Agreement, additionality will be assessed, although its Article 6.4 calls for a mechanism to continue to trade credits for emissions reductions caused by specific projects. Some argue that large hydro projects should be disqualified as a class, based on the presumption that hydroelectric dams are lucrative without subsidies. Cames et al. (2016, 113) assert that: "Overall, due to the fact that hydropower is common practice in many countries, the limited impact of CER revenues on the profitability of hydropower plants and the competitiveness of hydropower with fossil electricity generation in many cases, we consider additionality of hydropower projects as questionable… especially for large hydropower."

This perverse conclusion—that because hydropower has long been a source of electricity generation, subsidies are unnecessary—flies in the face of the fact that so many dam initiatives have been stalled, impeding the progress toward replacing fossil fuels. The Cames et al. (2016, 31) conclusion that "many renewable energy projects – in particular hydropower – show a relatively high economic performance without CER [Certified Emission Reduction] revenues" only reflects the fact that hydro projects that were not permanently stalled can have high *ex ante* rates of return, but says nothing about whether environmentally and socially responsible hydro projects would require CER revenues or other subsidies. These denials of the potential additionality of hydropower projects miss the crucial point that it is not the hydropower projects that have been financed—many of which cause unacceptable harm—but rather the hydropower projects with responsible designs that cannot proceed without additional support. *The additionality is in rescuing responsible but otherwise insufficiently profitable hydropower initiatives.*

If invoking additionality to revise otherwise damaging hydropower projects becomes more widely accepted, two obstacles still would remain. First, the wherewithal to identify and cost out optimal sites and designs certainly is a challenge. However, the technologies for identifying more benign designs have emerged; Winemiller et al. (2016, 128) declare that "[p]owerful new analytical tools and high resolution environmental data can clarify trade-offs between engineering and environmental goals and can enable governments and funding institutions to compare alternative sites for dam building." Community involvement may help to dispel exaggerated fears[8]. If more benign designs are accepted as credible, the bonus is that less opposition can reduce the risk and volume of cost overruns.

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[8] Mahato and Ogunlana (2011, 7) assert: "By using proper design, environmental and social impact can be minimized. Community participation during planning and design stage will be helpful in finding the best project location and in producing economical and acceptable design."

One very promising initiative is the proposed Hydropower Preparation Support Facility.[9] This initiative is intended to work with governments to design responsible hydroelectric projects and facilitate auctioning the opportunities according to these designs. The collaborations with the Clean Development Mechanism (or its successor), various climate funds, the organizations behind the Climate Bonds and other Green Bonds, the international financial institutions, bilateral foreign assistance agencies, and so on, would provide the opportunities for the subsidies to be channeled to hydropower projects. The initiative received an endorsement from the World Wildlife Fund, as Moncrieff (2017, 53), then at WWF-UK, explained:

> Project preparation facilities are being used to prepare and de-risk projects and create a pipeline of 'bankable' projects. These include those initiated by public sector finance institutions (for example, ADB's Asia Pacific Project Preparation Facility16), and the recently initiated Hydropower Preparation Support Facility (HPSF)… HPSF will manage a fund to select and prepare the most appropriate type and location of hydropower projects. Approved projects will be auctioned for

[9] The Report of the 2019 World Hydropower Conference (International Hydropower Association 2019) makes no mention of the Hydropower Preparation Support Facility, nor does the International Hydropower Association's 2019-20 Annual Report. However, the Annual Report does state: "We are also collaborating with international partners on the role of project preparation facilities and the policy and market changes needed to fully reflect hydropower's contribution to evolving electricity systems" (International Hydropower Association 2019, 23). The 2020 World Hydropower Conference hosted a plenary session on the Hydropower Preparation Support Facility (Hydropower Power Conference 2020).

development; as a result, the developer pays for project preparation without the risk of the project not being approved. Such facilities are potentially powerful instruments to promote basin-wide planning approaches that consider cumulative impacts of dam projects.

<<Figure 4 about here>>

A facility like this would go a long way to reduce the costs and frustrations of developers who find that their initiatives are delayed interminably. It would also address the skepticism that the developers' information advantage would manipulate the analysis on which the additionality claim is based. However, establishing a sufficient rotating fund and gaining credibility will be challenging. Gaining sufficient endorsements from prestigious institutions to vouch for the integrity of the project design and approval process has to overcome the reputational risk posed by the possibility of heated criticism of the dams certified through the Facility. Therefore, if such an institution is established, it would have to be accompanied by a robust communication strategy to convince potential funders to dispel suspicions that it is just a smokescreen for marginally improved but still unacceptably damaging dam designs and siting.

Another initiative would be a mechanism through which governments entertaining developers' proposals could accept funds to improve the design of hydro projects in order to reduce the environmental and social risks. The developers would have an incentive to alter the design in order to reduce the risk of community opposition, the government would gain credit from the community, and—most importantly for the transition from fossil fuels—the chances that the dam initiative would come to fruition could increase with greater community acceptance.

However, institutional weaknesses on the *international* level also are impediments to the development and acceptance of responsible hydro projects. Cawley (2019) argues that ensuring responsible dam siting, design, and operations—and, by extension, credibility to attract more funding—requires an elaborate Consulting & Impact Assessment Function, ongoing monitoring, and an ombudsman function. However, he also points out that "the Mechanism's functions rely upon the participation of existing parties—e.g., other accountability mechanisms, IFIs [international financial institutions], and NGOs [non-governmental organizations]" (Cawley 2019, 1343). With respect to the crucial monitoring function, he notes that

> The largest obstacle in obtaining such a breadth of information would be host governments. The governments of developing countries often restrict access to or outright ban parties from investigating project impacts, especially when those investigations aim to undermine a project's development…Compelling host governments to allow such investigation would thus require the backing of IFIs, who could then put pressure on host governments to permit independent review of projects by lending project funds contingent upon their compliance with the Monitoring Function" Cawley (2019, 1347).

Yet, the Monitoring Function's dependence on IFIs is jeopardized by the decline in the influence of the long-standing international financial institutions in the face of both the aforementioned expansion of private capital and the rise of the Chinese-dominated Asian Infrastructure Investment Bank (AIIB) that began operations in 2015 (Weiss 2017; Wang 2019). It is unlikely that the AIIB would be as adamant as the World Bank, the Asian Development Bank, and other major IFIs in insisting on compliance with safeguards against excessive damage. The worsening institutional weakness is the declining influence of the long-standing IFIs, particularly the multilateral development banks such as the World Bank, the Asian Development Bank, the Inter-American Development Bank, and so on. Weiss (2017, 13) reports that: "Recent research finds that many developing countries increasingly avoid seeking MDB [multilateral development banks] financing, especially for large infrastructure projects that trigger safeguards policies, a longstanding priority for the United States and other advanced economies at the MDBs".

However, perhaps the most glaring current international institutional weakness is the lag in fleshing out a successor to the CDM. This would have to accommodate the designation of less profitable hydroelectric design and site alternatives as qualifying as additionality. The institutional landscape also is missing a widely accepted mechanism to identify proposed or potential hydroelectric projects, evaluate whether design and siting alternatives could substantially reduce the potential harms of particular projects, assess the magnitude of subsidy required to make such projects profitable, and convey this analysis to climate funds, the CDM successor, and other means to transfer funds to responsible hydro projects.

3.5 Problem 5: General Climate Funding Shortage. We are confronted with the fact that although strong rationales exist to find and subsidize responsible hydropower as well as other renewable facilities, and channels exist to bring the finance to the projects, currently available funding is woefully inadequate. Although some financing has been channeled through the CDM and the donation-based funds—even for hydro projects despite the criticism regarding their suspect additionality—the total volume of "climate finance" is falling far behind the investment needs. The funds have failed to secure adequate buy-in; regarding the international fund hoped to bear the highest weight, Cui et al. (2020, 95) lament that "[t]hus far, efforts of the Green Climate Fund (GCF) to mobilize finance have failed to meet the needs of developing countries for addressing climate change." The Climate Policy Initiative (2019, 30) reports that climate finance, *across all categories*[10], averaged $579 billion for 2017/2018, with renewable energy generation at $336 billion, yet "action still falls far short of what is needed under a 1.5℃ scenario. Estimates of the investment required to achieve the low-carbon transition range from USD 1.6 trillion to USD 3.8 trillion annually between 2016 and 2050, for supply-side energy system investments alone…". If investment in renewable energy generation maintains the same 58 percent of total climate financing going forward, $928 billion annually would be required; the recent investment volume is only 36 percent of the Climate Policy Initiative target.

Of course, the supply of climate finance is shaped by the demand, which in principle could be increased as the supply becomes more attractive. More initiatives could be financed if particular hydro projects can be shown to be responsible, or to have the potential to be responsible, and if they then could be publicized and brokered.

4. Discussion

Incorporating knowledge of the physical as well as economic constraints on solar and wind power potential places the subsidized financing of hydropower as the greatest imperative for decarbonization of electricity generation. The reality, though difficult for many to accept, is that solar and wind power have very limited future potential. Hydro power, with high potential and therefore the major promise for decarbonization, has had a checkered history that needs to be overcome through responsible designs. Designing hydroelectric dams to minimize environmental and socio-economic damage is the highest priority. However, these designs often will not be economically viable without subsidies. For subsidies to be channeled for this purpose, the application of additionality has to overcome the skepticism as to whether these initiatives truly

[10] "Climate finance" includes both mitigation and adaptation.

are subsidy-dependent, as well as sufficient confidence that the chosen projects are sufficiently responsible. The institutions required to develop and assess the projects, create the opportunities to secure adequate far more funding, and ensure responsible execution, require concerted action by the international community. An institution like the Hydropower Preparation Support Facility could assist in responsible project development. A successor to the Clean Development Mechanism could assess eligibility for subsidies and channel the subsidies. Climate funds and climate bond mechanisms could reinforce a CDM-like instrument. The combination of a consulting and impact-assessment function, monitoring, and an ombudsman function could strive to maintain responsibility, requiring international actors ranging from international financial institutions to non-governmental organizations.

5. Conclusion

The most agonizing environmental tradeoff is combatting global climate change at the expense of the environment and damage to local people. How can decarbonization be pursued in the face of rapidly growing demand for electricity in developing countries, when every renewable-energy source risks both environmental and socioeconomic damage—hydropower more than the others?

Yet, hydropower has to be the answer, because there is no other. This requires, however, overcoming the legacy of harmful dams, long-standing animus against dams in general, institutional weaknesses within the country, lower profitability of responsible projects, under-developed international institutions to recognize the need for subsidies, and the overall anemic international effort to fund decarbonization efforts.

The opportunities to accelerate the transition away from fossil fuels require the development of a nuanced doctrine of additionality, new mechanisms to identify promising and salvageable hydro and utility-scale solar projects, and great increases in the volume of funding.

The optimistic outlook would be that as more groups and institutions recognize that hydropower projects can be responsible and meet the additionality criterion, the volume of available finance may increase if viable projects are publicized and the connections with the funds and mechanisms are integrated.

Adjustments must proceed on three tracks: changes in the mindsets of environmentalists whose hopes are still on other renewables, commitments by government leaders to eschew the tempting opportunities to maximize revenues through dams that would cause serious damage, and stronger domestic and international institutions. Hopefully, as decarbonization becomes even more compelling and the limits on other renewables recognized, the anti-dam environmentalists will moderate their opposition. Hopefully, government leaders, recognizing that community resistance to damaging designs often provokes huge delays because of community resistance, will pass up the high-revenue, irresponsible dams. Finally, strong institutional recommendations have been formulated; now they must be implemented.

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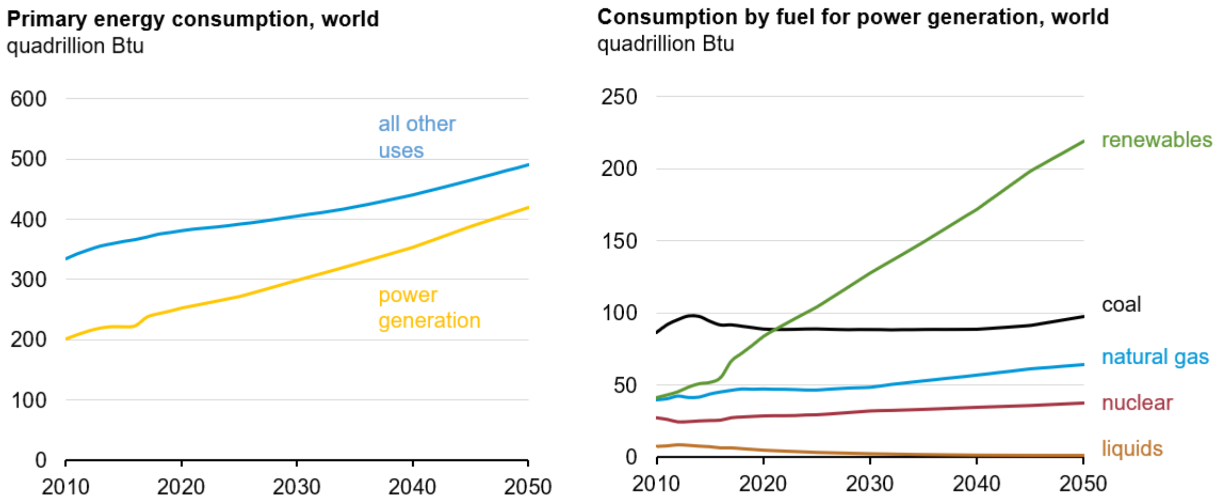
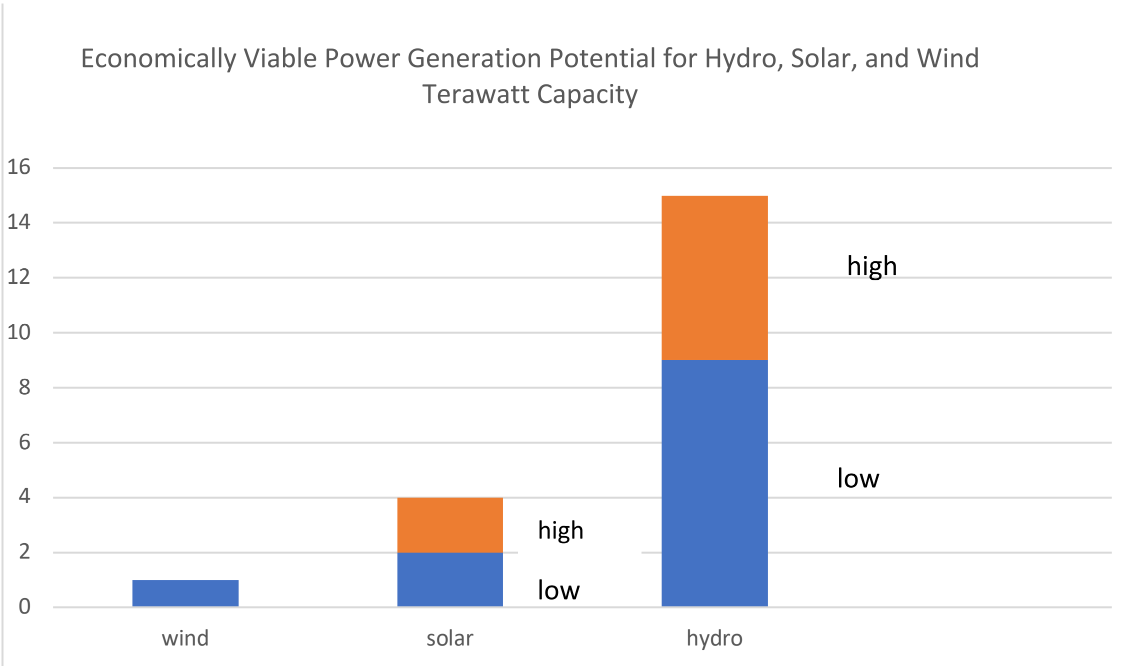
Figures 1 and 2



Source: U.S. Energy Information Administration, International Energy Outlook 2019

Figure 3



Sources: De Castro et al. 2011; De Castro et al. 2013; International Journal on Hydropower & Dams 2013; Zhou et al. 2015.

Figure 4 Hydropower Preparation Support Facility & a Monitoring Mechanism