



Estimating willingness to pay for greenhouse gas emission reductions provided by hydropower using the contingent valuation method



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ABSTRACT

Altering existing operations of large hydroelectric dams in the US, for such reasons as improving downstream environmental habitats and recreation, often constrain the production of hydropower. This results in increased use of electricity from fossil fuel based power plants, which emit greenhouse gases (GHG) that promote global climate change. However, the economic value of hydropower GHG reductions remains unmeasured in the US context. Using a recent proposal to re-purpose operations of Glen Canyon Dam, the largest producer of hydropower on the Colorado River, this study estimates US households' willingness to pay using the contingent valuation method to preserve GHG reductions provided by current Glen Canyon Dam operations. Results indicate that US households are willing to pay an additional \$3.66 per year in increased taxes to prevent increases in GHG emissions due to proposed re-purposing. This study has important policy implications for the role of hydropower in the renewable energy portfolio.

1. Introduction

Due to government mandates, advocacy coalitions, and changing public opinion, policymakers are often tasked with deciding between alternative operational arrangements of existing hydroelectric dams. In the US, much of the focus of dam re-purposing has historically been on improving downstream environmental and recreation conditions (e.g., Doremus and Tarlock, 2003; Welsh et al., 1995). However, in an era of increased understanding of the couplings between human and natural systems, it is becoming increasingly difficult for policymakers to ignore the extended social impacts of dams produced through the sale and distribution of hydropower.

Hydroelectric power is often associated with both positive and negative social externalities. On one hand, low-cost hydropower is associated with rural community viability, the economic livelihoods of farmers and ranchers, and provides fossil fuel offsets which reduce harmful air pollutants and greenhouse gas (GHG) emissions – see Mattmann et al. (2016). On the other hand, the hydropower production process is not totally free GHG emissions and is associated with downstream species habitat loss and lost recreational opportunities—see Jones et al. (2016). Owing to increased public discourse and mounting political pressures to include the social impacts of hydropower in official records of decision and environmental impact statements on dam operations (Jenkins-Smith et al., 2016), there is a need for additional

research on the economic value provided by hydropower externalities, especially in the US context where the extant literature is thin. In particular, the relationship between hydropower and climate change is an area of increasing public interest (Mattmann et al., 2016).

Hydroelectric dams are seen as an important renewable energy source that help reduce GHG emissions. Former President Obama publically called for increased federal investments in hydropower in order to reduce US carbon emissions. The 2015 COP21 Paris Climate Conference included discussions on how hydropower can be used within a renewables policy framework to reduce global GHG emissions (International Hydropower Association, 2016). Many countries including China, Brazil, and the US are using hydropower to help meet their COP21 GHG reduction commitments.

While discussions of GHG emissions are increasingly being incorporated into conversations around dam re-purposing (e.g., see the Glen Canyon Dam Draft Environmental Impact Statement, US DOI, 2015), little is known, especially in the US, about the value that the public-at-large places on GHG-specific reductions provided by hydropower. Existing studies, with the exception of Longo et al. (2008) in the UK context, have focused on general air pollution (e.g., non-GHG and GHG emissions) and air pollution-related human health impacts of hydropower (Mattmann et al., 2016). By contrast, this study seeks to isolate the specific value that the public places on reduced GHG emissions and associated climate change impacts of hydropower. That is, we

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seek to separate the GHG-climate change externalities of hydropower from the general air pollution and human health externalities.¹

Particularly, we use results from a nationally-representative non-market valuation survey of the US public on management of the Glen Canyon Dam, the largest producer of hydropower on the Colorado River, to estimate willingness to pay (WTP) for a small reduction in GHG emissions and climate change impacts brought about by maintaining existing dam operations compared to changing them as recently proposed by US government agencies. That is, we identify the intensity of support for hydropower as a reducer of GHG emissions using an actual proposal that was recently considered by the US Department of the Interior (DOI). WTP is estimated using the contingent valuation method (CVM), a widely used approach for estimating non-market, non-use values for public goods. To the best of our knowledge, this is the first such WTP estimate in the US context where hydropower has a long and contested history. This information can be used in benefit-cost analyses of re-purposing hydroelectric dam operations where, as is so often the case, there exist external social impacts that members of the public value.

The remainder of the paper is structured as follows. In Section 2, background information on Glen Canyon Dam, the GHG impacts of proposed operational changes in its management, and prior literature on this topic are provided. Section 3 presents the CVM survey and design and the econometric models used to estimate WTP. Section 4 presents results on how responses to the valuation question vary across observable respondent characteristics and also provides estimates of WTP across several different specifications. Finally, Section 5 provides conclusions and policy applications.

2. Background on Glen Canyon Dam and its impacts on GHG emissions

Constructed between 1956 and 1966, Glen Canyon Dam (GCD) is located on the Colorado River in northern Arizona and is a significant source of hydropower in the Western US, providing 11,599 MWh of electricity per day to the US states of Arizona, Colorado, Nebraska, Nevada, New Mexico, Utah, and Wyoming (US DOI, 2015). Beginning with the 1996 US DOI Record of Decision, GCD has increasingly been managed to improve downstream environmental conditions and recreational opportunities in the Grand Canyon, which is located less than 20 miles from the dam. This has been achieved by moderating daily fluctuations in water releases and using high intensity, short duration releases to rebuild downstream environmental habitats (US DOI, 1996).

Further flow moderations that would change GCD operations were recently considered by the US DOI as part of a 2015 federally-mandated long-term adaptive management plan (US DOI, 2015). Under the 2015 DOI's preferred alternative, GCD hydropower generation is expected to decrease by 1.1%/day and marketable capacity will decrease by 6.7%, requiring an estimated 4.8% increase in system-level generating capacity additions over the next 20 years, which will largely come from gas and coal power plants (US DOI, 2015). This policy proposal is expected to increase regional GHG emissions by 22,908 metric tons (MT) per year (0.042% of total US emissions), equivalent to the annual emissions of 4874 automobiles (US DOI, 2015). The Colorado River Energy Distributors Association estimates that in 2010 hydropower from GCD offset 3 million MT of carbon (CREDA, 2010). Hence, the DOI preferred alternative would reduce by approximately 0.76% the annual GHG offset provided by GCD hydropower.

Missing from discussions on operational changes to GCD is economic evidence on the GHG and climate change externalities that re-

purposing would have. Evidence from nationwide surveys in 2008 and 2014 found that large majorities of US residents consistently characterized hydropower as clean, safe, and renewable (Jenkins-Smith et al., 2015). In 2015, hydropower accounted for 6% of total US electricity generation (US EIA, 2016), displacing an average of 225 million MT of carbon per year (US DOE, 2016). The US Department of Energy estimates that over 2017–2050, existing hydropower capacity will reduce cumulative GHG emissions by 4.9 billion MT (US DOE, 2016). Members of the US public may hold non-market (as opposed to market) values for the GHG offsets provided by hydroelectric dams, such as GCD. Put differently, the public-at-large may be willing to pay to maintain existing GCD operations as a way to avoid anticipated increases in GHG emissions that re-purposing would create.

With one exception (i.e., Longo et al., 2008), existing research on hydropower externalities has measured the value of “general air pollution impacts” that dams have, which tend to combine GHG emissions, non-GHG emissions (e.g., particulate matter), visibility, and human health outcomes tied to air pollution (e.g., Klinglmair et al., 2012; Ku and Yoo, 2010; Bergmann et al., 2008). Since there is a cause and effect relationship between air pollution, GHG emissions, and climate change, the extant literature has therefore implicitly estimated non-market values for the GHG-climate changes benefits that hydropower provides. However, and more importantly, existing estimates will also contain values associated with other air pollution-related externalities (e.g., non-GHG emissions, human health, visibility), and are therefore likely to overestimate the specific GHG-climate change externality. By contrast, this study seeks to isolate the GHG-climate change externality from other air pollution externalities.

To the best of our knowledge, there is only one other study that has estimated WTP for climate change specific GHG reductions provided by a renewable energy portfolio that included hydropower, however, it was in a non-US context (Longo et al., 2008). Longo et al. (2008) find that UK residents are willing to pay £29.65 for a renewable energy policy that includes hydropower that decreases national GHG emissions by 1% a year. We might expect different values in the US because of the greater contribution that hydropower has to the overall energy portfolio and because of the contested history of US dams in the public discourse.²

The contribution of this study is to capture for the first time in the US context the non-market value of avoided GHG emissions and climate change impacts associated with proposed changes to hydropower production at a large US dam. Given that hydropower continues to play an important role in energy production in the US and elsewhere, there is a need for such information in order to help policymakers juxtapose the downstream environmental impacts of dams with the hydropower benefits held by members of the public (i.e., a green-vs-green tradeoff).

3. Methods

3.1. Survey data and design

A nationally-representative internet-based survey on management of GCD was fielded by the University of Oklahoma's Center for Energy, Security, and Society. The survey was developed in coordination with scientists and subject-matter experts from multiple organizations and agencies. Following development, the survey underwent rigorous pre-testing that included an open-ended survey of stakeholders from a farm association, a species conservation group, and an electric power distribution association on the Colorado River, and cognitive interviews of participants who were unfamiliar with the subject-matter. Following

¹ Naturally, air pollution and climate change externalities are related; the latter is likely a subset of the former. We do not dispute that. Rather, we try to isolate the economic value that the public places on the GHG and climate change externalities of hydropower from other externalities of air pollution (e.g., non-GHG emissions, human health, visibility).

² As a recent example of the on-going discourse over dams, former commissioner of the US Bureau of Reclamation, Dan Beard, has published a book calling for the removal of many US dams and the abolishment of the Bureau of Reclamation, which is the Federal agency tasked with overseeing dam building and operations (Beard, 2015).

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