Estimating Non-Use Values for Alternative Operations of the Glen Canyon Dam: An Inclusive Value Approach

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Center for Energy, Security & Society
A Joint Center of The University of Oklahoma & Sandia National Laboratories
Water, Non-Market Values, and Why it Matters

- The set of resources selected for valuation drives the results of non-market analyses
  - Non-Market valuation is a critical (often dominant) element of BCAs affecting storage, distribution and hydropower systems
  - History of damage assessment has led CV to be myopic
    - Narrow focus on environmental & recreational values
    - Presumes “uncontested values”
  - Tends to ignore other critical values in complex, coupled systems
- More broadly, BCA is a framework for balancing potential market and non-market losses against gains
  - Required of all major federal policies
  - The inclusion of all relevant categories of resources at risk is critical to providing balanced analysis to decision-makers
Overview of Research

- Logic of non-use, non-market valuation in *complex human and natural systems*
  - Hydropower, as a component of a larger system, operates to provide multiple dimensions of both market and non-market values
  - In part, inclusion of the relevant dimension of value provides guidance for research on implications of operational decisions
  - Recent focus has been on the Glen Canyon Dam – but the implications are much broader

- CES&S has examined how the set of resources selected for valuation affects results of non-market analyses
  
  Our focus today is on the research protocol necessary for an inclusive study of the non-market value implications of altering dam operations in a coupled human/natural system
Valuation in the Anti-alternative operation
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Abstract
Estimating willingness to pay for greener power provided by hydropower using the cc

1. Introduction
Due to government mandates, advocacy coalitions, and public opinion, policymakers are often tasked with deciding between alternative operational arrangements of existing hydroelectric power plants in the US. The focus of this paper is an empirical study of existing hydroelectric power plants in the US. The study is based on the relationship between the social costs and the operational costs of hydropower plants. The study is based on a survey of 500 households in the US. The survey was conducted between January and March 2018. The survey results were analyzed using a regression model. The results of the regression model indicate that the social costs of hydropower plants are significantly lower than the operational costs. The study also shows that the public is willing to pay more for greener power provided by hydropower. The findings of this study have important implications for policymakers. The results suggest that policymakers should consider the social costs of hydropower plants when making decisions about the operation of these plants.

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Overview of Protocol

- Loomis non-use value report (2014)
- Replication of early non-use value estimates
  - Experiments and proof of concept (2014)
- Analytical literature review (2015-2016)
  - Sandia White Paper
- Text analysis of public hearings on dams and hydropower (2015-2016)
- Survey 1: Stakeholder perspectives (2016)
- Survey 2: Value Demonstration and Definition (VDD) Survey (2016)
- Survey 3: Value Elicitation Survey (VES) (2016)
Characterizing the Change

♦ Non-use value impacts can be quite diverse
  • Predominant focus (form damage assessments) has been on environmental resources
  • Changes in cultures that are important to the publics’ sense of history, identity, diversity
  • Changes in land use that result from alterations in patterns of production

♦ Changes in complex systems may extend beyond the proximate source of change
  • Outside the immediate reach of the river below the dam

♦ Formal governmental venues for public input provide an open, credible source for identification of the affected values
  • We focused on aggregation and coding of public testimony at Congressional hearings
Text analysis of public testimony

- From 1995 to 2013, congress held 34 hearings that included 409 statements by 344 individuals about hydropower, water storage, and/or dams in the US
  - Government (68%)
  - Non-government (32%)
  - National/Regional (60%)
  - State (13%)
  - Tribal (5%)
  - Local (22%)
  - Energy (14%)
  - Water (16%)
  - Environment (14%)

- In these statements, individuals expressed policy preferences and justified their preferences by invoking one or more dimensions of value:
  - Culture (10%)
  - Recreation (6%)
  - Water (52%)
  - Hydropower (22%)
  - Economy (45%)
  - Environment (34%)
  - Governance (36%)

Hydropower (sentences)
  - Energy production (23%)
  - Cost of hydropower (26%)
  - Reduction of air pollution and/or fossil fuel consumption (33%)

"Hydropower enables the development of the region’s wind energy resource, because it can respond immediately to fluctuating energy demand and the intermittent nature of wind."
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Governance (sentences)
  - Legal expectation (25%)
  - Federalism (15%)
  - Bureaucratic burden (21%)
  - Coordination/collaboration (21%)
  “...landowners were told that they could lease the land back at the same rate until the project went through and that they could buy their land back for the same price if the project did not materialize. Neither one of those promises have been fulfilled.”
Survey #1: Stakeholder Perspectives

- Web-based survey conducted in March-April 2016
- Included listed leadership of three stakeholder groups
  - Farming
  - Species conservation
  - Power marketing
- Asked about relative priorities of value dimensions for deciding about GCD operations
- Focus is on identification of additional value dimensions not included in the DEIS
- Overall more than 23% of those contacted agreed to participate (some responded as groups)
Stakeholder identification of dimensions of value

- DEIS dimensions affirmed
- Air quality/visibility (air emissions)
- Greenhouse gas emissions
- Human health (air emissions)
- “Ways of life” for farmers and ranchers tied to a particular distribution of hydropower (sustainable rural communities and social inequalities),
- Climate change (air emissions)
- Governance (existing agreements, process)
Survey #2: Value Demonstration and Definition (VDD) Survey

- Nationwide Internet survey fielded June 18-21, 2016
  - 3002 completed surveys
  - Opt-in sample, based on large pool of willing respondents
  - Filtered to approximate national demographics
- *Not* intended to provide nationally representative estimates
- Results of VDD Survey were used in final design:
  - Technical input (e.g., “bid amount” ranges)
    - “Fat tails” problem identified
    - Use of fully randomized bid structure
  - Tests of relevance of dimensions of value for WTP
  - Tests of respondent comprehension and cognitive load
Survey #3: Value Elicitation Survey (VES)

- We utilized results of VDD Survey in final design
  - Technical input (e.g., “bid amount” ranges)
  - Comprehension and cognitive load
  - Relevance of dimensions of value for WTP
  - Model validation tests
- VES employed random sample of US residents
  - Permits inference from sample to households nationwide
VES Data

- 3017 interviews collected August 5-25, 2016
- Employed GfK’s online address-based sample
  - Non-internet households provided with devices and access
  - Provides a random sample of the US public
  - 54% completion rate (proportion of invited sample that completed an interview)
  - Sample closely mirrors the demographics of the adult US Census
  - Weights used to precisely match sample to Census
  - GfK sampling method compliant with the “Standards and Guidelines for Statistical Surveys” by the OMB
## Experimental Treatments

<table>
<thead>
<tr>
<th>Resource</th>
<th>Value Definition Survey [Track]</th>
<th>Value Elicitation Survey [Track]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3</td>
</tr>
<tr>
<td>River Beaches</td>
<td>X X X X X X X</td>
<td>X X X</td>
</tr>
<tr>
<td>Native and Non-Native Fish</td>
<td>X X X X X X X</td>
<td>X X X</td>
</tr>
<tr>
<td>Vegetation and Wildlife</td>
<td>X X X X X X X</td>
<td>X X X</td>
</tr>
<tr>
<td>Recreation and Tourism</td>
<td>X X X X X X X</td>
<td>X X X</td>
</tr>
<tr>
<td>Cultural Sites and Native Americans</td>
<td>X X X X X X X</td>
<td>X X X</td>
</tr>
<tr>
<td>Hydropower</td>
<td>X X X X X X X</td>
<td>X X X</td>
</tr>
<tr>
<td>Air Quality and Visibility</td>
<td>X X X X X X X</td>
<td>X X X</td>
</tr>
<tr>
<td>Health Effects of Air Pollution</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Farmers, Ranchers, and Associated Rural Communities</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Climate Change</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Additional Benefits of Hydropower</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Decision Making Process</td>
<td>X X</td>
<td>X</td>
</tr>
</tbody>
</table>
Assessment of Survey Respondent Confusion & Fatigue

(a) Information on Survey

- River Beaches
- Native and Non-Native Fish
- Recreation and Tourism
- Vegetation and Wildlife
- Cultural Sites and Native Americans
- Hydropower
- Air Quality and Visibility
- Health Effects of Air Pollution
- Farmers, Ranchers, and Rural Communities
- Climate Change
- Additional Benefits of Hydropower
- Decision Making Process

(b) Feedback on Survey

- The survey was confusing; I did not understand some of the information or questions
- The survey was too long; it was hard to stay focused the entire time
- The survey was irrelevant to me; I don't care about the Glen Canyon Dam
- There was not enough information on the survey for me to answer the questions
- The survey was interesting; I enjoyed the information and questions

Learned something new
Already knew the information
Don't understand the information

Percent
Estimate of Net Median WTP

• Multiple models employed, parametric and non-parametric
• Model controls in parametric model reflect familiarity with the GCD, preferences for hydropower, views of nature, and household income
• “Hypotheticality” in responses was addressed by including as “yes” votes only those who were very sure that they are willing to pay
• The data support the estimation of net median household WTP across the relevant options
  • Typically these will be a “no change” option and some option of particular interest (Jones et al 2018)
Implications

♦ This approach permits a balanced and inclusive set of non-use value dimensions within a complex, coupled human and natural system
  • Necessary to provide estimates when the value positions are contested within the population
♦ Required for valid measures of non-use values
  • Non-use value estimates are highly sensitive to omitted DOVs
♦ The inclusive value approach informs a research agenda on value impacts
  • Without it some domains are neglected, and allocations of research resources are suboptimal
Questions?

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Supplemental Slides
Publications


Related Works in Progress


## Voting Results for GCD Operational Preferences with Inclusive Treatment

<table>
<thead>
<tr>
<th></th>
<th>Number of respondents</th>
<th>Percentage of sample</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vote to Change Operations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Would pay &gt;$0 payment amount</td>
<td>54</td>
<td>5.2%</td>
</tr>
<tr>
<td>Would not pay &gt;$0 payment amount</td>
<td>56</td>
<td>5.7%</td>
</tr>
<tr>
<td>Not sure if would pay &gt;$0 payment amount</td>
<td>65</td>
<td>6.5%</td>
</tr>
<tr>
<td><strong>Vote to Continue Operations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Would pay &gt;$0 payment amount</td>
<td>218</td>
<td>21.7%</td>
</tr>
<tr>
<td>Would not pay &gt;$0 payment amount</td>
<td>217</td>
<td>20.4%</td>
</tr>
<tr>
<td>Not sure if would pay &gt;$0 payment amount</td>
<td>234</td>
<td>23.4%</td>
</tr>
<tr>
<td><strong>Would Not Vote</strong></td>
<td>155</td>
<td>17.2%</td>
</tr>
</tbody>
</table>
## Dimensions of Value by Source of Identification and Characterization

<table>
<thead>
<tr>
<th>Dimension of Value</th>
<th>Source(s) of Identification</th>
<th>Source(s) of Characterization</th>
</tr>
</thead>
<tbody>
<tr>
<td>River Beaches</td>
<td>Lit review, public hearings, stakeholder interviews</td>
<td>DEIS</td>
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<tr>
<td>Greenhouse gas emissions</td>
<td>Lit review, public hearings, stakeholder interviews</td>
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</tr>
<tr>
<td>Health Effects of Air Pollution</td>
<td>Lit review, stakeholder interviews</td>
<td>Lit review</td>
</tr>
<tr>
<td>Farmer/Rancher/Rural Communities</td>
<td>Lit review, public hearings, stakeholder interviews</td>
<td>Lit review</td>
</tr>
<tr>
<td>GCC Impacts of Hydropower</td>
<td>Lit review, stakeholder interviews</td>
<td>Lit review</td>
</tr>
<tr>
<td>Ancillary Hydropower Benefits</td>
<td>Lit review, public hearings</td>
<td>Lit review</td>
</tr>
<tr>
<td>Governance/Process</td>
<td>Public hearings, stakeholder interviews</td>
<td>Lit review</td>
</tr>
</tbody>
</table>
Estimation of WTP

\[ WTP_i = e^{x_i'\beta + \varepsilon_i} \]

\[ \Pr(WTP_i > Payment_i) = \Pr(\theta_i > \delta \ln(Payment_i) - X_i'\beta^*) \]

where \( \theta = \varepsilon/\sigma, \delta = 1/\sigma \)

and \( \beta^* = \beta/\sigma \)

\[ MD(WTP) = e^{x_i'\beta} \]

- WTP is estimated separately for those who prefer each option, weighted by the proportion of the sample that preferred each option
- The difference between them is “net” WTP (Carlson et al 2016)
Next Steps

♦ Evaluations of operational changes in GCD accounted for potential change in multiple dimensions of value, but could not address valuation for larger changes in the system
  - Evaluation of addition or reduction in capacity, such as modification/addition/removal of turbines at existing dams
  - Dam removal or addition

♦ Evaluation focused on a single (though large) component of a larger system (Colorado River system)
  - More general work would need to evaluate the implications of changes in that larger system
  - Alterations of working landscapes with extensive feedbacks among environmental services, hydropower, water storage, irrigation, flood control
  - All in the context of a changing climate