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Governing the transition to renewable energy: A review of impacts and policy issues in the small hydropower boom

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ABSTRACT

The transition to renewable energy technologies raises new and important governance questions. With small hydropower (SHP) expanding as part of renewable energy and climate mitigation strategies, this review assesses its impacts and identifies escalating policy issues. To provide a comprehensive literature review of small hydropower, we evaluated over 3600 articles and policy documents. This review identified four major concerns: (1) confusion in small hydropower definitions is convoluting scholarship and policy-making; (2) there is a lack of knowledge and acknowledgement of small hydropower's social, environmental, and cumulative impacts; (3) small hydropower's promotion as a climate mitigation strategy can negatively affect local communities, posing contradictions for climate change policy; and (4) institutional analysis is needed to facilitate renewable energy integration with existing environmental laws to ensure sustainable energy development. For readers interested in small hydropower, we clarify areas of confusion in definition and explain the corresponding impacts for distinct system designs. For a broader readership, we situate small hydropower implementation within international trends of renewable energy development – the contradictory impacts of climate change policy, emerging dynamics in energy finance, and reliance on market mechanisms. Our paper provides a timely contribution to scholarship on small hydropower and the transition to renewable energy.

1. Introduction

The worldwide transition to renewable energy technologies raises new and important governance questions. Each technology proposed within global climate change mitigation policy produces varying costs and benefits from local to international levels. Development of small hydroelectric power (hereafter referred to as SHP) is frequently mentioned and actively promoted within climate change mitigation policies and many national-level climate and renewable energy policy frameworks. Sector reviews, academic literature, and financing trends in renewable energy indicate that SHP has gained significant traction over the last ten years, and continues to gain momentum. The World Small Hydropower Report (Small Hydropower World (SHW), 2013), published under the auspices of the UN, [2] states that there is 75 GW of installed capacity of SHP globally, with an additional 173 GW of potential remaining to be developed.

Although SHP contributes less than approximately 2% of total electricity generation, these projects are established in more than 150 countries and are often concentrated in mountain regions. While SHP may support the transition from fossil fuels to more sustainable electricity systems, the prevalent assumption that SHP is an inherently low impact technology (Bakiş, 2007; Boustani, 2009; Dudhani et al., 2006; Dursun, and Gokcol, 2011; Kaldellis, 2007; Khan, 2015; Khurana and Kumar, 2011; Nautiyal et al., 2011; Ohunakin et al., 2011; SHW, 2013; Yuksel and Dorum, 2011) is informed by little systematic analysis or debate. There is, in fact, growing evidence from case studies around the world that the current explosive growth in SHP is associated with a range of negative impacts and increasing social conflict.

For example, in British Columbia, Canada, hundreds of new SHP projects are planned with little government oversight or planning, leading to "willy-nilly industrialization of the landscape" (Shaw, 2011: 753), eroding public trust in energy governance (Shaw et al., 2015), and creating major challenges for public participation and consideration of local environmental impacts (Jaccard et al., 2011). In Turkey, plans for development of SHP have provoked conflict over private appropriation of land, water and forests, as well as environmental impacts (Başkaya et al., 2011; Islar, 2012; Konak and Sungu-Eryilmaz, 2015; Kucukali, 2014). In Norway, researchers find that the social impacts on activities such as hunting and recreation, as well as the

Abbreviations: SHP, Small Hydropower; SHW, Small Hydropower World; LHP, Large Hydropower; EIA, Environmental Impact Assessment; MW, Megawatt; ROR, Run-of-river; LCOE, Levelized Cost of Electricity; IRENA, International Renewable Energy Agency; CDM, Clean Development Mechanism

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cumulative environmental impacts which harm wilderness areas, endangered species, and landscape aesthetics, are more substantial per megawatt (MW) produced by SHP than for large hydropower (LHP) (Bakken et al., 2012, 2014). In Chile, SHP projects face local opposition from municipalities, the tourism sector, and indigenous communities (Susskind et al., 2014). In India, Kumar and Katoch (2015a) document struggles of affected communities for more robust employment, community development, and compensation for negative impacts. As these examples illustrate, conflicts involving SHP go beyond water use, touching on multiple resources, and involving a variety of actors and interests at different scales.

To better understand the scope and nature of conflicts, in this paper we address the lack of systematic analysis of SHP by providing a comprehensive literature review of trends in both academic and policy literature. Our approach to the review was informed by three general questions: (1) How is SHP defined in policy and academic contexts?; (2) What are the main impacts identified in the literature?; and, (3) How is SHP addressed within climate change and energy policy, and what are the governance implications? The review focuses on key themes that are useful in understanding the balance of costs and benefits associated with this set of technologies, and their relation to governance. A full analysis of the governance of SHP requires attention to both energy aspects – including electricity markets and arrangements of public and private actors in decision-making – as well as examining interactions with institutions that govern water and land use. Approaching SHP as a question of environmental governance includes considering the work of government and third party actors to coordinate resource use, assign rights to resources and resolve conflicts, as well as shape policy and regulation.[1] As such, we highlight what is being overlooked in current debates over SHP development and suggest ways that policies could more effectively address ongoing challenges.

Following introductory sections, the paper is structured around four key problems within the existing debate on SHP. The first two problems, apparent in academic literature, are addressed in Section 4. First, SHP is defined in a variety of conflicting and often misleading ways. As a category, SHP is often defined according to generating capacity with widely varying upper limits, and a broad range of system designs are grouped together under this label. We propose that system design is a more useful criterion for understanding SHP impacts and governance implications than generating capacity. In the literature on small hydropower, the type of system design is often overlooked, presenting an obstacle for comparative study and policy-making. The second problem is further complicated by the first. The impacts of SHP are underestimated and poorly understood in the climate mitigation and renewable energy policy literatures, in particular because they are so site-specific (IPCC, 2011). To address this gap, we outline the different system designs and their influence on impacts (Sections 4.1–4.2), and the sets of impacts drawn from case studies (Sections 4.3–4.7). The interconnection of the two problems creates some overlap in the section contents.

The next two problems, addressed in Section 5, received less direct attention in the academic literature, and are more apparent in international policy debates. First, SHP project implementation demonstrates the potential for conflict between climate change adaptation and mitigation. This presents paradoxical challenges for confronting climate change, from the local to international level. Second, international support of market mechanisms as the means to encourage renewable energy development and the role of public and private actors in the governance of energy finance (Newell, 2011) is resulting in institutional confusion and incoherence. Not only may reliance on market mechanisms overlook citizen participation in decision-making, but case studies also suggest that new policies are interacting with existing environmental laws in unintended ways. For example, renewable energy goals and financial drivers can stress national environmental laws and policies.

After examining each problem, in the concluding section we focus on critical factors shaping the balance of costs and benefits, in the hopes of advancing scholarship and informing more comprehensive policy-making for small hydropower. We use the term costs to discuss social and environmental burdens, however we note that applying an economic (price) based metrics to measure impacts can oversimplify cumulative and cultural impacts.

2. Background

In industrialized countries of Europe and the U.S., as well as other countries such as South Africa, industry engineers promote a future focus of SHP development on refurbishing previously developed dam sites and retrofitting irrigation canals and urban water supply systems (Bartle, 2002; Butera and Balestra, 2015; European Small Hydropower Association, 2004; Kosnik, 2008; Kucukali, 2010; Loots et al., 2015; Paish, 2002b). In contrast, case studies and articles focused on identifying small hydropower potential suggest that in much of the developing world, growth is oriented to new 'high head' sites, located in mountainous regions (Al-Juboori and Guven, 2016; Boustani, 2009; Dudhani et al., 2006; Durson and Gokcol, 2011; Khurana and Kumar, 2011; Kusre et al., 2010; Larentis et al., 2010; Purohit, 2008; Rawat et al., 2013; Rojanamon et al., 2009; Sharma et al., 2013; Zarfl et al., 2015; SHW, 2013; Yi et al., 2010).[2] High head sites are those that have steep elevation gradients, or relief, and typically occur in mountainous terrain (Anderson et al., 2015; IPCC, 2011; Paish, 2002b). Without overgeneralizing these regions, we can say that the development of SHP in mountainous areas that are sensitive to climate change and rich in biodiversity and cultural importance raises a common set of issues globally.

In mountainous landscapes with less infrastructural development, the impacts of hydropower construction, particularly through habitat fragmentation, are more significant than in river basins with existing infrastructure such as dams and roads (Anderson et al., 2008; Bakken et al., 2012). These changes can provoke profound social impacts (Abbasi and Abbasi, 2011; Bakken et al., 2014; Kumar and Katoch, 2014b, 2015b; Lazzaro et al., 2013; Pinho et al., 2007; Premalatha et al., 2014). Rivers and surrounding landscapes are culturally significant in many societies, in particular for indigenous people (Durning, 1993; Toledo, 2001). Since mountainous regions are currently experiencing faster than average rising temperatures and increasing hydroclimatic variability (IPCC, 2007), promoting infrastructural development may place additional pressure (costs) on vulnerable ecosystems and the people who rely on them for their livelihoods. On the other hand, depending on how SHP is developed, it may provide benefits (low cost electricity, access roads, development programs) that support local communities and their ability to adapt to changing circumstances.

In many nation states, SHP is often misconstrued as benign, which is used to justify minimal regulation and oversight (Premalatha et al., 2014). We suggest this stems from policymakers' lack of knowledge and acknowledgement of the impacts associated with individual projects as well as the cumulative effects of developing multiple projects in a river basin. Failure to consider the site-specific impacts of SHP projects illustrates the importance of governance arrangements, i.e. policy, regulation, and decision-making, in determining how the costs and benefits of SHP are distributed. These arrangements largely dictate how projects are planned and sited, and the role of local communities in these processes.

[1] We follow similar definitions by Bauer (2015) and Lemos and Agrawal (2006).

[2] See the Small Hydropower World (2013) for additional information on SHP potential by nation state and region.