Public Willingness to Pay and Policy Preferences for Tidal Energy Research and Development: A Study of Households in Washington State

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Abstract

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Puget Sound in Washington State (WA) has significant tidal energy resources, but the industry is at a nascent stage of development. At this stage, the availability of research and development (R&D) funding plays a critical role in the success or failure of renewable energy schemes. However, information about public interest in developing marine renewable energy technology, including tidal energy technology, in WA and the U.S. has been limited. Responses to a dichotomous choice referendum question on a mail survey sent to a representative sample of WA households were used to estimate residents' Willingness To Pay (WTP) for tidal energy R&D. Public preferences for policies to support tidal energy R&D were also assessed. WA households

are WTP a median of $1.62 per month for tidal energy R&D, indicating public preference for an increase in public spending on tidal energy R&D over current levels. Public perceptions of potential social, environmental, and economic risks and benefits of developing tidal energy emerged as highly significant predictors of WTP.

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Chapter 1. INTRODUCTION

Over the past 30 years, concerns about the impacts of greenhouse gas emissions have grown in the global political arena. At the same time, expenditures on energy R&D in the United States by both the private and public sector have been flat or declining since the late 1980s (Nemet and Kammen, 2007). Declines in spending are largely a result of the deregulation of the U.S. electricity sector, diminishing private sector interest in nuclear energy R&D, and inconsistent renewable energy R&D subsidy policies (Nemet and Kammen, 2007). This has resulted in levels of funding that are inadequate to meet the rising challenges of developing new renewable energy technologies. This funding situation may change in the near future, as renewable energy R&D has come to the forefront of climate change policy discussions and unprecedented levels of new private and public investment in renewable energy R&D were pledged alongside the Paris Agreement (Davenport and Wingfield, 2015). This elevates the importance of understanding how to provide funding support for early stage energy technologies in ways that align with public preferences.

Tidal energy resources consist of differentials between high and low tides created by the gravitational interaction between the sun, moon, and earth's oceans (Tsantes, 1974). Elevation differences between high and low tides can be exploited directly for electrical power generation, and there are two prominent types of technologies that are being developed to capture this energy. A "tidal barrage" produces electricity through the placement of dams in a basin or estuary situated to capture the energy in the difference between high and low tides (analogous to conventional hydroelectric dams). Tidal current energy turbines can harness the energy generated when elevation differences between high and low tides produce strong currents (analogous to wind energy). This study is specifically focused on tidal current energy, which is referred to as in-stream tidal energy in the survey instrument. Tidal energy is a clean, renewable energy resource and because of its gravitational origin, predictable over the lifetime of a generation project (Denny, 2009). Turbines used to harness tidal current energy are an example of an emergent energy technology that is in the early stages of development and requires substantial levels of initial funding to move forward. To bring a tidal energy concept from conceptual inception to readiness is generally estimated to require investment in excess of $100 M.

Tidal energy technology is currently being developed globally; however the devices that are presently in operation are prototypes. The first commercial project in the world is MeyGen, located in the United Kingdom. The first phase of the project, consisting of four megawatt-scale turbines is likely to be fully commissioned by the end of 2016. Pending the outcome of environmental studies, the project may be authorized to expand to an array of several hundred turbines (Meygen, 2016). In the U.S., there are currently no fully commercial-scale arrays permanently deployed. As a result, there have been few opportunities for the public to gain exposure to this type of technology and a lack public knowledge about tidal energy is recognized as a source of possible bias in this study. Several explanations have been advanced for why this technology has yet to progress to the fully commercial level. These explanations include public opposition to the siting of individual projects, lack of a precedent for governance structures and regulatory processes, uncertainty about environmental effects, competition with multiple other uses of the marine environment, technical development issues, and high economic costs of tidal energy development (Kerr et al., 2014).

Puget Sound in Washington state is an area where tidal energy holds the potential to supply a significant percentage of local energy needs (Polagye et al., 2009). However, no tidal energy projects have advanced beyond the planning phase in Puget Sound. A recent project proposed for Admiralty Inlet in Puget Sound was cancelled in 2014 before deployment due to high development costs relative to the level of available public financing (Vaughn, 2014). Marine renewable energy project costs are frequently increased by unforeseen social, economic and environmental concerns raised by various stakeholder groups, as well as costs related to regulatory compliance. Such project difficulties point to the importance of identifying areas of social, economic, and environmental risks and benefits before future projects are developed.

Currently about 75% of the electricity produced in the state of Washington (WA) comes from hydroelectric sources, but there is strong interest in developing other types of renewable sources in the state to supplement hydroelectricity (U.S. Energy Information Administration Service, 2015). In 2006, WA state residents voted for an initiative that mandates a Renewable Portfolio Standard (RPS), which requires large utilities in the state to generate at least 15% of their power from renewable sources[1] (not including traditional hydropower) by 2020 (WA Department of Commerce, 2015c). In 2013, The WA state legislature voted to create a clean energy biennial fund worth $76 million, to support clean energy projects in the "development, demonstration, and deployment" phases (WA Department of Commerce, 2015a).

Here we examine tidal energy R&D in WA from an economic and policy perspective. However, because the challenges associated with developing tidal energy are multi-faceted, the research design was informed by input from researchers in other disciplines in order to ensure that a full and diverse set of social, environmental, technical, and economic issues were addressed in our study. This research is nested within a larger project being performed by team of investigators that addresses the challenges of tidal energy development from an

[1] Renewable sources that count towards the RPS standard include water, wind, solar energy, geothermal energy, landfill gas, wave, ocean or tidal power, sewage gas, biodiesel, and biomass.

interdisciplinary problem-driven perspective. Engineers, fisheries biologists, oceanographers, physicists and social scientists are collaborating to understand the most sustainable way to develop tidal energy using multidisciplinary criteria.

The metrics that are typically used to value marine renewable energy projects[2] such as the Levelized Cost of Energy (LCOE) do not take into account the total economic value and non-market costs and benefits of investing in the development of this technology (Goldsmith, 2015). A recent summit of ocean energy industry stakeholders identified a lack of quantification of the total economic value of marine renewable energy R&D as one of the major challenges to industry development (Goldsmith, 2015).

The objectives of this study are two-fold, first to assess public preferences for potential policy incentives and funding sources to support tidal energy R&D and also to understand the non-market values associated with tidal energy R&D in WA through investigating public Willingness to Pay (WTP). Contingent valuation methodology is used to investigate how previously-untested constructs from environmental psychology affect WA state households' WTP for tidal energy R&D.

Chapter 2. PREVIOUS RESEARCH

2.1 INNOVATION THEORY

The key economic challenge inherent in science and technology innovation theory and currently hindering the development of marine renewable energy projects occurs when projects commonly become trapped and fail in the phase of development known as the 'valley of death' (Corsatea, 2014). The public sector generally provides the funding for basic research in the early stages of

[2] A blanket designation generally taken to refer to power generation from waves, currents (ocean, tidal, and river), thermal gradients, and salinity gradients.

marine renewable energy development and the increasing market pull allows the private sector to supply most of the financing of these resources once the technology reaches a commercial scale (Leete et al., 2013). This often leaves an inevitable gap in funding sources in the pre-commercial phase. The 'valley of death' includes the full-scale prototype construction, testing and deployment stages of technology development. The risks associated with investments at this phase of development are especially high for marine renewable energy, because devices must be tested in the marine environment, where there is a risk that devices could be damaged or lost. There is also a high degree of uncertainty about many aspects of the new technology, including public acceptability, market potential, and consistency of funding support policies (Corsatea, 2014).

2.2 Policy Support

We had an interest in understanding public support for financial policies and funding sources that could be used help specifically bring tidal energy to commercialization. Several governmental financial policies have been employed to support the development of tidal energy projects in other states and countries. Similarly, successful policies have been shown to bring other types of alternative energy technologies to market but such policies are not currently employed for tidal energy in WA. Consequently, in addition to assessing WTP, we surveyed residents' opinions on a subset of policies that tidal energy researchers believe hold the most potential for tidal energy, including Technology Innovation Systems (TIS), green loan guarantee programs, community feed-in-tariffs, and contract for difference policies. These policies are described in the following paragraphs.

Technology Innovation Systems (TIS), or innovation clusters can be defined as "localized groups of companies developing creative products and services within an active web of collaboration that includes specialized suppliers and service providers, universities, and research institutes and organizations" (Wessner, 2013). The presence of all these different actors in one regional location allows knowledge to diffuse faster between them (Corsatea, 2014). TIS also allow for the creation of 'nursery markets,' which are support mechanisms for early-stage tidal energy development, such as government-supported facilities for device testing. TIS have shown promise for tidal energy development in Europe and could help support tidal energy through the 'valley of death' in ways that other market-based policies cannot through the creation of nursery markets and acceleration of knowledge diffusion (Corsatea, 2014).

In the 1970s the U.S. government developed a green loan guarantee program to assist commercial developers with the construction of alternative energy source projects (Herrick, 2003). A traditional loan guarantee agreement allows the government to assume the loan if the developer defaults. The purpose of these programs is to help draw private capital into stages of technology development that are considered risky to finance, such as testing or scaling projects up to a commercial level (Herrick, 2003). Marine renewable energy projects in Washington are currently eligible for a type of loan guarantee program called a Clean Energy Revolving Loan Fund Grant available through the WA state Clean Energy Fund (WA Department of Commerce, 2015b).

The community feed-in-tariff is another policy that has shown promise for supporting tidal and wind energy development in the Bay of Fundy. This type of policy specifically provides support for community-based tidal energy projects through mandating that community-level developers be paid higher rates for the electricity they produce from tidal sources relative to other more advanced renewable energy technologies (Mudasser et al., 2013).

A contract for difference is a government subsidy policy for renewable projects that supply electricity to customers (DECC, 2013). Through a contract for difference policy, the government enters a contractual agreement with renewable energy producers. The government agrees to pay the difference between the market price for electricity generated by these producers and a previously agreed upon fixed price based on the cost of electricity generation for a specific type of renewable energy. In return, the producers agree to repay the government when the market price goes above the fixed price. Contract for difference policies have been used to reduce investor uncertainty and risk for tidal energy investment in the United Kingdom (DECC, 2013).

We also had an interest in understanding public preferences for which organization or institution should be responsible for funding tidal energy R&D. In terms of overall funding preferences, Wiser (2007) found that U.S. residents had a higher WTP for private-sector provision of renewable energy than public-sector provision. We had a special interest in determining public support for state-level funding, since the WA state government has committed to funding renewable energy R&D in general and tidal energy is eligible for support from the state Clean Energy Fund.

2.3 Previous Contingent Valuation Research

Contingent Valuation Methodology (CVM) is the standard non-market valuation technique for renewable energy technology (Mitchell and Carson, 1989). CVM combines economic theory and survey methodology to better understand how individuals value public goods, by asking them how much they would be willing to pay for the goods (Carson, 2000). A review of previous studies has shown that WTP for renewable energy is positively correlated with income, exposure to information about energy issues, environmental awareness, and level of education (Stigka et al., 2014). Studies have also shown that WTP is negatively correlated with age and size of household (Stigka et al., 2014).

Most previous CVM studies focused on renewable energy have asked about respondents' WTP for electricity supplied from renewable sources. Because several tidal technology pathways and project developments have been discontinued due to challenges related to securing funding in the R&D phase, the contingent valuation question was phrased specifically as WTP for renewable energy R&D, rather than electricity supplied from renewable sources[3]. Two previous studies have specifically focused on WTP for energy R&D (Li et al., 2009; Mueller, 2013). Li et al. (2009) found that U.S. residents were willing to pay a median monthly amount of $11.42 for general energy R&D. Significant predictors of WTP for energy R&D included income, gender, political ideology, and beliefs about the importance of energy issues, reducing dependence on foreign oil, and carrying out R&D on crop-based fuels. Mueller (2013) found that Arizona residents were willing to pay a mean of $17.03 per month for solar energy R&D. Belief in human-caused climate change was identified as a significant predictor. Specific to WTP for marine renewable energy, Kwak and Yoo (2015) found that Korean households were willing to pay a mean of $0.90 per month.

We specifically sought to investigate whether the psychological constructs of perceived risks and benefits were significant predictors of WTP. These constructs have not been included in other studies about WTP for renewable energy. In addition, previous studies have looked at perceived rewards and risks of wave energy development on the individual project or community

[3] The purpose of asking about WTP for general renewable energy instead of directly about WTP for tidal energy was to reduce issues associated with embedding. Bateman (2011) has shown that contingent valuation can be challenging when respondents have little experience with the good being valued. There was a concern that this might cause respondents to have a difficult time distinguishing their WTP for tidal energy R&D from their WTP for all or any other type of renewable energy R&D. Therefore, the purpose of asking later on about WTP for tidal as a percentage of general renewable energy R&D was to force respondents to think about their value for tidal energy relative to other types of renewable energy. Additionally, our results showed that respondents have low levels of knowledge about tidal energy, confirming Bateman's concern.

acceptance level in Europe, but no previous studies have measured the perceived benefits and risks of tidal energy development beyond the community level in the U.S (Bailey et al., 2011).

Chapter 3. SURVEY DESIGN AND DATA

We surveyed a random sample of WA state households by mail. We used a split-sample survey technique in which surveys were sent to an equal number of Puget Sound coastal and non-Puget Sound coastal WA state households. Coastal residents were defined as living within 15 miles of Puget Sound coast, where tidal energy resources are concentrated. Marine renewable energy technologies, like tidal energy, are likely to impact coastal residents and non-coastal residents in different ways and we wanted to understand if this leads to a difference in opinion about tidal energy development (Petrova, 2010). We anticipated that non-coastal residents would be under-represented in our sample and therefore we oversampled non-coastal residents to ensure that we could make comparisons between the two groups.

We received informal preliminary survey feedback from an interdisciplinary group of researchers at the University of Washington who conduct marine renewable energy work in a variety of disciplines including mechanical engineering, oceanography, applied physics, and fisheries biology. We then pre-tested the survey with a group of students and professors that attended a marine renewable energy seminar at the University of Washington. A more final version of the survey was subsequently pretested with two focus groups with members of the general public in Seattle, WA who were incentivized to participate with a $25 gift card (n = 7 n=8; respectively). Focus group members were selected to include a diverse mix of ages, races, incomes and other demographics.

We administered the survey according to a modified Tailored Design Method with an introductory postcard, survey, and follow-up reminder letter (Dillman et al., 2014). A one-dollar bill incentive and cover letter explaining basic information about tidal energy technology were included with the survey. The cover letter specifically explained that in-stream tidal energy is unique from hydropower dams and other types of marine renewable energy such as wave energy. To deploy the full survey, we purchased a sampling frame from InfoUSA.com and we mailed 3,000 surveys to a random sample of 3,000 WA state households in early July 2015.

The current study was part of a larger survey effort, and only items specific to this study will be discussed below (see Appendix A for full survey).[4] The first section began with a set of questions assessing state residents' knowledge level about tidal energy and specifically the current stage of development of the technology. The second section of the survey contained questions intended to reveal residents' opinions on specific economic policies to support tidal energy development and preferences for potential sources of funding. Statements about environmental, social, and economic risks and benefits of tidal energy development were also included. Risk and benefit constructs were developed from lists of perceived risks and benefits articulated by tidal energy researchers, a review of media pieces reporting the opinions of various stakeholder groups regarding the proposed tidal project in Admiralty Inlet, and feedback on perceptions of risks and benefits from a general public focus group.

The third section of the survey contained the WTP question and questions to ascertain certainty. An additional question was included in this section to distinguish respondents' WTP for tidal energy from other sources of renewable energy. The contingent valuation question featured a scenario that provided respondents with the choice to create a hypothetical fund to support general renewable energy R&D. The hypothetical scenario was developed using an

[4] See Dreyer et al. (In Preparation) for other results from the survey.

advisory referendum format instead of a voluntary response format in order to reduce hypothetical upward bias (Carson, 2001; Little and Berrens, 2004). Advisory referendum formats have proven to be incentive compatible (Carson and Groves, 2007). The CV question was as follows:

> *Suppose the state of Washington would like to create a fund that would support the research and development of renewable energy technologies by providing funds to organizations that work on either the research or the development of these technologies. Suppose a statewide referendum vote was held today. You could advise the WA state government whether to create the new renewable energy research and development fund. This fund would be created by adding a fee to WA households' electricity bills. The law states that money collected for this fund could only be used for the research and development of renewable energy technologies to make electricity.*
>
> *If the fee for creating this new renewable energy research and development fund would increase your household's electricity bill by $ per month, would you vote for or against creating the fund? Mark an X in the corresponding box.*
>
> *For   Against*

The CV question featured 12 different bid amounts ranging from $1-$100 that were randomly assigned to an equal number of households. Bid amounts were adapted from those of Li et al. (2009) and scaled to be monthly payments instead of annual payments. The scaled monthly $200, $150, $0.50 bid amounts used by Li et al. (2009) were excluded for this study in order to scale down from a national sample to a state sample and to reduce variance (Kanninen, 1995). Respondents were asked a follow-up question regarding their level of certainty about their response to the WTP question which was later used to recode results to reduce hypothetical upward bias (Champ and Bishop, 2001; Little and Berrens, 2004).

> *On a scale of 0 to 10, please rank how certain you are about your decision above by circling the number which best represents your answer.*

A second WTP follow-up question was asked to understand respondents' preferences for funding different renewable energy sources.

Hypothetically, if the referendum passed and the fund was created then the State of Washington could fund the R&D of multiple renewable electricity sources. Please show the proportion of the research and development funds that you think should be spent of each on the following renewable electricity sources: solar energy, offshore wind energy, wave energy, tidal energy, land-based wind energy, and geothermal energy.

The renewable energy sources were presented in reverse order in half the surveys to control for order effects. A seventh write-in option for other energy sources was also presented (see Appendix A). The fourth and final section contained questions about basic demographic information including political orientation and a provided room for respondents to leave comments.

Chapter 4. RESULTS AND DISCUSSION

4.1 Response Rates and Distribution

A total of 661 complete surveys and 21 partial surveys were returned, resulting in a 22.7%[5] response rate (N = 682)(American Association for Public Opinion Research, 2015). Survey responses received were split evenly between coastal and non-coastal resident groups, as the research design prescribed. The true population of WA state residents is more heavily distributed towards the coast. In order to ensure the dataset was representative of residents in the state of WA, the variable of coastal residency was used to weight the dataset according to pure proportional weighting procedures (Maletta, 2007). We assessed non-response bias through telephoning a random sample of 285 non-respondents and asked them to complete a short follow-up questionnaire featuring a few key questions from the survey[6]. A total of 21 non-

[5] Calculated according to the Response Rate 2 formula from the AAPOR standard guidelines

[6] Non-respondents and respondents did not differ significantly in their support for tidal energy or acceptability of tidal energy, providing no indication that residents with more favorable views towards tidal energy development were more likely to complete the survey (Welch's t-test, ps > .05) Non-respondent and respondent mean scores also did not differ significantly for significant predictors of WTP for tidal energy (ps > 0.1), indicating that WTP values are not likely to differ significantly between respondents and non-respondents.

respondents completed the questionnaire. Follow-up questions were selected based on a preliminary analysis of significant predictors of WTP.

The average respondent was more likely to be older, white, and male than the WA state average (U.S. Census Bureau, 2016). Respondents perceived themselves to be only somewhat informed about tidal energy in WA, indicating low overall levels of knowledge about the technology. Survey respondents did not have distinguishably different levels of education and income from the WA average (U.S. Census Bureau, 2016).

Table 4.1. Descriptive Statistics of Demographic Variables Tested in the Model

Variables	Items	Mean (S.D.)
Coastal	1 if resides within 15 miles of Puget Sound; 2 if resides elsewhere in state of Washington	1.350 (0.478)
Pay	Randomly-assigned bid amount ($1, $2, $4, $6, $8, $10, $20, $30, $40, $50, $80, $100)	28.460 (32.729)
Know	Respondent's perceived knowledge level about tidal energy in Washington state (1-5 scale) 1= very well informed, 2= well informed, 3= informed, 4= somewhat informed, 5= not informed	4.110 (0.897)
Education	1-5 scale (1=less than high school, 2=high school grad, 3=associate's or some college, 4=bachelor's degree, 5=graduate or professional degree)	3.580 (1.090)
Age	In years	63.010 (13.432)
Income	Annual Household income (2015 USD) 1= less than $10,000, 2= $10,000 - $14,999, 3= $15,000 - $24,999, 4= $25,000 - $34,999, 5= $35,000 - $49,999, 6= $50,000 - $74,999, 7= $75,000 - $99,999, 8= $100,000 - $149,999, 9= $150,000 - $199,999, 10= $200,000 or more 11= I Prefer Not to Answer	6.348 (2.157)
Gender	1=Female, 2=Male	1.310 (0.463)
Conservatism	1-7 scale (1= very liberal, 2= liberal, 3= moderately liberal, 4=neither liberal nor conservative, 5= moderately conservative, 6= conservative, 7= very conservative)	4.060 (1.614)

4.2 POLICY PREFERENCE RESULTS

Respondents believed that the federal government and private companies should be most responsible for funding tidal energy R&D, whereas local governments should be least responsible (Table 2). Results show that WA state residents do not prefer state tax dollars as a primary funding source for tidal energy R&D.

Table 4.2. Perceived Funding Responsibility for Tidal Energy R&D

Institution/Organization	Percentage	Institution/Organization
Federal government	37.5%	Federal government
Private companies	27.3%	Private companies
Public Utility District	12.8%	Public Utility District
Other	10.2%	Other
State government	9.1%	State government
None	2.1%	None
Local government	1.1%	Local government

Furthermore, respondents favored government funding for partnerships between public, private, and academic sectors to develop tidal energy technology. When respondents were asked how they would vote on a series of hypothetical ballot initiatives to support policies that have been used to fund tidal energy development in other countries or other types of renewable energy in the United States, increasing government funding for Technology Innovation Systems (TIS) emerged as the preferred policy support approach for tidal energy development. Nearly 78% of respondents would vote "Yes" on a ballot initiative to support TIS. Respondents were less likely to support subsidy-based policies for electricity supplied from tidal sources, as support was low for both a community feed-in-tariff policy (26.4% of respondents voted "Yes") and contract for difference policy (35.9% of respondents voted "Yes"). A green loan guarantee program was similarly unpopular (29.9% of respondents voted "Yes"). A preliminary analysis of respondents' open-ended comments revealed that many respondents were mistrustful of providing funding to either the private or public sector, but not both. It is possible that respondents' prefer a TIS approach, because they favor the type of public and private sector accountability that this approach provides.

Results from the WTP follow-up question revealed that respondents preferred a fairly even portfolio allocation of R&D funding to different renewable energy technologies. Respondents believe that the top renewable energy technologies to receive WA state R&D funding should be solar (21% of funds), tidal (19%), onshore wind (16%), geothermal (15%), offshore wind (13%), and wave (12%). Possible explanations for why respondents were more likely to pay for tidal energy than other marine and even land-based renewable energy sources include the fact that the technology is not visible from shore and that is currently the most prominent type of marine renewable energy technology being developed in the state.

4.3 WILLINGNESS TO PAY MODEL DESIGN

Generalized linear models allow for the modeling of binary choice or two outcome variables, such as the "for" or "against" outcomes of the hypothetical referendum question. In this case, Maximum Likelihood Estimation (MLE) was used to model WTP for tidal energy.

The WTP question was phrased to elicit respondents' preferences for general renewable energy R&D, but both the bid amount and the "For/Against" answer to the WTP question were recoded in order to modify the analysis to be specific to tidal energy. We employ a standard maximum likelihood estimation approach with an exponential probit model to estimate WTP, where β is an estimated vector of coefficients, x_i is an estimated vector of explanatory variables and μ_i is an error term.

$$WTP_i = \exp^{\beta' x_i + \mu_i} \quad (4.1)$$

The willingness to pay function cannot be observed directly, but we can use respondents' votes on the WTP referendum question to develop a latent indicator variable, P_i, which can be used to estimate a WTP function. In this case BID_i is the 12 bid amounts randomly assigned on the surveys, T_i is the percentage of the hypothetical fund that the respondent would like to see allocated towards tidal energy, and σ represents a variance term. If a respondent indicated they would be willing to allocate a percentage of the renewable energy R&D fund towards tidal energy, then the original bid amount was multiplied by the percentage allocated to tidal. Conversely, if respondents indicated that they would be willing to allocate funds towards other renewable energy sources but not tidal, then the "For" vote on the general renewable energy R&D vote was recoded to an "Against" vote.

$$P_i=1 \text{ if } LN(WTP_i)> LN(BID_i) \text{ and } T>0,\ P_i=0 \text{ otherwise.} \quad (4.2)$$

$$LogL=\sum\{P_i\log([1-\theta((\log(BID_i*T_i)-\beta'x_i)/\sigma)] +(1-P_i)\log[\theta((\log(BID_i)-\beta'x_i/\sigma)]\} \quad (4.3)$$

The Krinsky and Robb (1986) procedure was used to estimate the willingness to pay values and 95% confidence intervals using 5,000 draws.

4.4 Recoding for Uncertainty

Hypothetical bias is a concern when respondents' answers to a survey WTP question involving a hypothetical scenario are different than they would be willing to pay in reality. Champ and Bishop (2001) explored this issue by comparing answers from respondents who were offered an opportunity to actually pay for wind energy to those who were offered a hypothetical opportunity, and found the amount they were hypothetically WTP was higher than what they were actually WTP. They concluded that asking respondents a follow-up "certainty" question about their WTP answer and then recoding "Yes" votes to "No" votes for respondents who indicated that they were uncertain about their answers could reduce this hypothetical bias.

We applied the uncertainty recoding methodology from Champ and Bishop (2001) to this study, in line with previous studies on WTP for renewable energy R&D (Li et al., 2009; Mueller, 2013). In keeping with the procedure used in each of these studies, "yes" votes were recoded to "no" votes at certainty level cutoffs of less than 7, less than 8, and less than 9 on a ten-point scale. To illustrate, if data was recoded at the 8+ certainty level it would mean that if respondents circled a 7 or below, their WTP answer would be recoded as a No and if they circled an 8, 9, or 10, their WTP response would remain as their original answer. Maximum Likelihood Estimation results are presented using the raw dataset and datasets recoded at the 7+, 8+ and 9+ certainty levels for comparison (Table 3). Champ and Bishop (2001) found that recoding results at the 8+ certainty level produced the best estimates of actual WTP. Therefore all projections in this study were completed using data recoded at the 8+ certainty level.

4.5 Maximum Likelihood Estimation Results and Discussion

4.5.1 *Modeling WTP for Tidal Energy R&D*

The results discussed in this section are reported and discussed using four different models. The first model includes the full dataset and the next three models include datasets recoded at the 7+, 8+, and 9+ certainty levels respectively. Variables such as knowledge and psychological constructs like place-attachment were tested but did not produce the best model fit and were not included in the final regression output[7].

[7] Descriptions and descriptive statistics of all variables tested in the model is included in Appendix A

Table 4.3. WTP for Tidal Energy Maximum Likelihood Estimation Results

Variable	Full dataset	7+	8+	9+
(Intercept)	0.400 (1.135)	0.368 (1.133)	-0.984 (0.163)	0.0648 (1.222)
AGE	0.009 (.008)	0.006 (0.008)	0.007 (0.008)	-0.005 (0.010)
EDUCATION	-0.006 (0.110)	-0.139 (0.107)	0.066 (0.107)	0.061 (0.062)
COASTAL	0.0209 (0.210)	0.119 (0.209)	0.163 (0.207)	0.164 (0.226)
GENDER	-0.279 (0.245)	-0.202 (0.243)	-0.353 (0.246)	-0.265 (0.265)
CC_INDEX	0.264** (0.135)	0.152 (0.134)	0.121 (0.132)	0.094 (0.144)
CONSERVATISM	-0.202** (0.080)	-0.199** (0.079)	-0.168** (0.078)	-0.134 (0.083)
INCOME	0.0740 (0.058)	0.138** (0.058)	0.161*** (0.059)	0.037 (0.062)
BID AMOUNT	-1.123*** (0.021)	-1.056*** 0.104	-0.984*** (0.103)	-0.953*** (0.112)
ENVB_INDEX	0.782*** (0.138)	0.877*** (0.142)	0.867*** (0.142)	0.678*** (0.146)
Median WTP [95% CI]	3.30 [2.69, 3.96]	2.20 [1.75, 2.70]	**1.62** [1.23, 2.02]	0.96 [0.67, 1.27]
Mean WTP [95% CI]	4.90 [3.98, 6.48]	3.45 [2.77, 4.62]	2.71 [2.14, 3.72]	1.67 [1.30, 2.30]
Pseudo-R2	0.676	0.643	0.601	0.563
Log-Likelihood	-94.588	-97.53	-100.388	-81.851

Notes: 1. Standard errors are in parentheses 2. *, **, *** represent significance at the 0.10, 0.05, and 0.01 levels. 2. Numbers in parentheses are standard errors 3. Bid amounts are adjusted to the 80% certainty level 4. Dependent variable is the binary "for" or "against" response to the hypothetical referendum question 5. 95% confidence intervals were calculated using methods from (Krinsky and Robb, 1986) 6. Values of mean and median WTP are significantly different than zero for all models 7. CC_Index stands for Climate Change Index and EnvB_Index stands for Environmental Benefit Index

Perceived risks and benefits are belief constructs that have not previously been tested in other WTP for green energy development or electricity studies. These indices were standardized for comparison. When run in a model with data recoded at the 8+ certainty level, all three risk indices are highly significant predictors of WTP and negative and all three benefit indices are highly significant predictors of WTP and positive. The variables of social, environmental, and economic risks and benefits are also highly correlated (Appendix A). When each risk and benefit index was run in a separate model with data recoded at the 8+ certainty level, the environmental benefit index produced the best overall measures of model fit. In order to address concerns about multicollinearity, the environmental benefit index was the only risk or benefit index included in the final models. Descriptive statistics corroborate this finding, as the means for all the risk indices did not differ greatly and the same was true for the benefit indices. Index score means revealed that respondents tended to have slightly more neutral or undecided views about perceived risks than perceived benefits.

Results indicate that the more respondents believe that tidal energy will create environmental, economic, and social benefits, the higher their willingness to pay. Conversely, respondents with stronger beliefs that tidal energy R&D will create economic, social and environmental risks had a lower willingness to pay. Given that there are no tidal energy devices in Puget Sound, there is a lack of scientific data about the environmental, economic, and social impacts of tidal energy in the region. It is hard to study what does not yet exist. The results suggest that in the absence of this concrete information, participants' WTP to invest in the R&D of this technology was heavily influenced by their perceptions about the potential risks and benefits of developing tidal energy.

Table 4.4. Descriptive Statistics of Index Items

Variables	Items	Mean (S.D.)
Climate Change Index	Renewable energy is necessary to reduce human contribution to climate change Humans are contributing to climate change. Climate change is a problem, which deserves attention.	4.014 (1.034)
Economic Benefit Index	Developing tidal energy could help create a diverse energy portfolio in WA. Tidal energy development will create jobs in WA. Tidal energy can offer a sustainable form of energy	3.839 (0.528)
Social Benefit Index	The development of tidal energy in WA can provide a sense of pride for the region. Developing tidal energy fits in with the clean energy culture of our region. Having a local source of energy will benefit current and future generations.	3.793 (0.585)
Environmental Benefit Index	If implemented on a commercial scale, tidal energy can reduce carbon emissions. Tidal energy is predictable and therefore beneficial, because we can depend on it being available. Developing tidal energy in Puget Sound can increase local understanding of environmental and energy issues.	3.707 (0.566)
Environmental Risk Index	The moving blades of tidal turbine will injure marine mammals. The level of underwater noise from tidal turbines will harm marine mammals. Tidal energy devices will change ocean currents enough to harm ocean life.	2.945 (0.614)
Social Risk Index	Developing tidal energy in Puget Sound will disrupt existing fishing grounds. Tidal turbine platforms will disrupt the view of the water. A commercial scale tidal energy plant in Puget Sound would negatively affect my enjoyment of the area.	2.819 (0.636)
Economic Risk Index	Developing tidal energy is not a good use of taxpayers' money. The upfront costs of developing tidal energy will be too high. There is too much economic uncertainty to invest in tidal energy.	2.728 (0.713)

Notes: The following variables were measured on a 1-5 scale (1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4= agree, 5= strongly agree)

Political affiliation and income were generally significant predictors of WTP across all certainty models (Table 4). Therefore, the higher the respondents' income and the more that respondents consider themselves to be liberal, the higher the WTP. The coefficient for climate change index was significant in the model with the full dataset, but became non-significant in the models recoded for uncertainty. Because the full dataset may suffer from hypothetical bias, we cannot conclude that the belief that climate change is a human-caused problem that deserves attention contributes to a higher WTP for tidal energy R&D. Previous studies have shown that income (Stigka et al., 2014) and political ideology (Knapp et al., 2013; Wiser, 2007) have consistently been significant predictors of WTP for renewable energy with the same directional relationships. Additionally, we expected coastal residents to be more likely to benefit from tidal energy projects and thus be more likely to WTP for tidal energy R&D than non-coastal residents. The variable of coastal residency was not significant in any of the models, indicating that this is not the case.

4.5.2 *WTP for Tidal Energy R&D Estimate Projections*

Similar to Li et al. (2009) we used the median for projections, because it is considered to be a more robust measure of average than the mean. When the median WTP value of $1.62 for tidal energy R&D with data recoded at the 8+ certainty level is projected to reflect the amount that all 2.9 million[8] households in WA would be WTP, it equates to $57 million annually for tidal energy R&D. In comparison, the entire combined marine renewable energy and hydropower R&D budget for the U.S. Department of Energy Water Power Program in fiscal year 2015 was $60 million (Office of Energy Efficiency and Renewable Energy, 2016). Furthermore, the two-year budget for the state of WA's clean energy fund, which is the main source of state-level renewable energy R&D fund, is $76 million for a two-year time period from 2015-2017. The state has spent $0.6 million on marine renewable energy R&D to date (WA Department of Commerce, 2015b) The discrepancy between public WTP and government provision of tidal energy R&D funding can likely be explained by the idea that individuals associate non-market benefits with investing in tidal energy R&D. This is supported by the evidence that the non-market benefits of developing tidal energy, such as reduction of carbon emissions, having a local source of energy that will benefit current and future generations, and increasing local knowledge of energy issues were included in environmental and social benefit indices, which were significant predictors of WTP. In addition, these non-market benefits are not captured in metrics commonly used by the government to evaluate the cost of tidal energy projects, such as the Levelized Cost of Energy (LCOE).

4.5.3 *WTP for General Renewable Energy R&D*

Maximum Likelihood Estimation was also used to fit a model of WTP for general renewable energy R&D (Table 5). The model for general renewable energy R&D included the same variables as the model for tidal energy R&D with the exception that the variable of coastal residency was dropped from the general renewable energy R&D model, in order to produce a better model fit. Estimates for general renewable energy produced wider confidence intervals and less consistent estimates of the mean and median across uncertainty levels, as compared to estimates for tidal energy R&D. A likely explanation for this is that we asked about WTP tidal energy as a fraction of WTP for general renewable energy, which resulted in a narrower range of possible estimates for tidal energy R&D. Phrasing questions about WTP for a specific renewable energy source in this way could help reduce issues associated with embedding and produce estimates with smaller confidence intervals in future studies

Table 4.5. Mean and Median Willingness to Pay for General Renewable Energy R&D

	Full Dataset	7+	8+	9+
General Renewable Energy R&D Mean (CI)	39.73 (24.07, 100.00)	20.97 (13.22, 50.53)	20.54 (10.77, 91.22)	9.49 (4.77, 63.99)
General Renewable Energy R&D Median (CI)	7.33 (5.62, 9.36)	3.96 (2.84, 5.22)	1.85 (1.02, 2.81)	0.60 (0.21, 1.15)

Notes: 1. 95% confidence intervals were calculated using methods from (Krinsky and Robb, 1986)

Chapter 5. CONCLUSIONS

Recently, private investors and governments pledged unprecedented support for renewable energy R&D in conjunction with the Paris Agreement. This is likely to create push for both the development of new energy technologies and also demand for an acceleration of bringing these technologies to market. Studies such as the analysis presented here help ensure that funding is directed in a way that aligns with societal preferences along with market acceleration objectives.

Relevant areas of future research include expanding studies about policy preferences to technology developers and other relevant actors involved in the tidal energy R&D process. This study is limited in the fact that it only focuses on the state of Washington. Survey respondents preferred that the federal government be primarily responsible for funding tidal energy R&D, so expanding this study to a representative sample of U.S. residents may be appropriate. Future questions of interest include understanding why the Washington state public stated a preference for funding tidal energy over other types of marine renewable energy such as wave and offshore wind energy and understanding if the public prefers certain types of tidal energy technology.

Results from this study demonstrate that for the relatively early-stage tidal energy technology, providing R&D funding from both the private sector and federal government through a TIS approach would likely be popular with the public. We found that the previously un-tested belief constructs of perceptions of risks and benefits are strong predictors of WTP for tidal energy. Interdisciplinary collaboration on the creation of these indices helped to capture a robust picture of possible risks and benefits.

When median estimates recoded at the 80% certainty level are projected to the state level, we estimate that WA state households would be willing to pay $57 million annually for tidal energy R&D. The amount that WA state households would be WTP for tidal energy R&D is almost equivalent to the annual federal budget of $60 million allocated to marine renewable energy and hydropower R&D in fiscal year 2015 (Office of Energy Efficiency and Renewable Energy, 2016). In addition, the amount WA residents are willing to pay for tidal energy R&D is more than 100 times greater than the estimated $0.6 million that the state of Washington has provided to support tidal energy to date (WA Department of Commerce, 2015b). This indicates that WA state residents have in interest in developing tidal energy and would be in favor of a significant increase in tidal energy R&D investments over current public spending levels.

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APPENDIX A: SURVEY INSTRUMENT

Tidal Energy *in* Washington

A STATEWIDE STUDY OF
RESIDENTS' OPINIONS ON TIDAL ENERGY
AND HOW IT SHOULD BE DEVELOPED

University of Washington | Seattle, WA 98105 | 1-206-556-6562

Section One

Thank you for taking this survey. In this section, we would like to ask you about your knowledge of in-stream tidal energy, and where you like to get your information from. **In-stream tidal energy is a form of power that converts the energy from quickly moving water created by the tides into electricity that we can use** (see images on cover and information in the cover letter). In the rest of this survey, we refer to in-stream tidal energy as *tidal energy.*

1. Many people in Washington State are still learning about tidal energy as a potential resource for electricity. How informed do you consider yourself to be about tidal energy issues in Washington (WA)? **Mark an X in the corresponding box.**

☐	☐	☐	☐	☐
VERY WELL INFORMED	WELL INFORMED	INFORMED	SOMEWHAT INFORMED	NOT INFORMED

2. People like to use different media sources to find out information about current events and topics. **Over the next year,** how often do you think you will use each of the following sources to learn about **renewable energy** in WA?
Mark an X in the corresponding box.

	DAILY	WEEKLY	MONTHLY	QUARTERLY	YEARLY	NEVER
a. Newspaper (print / online)	☐	☐	☐	☐	☐	☐
b. Social Media	☐	☐	☐	☐	☐	☐
c. Community Meetings	☐	☐	☐	☐	☐	☐
d. Television News (broadcast / online)	☐	☐	☐	☐	☐	☐
e. Radio News (broadcast / online)	☐	☐	☐	☐	☐	☐
f. Information Website	☐	☐	☐	☐	☐	☐
g. Industry Conference	☐	☐	☐	☐	☐	☐
h. Other (please elaborate below)	☐	☐	☐	☐	☐	☐

____

3. Please indicate your level of trust in the following primary sources to supply you with information about **renewable energy** in WA **by marking an X in the corresponding box.**

	I DO NOT KNOW THIS SOURCE	NO TRUST	LOW TRUST	MEDIUM TRUST	HIGH TRUST
a. Academic Institution	☐	☐	☐	☐	☐
b. Utility District	☐	☐	☐	☐	☐
c. Federal Government Agency	☐	☐	☐	☐	☐
d. State Government Agency	☐	☐	☐	☐	☐
e. City Government	☐	☐	☐	☐	☐
f. Extension Agency (WA Sea Grant, WSU Extension)	☐	☐	☐	☐	☐
g. State Elected Officials	☐	☐	☐	☐	☐
h. County Conservation District	☐	☐	☐	☐	☐
i. Environmental Groups	☐	☐	☐	☐	☐
j. Magazines	☐	☐	☐	☐	☐
k. Other (please elaborate below)	☐	☐	☐	☐	☐

____

This question and some following questions ask you to think about *research and development,* commonly known as R&D. *Research* includes studies aimed at increasing scientific knowledge and understanding, and *development* is the use of the knowledge gained from research to produce new materials or to improve upon existing processes.

4. Please **mark an X in the one box** which most closely aligns with the stage of research and development that tidal energy is currently in, **within the US**. If you are not sure, just mark the last box.

	STAGE
☐	**Researchers have not yet begun to conduct research on tidal energy technology in the lab.**
☐	**Researchers are currently developing tidal energy turbines in the lab.**
☐	**Researchers have previously tested tidal energy turbines in the sea and have plans to continue to do so.**
☐	**Tidal energy turbines are permanently connected to the electricity grid and supplying energy to coastal communities in the US, but substantial public funding is still required to finance the devices.**
☐	**Several tidal energy power plants exist at the large-scale commercial level and these plants function similar to any other US power source. These power plants are profitable and no longer require substantial public funding**.
☐	**I am not sure.**

Section Two

In this section, we would like to know your opinions on the research and development of tidal energy, funding for R&D, and policies.

1. Which organization or institution do you think should be **the most** responsible for funding tidal energy research and development? Please **mark an x in the one box** that reflects your top choice.

- ☐ **Local Government**
- ☐ **State Government**
- ☐ **Federal Government**
- ☐ **Private Companies**
- ☐ **Public Utility District**
- ☐ **Other** ____________________
- ☐ **None**

2. If the following policies were presented to you on a ballot initiative, please indicate how you would vote by **marking an X** in either the "yes" or "no" box.

POLICY	YOUR VOTE	
An initiative to...	YES	NO
Increase government funding for the creation of partnerships between universities, the government, and private companies to work on tidal energy research and development.	☐	☐
Establish a program where the government pays the difference between the cost of supplying electricity from tidal sources and the price the suppliers are paid for the electricity they produce (Currently, the cost of supplying electricity from tidal energy is higher than the amount a supplier would be paid).	☐	☐
Provide support for community and small-scale tidal energy producers by mandating that they be paid higher rates for the electricity that they produce from tidal sources relative to other types of renewable energy sources.	☐	☐
Establish a fund where the government provides loans to qualified tidal energy developers and then agrees to take over the debt if the developer can't pay.	☐	☐

3. Please rate your level of **agreement** or **disagreement** with the following statements by **placing an X in box** in the column that corresponds to your views.

	STRONGLY DISAGREE	DISAGREE	NEITHER AGREE NOR DISAGREE	AGREE	STRONGLY AGREE
Renewable energy is necessary to help reduce human contribution to climate change.	☐	☐	☐	☐	☐
I am not in favor of developing tidal energy as a renewable resource from WA State.	☐	☐	☐	☐	☐
I would be willing to sign a petition to oppose the development of tidal energy in Puget Sound, even if satisfactory environmental assessments were carried out.	☐	☐	☐	☐	☐
Humans are contributing to climate change.	☐	☐	☐	☐	☐
I support the use of tidal turbines to generate electricity.	☐	☐	☐	☐	☐
The development of tidal energy is a worthwhile pursuit.	☐	☐	☐	☐	☐
If tidal energy were to be developed in Puget Sound, a share of the developer's profits should be distributed among local communities.	☐	☐	☐	☐	☐
I disapprove of tidal energy, in general.	☐	☐	☐	☐	☐

	STRONGLY DISAGREE	DISAGREE	NEITHER AGREE NOR DISAGREE	AGREE	STRONGLY AGREE
Community members should be consulted early in the tidal energy planning phase.	☐	☐	☐	☐	☐
I feel an emotional attachment to the region that I live in.	☐	☐	☐	☐	☐
Social concerns should be accounted for in the use of tidal turbines.	☐	☐	☐	☐	☐
I oppose the use of tidal turbines to generate electricity.	☐	☐	☐	☐	☐
I would be willing to contact a representative to voice a positive opinion regarding tidal energy research.	☐	☐	☐	☐	☐
Climate change is a problem which deserves attention.	☐	☐	☐	☐	☐
I feel an emotional attachment to Puget Sound shores and waters.	☐	☐	☐	☐	☐
Overall, I approve of tidal energy.	☐	☐	☐	☐	☐
The tidal energy industry should institute a sustainable certification program, similar to those in fisheries or agriculture (see examples).	☐	☐	☐	☐	☐

4. The following statements regard possible benefits and risks of tidal energy. Some of the risks and benefits are still uncertain, so please chose the answer that most reflects your own concerns and perceptions about tidal energy development by indicating how strongly you **agree** or **disagree** with each statement **by marking an X in the corresponding box.**

	STRONGLY DISAGREE	DISAGREE	NEITHER AGREE NOR DISAGREE	AGREE	STRONGLY AGREE
Tidal energy development will create jobs in WA.	☐	☐	☐	☐	☐
The moving blades of the tidal turbine will injure marine mammals.	☐	☐	☐	☐	☐
Tidal energy is predictable and therefore beneficial, because we can depend on it being available.	☐	☐	☐	☐	☐
Developing tidal energy is not a good use of taxpayers' money.	☐	☐	☐	☐	☐

	STRONGLY DISAGREE	DISAGREE	NEITHER AGREE NOR DISAGREE	AGREE	STRONGLY AGREE
If implemented on a commercial scale, tidal energy can reduce carbon emissions.					
It is only fair that local communities should benefit from electricity generation near their community.					
Developing tidal energy in Puget Sound will disrupt existing fishing grounds.					
Having a local source of energy will benefit current and future generations.					
The development of tidal energy in WA can provide a sense of pride for the region.					
There is too much economic uncertainty to invest in tidal energy.					
Tidal turbine platforms will disrupt the view of the water.					
Developing tidal energy in Puget Sound can increase local understanding of environmental and energy issues.					
Tidal energy can offer a sustainable form of energy					
The level of underwater noise from tidal turbines will harm marine mammals.					
The upfront costs of developing tidal energy will be too high.					
Developing tidal energy could help create a diverse energy portfolio in WA.					
Tidal energy devices will change ocean currents enough to harm ocean life.					
Developing tidal energy fits in with the clean energy culture of our region.					
A commercial scale tidal energy plant in Puget Sound would negatively affect my enjoyment of the area.					
It is unfair to make tidal energy developers engage with the public concerning tidal energy development.					

5. The following statements regard your support or opposition to different aspects of research and development of tidal energy. Please indicate how strongly you **support** or **oppose** each statement. **Mark an X in the corresponding box.**

	STRONGLY OPPOSE	OPPOSE	NEITHER SUPPORT NOR OPPOSE	SUPPORT	STRONGLY SUPPORT
How strongly do you support or oppose...					
Conducting research on tidal energy in the lab.	☐	☐	☐	☐	☐
The development of a tidal energy turbine in the lab.	☐	☐	☐	☐	☐
The siting of a tidal pilot project in Puget Sound, with a turbine that is not connected to the energy grid (not producing electricity for public use) and will not turn in to a commercial project .	☐	☐	☐	☐	☐
The siting of a tidal pilot project in Puget Sound, with turbines that are connected to the grid (producing electricity for public use) as a pilot for a future commercial scale project.	☐	☐	☐	☐	☐
The siting of multiple grid-connected turbines in Puget Sound, that rely partly on government funding.	☐	☐	☐	☐	☐
A full-scale commercial facility in Puget Sound that does not rely on government funding.	☐	☐	☐	☐	☐
The testing of a tidal turbine in Puget Sound that would later be deployed in another state, such as Alaska.	☐	☐	☐	☐	☐

Here, we would like to know a little bit about your opinions on a **hypothetical situation** concerning **renewable energy** research and development.

1. Suppose the state of Washington would like to create a fund that would support the research and development of renewable energy technologies by providing funds to organizations that work on either the research or the development of these technologies. Suppose a statewide referendum vote was held today. You could advise the WA state government whether to create the new renewable energy research and development fund. This fund would be created by adding a fee to WA households' electricity bills. The law states that money collected for this fund could only be used for the research and development of renewable energy technologies to make electricity.

If the fee for creating this new renewable energy research and development fund would increase your household's electricity bill by $ per **month,** would you vote **for** or **against** creating the fund? **Mark an X in the corresponding box.**

☐ **For** ☐ **Against**

2. On a scale of 0 to 10, please rank how certain you are about your decision above (Question 1) by **circling the number which best represents your answer.**

0 1 2 3 4 5 6 7 8 9 10

VERY UNCERTAIN (0) — **NEITHER CERTAIN NOR UNCERTAIN** (5) — **VERY CERTAIN** (10)

3. **If you answered "against" to question 1 on the previous page,** please tell us why, by **marking an X** next to **the one** main reason that best explains why you voted **"against"** the referendum. **Move to question 4 if you answered "for" to question 1.**

☐ I don't believe that adding a fee to my electricity bill is the correct way to pay for renewable energy research and development.

☐ I don't believe that the public should be asked to pay more for renewable energy research and development.

☐ I don't believe that the money from the fund would be used correctly.

☐ I don't have enough income to contribute to the fund.

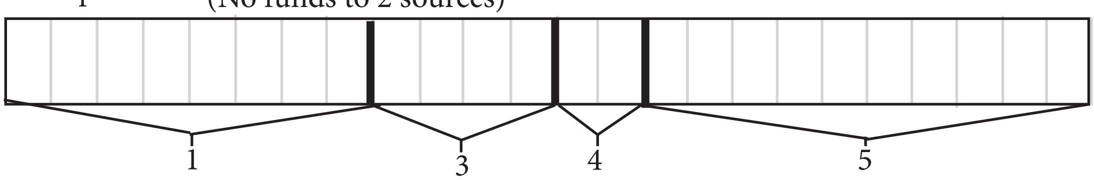
☐ I would rather spend my money in other ways.

☐ Other ____

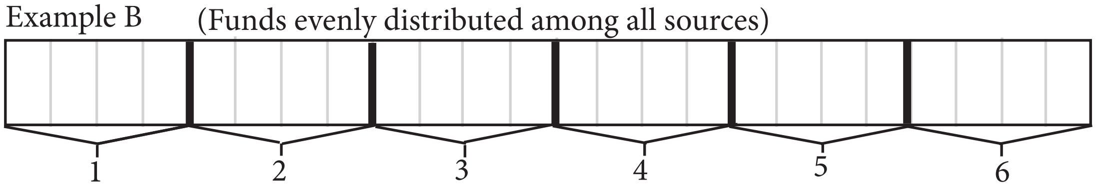
4**. Hypothetically,** if the referendum passed and the fund was created then the State of Washington could fund the R&D of multiple renewable electricity sources. Please divide up the rectangle below by drawing along the gray lines in the rectangle to show the proportion of the research and development funds that you think should be spent of each on the following renewable electricity sources. Then label the rectangle with the correct source number. There are **six sources** total, but you can use less than six sources if you prefer. If there is a source you prefer that isn't listed, please write it in the other category to make seven possible sources. See examples below.

1= Solar Energy
2= Offshore Wind Energy
3= Wave Energy
4= Tidal Energy
5= Land-based Wind Energy
6= Geothermal Energy
7=Other (please specify)________________

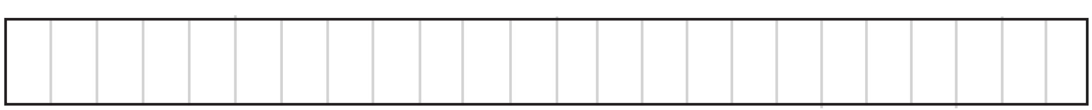
Example A (No funds to 2 sources)



Example B (Funds evenly distributed among all sources)



Your turn: Note: There are 24 boxes.



Here, we would like to know a little bit about you for statistical purposes. All of your answers are confidential. However, we need this information to be able to compare your responses with other WA residents. We thank you again for completing this survey.

1. What is your current age in years? _______

2. What is the highest education level you have completed?

- ☐ Less than high school
- ☐ High school graduate
- ☐ Associate's degree or some college
- ☐ Bachelor's degree
- ☐ Graduate or professional degree

3. Which of the following describes your household income before taxes in 2014?

- ☐ Less than $10,000
- ☐ $10,000 - $14,999
- ☐ $15,000 - $24,999
- ☐ $25,000 - $34,999
- ☐ $35,000 - $49,999
- ☐ $50,000 - $74,999
- ☐ $75,000 - $99,999
- ☐ $100,000 - $149,999
- ☐ $150,000 - $199,999
- ☐ $200,000 or more
- ☐ I prefer not to answer

4. What is your gender?

- ☐ Male
- ☐ Female
- ☐ Other (please specify)

  ____

5. What is your zip code?____________

6. How many people currently reside in your household, including yourself? _________

7. Which of the following best describes your work situation?

- ☐ Employed full-time
- ☐ Employed part-time
- ☐ Not employed outside the home
- ☐ Unemployed
- ☐ Student
- ☐ Retired
- ☐ Other ______________________

8. Which of the following describes your current political orientation?

- ☐ Very liberal
- ☐ Liberal
- ☐ Moderately liberal
- ☐ Neither liberal nor conservative
- ☐ Moderately conservative
- ☐ Conservative
- ☐ Very conservative
- ☐ Other _____________________

- ☐ I prefer not to answer

9. Which of the following best describes your ethnicity? *(Please select one).*

- ☐ Black or African American
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ White or Caucasian
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ Hispanic or Latino
- ☐ Some other race
- ☐ Two or more races
- ☐ I prefer not to answer

Thank you again for completing this survey. Please use this page to add any additional comments that you think are important for us to know.

If you have misplaced the enclosed return envelope, please mail the completed survey to:

Dr. Stacia Dreyer
University of Washington
3707 Brooklyn Ave NE
Seattle, WA 98105

If you are interested in staying informed about survey results, please send an information request to either tidalnrg@uw.edu or the address above, and we will send you this information once our report is complete. You may also call 206-556-6562 to make your request.