MEASURING THE PUBLIC ON ENVIRONMENTAL CHANGES:

ESSAYS ON OFFSHORE WIND POWER SPATIAL HETEROGENEITY,

ECONOMIC VALUATION, AND SURVEY METHODOLOGY

by

Lauren A. Knapp

A dissertation submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Marine Studies

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Approved: ____
Mark A. Moline, Ph.D.
Director of the School of Marine Science and Policy

Approved: ____
Estella Atekwana, Ph.D.
Dean of the College of Earth, Ocean, and Environment

Approved: ____
Ann L. Ardis, Ph.D.
Senior Vice Provost for Graduate and Professional Education

I certify that I have read this dissertation and that in my opinion it meets the academic and professional standard required by the University as a dissertation for the degree of Doctor of Philosophy.

Signed: ____
Jeremy Firestone, Ph.D., J.D.
Professor in charge of dissertation

I certify that I have read this dissertation and that in my opinion it meets the academic and professional standard required by the University as a dissertation for the degree of Doctor of Philosophy.

Signed: ____
George Parsons, Ph.D.
Member of dissertation committee

I certify that I have read this dissertation and that in my opinion it meets the academic and professional standard required by the University as a dissertation for the degree of Doctor of Philosophy.

Signed: ____
Rodney Cluck, Ph.D.
Member of dissertation committee

I certify that I have read this dissertation and that in my opinion it meets the academic and professional standard required by the University as a dissertation for the degree of Doctor of Philosophy.

Signed: ____
Debi Elliott, Ph.D.
Member of dissertation committee

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I am consistently reminded that I live in a world where women are
held back from their true potential by others, religious norms or societal
expectations, as well as their internal outlook. This dissertation is dedicated
to the women in my family, those already here and not yet arrived:
may you seek laughter; not tolerate the intolerant; question the unquestioned;
love unconditionally; and cherish each day as a gift to grow.

"Success is not final, failure is not fatal. It is the courage to continue that counts."
\- *Winston Churchill*

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ABSTRACT

As the effects of climate change are felt world-wide, exacerbated by emissions from the automotive and electricity generation sectors, the United States and elsewhere are promoting renewable technologies to transition to a clean energy future. Offshore wind power is one such option that offers significant promise, garnering notable regulatory, private industry, and stakeholder attention. But each technology has tradeoffs. This dissertation addresses the economic and policy aspects that policymakers will inevitably face when considering how to economically evaluate such offshore wind projects. The three individual essays in this dissertation, one already published, offer insight into (1) how aspects of the spatial location of offshore wind turbines influence their economic desirability; (2) the economic valuation question of how much extra residents might pay for this technology; and (3) how modern survey techniques employed in the aforementioned essays offer decision makers robust data that can be relied on for policy analysis.

The first essay offers an in-depth review of spatial components that will be relevant for offshore wind power development and how those matter for economic preferences. Studies in the environmental and resource economics literature suggest that preferences for changes or improvements in environmental amenities, from water quality to recreation, are spatially heterogeneous. One of these effects in particular, distance decay, suggests that respondents exhibit a higher willingness to pay (WTP) the closer they live to a proposed

environmental improvement and vice versa. The importance of spatial effects cannot be underestimated. Several of these studies find significant biases in aggregate WTP values, and therefore social welfare, from models that disregard spatial factors. This relationship between spatial aspects and preferences, however, remains largely ignored in the non-market valuation literature applied to valuing preferences for renewable energy, generally, and wind power, specifically. To our knowledge, fourteen peer-reviewed studies have been conducted to estimate stated preferences (SP) for onshore and/or offshore wind development, yet less than half of those utilize any measure to account for the relationship between spatial effects and preferences. Fewer still undertake more robust measures that account for these spatially dependent relationships, such as via GIS, outside incorporating a single 'distance' attribute within the choice experiment (CE) referenda. This essay first reviews the methodologies of the SP wind valuation studies that have integrated measure(s) to account for spatial effects. These effects are then categorized—distance to a proposed wind project, distance to existing wind project(s), and cumulative effects—supporting each with a discussion of significant findings, including those found in the wind hedonic and acceptance literature. Policy implications that can be leveraged to maximize social welfare when siting future wind projects and recommendations for additional research for wind CEs are also posited.

The second essay presents a discrete choice modeling approach to estimate whether Mid-Atlantic residents would be willing to pay for offshore wind power near Maryland and

Delaware. While advanced forms of renewable energy tout climate benefits of presumed value to individuals, a nascent U.S. offshore wind industry faces steep levelized cost of energy (LCOE) for consumers, policy barriers to entry and local disamenities and anticipated conflict with existing ocean use. The U.S. Bureau of Ocean Energy Management (BOEM) in recent years has leased thousands of offshore km^2 to wind energy developers, but an offshore wind project has yet to be built outside of the five-turbine, Block Island offshore wind project commissioned near Rhode Island in late 2016. A robust, non-market valuation literature has grown over recent decades offering improved methodologies to indirectly value environmental projects and services. We present results using one of those techniques, a stated preference choice experiment, to discern residents' willingness to pay (WTP) to develop an offshore wind project in the Mid-Atlantic, USA. Respondents from Delaware and Maryland, USA (N=973) were asked their WTP electricity premiums for an offshore wind project near Maryland as well as preferences for specific project characteristics (number of turbines and specific location) relative to an opt-out natural gas plant. Generally, the majority of Delawareans and Marylanders support offshore wind development. Conditional logit choice model findings reveal site-explicit social welfare, with Marylanders and Delawareans WTP for offshore wind power ranging from \$1.35 - \$51.26 per household per month, depending on where the project is built and its size. Delaware exhibits a highest baseline WTP for smallest projects located in the South, i.e., away from them, but as these projects get larger, their WTP erodes more quickly than if they were built in the north of the wind energy area (WEA). Compared to their baseline, residents are willing to pay $0.41 (DE) to $1.00 (MD) less per month for each additional 6 Megawatt (MW) turbine built across the entire WEA.

The final essay examines the reliability and quality of data collected in the aforementioned study. There remains a gap between advancing data collection methods, including mixed-mode and online surveys, and an understanding of how mode choice affects perceptions of politically sensitive issues, such as climate change and renewable energy. With data from a 2015 tri-mode survey (mail, mixed, and online panel, N=973) across the US Mid-Atlantic region, we compare modes using unweighted, weighted demographics, total survey error (TSE), and ordered Likert regressions. We find no evidence for statistical differences across modes concerning weighted support for offshore wind power development, attitudes toward state-level renewable energy standards or climate change perceptions. The online panel performs as well or better as the mail based survey in most respects. Findings offer insights on design tradeoffs (i.e. quality, mode, and cost).

NOMENCLATURE

BOEM:	Bureau of Ocean Energy Management
CE:	Choice experiment
DEPSC:	Delaware Public Service Commission
DPL:	Delmarva Power and Light
DOI:	Department of Interior
LCOE:	Levelized Cost of Energy
MW:	Mega-watt
MWEA:	Maryland Wind Energy Area
OCS:	Outer Continental Shelf
PPA:	Power purchase agreement
REC:	Renewable energy credit
RPS:	Renewable Portfolio Standard (also Renewable Energy Standard)
SP:	Stated preference
WTP:	Willingness to pay

Chapter 1

INTRODUCTION

1.1 Motivation

Rising atmospheric carbon concentrations pose arguably the greatest threat to the balance of healthy functioning human and natural systems worldwide. Global climate change and associated warming induce multiplicative effects, from sea-level rise to species extinction. The scientific consensus remains steadfast that these changes are anthropogenic (Doran and Zimmerman, 2009). Outside the transportation sector, these emissions trace their origin to fossil fuel combustion in developed states via electricity generation from natural gas and coal-fired power plants. A global population surpassing 7.6 billion people presents never-before-seen industrialized demands for luxuries that require extensive resources, and emissions, to produce. With much international attention surrounding tipping points and clean energy transitions, policy makers are promulgating climate mitigation and adaptation schemes to ensure necessary electricity production through cleaner means. Offshore wind power is one such technology. States globally were poised to spur into action under the Paris Agreement, and the (now under threat) Clean Power Plan would have engendered a top-down transformation to the US electricity portfolio of emissions. How will policy makers now face this inevitable environmental call to action while also satisficing augmenting electricity needs through development that is societally-optimal?

1.2 Progress

Offshore wind has the *potential* to play a significant role in climate change mitigation and coastal energy policy in the coming decade (Gasparatos et al., 2017). Late 2016 marked a pivotal juncture in the US with the successful commissioning the nation's first offshore wind energy project off the coast of Rhode Island. This project came to fruition, in part, because the nearshore eastern US boasts a high, steady wind resource directly adjacent to demand, called load, centers (Kempton et al., 2007). In perhaps a new energy era, this project leads credence to the contention that change and transformation of the ocean is on a path to becoming economically viable as much as politically-palatable. The Department of the Interior's (DOI) Bureau of Ocean Energy Management (BOEM) meanwhile has leased large swaths of the ocean designated as wind energy areas (WEAs) near some of the most populated cities along the eastern Outer Continental Shelf (OCS), with Avangrid's Vineyard Wind securing an 800 MW proposal off of Martha's Vineyard, Massachusetts, this May. Nearby, New York has set a goal for 2.4 GW offshore wind. In response, some of the 29 states with state renewable energy (portfolio) standards (RES/RPS) are augmenting those stipulations to allow for offshore wind energy premiums. This action is in response to a realization that the economic viability could be one of the most significant hurdles for offshore wind deployment as electricity from offshore wind is presently at least double the price on a per-MWh, levelized-cost-of-energy (LCOE) basis compared to new natural gas fired electricity generation (Beiter et al., 2016). Given the BOEM has substantial plans for additional WEA leases, there is ample room and need for social welfare measures to be integrated into stakeholder discussion, policy formulation, analysis, and the like.

1.3 Issues

Globally, countries are dismantling their carbon-free, base-load generating nuclear capacity in lieu of serious renewables and emission reductions targets. Presumably, these states will need to replace that generation capacity. The magnitude of such targets cannot be understated. In 2018, Germany has made indications of desires to curtail its ambitious national energy strategy, *Energiewinde*, the flagship program meant to achieve robust emission reductions and eliminate their fleet of nuclear power stations. In the US, substantial opposition over the course of a decade to the most prominent proposed offshore wind power development in the US—Cape Wind—ultimately derailed the project. Relative to European countries with decades of experience, the US is a novice in the offshore wind industry from nearly every perspective. Issue conflicts are anticipated to need careful management, as erecting turbines in the near-shore marine environment could significantly impact existing users of coastal amenities. Mitigation options for siting are not a clear one-size-fits-all approach and will likely need to be evaluated on a project-by-project basis (i.e., building projects further from shore could provide greater benefits in some areas relative to others). Whether a project will be built in a leased area, significant costs and challenges, in addition to benefits, to coastal communities will likely ensue.

1.4 What We Know

One staple approach through which researchers measure whether the public is willing to pay (WTP) premiums for any improvement in an environmental amenity, e.g., restoring a wetland, and estimating the welfare change to society, is to employ a choice experiment (CE). These surveys ask respondents to state their economic preferences for the good of interest. This example, and the one detailed in Essay 3, is an illustration of the stated preference (SP) approach. A respondent's WTP for a proposed environmental change—here, whether to build a renewable electricity generation project that offers local and global climate and health benefits—will largely depend on both the characteristics of those facilities and the respondent herself. Locational proximity, demographics, respondents' attitudes, related preferences, and random error also play a role in estimating these preference functions.

Ladenburg and Dubgaard (2007) were the first to test economic tradeoffs and measure visual disamenities from offshore wind farms in a SP approach. Since then, the majority of the literature has approached offshore wind power valuation of social welfare implications in the form of CEs to quantify externalities through WTP for this new technology or alleviate negative externalities from the project (Krueger et al., 2011). A myriad of specific attributes about the renewable energy project as well as variations of those attributes have been investigated, ranging from project size (single turbines to GWs), location and surrounding environment (onshore vs. offshore), impact on bird species, distance from home, as well as the proposed payment 'vehicle' (fund or payment to the government). Specific project characteristics of research interest have aimed at estimating discrete choices and WTP related to viewshed disamenity tradeoffs (Krueger et al., 2011; Ladenburg and Dubgaard, 2007); ecological impacts (Meyerhoff, 2013; Westerberg et al., 2015); tourism (Landry et al., 2012; Westerberg et al., 2015); and development and or project ownership aspects (Brennan and Van Rensburg, 2016).

1.5 The Three Essays

Hurdles to US wind power development are not so much technical as they concern arguably impacts on social and economic well-being of users in the coastal environment. How can we employ modern methods and robust data to inform the policy process that captures an accurate pulse of public's preferences? Chapters 2, 3 and 4 present multidisciplinary essays to shed light in this vein. These essays measure various socioeconomic dimensions at stake for the future of U.S. offshore wind power development, drawing upon a body of literature from the Mid-Atlantic region and globally. Findings also build off concurrent research conducted over the past four years (Firestone et al., 2018; Firestone et al., 2015; Kecinski et al., 2017; Shirazi et al., 2015).

Essay 1 (Ch. 2): Review of Economic Valuation Wind Literature and Spatial Heterogeneity[1]

This first essay in this dissertation reviews the non-market, SP literature on offshore and onshore wind energy (Knapp and Ladenburg, 2015). This paper identifies spatial nuances critical to specifying robust and externally valid onshore and offshore wind energy

[1] This essay was published in 2015 in *Energies* 8 (6177-6201). Please see Appendix C to obtain permission letter for use in this dissertation and documentation of ownership of copyright.

econometric models. We find respondents, their daily routine, the location of existing wind projects, and the location of proposed wind projects contribute significantly to individual economic preferences for future wind projects. This paper suggests these spatial aspects could bias models up or down if not included, as suggested in a vast body of non-market literature on preferences for a myriad of environmental goods. Higher-fidelity spatial controls should be considered in non-market valuation studies that investigate welfare estimates for wind power, and perhaps renewable energy projects.

Essay 2 (Ch. 3): Willingness to Pay Premiums for Offshore Wind Power – A Choice Experiment

In 2014, the U.S. BOEM auctioned an offshore lease of a 124 mi^2 (312 km^2) area roughly 11 miles from the Delaware/Maryland coastline for permitting and building an offshore wind project, termed the Maryland Wind Energy Area (MWEA). It is one of 13 areas leased by the BOEM for offshore wind development along the Eastern OCS. Previously, in neighboring Delaware, the Delaware Public Service Commission (DEPSC) approved a power purchase agreement (PPA) between Bluewater Wind and Delmarva Power and Light (DPL), since abandoned, that would have required ratepayers to pay approximately an additional $0.75 on their monthly bills. As of 2013, Maryland's RPS can allow a charge of up to a $1.50/house/month to pay for electricity from an offshore wind project, if ever built.

During the first quarter of 2015, data regarding the opinions and economic preferences for developing the MWEA were collected from Delaware and Maryland residents in an energy development CE. The tri-mode sampling approach (mail, mixed-mode mail or internet option, and online panel) resulted in *n*=973 valid responses. The instrument consisted of four sections, with the choice experiment being the focus. A suite of choice sets in a policy 'referenda' prompted respondents to cast a vote for her preferred an energy scenario for the Mid-Atlantic region. Respondents weighed decisions between two offshore wind projects of varying characteristics (size, location, price premium) and a status-quo natural gas plant at $0 extra cost. Maps and offshore wind project photosimulations accompanied the survey. These depicted each project combination so respondents could realistically consider each policy referenda with anticipated visual impacts.

A future where thousands of MWs of offshore wind power capacity are deployed across national WEAs would necessitate both robust federal and state policy drivers. The importance of states ought to be underscored, with Massachusetts, Maryland, and New York leading efforts to spur policy certainty and create markets for offshore wind electricity through their RPSs. These efforts rely heavily on the electricity price surcharge that states would be willing to integrate into their RPS, and normatively in turn, for which residents have an economic appetite. In both Delaware and Maryland, policymakers used their judgment, presumably in part based on political considerations, as to the public's WTP a price premium for electricity generated from offshore wind power to set the upper limit for ratepayer impacts. Yet, the knowledge on whether and what monthly surcharge constituents would be willing to pay for electricity from offshore wind power, and how to best design a state RPS for an electricity future that includes offshore wind, remains unclear.

This essay aims to directly inform these regulatory processes by providing an empirical answer to the question of how much above current rates households are WTP for offshore wind power. Using discrete choice models, it focuses on the survey's CE data eliciting respondents' preferred energy futures. Results estimate unobserved economic welfare impacts (WTP price premiums for offshore wind power's avoided externalities) not captured in markets, as well as the relationship between underlying factors about respondent's coastal living demographics that influence respondents' preferred energy choice.

Essay 3 (Ch. 4): Effects of Survey Mode on Preferences for Renewable Energy Policy Futures & Climate Change Perceptions

The final essay[2] (Knapp and Firestone, 2018, *under review*) also analyzes the data from the multi-mode offshore wind CE. Utilizing various statistical techniques, this essay establishes measured similarities and minor differences in reported energy preferences and climate change perceptions that arise under the tri-mode survey. It offers insight on reliability measures for modern survey techniques to rapidly gauge public appetite for politically sensitive energy development futures. Findings on how various modes influence collected data regarding public policy perceptions are germane for environmental economic CEs as well as potentially for social science survey research on politically-contentious environmental issues, broadly speaking.

[2] By the time of submission of this dissertation, this essay received a revise-and-resubmit decision from the editors of the *International Journal of Public Opinion Research* (May 2018).

1.6 Policy Implications

These essays aim to inform federal and state policymakers that in coming years are tasked with complex analyses concerning the use of coastal resources and avoiding unintended consequences that could accrue from ill-informed policies. Nuanced aspects of making environmental decisions to capitalize on coastal energy resources are explored, including how impacts are spatially heterogeneous across the landscape. Foremost, understanding public demographics that underlie support or opposition can directly inform the policy making process to minimize expected impacts and can be incorporated in benefit-cost analyses. Findings here are also expected to be relevant for planners and stakeholders, including existing users of the coastal environment. A final chapter concludes and posits recommendations for future policies considering this technology.

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Chapter 2

HOW SPATIAL RELATIONSHIPS INFLUENCE ECONOMIC PREFERENCES FOR WIND POWER—A REVIEW

2.1 Introduction

A cost-efficient transition to larger wind power capacities in the electricity generation mix requires prioritization of the least cost wind power locations. Accordingly, an energy planning authority's goal is to create a policy scheme to ensure costs are minimized relative to the generation output. This cost minimization problem involves the trade-off between, on one hand, exploiting the sites with best wind regimes, and on the other hand developing sites with the least costs given available technology. A simplified generation cost function (GCF) of wind power can therefore be defined as:

$$GCF = Cost_{Turbine} + Cost_{Grid} + Cost_{Operation} + Cost_{External} \quad (1)$$

where $Cost_{Turbine}$ is a function of the power capacity and type of the turbine, tower height and the foundation type, while $Cost_{Grid}$ is a function of the length and type of both (a) the inter-array (within wind farm) cabling; and (b) the cable to the grid as well as grid investments, such as transmission or substation upgrades (Krohn et al., 2009). The third element, $Cost_{Operation}$, or operation cost, includes the cost of turbine maintenance, upkeep, and repair (Krohn et al., 2009). Together, these cost components are spatially dependent upon the quality, speed and frequency of the wind resource in a given area. Accordingly, the choice of wind farm location and configuration or layout of a project's individual wind turbines affects the generation cost function. This spatial dependency is a function on the cost of wind power development at both a micro as well as macro level. The final component in the cost function is the external cost, which we will elaborate on in the section below.

External Costs

Depending on the location of wind turbines within projects and the locations of the wind farm relative to the grid, spatially induced external costs are likely to emerge on a micro and macro scale. The specific placement of wind turbines at a project scale in the vertical and horizontal dimensions can influence overall generation output and efficiency within the wind farm (micro scale). Vertically speaking, deployment of turbines with varying rotor diameters and hub heights in a single wind farm can reduce wake effects and turbulence, thereby improving generation efficiency (Chen et al., 2013; Chowdhury et al., 2012; Rahbari et al., 2014). Proximal obstructions (i.e., natural ground cover, vegetation and/or the built environment) can negatively impact optimal wind characteristics depending on their physical magnitude and location relative to the project site. So, horizontally speaking, spatially dispersing wind turbines onshore, either to account for landscape restrictions or wake effects in both onshore and offshore settings, has also been found to increase efficiency (Archer et al., 2014; Rahbari et al., 2014).

On a macro scale, perhaps the strongest spatial driver of development, and subsequently costs, are the available wind resources across different locations. All else equal, this factor will result in a concentration of wind farms at locations with the highest average wind speed, which is optimal from an investor's point of view. However, though generation output is maximized, concentrating wind turbines in few locations might not be optimal from a welfare economics perspective due to external production costs associated with higher power production fluctuations and consequently a need for further investments in baseload capacity or storage. For example, using Germany and southern Iberian Peninsula as cases, Grothe and Schnieders (2011) and Santos-Alamillos et al. (2014), respectively, find that optimizing the spatial allocation of onshore and offshore wind projects (and individual turbines) can stabilize the generation output and in some cases contribute to baseload. Accordingly, by taking into account the spatial and geographic variation in wind resources in combination with leveraging existing grid connections, more optimal wind power deployment can be achieved.

In the same line of thinking, the distance to a stable grid is also a spatial driver when choosing locations to build wind projects. As argued in Rahmann and Palma-Behnke (2013), locations with favorable wind regimes might be located in weak or challenged transmission areas, whereas less favorable wind regime locations might be near a stronger transmission area that is also close to load (demand) centers. In that case, the location with favorable wind conditions might exhibit higher generation costs relative to sites with less favorable wind conditions. In addition, adding an additional wind turbine at the margin to the generation portfolio could increase the need for investments in a stronger grid and potentially also backup generation capacity for periods with unfavorable wind conditions (Godby et al., 2014; Kucsera and Rammerstorfer, 2014; Mount et al., 2012).

Finally, wind projects built in offshore environments face additional spatially induced considerations for expenditures. Initial capital investment costs, such as turbine foundations, installation and grid costs, increase linearly as distance from the shore increases but exponentially as water depths increase (European Environment Agency, 2009). For example, holding distance from the shore constant, an increase in water depth from 10–20 m to 30–40 m increases investment costs by around 25% (European Environment Agency, 2009). As greater distances from the shore are generally associated with increased water depths and deeper bathymetry, costs, therefore, can increase substantially if an attempt is made to site wind farms further offshore out of view.

These spatial relationships solely focus on generation and maximising the associated power production related to the technical inputs and characteristics of the generating units in the system. The energy planner could exclusively leverage these elements to identify the socially optimal locations for wind-powered electricity production. However, the spatial properties of wind power development are inherently not restricted to the technical aspects or investment decisions alone. Public preferences to deploy particular energy technologies often have nothing to do with the aforementioned cost generation considerations but can be significantly related to public appetites for electricity price premiums. As discussed in the reviews by Ladenburg et al. (2013) and Ladenburg and Möller (2011), the attitude toward and acceptance of wind power are significantly related to the spatial location of wind turbines relative to places of residence. Along the same line, Ladenburg (2014) reviews and finds evidence that spatial interaction with energy sources influence preferences for different energy types. Furthermore, the vast literature on preferences for improvements in or amenities provided by the environment display significant spatial patterns which have an influence on both their distribution and supply (see, for example, the special issues in Resource and Energy Economics (2010) and Ecological Economics (2013)).

Incorporating spatial aspects can help explain preferences for environmental goods, broadly speaking, and renewable energy generation initiatives. The aim of the present article is, therefore, to review and discuss the findings of studies that estimate spatial relationships between individuals and their preferences for on- and offshore wind power, generally; consider preferences for the location of wind power projects, specifically; and detail how the results can be used in order to increase a cost efficient transition to increased wind generation capacities. These spatial issues related to preferences for onshore and offshore wind farms can be grouped around three core elements in the environmental economic literature and are related to distance dependency (travel distance) to the nearest existing wind project, distance dependency to the nearest proposed wind development, and cumulative daily exposure and impacts from wind turbines.

2.2 Spatial Methods Review: Stated Preferences for Onshore and Offshore Wind Farms

To the authors' knowledge, stated preferences for wind power development have been elicited through fourteen peer-reviewed choice experiment (CE) studies over the past decade. Of those, eight tested for spatial aspects either by including this dimension explicitly as an attribute within the CE or as a more discrete measure outside the CE (see Table 2.1). Those eight studies along with unpublished results from one analysis (Ladenburg and Knapp, 2015) and three graduate theses/dissertations (Abay, 2014; Knapp et al., 2013; Lutzeyer, 2013) are summarized below with an emphasis on the spatial variables. For further methodology details on some of these peer-reviewed studies, see Ladenburg and Lutzeyer (2012). Although some of the following studies received low response rates, the main focus in this section is to overview both the experimental designs and the methods of estimation for spatial effects influencing stated preferences for wind power.

Table 2.1: Peer-reviewed choice experiment studies estimating stated preferences (SP) for onshore and offshore wind power. Adapted from Ladenburg and Dubgaard (2009) and Strazzera et al. (2013).

Study	**Wind Project Location**	**CE Attributes**	**Attribute Levels**	**Significant WTP (€/year)**	**Significant Spatial Variables**
Ek and Persson (2014)	Onshore or offshore (30 turbines)	(1) Landscape; (2) ownership; (3) consultation; (4) 5% of annual revenue transfer to defined party	(1) Offshore, open/plains, mountains or forest; (2) state, municipality, private, or cooperative; (3) mandatory or extended; (4) municipality or local community	Mountainous area (−2.42), Offshore (2.59), Cooperative (0.65), Municipality (1.1), Private (−3.09), Earmarked (0.77), Extended consultation (0.32) a	N/A
Mariel et al. (2015)	Onshore	(1) Decline in red kite population; (2) **minimum wind farm distance to residential areas**; (3) size of wind farm; (4) maximum turbine height	1) 5%, 10% or 15%; (2) **750, 1100 or 1500 m**; (3) small, large or medium; (4) 110, 150 or 200 m	(LC Model, Class 3) (Small wind farm) 1.88; (Red low, high) 1.66, −2.14; (Minimum distance medium, high) 2.72, 2.85	**Minimum distance, medium and high (LC model, Class 3)**
Vecchiato (2014)	Onshore or offshore	(1) Wind turbine location relative to plains baseline; (2) turbine height relative to 50 baseline; (3) no. of turbines per project; (4) minimum distance from town center	(1) Mountains/hills or sea; (2) 50, 120 or 200 m; (3) 4, 15 or 50; (4) 100, 250 or 1000 m	N/A, 96.5; −29.4, N/A; −13.3, N/A; 47.1, 78	**Minimum distance from town center**

Table 2.1: Continued.

Westerberg et al. (2013) *	Offshore (108 MW = 30 turbines)	(1) **Wind farm distance from shore**; (2) wind farm recreation opportunities; (3) adoption of local environmental policy	(1) **5, 8, 12 km**; (2) yes/no; (3) yes/no	(LC Model, Segment 1 aka Loyal LR tourists in WTP, [WTA]) WF 5, 8 & 12 km (−29.3, [8.8]; 24.1, [10.1]; 1.4, [4.2]), WF recreation opp. (21.9, [4.5]), Environmental policy (39.2, [2.7])	**Distance from shore; group of respondents live far from project and close to project in latent class model (discrete)**
Ladenburg et al. (2011) b	Offshore 500 MW (100 turbines)	(1) **Distance from shore relative to 8 km baseline**	(1) **12, 18, or 50 km**	18, 50 km (162, 275)	**Distance from shore**
Landry et al. (2012) *	Offshore (3 MW turbines)	(1) No trip; (2) park fee; (3) congestion; (4) **location in ocean**; (5) **location in sound**	(3) medium or high; (4**) 4 or 1 miles**; (5) **1 or 4 miles**	341.3, 12, N/A, 104.7, 102.5, N/A, N/A, N/A	**Location**
Strazzera et al. (2013) c	Onshore	(1) beach SI and beach MC; (2) archeology impact (close to site, away from site); (3) property; (4) services	(1) well visible, not well visible, not visible; (2) close to site or away from site; (3) private, public regional, or public local; (4) no services, training, training and microcredit	(Willingness to accept) 166.45, 233.12, 165.91, 44.2	N/A
Krueger et al. (2011)	Offshore (500 turbines)	**Distance from shore (0.9, 3.6, 6 or 9 miles)** in inland, bay, and ocean		Inland (18.9, 8.7, 0.8, 0); Bay (34.4, 11.1, 5.8, 2.1); Ocean (80.0, 68.8, 35.1, 26.6)	**Distance from shore**

Table 2.1: Continued.

Meyerhoff (2013)	Onshore	Effect on red kite population (5%, 10%, 15% decline); **minimum wind farm distance to residential areas (750, 1100, 1500 m)**; size of wind farm (small, large, medium); maximum turbine height (110, 150, 200 m)		−6.24 and −5.52; 38.16 and 46.44; 45.72 and 51.72, N/A/, N/A	**Minimum distance to residential areas**
Dimitropoulos and Kontoleon (2009)	441 MW	(1) Number of turbines; (2) turbine height; (3) conservation status of the site; (4) participatory planning		18.7, −439.6, −718, −854.5	N/A
Ladenburg and Dubgaard (2007)	Offshore, 3600 MW	(1) **Distance from shore relative to 8 km baseline**; (2) number of turbines; (3) total number of projects to be built	(1) **12, 18, or 50 km**	47, 98, 125, N/A, N/A	**Distance from shore**
Bergmann et al. (2006)		(1) Landscape impacts; (2) wildlife impacts; (3) air pollution; (4) employment benefits		−12, 6, 20, N/A	N/A
Alvarez-Farizo and Hanley (2002)		(1) Protection of an environmental feature	(1) cliffs, habitat and flora, or landscape	22, 38, 37	N/A

Table 2.1: Continued.

Ek (2002)	Onshore and offshore	(1) Turbine location; (2) size of project in # of turbines; (3) sound impacts; (4) size of turbine	(1) mountains, onshore or offshore; (2) single, <20, 10–50	0, 12, 29, 10, 20, 0, N/A, N/A	N/A

Notes: * Denotes recreation study; a Presented in marginal WTP estimates in Öre/kWh; b Measured in marginal WTP/household/year in DKK; c The bid values were measured in willingness to accept (WTA).

2.2.1 Abay

Abay (2014) is a master's thesis. Abay employed a web-based CE to estimate the relative preferences for onshore compared to offshore wind farms using location-specific settings. The distance was specifically tested both as an onshore attribute with two levels (0.5 or 1 km from the nearest residential area) and an offshore distance attribute with levels of 8, 12, 18, and 50 km from shore. In the choice scenario, 450 MW of wind power must be built either onshore or offshore. For onshore, the preamble stipulated that the power capacity would be built through municipal-scale projects (3 MW each) across 150 locations. If offshore, the power generation capacity would be built within a single 450 MW wind farm (containing 90, 5 MW turbines) in only one of 5 possible offshore locations. This CE design allows testing onshore and offshore specific attributes while holding the wind power development capacity fixed, allowing the scenario to be independent of "installed capacity demand effects" (2012). For onshore development, variables tested in addition to the distance attribute included size and number of turbines (1 x 3 MW, 2 x 1.5 MW and 4 x 750 kW) and number of residents in the nearest residential area (below 10, 11–100 or more than 100 persons). For offshore, a geographical location attribute for the proposed wind farm was also included in addition to the four offshore distances. The potential offshore sites in Denmark were Southeast (Bornholm and Moen), Northeast (Anholt), Northwest (Jammerbugten) or West (Vesterhavet). An included map showed the location and the size of the proposed and existing Danish offshore wind farms. The cost attribute was common for both onshore and offshore wind alternatives at a fixed, annual increase in the electricity bill (0, 50, 100, 300, 600 and 1200 DKK/household/year). Visualizations were included for both onshore and offshore wind farm alternatives. The sample of 2331 respondents was drawn as a quota on geography, gender and education, yielding in a response rate of 8.6%, not uncommon for web surveys.

2.2.2 Knapp et al.

Like Krueger et al. (2011) and Ladenburg and Dubgaard (2007), Knapp et al. (2013) spatially elicited preferences by testing three offshore project locations: 4.8, 9.7, and 16.1 km (distances in the study were shown to respondents in miles at 3, 6 and 10, respectively). This CE was just one of a few to employ both WTP and WTA measures through a dichotomous choice of whether respondents would be supportive of the project with an opt-out alternative, similar to Westerberg et al. (2013). Data for this master's thesis was collected from a sample split in two coastal, Lake Michigan communities (USA) through a web-based survey. For each distance, respondents were shown corresponding visualizations of a 400 MW wind farm consisting of 80 turbines. Each choice question was followed with a 0 10 scale, prompting respondents to denote their certainty for each vote. Whereas one half of the sample (Michigan, response rate = 13%, n = 208) saw a randomized order of the visualizations, the other (Illinois, response rate = 7%, n = 122) saw each distance in ascending order starting with the 3-mile scenario. For the entire sample, pre-determined bid prices were randomly assigned to each respondent but remained internally constant across the three choice sets.

2.2.3 Krueger et al.

Using a CE, Krueger et al. (2011) utilized distance from shore as the spatial attribute to estimate demand for reducing offshore wind farm visual disamenities.

Specifically, the preamble stipulated a scenario in which a wind farm with 500 turbines was slated to be built 1.44, 5.76, 9.6, 14.4 km or too far to see from shore (the original distances are defined as 0.9, 3.6, 6 and 9 miles, respectively) depicted with corresponding visualizations at each of the five distances. Besides the distance attribute, the study also discretely accounted for spatial effects though stratification of the sample based on how close each household was located to the coast, and thus the site (and view) of the proposed wind farm. Respondents were geographically divided from closest to the furthest in the Ocean (n = 182), Bay (n = 203), and Inland (n = 564) samples. This geographic stratification compares preferences for respondents in the different stratum that are close and far from the wind farm, discretely capturing a spatial dimension through expected exposure to the wind farm. In addition, the choices designated the wind farm might be located off of one of three Delaware (USA) beaches (either Delaware, Rehoboth or Fenwick Beach)—another attribute capturing some element of spatial and possibly place-based characteristics. Three choice sets per respondent included one opt-out with two offshore development options. The opt-out informed respondents that fossil fuel (natural gas and coal) power would be increased and no wind farms would be developed offshore. Other attributes included a renewable energy fee on the ratepayer's monthly electricity bill up to three years (bids were 0, 1, 5, 10, 20 and 30 $USD/month); the amount of a royalty payment from the project developer to a fund (1, 2 or 8 million $USD); and the fund's purpose (beach nourishment, renewable energy development or general). This analysis received a high 52% response rate.

2.2.4 Ladenburg and Dubgaard

Ladenburg and Dubgaard (2007, 2009) were the first economic valuation studies to address preferences for the reducing visual disamenities of offshore wind farms and were part of a larger study on offshore wind farms (Ladenburg et al., 2006; Nielsen, 2006). These studies tested the spatial attributes of offshore wind power locations as a distance attribute (12, 18 or 50 km relative to 8 km from the coast) and how the spatial location of offshore wind farms influence the preferences for the distance attribute (see later). The CE valuation scenario stipulated an increase of 3600 MW in power produced by offshore wind farms. Each respondent evaluated three choice sets consisting of two hypothetical wind farm layouts (varied in distance to shore as well as by the number of turbines per wind farm) with no opt-out alternative along with a fixed increase in the household electricity bill. In addition to the spatial dimension represented by the distance attribute, the researchers include a qualitative spatial variable in the form of whether or not an offshore wind farm was located in the respondents' residence or summerhouse view. Using visualizations of 5 MW turbines (the turbines had a 100 m nacelle and 60 m blades = 160 m in total), a wind farm at 50 km would not be visible from the coast, and the locations were not site specific. The other attributes in the CE were "wind farm size" and "total number of wind farms to be erected". In total, (n = 375) of 700 respondents that were initially randomly drawn from a national Danish Civil Registration System survey responded, equaling a 53.6% response rate.

2.2.5 Ladenburg et al.

Estimating WTP to reduce the visual disamenities of offshore wind farms in Denmark, Ladenburg et al. (2011) only tested for spatial dimensions by included an attribute for an offshore wind farm's distance from shore. The authors also tested the effect of "Cheap Talk" (Bosworth and Taylor, 2012; Cummings and Taylor, 1999), a method that has shown evidence in reducing hypothetical bias in stated preference studies. The wind farm scenario stipulated the development of 7 wind farms with 100, 5 MW turbines in each project, equaling a total capacity of 3500 MW to simulate the 3600 MW government target. For the proposed offshore wind development alternatives, the projects could be located at 12, 18 or 50 km from the coast, representing reductions in the visual impacts compared to the status quo projects. It was indicated that projects in this status quo alternative were located at 8 km from shore with no additional cost to the household, ensuring that the estimated demand to reduce visual disamenities would not be confounded with a general preference for wind energy (as is the case when the choice is given between a wind turbine alternative relative to a non-wind turbine alternative). At 50 km, a wind farm with 5 MW turbines (the turbines had a 100 m nacelle and 60 m blades = 160 m total) would not be visible from the coast. For the payment vehicle, an annual fixed increase in the household electricity bill was used of either 100, 400, 700 or 1400 Danish Kroner (DKK)/household/year, equaling 13.4, 53.7, 94 and 187.1 €/household/year. Respondents each faced a total of six choice sets; each included visualizations of the wind farm scenarios in addition to a map showing the location of existing offshore wind farms and the expected location of the proposed offshore wind farms. Respondents were randomly sampled from a nationwide, Danish internet panel consisting of approximately 17,000 people.

2.2.6 Ladenburg and Knapp

To the authors' knowledge, Ladenburg and Knapp (2015) is the first analysis that estimated preferences for offshore wind farm locations by addressing the spatial relationship between the location of proposed offshore wind farms and the respondents' residences as well as the cumulative effects from the number of turbines seen. In addition, the study tested viewshed effects for onshore and offshore wind farms but found no significant results. Ladenburg and Knapp (2015) employed the Cheap Talk (CT) data sample from Ladenburg et al. (2011) (see Section 2.5). The properties of the study design are thus equivalent to Ladenburg et al. (2011). To obtain 350 respondents in both the CT sample, 619 respondents were e-mailed an invitation to participate in the survey. There were 338 respondents, equal to a response rate of 54.6%.

2.2.7 Landry et al.

Landry et al. (2012) was one of the few recreational demand studies to estimate SP and changes in future beach visitation (n = 118) given an offshore wind farm was built adjacent to North Carolina beaches (USA). A spatial attribute for distance was included in the CE, prompting respondents to choose their trip at a site-generic beach with a wind farm located either in the Atlantic Ocean or in inland, sound waters. For the sound and ocean waters, the view varied in three dimensions in that it was either unobstructed with no wind turbines or had a wind farm sited either 1.6 or 6.4 km from shore (the distances were presented in the CE at distances of 1 and 4 miles, respectively). Other attributes included number of people for beach congestion, the travel distance to the beach from the respondent's home, and a parking fee. The preamble scenario prompted respondents to complete six choice sets with corresponding visualizations of the ocean vs. sound views, each having three beach vacation options with an opt-out choice to stay home. The scenario did not stipulate the amount of generation (power capacity) to be built, the number of turbines and their specific location where they were to be erected, nor the specific places of the beaches.

2.2.8 Lutzeyer

Part of a Ph.D. thesis, Lutzyer (2013) carried out both a General Population (GP) and a Vacation Rental (VR) study to garner preferences for offshore wind farms and their locations. The spatial attributes in both mail surveys included the number of turbines visible from shore (64, 100 and 144) and their distance to shore (5, 8, 12 and 18 miles). Both studies stipulated the development a 720 MW wind farm with 144, 5 MW turbines (measuring approximately 104 m to the nacelle with 69 m blades) and respondents were asked to rank the three alternatives in each of eight choice sets: two wind development alternatives and a status quo. Additional attributes included in the GP study included a CO2 emission reduction equivalence (100,000; 200,000; 300,000; 400,000 and 500,000 cars), number of jobs created (500, 800, 1100 and 1400 jobs) and cost/addition to the electricity bill ($2, $5, $8, $12, $16, $20, $25 and $30 USD). Meanwhile, the objective for the VR study was to elicit preferences for beach vacation sites near an offshore wind project. In addition to the number of turbines and their distance, the VR study included an attribute noting a change in the vacation rental price (+5%, 0%, −5%, −10%, −15%, −20% and

−25%). While visualizations for each alternative were included in both studies, one unique aspect about the VR design is that it included both daytime and nighttime visualizations. The GP survey received a response rate of 33% (N = 1050, n = 303) while the VR survey received a 62.3% response rate (N = 792, n = 484).

2.2.9 Meyerhoff; Mariel et al.

Meyerhoff (2013) tested for spatial relationships in an interview-based CE (n = 353) by denoting the minimum distance of the turbines to onshore, residential areas. A second spatial variable was incorporated ex-post using GIS to estimate respondents' distance to nearby turbine(s), and other spatial characteristics such as nearby turbine density, as a proxy for experience with wind turbines. This CE investigated whether different degrees of exposure and experiences with existing wind turbines influenced preferences for additional wind development in Westachsen, Germany. Three proposed development programs were laid out in the choice sets. The first proposed how wind power would develop through 2020 (that is, no-cost status quo). The remaining programs stipulated that wind power would also develop through 2020 but each with different restrictions on one of the CE attributes. These options also included a monthly ratepayer surcharge due to higher costs as a result of those restrictions. In addition to the spatial attribute tested within the CE, the other attributes included the size of wind farms, the maximum height of the turbines, and impact on the red kite population (*Milvus milvus*, a bird of prey). Mariel et al. (2015) used the same dataset as Meyerhoff (2013).

2.2.10 Vecchiato

Similar to Abay (2014), Vecchiato (2014) carried out a CE prompting respondents to choose between onshore or offshore projects in Italy (n = 383). The web-based instrument controlled for spatial effects by including a distance attribute measuring the minimum distance of the wind farm, presented in three levels: 0.1, 0.25, or 1.0 km from the nearest town or coast (if sited offshore). The preamble thoroughly describes the policy motivation, informing the respondent that Italy plans to increase its current renewable generation from 5.2% to 17% by 2020, increasing annual renewable energy output from ~4 MWh to 10 MWh. Other attributes tested in the CE include “position” of the wind project on the landscape/seascape (mountain/hills, offshore, or plains), height of the wind turbines, and number of wind turbines per project while the cost bids varied from 20, 50, 100, or 150 €/year. Respondents were shown eight choice tasks containing three alternatives—two new wind development options of varying attribute-level combinations plus one opt-out status quo alternative at a 0 €/year cost. Visualizations of what each project might look like in the various environments were not shown.

2.2.11 Westerberg et al.

Following Landry et al. (2012), Westerberg et al. (2013) examined offshore wind development impacts using a coastal, recreational demand model in the Languedoc Roussillion region of the French Mediterranean. The authors estimated WTP and WTA for coastal recreation, defined in the payment vehicle as a change in the accommodation price, near a proposed 108 MW offshore wind project (consisting of 30 × 3.6 MW turbines, typically 80 m nacelle and 55.5 m blades =133.5 m total) using an explicit distance attribute at five, eight or twelve km from shore. The following WTA and WTP levels were used (in €/per week): −200, −50, −20, −5, +5, +20, +50 and +200. An additional (discrete) spatial variable was estimated upon analysis in the latent class model (LCM), discussed in Section 3. Non-spatial attributes also tested in the CE included either permitting or not permitting the public to partake in associated tourism opportunities created by the project's foundation (boating, scuba and skin diving and possibly angling) and whether or not the adoption of local environmental policy would be promulgated alongside the wind development (a policy that would favor additional bike lanes, public transport, solar panels, etc.). Each respondent evaluated eight choice sets consisting of two hypothetical alternatives (with visualizations) and an opt-out alternative defined as the current vacation destination and conditions (i.e., no offshore wind farm, associated recreation activities, or municipal environmental policy). Respondents were sampled and personally interviewed on nine different beaches along the coastlines of two locations. Approximately 50% of tourists asked were willing to participate, resulting in an effective sample of n = 339.

2.3 Spatial Drivers of Preference Heterogeneity

Over the past decade, spatial effects have been shown to significantly affect preferences for improvements in environmental goods and services (Brouwer et al., 2010; Jørgensen et al., 2013; Schaafsma et al., 2012). Accordingly, how the benefits resulting from protecting amenities—or improving their quality—are spatially supplied is far from irrelevant through an economic welfare perspective. In the next three sections, the spatial properties tested in the stated and revealed preference literature for wind power are presented.

2.3.1 Distance to an Existing Wind Project

The environmental economics literature has several findings of how preferences for amenities are influenced by the distance to existing amenities/substitute goods. Pate and Loomis (1997) was the first study that addresses this issue in the economic literature, but lately a relatively large number of studies have been undertaken (see for example (Bateman et al., 2008; Brouwer et al., 20120; Moore et al., 2011). Accordingly, we observe that proximity to substitute goods reduce the demand for the amenity improvement in question. This relationship also demonstrates a relevant spatial element in preferences for the preferred location of wind turbines.

2.3.1.1 Distance to the Nearest Wind Project (or Substitute), Stated Preference Studies

Generally speaking, people consider the visual aspects of wind farms to be a disamenity. Accordingly, the presence of an existing wind farm at a relatively close distance to a residence might have different effects on preferences for the location of additional wind turbines. For example, people who live far from an existing wind farm, i.e., those without a view from their home of any wind turbines, might find the impacts of a proposed wind farm more negative compared to people who live relatively close to a wind farm. Conversely, people who have a wind farm close to their residence might have more negative experiences and thus also might perceive the impacts as more negative compared to individuals with less experience by physical proximity. Meyerhoff (2013) supports the latter argument and finds that individuals living closer to existing onshore wind turbines are less likely to prefer additional onshore wind development.

In addition to Meyerhoff (2013), Ladenburg and Möller (2011) find that the distance to existing offshore wind farms negatively influences respondents' acceptance of existing offshore wind farms. Additionally, they find that respondents living within 30 min of driving distance from an existing offshore wind farm are significantly more adverse toward existing onshore wind farms. However, as highlighted in the review by Ladenburg and Möller (2011), the distances to existing wind projects might not be unidirectional. Ladenburg (2014) finds that respondents with a view of a large, near-shore wind farm compared to a wind farm of similar size further away have weaker preferences for wind power relative to biomass and solar energy.

2.3.1.2 Distance to the Nearest Wind Project (or Substitute), Revealed Preference Studies

An increasing number of hedonic price method (HPM) (1979) house studies have analyzed whether home values are influenced by the proximity of wind turbines. If such post-development effects are found, this finding would suggest that the location of wind turbines influence the preferences and subsequently residential spatial sorting. Typically these studies have combined both qualitative measures (whether the property has a view to wind turbines) and quantitative measures (the quantitative distance to wind turbines). Overall, the results are mixed. The majority of the studies have found that onshore wind farms either exhibit no negative net effects on nearby home values [49, 50, 51, 52, 53, 54, 55] or even slightly increase property values (Gorelick, 2014). Several studies suggest, however, that distance-related attributes, tested either by the ability to see a nearby wind project from the residence or as an interactive effect of the visual attribute with distance from the project, exhibit negative effects on revealed preferences and home values either in the short run or when considering net impacts (Gibbons et al., 2014; Heintzelman, 2012; Jensen et al., 2014). These findings of distance decay for RP are summarized in Table 2.2. Finally, it is critical to note that no peer-reviewed RP studies, to the authors' knowledge, have been undertaken to estimate impacts on property values for homes located in areas adjacent to offshore wind projects, either existing or proposed; therefore, preferences for offshore wind farms have only been estimated using SP.

2.3.2 Distance to a Proposed Wind Project

The second spatial element takes into account that the preferences for siting new wind farm(s) might be a function of the distance that people live from its proposed location. This expectation takes the point of origin first described by Sutherland and Walsh (1985) who find that WTP for river quality is a function of the visit rate to the river. The authors find that the visit rate decreases with the distance to the river. Grounded in distance dependency of residents' distance to the good in focus, this relationship can be applied to non-market valuation for wind power by using the distance or travelling time to the nearest potential onshore or offshore wind farm site. The aggregate consumers' WTP for a particular site is critical because the location of wind projects has a substantial influence on the electricity generation costs—and ultimately how much the end user pays for the energy consumed.

Studies examining spatial preferences for proposed wind farm locations can be divided in two approaches, presented below. The first tests for a spatial relationship by including a distance attribute in the CE design. This distance measure typically represents the distance of the proposed wind project to the nearest residential ‘area’ (for onshore) or the shore (for offshore). The second tests for a spatial relationship by explicitly analyzing if the actual distance between the respondents’ homes and the proposed project influences preferences for the potential wind turbine locations.

Table 2.2: Hedonic results estimating distance dependence of revealed preferences (RP) for onshore wind farms.

Study	Location	Variable(s) Estimated Distance Dependency	Property Distance from Turbine(s)	Sample size (N = # properties)	Key Conclusions
Jensen et al. (2014)	Denmark	Wind turbine visibility; interaction of visibility with distance to wind turbine	≤2.5 km	12,640 across 21 municipalities	Up to 10% of home values can be explained by sound and visibility. Negative explained by sound and visibility. Negative distance from the nearest wind turbine.
Lang et al. (2014)	Rhode Island State (USA)	Proximity to turbines; viewshed (None, Minor, Moderate, High, or Extreme)	Homes within 0–0.8, 1–1.61, 1.6–3.2, 3.2–4.8 km (relative to 4.8–8 km)	48,554 single-family home sales near ten sites (3254 are <1.61 km from wind turbine)	Negative short-term effects on home values close to turbines. No significant effects on long-term or net property values.

Table 2.2: Continued.

Gibbons (2014)	England and Wales	Wind turbine visibility; distance	0–1 km, 2–4 km, 4–8 km, 8–14 km	38,000 quarterly housing price observations	Analyzing visual impacts for small rural wind projects, found negative long-term or net effects. Home price decreases approximately 7% if within 1 km of a wind turbine but less than 1% if home is beyond 4 km.
Heintzelman and Tuttle (2012)	New York State (USA)	Distance to nearest turbine[3]; number of turbines in distance bands	0–0.5, 0.5–1, 1–1.5, 1.5–2, and 2–3 miles	11,331 properties	Wind projects significantly reduce net or long-term property values in 2 of three 3 counties for homes with wind turbine visibility versus homes with no visibility.

2.3.2.1 Spatial Preferences Related to Distance Attributes

Spatial preferences estimated using a pre-defined distance attribute in the CE have been analyzed for onshore wind farm development (Abay, 2014; Mariel et al., 2015; Meyerhoff, 2013; Vecchiatio, 2014). Generally, individuals prefer onshore wind farms to be located at greater distances from residential areas. Abay (2014) finds that the distance effect is significantly influenced by the size and number of wind turbines. In that study, the respondents have particularly strong preferences for several, smaller turbines to be built 1

[3] Notes: Used as a proxy for viewshed effects.

km (relative to 0.5) from nearby residential areas relative to one or two larger (1.5–3 MW) turbines. Vecchiatio (2014) finds distance from the nearest homes/coast (1 km relative to 0.1 km) was the second most influential attribute related to wind choices and preferences in the CE. This study also estimates a significant, non-linear distance decay effect, or a declining marginal utility to site the wind project further from the nearest town/coast. Respondents exhibit a WTP of 47 € to move the project from 0.1 to 0.25 km and 78 € from 0.1 to 1 km. Meyerhoff (2013) also finds that the respondents prefer wind farms to be located at the greatest distance from residential areas. However, noteworthy preference heterogeneity seems to be present in that minimum wind farm distance from the nearby residential area is not statistically significant for Class 2 ("moderates"), comprising 26% of the sample (Meyerhoff, 2013).

For offshore, Ladenburg and Dubgaard (2007) was the first study to test spatial preferences in the CE using the distance to the coast as an attribute. Subsequently, a range of SP studies have tested attribute-specific spatial preferences for offshore wind farms locations (Abay, 2014; Knapp et al., 2013; Krueger et al., 2011; Ladenburg and Knapp, 2015; Ladenburg et al., 2011; Landry et al., 2012; Lutzeyer, 2013; Westerberg et al., 2013). Together, the studies generally suggest that there are significant preferences for building offshore wind farms some distance away from the coast. However, as put forward in the review by Ladenburg & Lutzeyer (2012), there is likely substantial preference heterogeneity in that some share of the coastal population might even have positive preferences, or a WTP, to build offshore wind farms closer to shore.

2.3.2.2 Spatial Preferences in a Distance Decay Approach

Whether there exists a spatial relationship with preferences for a proposed wind farm given its actual distance from respondents has so far only been explicitly tested in Ladenburg and Knapp (2015). To estimate this variable, they use travel time via roads from the respondents' zip code area to the nearest proposed site for an offshore wind project. This individual travel time is then used to test if preferences are spatially dependent on the whether the respondents have short or long travelling time to the nearest proposed development area. Through this approach, they find respondents exhibit a lower WTP to reduce anticipated visual disamenities the further away they live from the closest proposed offshore wind farm development site. In other words, respondents exhibit a lower WTP to move the project away the longer travelling time the respondents live from that site. Furthermore, the authors find indications that this estimated distance decay effect is non-linear. They test several distance decay functions, including linear and quadratic, but find that that a spline-threshold approach to be the most appropriate. Specifically, they find that the 60th percentile of respondents with the shortest travel time to the nearest proposed offshore wind farm sites is significantly less adverse to the cost attribute compared to the respondents that live further away. From an economic perspective, this finding suggests that respondents in the 0–60th percentile have a 37% higher WTP for the proposed offshore wind farm to be located at 12, 18 or 50 km, relative to eight km, compared to the respondents in the 61–100th percentile.

In addition, Krueger et al. (2011) and Westerberg et al. (2013) control for spatially distributed preferences. Krueger et al. (2011) find indications that respondents in the subsample furthest from the area designated for offshore wind power development exhibit the weakest preferences to reduce visual impacts from those offshore wind farms. These results are somewhat supported by Westerberg et al. (2013). Compared to segment 3 in their latent class model, segment 2 respondents contain a significantly higher number of respondents from northern Europe, and thus they live far from the French coastline with the proposed wind development of interest. Segment 2 respondents appear to hold relatively weaker preferences for visual impact reductions compared to tourists from southern France that physically live, and perhaps work, much closer to the proposed site. This finding could suggest that people living far from the area of attention have weaker preferences for reducing the visual disamenities in terms of the level of compensation required to stay for a week of vacation. However, the respondents in segment 1 also have weaker preferences compared to segment 2 and this segment does not have a significantly higher ratio of respondents from northern Europe as in segment 2. Furthermore, it is also important to note potential cultural effects in this relationship.

2.3.3 Cumulative Effect

The final spatial element associated with wind power preferences is the influence of the number of turbines that respondents see cumulatively during their daily traveling patterns and routines. Capturing cumulative effects expands the traditional, one-dimensional distance decay function in the sense that the distance to the good in focus/substitutes alone might not be the sole driver of preferences. Rather, the number of substitutes, and the distances to those cumulatively, might drive preferences, particularly if respondents feel surrounded by turbines. Jorgensen et al. (2013) illustrate this multidimensional effect, finding that the distance to both seawater and fresh water substitutes have a significantly negative effect on preferences for river restoration, suggesting respondents show weaker preferences the closer to, and higher availability of, substitutes. The cumulative effect of both proposed, and existing, development on preferences is perhaps the least tested spatial attribute discussed in the literature. Such an effect, if present, would suggest that the location individual wind turbines coupled with the spatial location of other wind turbines drive external welfare costs.

Respondents have been found to prefer larger but fewer wind projects (Navrud and Bråten, 2007; Vecchiatio, 2014). Development through such an approach may be a way to potentially minimize the spatial inundation of the turbines across concentrated areas. Ladenburg and Dahlgard (2012) and Ladenburg et al. (2013) find evidence that the higher (stated) number of turbines seen day-to-day decreases acceptance for onshore wind power. Similarly, Ladenburg (2010) finds some support that respondents who see twenty or more turbines on a daily basis are more negative toward existing offshore wind farms relative to respondents who see only 0–5 turbines in a given day. However, additional evidence suggests that a higher number of cumulative sightings of wind turbines does not have an impact on the relative attitude towards additional onshore and offshore wind farms (2015). Ladenburg and Knapp (2015) test but do not find significant cumulative effects on preferences for offshore wind farms. Specifically, respondents that encounter more than twenty turbines daily do not have significantly different preferences for siting offshore wind farms at distances beyond eight km than respondents who see five or fewer turbines daily. Abay (2014) also tests the cumulative effects regarding preferences for both onshore and offshore wind farms. Interestingly, while Abay (2014) finds that the number of turbines seen daily does not influence the preferences for the spatial attributes of onshore and offshore wind turbines, respondents that see more wind turbines on a daily basis exhibit stronger preferences to develop the proposed 450 MW of wind power in a single, large offshore wind farm relative to 150 onshore locations. More specifically, respondents who see 1–5, 6–15 or 15+ turbines daily have 21%, 36% and 44% higher WTP to build the 450 MW offshore relative to onshore, compared to respondents who see no turbines daily. These results are thus in contrast to the related results and attitudes in Ladenburg (2015).

2.4 Qualitative Spatial Impacts

In the wind power perception literature, many studies use information on either whether respondents have ever seen a turbine/wind farm or have a wind farm in their viewshed (see Ladenburg and Möller (2011) for a review). While these qualitative variables are not related to a particular quantitative spatial dimension per se, they nevertheless capture spatial relationships between the respondents and the location of wind farms. For example, respondents that have a wind farm in view from their home live closer to wind turbines compared to those who do not. Significant spatial relationships in these qualitative dimensions thus provide valuable insight regarding spatial effects on quantitative WTP estimates. Having a viewshed with offshore wind farms is used as a determinant of preferences to reduce associated visual disamenities in Ladenburg and Dubgaard (2007). In their model, they find that respondents with a view of an offshore wind farm from their residence or summerhouse exhibit significantly stronger preferences to locate the project farther from shore. Their WTP is a factor of 2.1–3.6 larger for siting offshore wind farms at 12, 18 or 50 km from the shore, relative to the respondents without an offshore wind farm in view. However, as the authors mention, this estimated effect is based on the stated preferences for 17 respondents and is only significant on a 90 percent level of confidence and should therefore be interpreted with caution.

Given that caveat, these results should be interpreted in context with two recent studies that also estimate Danish preferences to reduce visual diamenities. The first study, Ladenburg and Knapp (2015, unpublished results), is based on a Danish survey from 2006. The results do not suggest that respondents with an offshore wind farm near either their residence or summerhouse demonstrate a higher WTP to reduce offshore wind farm visual disamenities. The second, Abay (2014), is based on a survey from 2011 to 2012 and finds that respondents with an onshore or offshore wind farm located in their home's viewshed exhibit stronger preferences to build 450 MW of wind power in locations offshore relative to onshore. More specifically, the WTP to build the 450 MW offshore is nearly 16% and 38% higher among respondents who can see an onshore or offshore wind farm from their residence or summerhouse, respectively.

It is once again important to stress that both of these papers use data from relatively few respondents that actually have a view of an offshore wind farm from their residence or summerhouse. Nevertheless, the more recent studies point towards having a viewshed with an offshore wind farm might not be uniform compared to Ladenburg and Dubgaard (2007). A potential explanation could be that Ladenburg and Knapp (2015) and Abay (2014) include a map of Denmark that denotes existing and proposed offshore wind farms whereas the geographical location of offshore wind farms in Ladenburg and Dubgaard (2007) was not specified. The results in Ladenburg & Dubgaard (2007) could thus potentially be explained in that respondents with a view of an offshore wind farm are willing to pay an additional risk-premium to site offshore wind farms further from the shore given the specific geographic location for the proposed development is not identified; therefore, they might be more risk-averse to having future, additional offshore wind farms possibly sited close to the project already in sight. Another possible explanation might also be that individual preferences have changed over time with increased development onshore and offshore. However, the data in the Ladenburg and Knapp (2015) is from 2006 and, thus, only a few years after Ladenburg and Dubgaard's (2007) research was carried out.

As illustrated in Ladenburg (2014), another explanation could also be that that the type of wind farm of which respondents have a view is relevant. This paper focuses on the preferences for power production from wind relative to biomass or solar energy in Denmark. Though the preferences are not estimated monetarily, the paper offers insight on some meaningful viewshed and spatial relationships. First, a respondent with view of an onshore wind turbine from his or her residence or summerhouse has lower preferences for wind power, while having the project offshore appears to increase preference for wind power (significant at a 90% confidence level). This study takes advantage of a pseudo-natural experiment by including preferences for the relative renewable generation technologies of two distinct populations: on adjacent to the Nysted offshore wind farm and the other to the Horns Rev project. What makes these samples unique is that while the two wind farms were built at approximately the same time, the otherwise highly similar wind farms (72–80 tall turbines; a height of 110 m) were built at different distances from the coast: the Nysted project is located approximately 6–10 km from the coast whereas Horns Rev is 14–17 km. Consequently, these projects provide distinct impacts on the view of the seascape. Accounting for the differences in experience, Ladenburg (2014) finds that the respondents with the closer offshore wind farm (Nysted) in their viewshed exhibit significantly weaker preferences for wind power compared to respondents who see Horns Rev in their view. Finally, Ek and Persson (2014) also inquire about experience with wind farms (that is, whether or not a respondent has wind turbines in sight of their residence or cottage), but interestingly this variable had no effect on latent class membership.

Finally, it is worth highlighting that several related non-economic surveys have also found spatial effects for wind power and energy development (Jacquet, 2012; Pocewicz and Nielson-Pincus, 2013; van Rijnsoever et al., 2014). While these studies do not quantitatively elicit WTP estimates, and consequently do not define the spatial dimensions through which social welfare could be maximized, they do estimate significant spatial parameters related to individual wind power attitudes, beliefs and perceptions. Moreover, these findings suggest siting wind farms offshore tends to be preferred, generally speaking. Together, these studies suggest that attitudes toward and economic preferences for wind power are interlinked and influenced by both the spatial attributes of the development itself and interaction of the individual with the technology.

2.5 Conclusions and Policy Prospects

This article has reviewed the relevant literature on economic preferences for wind power, both on and offshore, while focusing on the spatial dimensions that influence those preferences. Together, these studies make the case that spatial effects significantly contribute to preference heterogeneity. In addition to 14 CE stated preference analyses, several unpublished studies also find evidence suggesting that spatial elements affect preferences for wind development.

The reviewed papers thus clearly indicate that stated preferences for wind farm locations are spatially distributed with regard to the location of wind turbines within a specific area via the distance attributes. Preferences are also spatially distributed in regard to the respondents' homes and their distances to the proposed wind development site. To this end, the review demonstrates that when confronted in a CE with direct trade-offs between costs, various wind farm attributes, and a distance attribute, respondents significantly associate a higher utility with alternatives at greater distances. This finding naturally lends valuable information in relation to the relative societal welfare gains associated with the spatial distribution of wind turbines within a specific area designated for wind power development.

The review thus demonstrates a significant gap in that outside specifically testing a pre-defined spatial attribute within the CE, aside with a few examples of discrete measures via sample stratification, controls for spatial effects on SP in an actual distance decay framework are almost non-existent. Clearly more studies are needed that address how individuals trade-off the actual distance/travelling time to proposed wind farm sites and their willingness to pay to reduce its visual impacts or to even build the project. Following the findings in Ladenburg and Knapp (2015), such spatially distributed preferences might have a significant influence on the choice of wind farm locations, resulting in tradeoffs between potentially higher technical costs associated with deploying the projects further from shoreline populated areas and the social welfare benefits that accrue as a result of such actions. There thus remains a significant opportunity moving forward to test for spatial dimensions explicitly as attributes within a choice experiment, including controlling for travel time or distance to proposed projects using geographic information systems (GIS) software. Further research also should explore how ancillary dimensions influence WTP and welfare estimates such as directional effects as well as users vs. non-users of the space near or surrounding these projects given that potential conflicts between recreational and commercial users are likely to occur for offshore projects, especially. Previous evidence suggests users exhibit higher WTP for environmental amenities or WTP to avoid conflicts compared to non-users; similarly, use-status of areas valued for water quality improvements have been found to significantly affect welfare estimates in that users and non-users' distance decay functions take on different shapes (either linearly or logarithmically) with decreasing proximity (Jørgensen et al., 2013; Schaafsma et al., 2013).

Finally, governments across Europe as well as the United States have plans to proliferate their offshore wind capacity in the coming decade. It is therefore paramount to understand if and how preferences are spatially correlated with the proposed wind development locations or, for countries with substantial existing onshore and offshore wind capacity, if preferences for future projects are spatially correlated with the location of existing wind development. Both Ladenburg and Knapp (2015) and Abay (2014) provide strong, preliminary indications that cumulative effects in terms of the (stated) number of turbines seen on a daily basis significantly influence stated preferences. Though Ladenburg and Knapp (2015) also test whether this cumulative effect is negatively correlated with an attitude towards additional offshore wind farms and find no significance, next research steps would be to include more objective measures to test for cumulative effects.

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Chapter 3

ARE RATEPAYERS WILLING TO PAY PREMIUMS FOR OFFSHORE WIND POWER? EVIDENCE FROM A CHOICE EXPERIMENT IN THE MID-ATLANTIC, USA FOR THE NATION'S FIRST UTILITY-SCALE PROJECT

Offshore wind (OSW) power has the potential to play a significant role in climate change mitigation, reduction in negative health impacts from electricity generation and a coastal energy policy in the coming decade. The Eastern Seaboard of the United States touts significant wind resource areas that coincide with shallow continental shelves in direct proximity to large population centers, and, significant load (Firestone et al., 2015a). Yet, the path from 2001, when the first project was proposed, to 2018 has not been one not without setbacks. Development of any major utility-scale offshore wind project in the US continues to be a long time coming, although the states of Massachusetts, Rhode Island, Connecticut, New York, New Jersey and Maryland are committed to more than 8000 MW.

The US Department of the Interior's (DOI) Bureau of Ocean Energy Management (BOEM) over the last several years has leased thousands of square kilometers of offshore wind energy areas (WEAs) designated for development near some of the highest load (demand) centers along the Eastern Coast of the US. One of the thirteen presently existing WEAs, referred to as the Maryland WEA (MWEA), adjacent to both Ocean City, Maryland and Fenwick Island, Delaware, is the research focus of the present analysis. In late 2014, the DOI and BOEM auctioned an offshore lease of a 124 mi^2 (312 km^2) area roughly 18 km from Ocean City, Maryland to developer U.S. Wind Inc. for the purpose of permitting and building an offshore wind project (Figure 3.1).[4] Subsequent to this study, US Wind assented to state terms to sell energy generated from 248MW to be developed in the Maryland WEA. Significant costs and challenges, as well as benefits, to adjacent coastal communities are expected to follow.

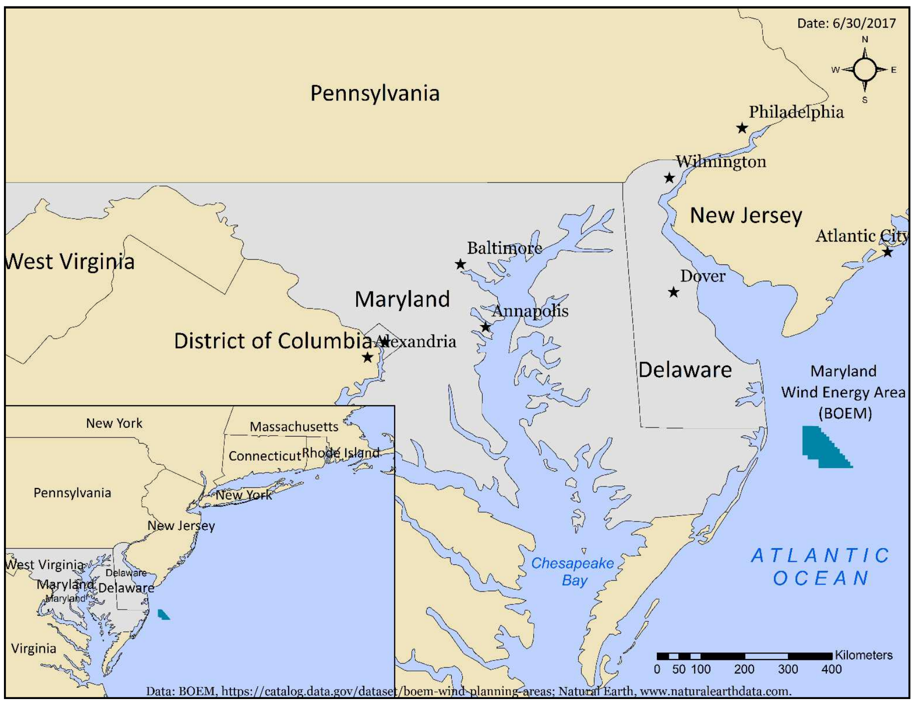

Figure 3.1: Choice experiment sample area (in gray) across the mid-Atlantic, USA, in Delaware and Maryland.

[4] The North and South halves of the WEA were auctioned separately. US Wind Inc. was the high bidder in each.

Several states along the eastern US have adopted laws called renewable portfolio standards (RPS) to incentivize development of offshore wind power or are augmenting those portfolio requirements to offer premiums for offshore wind energy. In late 2013, Maryland passed legislation to allow a charge of up to a $1.50 per household per month to help pay for electricity from an offshore wind project, if built. Previously, in neighboring Delaware, the Delaware Public Service Commission (DEPSC) approved an offshore wind power purchase agreement (PPA) between Bluewater Wind (BWW) and Delmarva Power and Light (DPL), since abandoned by the developer based on estimates that it would have cost ratepayers an additional $0.75 on their monthly electricity bills. BWW had intended to build in the Delaware WEA; with the PPA abandonment, the lease has since been transferred to another entity.

One reason for the adoption of state policies that allow renewable premiums to be cost-shared amongst ratepayers is that the levelized-cost-of-energy (LCOE) of future offshore wind in the US is presently substantially above market prices, at least double the cost of new advanced combined natural gas. That said, some cost modeling forecasts anticipate cost decreases for new offshore wind that could range anywhere from $95/MWh to $300/MWh by 2022 (Beiter et al., 2016). Yet, the knowledge of what monthly surcharge households would be willing to pay for electricity from offshore wind power—whether it be $0.25 or $25 more per month—and therefore how to best design a state RPS that distributes costs efficiently or fairly, remains unclear. This critical economic gap is exacerbated by the fact that more generally, underlying factors for offshore wind power project support and opposition are not well understood (Bates and Firestone, 2015).

Furthermore, none of the previous wind valuation studies, to our knowledge, have been proposed to estimate costs for projects in a federally designated wind area. Policy recommendations therefore can be informed by respondents' preferences to minimize impacts (Landry et al., 2012). The present study thus fills a gap in understanding on the rate premium question that both Delaware and Maryland policymakers faced blindly.

Choice Experiment: Offshore Wind Power in the Mid-Atlantic, USA

The present study employs data (N=973) from a choice experiment (CE) to estimate whether Delaware and Maryland households exhibit willingness-to-pay (WTP) to develop the MWEA. During the first quarter of 2015, survey data regarding the opinions and stated preferences were collected across randomly stratified Delaware and Maryland residents. Respondents were presented with a choice experiment of either a new offshore wind power or natural gas generation facility, defined in the study to respondents as the no-cost, 'status quo' option across a tri-mode (mail, mixed mail and online, and online panel) survey (Knapp and Firestone, 2018). Table 3.1 presents the study's research questions.

Table 3.1: Study hypotheses and reasoning.

Hypothesis	Reasoning
Residents will be willing to pay premiums for offshore wind power on their monthly electricity bill compared to a new natural gas project in the region.	There is strong general support for offshore wind near Maryland, Delaware, and New Jersey (Bates and Firestone, 2016). This support will likely translate into stated economic preferences for some or many.
Project characteristics will affect WTP price premiums, but not all in a negative direction.	Visual aesthetics associated with offshore wind projects have been demonstrated to incur a disamenity (Krueger et al., 2011; Ladenburg and Dubgaard, 2007), with evidence demonstrating WTP to move the projects further from shore. This evidence suggests residents might care about where exactly the project is sited in the wind energy area, i.e. furthest away from Ocean City, MD. However, they might not care how many turbines the project has, perhaps valuing the project with more turbines if that results in higher amounts of clean electricity benefits.
Delaware will exhibit relatively statistically similar WTP to pay price premiums compared to Maryland residents.	Maryland is actively considering the project, not to mention has as a state policy (renewable portfolio standard) already in place for the project. There is much literature to suggest residents prefer projects to be further from shore; Delawareans will see the project offset, not straight on as from Maryland, also from slightly further away. That said, there is no evidence *a priori* suggesting Delaware residents prefer offshore wind over Maryland, or vice versa.
There will be significant spatial heterogeneity in preferences across strata and subgroups that identify with the coast. *Ceteris paribus*, residents on the coast; those that own a beach house; and/or those that recreate at nearby beaches will exhibit a lower willingness to pay for an offshore wind project in the MWEA relative to their counterparts.	Coastal residents have higher at stake with the perceived impacts to their livelihoods, recreation activities, and attachment to that place. Coastal residents likely also hold stronger values related the coastal environment relative to their inland counterparts (Stedman, 2006).

Results indicate both general support for building offshore wind power, but also that respondents are WTP price premiums for the ancillary renewable electricity generation. Interestingly, respondents in Delaware and Maryland exhibit minor decreases in implicit prices for marginal additions to project size (additional turbines) projects located in the north of the WEA. First, we estimate the magnitude and direction of underlying factors related to the likelihood of public support for and opposition to developing utility-scale wind power within the Maryland WEA. This concerns specifying significant project attributes as well as individual demographic predictors related to coastal living with respondent choices for wind power options. Second, we estimate related social welfare and WTP. We present a demand curve for offshore wind power as a function of project size and price ($/month/household). Finally, the paper concludes with offering insights to inform state policies.

3.1 Previous Valuation Studies

Over the past decade, there has been a burgeoning interest in the valuation literature in investigating various socioeconomic dimensions of and preferences for renewable energy, in particular for on- and offshore wind power (for example Ek, 2005; Ek and Persson, 2014; Hanley and Smith, 2002; Koundouri et al., 2009; Nkanash and Collins, 2018; van Rijnsoever et al., 2014; Vecchiato and Tempesta, 2015). Respondents are presented with a detailed series of choices among electricity generation projects of differing characteristics and asked to vote for their preferred energy future scenario(s). Most of this literature has approached the quantification of associated positive and negative impacts through WTP either for the technology or to alleviate negative externalities associated therewith (Krueger et al., 2011), and to a much smaller extent, willingness to accept (WTA) money to live near it (Brennan and van Rensburg, 2016).

In addition to marine or avian wildlife impacts, much of the concerns regarding offshore wind power relate to possible impacts on socioeconomic dimensions of the coastal way of life that stem from visual impacts. In the seminal paper in Denmark, Ladenburg and Dubgaard (2007) were the first to test economic tradeoffs and measure visual disamenities from offshore wind farms in a stated preference approach, and have since built upon their analysis (Ladenburg, 2015; Ladenburg and Dahlgaard, 2012).

CEs for offshore wind power have a myriad of specific attributes and levels to account for features such as project size (Vecchiato, 2014); location (e.g., onshore or offshore); ecological impacts (Börger et al., 2015; Mariel et al., 2015; Meyerhoff, 2013; Westerberg et al., 2015); distance disamenity/viewshed (Krueger et al., 2011; Ladenburg and Dubgaard, 2007; Vecchiato, 2014); project ownership (Brennan and Van Rensburg, 2016); and have explored various payment 'vehicles' (García et al., 2016; Kermagoret et al., 2016). A subset of this literature has investigated effects on recreation and beach tourism activities (Landry et al., 2012; Parsons and Firestone, 2018; Voltaire, 2017; Westerberg et al., 2013, 2015). Many of the attributes have proven to be statistically significantly related to preferences and respondents' choices, tend to be project-specific, and are subject to external validity evaluation.

Additional factors that extend beyond the physical characteristics of the wind project itself have played a notable role in capturing stated preferences. Brennan and van Rensburg (2016) employed a discrete choice experiment (CE) to estimate local externalities for onshore wind development in Ireland. One of their main research objectives was to test whether the presence of a community representative in the development process would alleviate localized externalities, finding a representative for the community in the planning process alleviated the discount (i.e., WTA) required on the respondent's annual electricity bills (Brennan and Van Rensburg, 2016). These findings are bolstered by relevant research in the perception literature. Community relationships have been found to be significant predictors of support for offshore wind power. Place-based attachment has helped explain perceptions (e.g., Devine-Wright, 2009; Firestone et al., 2015b) and early engagement of the community has been shown to be a critical component for future offshore wind power demonstration projects (Bates and Firestone, 2015). The mechanism by which respondents are compensated has also been found to substantively influence preferences, with respondents preferring public to personal compensation (García et al., 2016; Kermagoret et al., 2016).

Yet nuances remain. Preference heterogeneity exists across both WTP and WTA for renewable electricity and can be technology, or even more so, geographically or spatially specific (Brennan and van Rensburg, 2016; Gracia et al., 2012; Krueger et al., 2011; Landry et al., 2012; Yoo and Ready, 2014). In general, individuals frequently exhibit lower WTP, and expect to receive smaller benefits for new environmental goods (recreation areas, for example) if they live far from the proposed location or have nearby alternative location(s), all else constant (Brouwer et al., 2010; Glenk et al., 2014). This *distance decay* concept has also been found for other energy technologies, i.e., in decreased social welfare among residents living close to hydraulic fracturing sites on average in New York State (Popkin et al., 2013).

Heterogeneous preferences and distance decay for onshore and offshore wind have been found to be significant, but these relationships are still on their way to being robustly characterized (Börger et al., 2015; Brennan and van Rensburg, 2016; Knapp and

Ladenburg, 2015; Ladenburg and Lutzeyer, 2012; Mariel et al., 2015; Meyerhoff, 2013; Oerlemans et al., 2016; Strazzera et al., 2012). Findings suggest residents' WTP falls at an increasing rate with distance a project is from shore (Krueger et al., 2011). As such, building an offshore wind project further away from shore can decrease welfare costs. While the present analysis does not explicitly test the effect of an OSW project's distance from shore per se, it does focus on the distance a residence is from the shore adjacent to the project and the angle of view (hence distance). Increasing the distance to the project has been found to alleviate WTA values for residents living near an onshore turbine (Brennan and Van Rensburg, 2016). Geographic discounting for wind and oil and gas development also has been found to assuage WTA, and perhaps even concentrating development in a single area (Pocewicz and Nielsen-Pincus, 2013). To further muddle matters, perceptions can change through time regarding the permitting and development processes as residents learn about the energy technology (Bush and Hoagland, 2016), and that a one-size-fits all strategy, particularly concerning the issue of optimal distance from shore, is too simplistic (Fooks et al., 2017).

Attributes aside, the bottom-line evidence suggests that whether it is for a mix of renewable energy (Yang et al. 2016), reduction in greenhouse gas emissions from carbon-free nuclear and renewable sources (Murakami et al., 2015), or offshore wind specifically (Georgiou and Areal, 2015; Krueger et al., 2011), there is significant public WTP premiums for carbon-free electricity. While Gracia et al. (2012) find that most respondents in Spain require a discount for more of their electricity to come from renewables, they identified 20 percent who were WTP premiums, but that the extent of premium depends on the type of renewable technology in question. The geographic location of the wind, solar or biomass mattered more than its type for individual preferences. Some studies also take WTP figures further to estimate the wider-reaching social welfare implications from building a renewable energy project, as these values can be incorporated in cost-benefit analyses and ultimately into the normative decision of whether to build the project (Snyder and Kaiser, 2009).

3.2 CE to Develop the Maryland Wind Energy Area

Survey Development

The instrument underwent several iterations before becoming finalized in May 2014. While no explicit pre-interviews took place, instrument content built off previous wind valuation studies in the literature as well as the broader wind power survey research. The final instrument was pilot tested among graduate students in a marine policy program and faculty members for clarity. Once edits were made, it was pre-tested at a Department of Motor vehicles location to test the choice experiment attribute and bid levels, clarity of question wording, photomontages, instructions, and glean additional thoughts. 50 complete or semi-complete surveys were recorded as well as general comments that were told to the researchers administering the pre-tests. Survey language was modified as appropriate to reflect germane comments. The upper bound of the choice experiment bid selection was increased with the goal that even the most ardent offshore wind power supporters would ‘vote’ no for an offshore wind power option at the highest price level to facilitate proper estimation of the demand curve.

Survey Structure

The energy choice experiment was divided into four key sections. The first solicited general opinions about wind power and developing an offshore wind project in the MWEA. It also sought to collect data on perceived effects on various socioenvironmental aspects. The choice section immediately followed, described later in further detail (Section 2.1). General questions including specific aspects of respondent preferences regarding environmental attitudes and behavior, world views (e.g., climate change beliefs and views of government) as well as beach and ocean going activities followed. Respondents were then presented household questions, including a detailed question on second homes in coastal/beach areas in any adjacent communities to the MWEA. Standard socio-economic and demographic questions such as age, education, employment, political views, etc., concluded the instrument.

Modes

Surveys were administered across three modes: a mail-only sample[5], a mixed mode with mail or internet option, and an online-only, opt-in (panel) mode. Taking a multi-mode approach allowed us to reach a representative set of age and socioeconomic population as well as glean survey method influences – because paper mail surveys are typically

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[5] Potential mail-mode respondents were given a new option in their final postcard to complete the survey online in an attempt to increase response rates. Six respondents chose to do so.

answered disproportionately by older, white males (Dillman, 2014). Thus, an identical online version was developed concurrently to reach a broader demographic group and to control for mode differences in the choice experiment. The panel mode was comprised of individuals recruited[6] by Survey Sampling International (SSI[7]) who are paid a fee to answer surveys that they are invited to complete by SSI (hereinafter "panel" or "panel survey"). Dillman (2014) protocol was followed for contacting all potential non-panel respondents, consisting of an initial pre-notification letter followed by a survey packet that included a cover letter, survey booklet, a pre-stamped return envelope, and photomontages; a follow-up post card; second packet (consisting of the same materials as the first packet); and a final follow-up reminder post card.[8] See Knapp and Firestone (2018) for full details regarding the sample design and mode sampling approach.

The online instrument was hosted via Qualtrics, one of the prominent online survey research platforms. Photomontages were hosted and created by an Irish firm, Macro Works (www.macroworks.ie), that specializes in visual impact graphics and analysis. Images were

[6] Panelists for the internet panel sample were recruited by SSI through a myriad of membership lists from over 3300 partners, companies and organizations (e.g., Amtrak, Apple, social networking, frequent fliers, readership clubs). Possible panelists are invited via email or pop-up and asked if they're interested in joining a survey panel. Potential panelists are first vetted for accuracy through a battery of questions (geographic and demographic) prior to joining. Throughout their duration on panel, each panelist maintains a quality score; if this score falls too low due to failure to finish surveys, they are given a warning. If it remains low, they are removed from the panel.

[7] Survey Sampling International (SSI) is a prominent survey sampling firm.

[8] The mail-only sample received an option to complete the instrument online instead in their second follow-up post card. This increased response rates by n=6.

pre-tested by Macro Works to ensure they were properly displayed on desktops, laptops and tablets using various browsers (Chrome, Internet Explorer, Firefox and Safari) and that survey respondents would leave the Qualtrics platform to view a given photomontage and then be directed back at the proper point in the survey. Respondents were asked to not use readers or smartphones. The online version of the survey differed only slightly in several ways. First, respondents saw the photomontages on their computer or tablet screen. Any questions that needed to be skipped did not appear on their web interface. Finally, respondents saw five debriefing questions immediately following the final demographic section, including whether they viewed the photomontages during the choice experiment (and if so, how many) and on what electronic device they completed their answers.

Implementation and Photomontages

Because of the visual nature of offshore wind turbines and the hypothetical nature of an offshore wind project, photomontages were necessitated to provide a robust sense of realism and context to the welfare scenario (Hevia-Koch and Ladenburg, 2016). Supplemental materials of the quality employed here have not frequently been used in previous wind valuation studies (Hevia-Koch and Ladenburg, 2016; Knapp and Ladenburg, 2015). Using a series of photographs from various beach locations adjacent to the Maryland WEA from different vantage points for DE and MD residents, realistic place-based photomontages of what 6-MW GE Halidade offshore wind turbines with 150-m rotor diameters, separated 0.9km (8 rotor diameters), would look like from each state's beach were created (Figure 3.2). Each photomontage was created using attribute-specific characteristics (e.g., size, location and vantage point) of a given proposed project for each choice option across all choice sets. The third, 'opt-out' alternative for a natural gas plant in each choice set did not come with an accompanying photomontage. In the southern half, where a southern project would be located, we chose to locate the wind turbines as far north as possible so that the projects would appear the same distance from shore at their closest point. We did not provide a statement to respondents to that effect nor did we depict schematically where a given project's individual turbines were located. Doing so instead left it to the respondent to interpret the photomontage.

Figure 3.2: Photomontage depicting a 300 MW offshore wind project (located in the southern part of the MWEA) shown to Maryland respondents. Project viewing location is from Ocean City, MD. Photomontage here not to scale.

Instructions were given to respondents on how to view the photomontages, depending on whether a paper or internet survey was completed, and if an internet survey, the size of the screen. During this time, all respondents were prompted to consider expected visual impacts while making their decisions.[9] Then while answering choice questions, respondents were prompted to view the photomontages provided in the survey packet of how each proposed project (which vary by project size and location), and specific offshore wind choice within a given choice set would appear from Fenwick Island, DE (Delaware respondents) and Ocean City, MD (Maryland respondents). The different vantage points were used to make the hypotheticals as realistic as possible, resulting in Marylanders having rather straight-on views and Delawareans viewing the project simulations at an angle, particularly for those projects located in the southern section of the WEA. For any respondent completing the survey online, the photomontages were stored on an external server and programming directed respondents to and from the photomontages. The images had to properly project using various operating systems (e.g., IOS and Windows) on desktops, laptops and tablets. All internet users were given a test photomontage early on. If they could not view it properly, they were requested to notify the research team and terminate the survey.[10] A map of the MWEA in which the projects would be located generally was also presented toward the beginning (Figure 3.3); while primarily adjacent to Ocean City, MD, it extends as far north as Fenwick Island, DE.

[9] All DE and MD respondents were also prompted to view a photomontage for the general support question of whether to build wind power in the MWEA in the first section of the survey before the choice experiment section from their state's vantage point. During this question residents also saw a stylized map to orient them to the location of the MWEA relative to the shore and familiar landmarks.

[10] Only for < 1% did this occur.

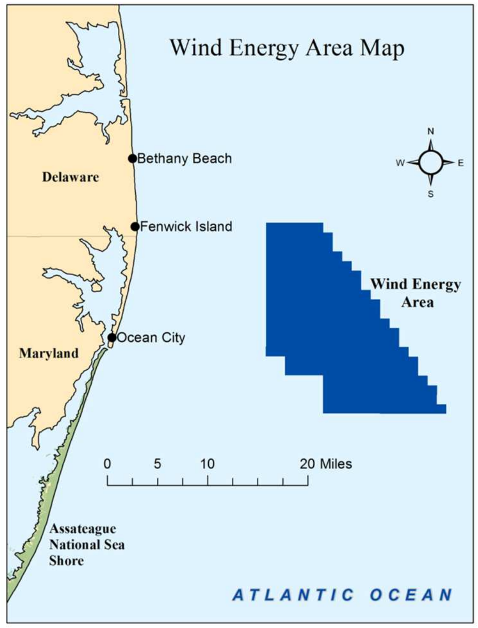

Figure 3.3: Map depicting MWEA shown in accompanying materials during the CE (map, L. Knapp).

For the panelists completing the survey online (and any mixed-mode respondents opting to complete their survey via the web), the first Maryland respondent was directed to the CE instrument version (of 12) with a Maryland vantage point, the second such respondent to the second version and so on. The thirteenth respondent to enter the survey was then directed to the first Maryland version and subsequent respondents continued the loop. Delaware panel and online, mixed-mode respondents were treated similarly. Section 2.1 details the CE versions.

Sampling and Stratification

To ensure a representative sample of coastal residents given the potential for spatial heterogeneity in WTP and in an attempt to decrease variance in estimates, Delaware and Maryland were geographically stratified. Delaware was stratified into two strata: a Coastal stratum, consisting of Block Groups bordering the Delaware's Atlantic Ocean coastline, and an inland stratum, consisting of everything else. Maryland was stratified in three strata with a similar coastal stratum (including Assateague National Park Island that lines most of Maryland's Atlantic shoreline); a mountain stratum consisting of Maryland's three westernmost countries; and a central stratum consisting of everything else in central Maryland, including Baltimore and environs and the Maryland suburbs of Washington D.C. Of the mail sample across Delaware and Maryland that received an option to complete their survey online (i.e., mixed-mode), respondents were mailed an individualized web address and PIN to take the survey. One-half of the mail sample was (n=1850) was assigned at random to the mixed-mode sub-group; the remaining half were assigned the mail-only treatment. Further details regarding the instrument including the survey structure, modes, the Dillman contact administration, stratification, and other instrument aspects can be found in Knapp and Firestone (2018).

Responses

Valid mail and online surveys were completed January through April 2015 (N=973). The panel was administered to 137[11] residents in Delaware and 424 residents in Maryland (total N=561). In total, 412 usable surveys were received via the mail-mode or mixed-mode (either web or paper). After removing bad addresses, opt-outs, etc., effective response rates were 25% for the mail-mode, 30% for the mixed-mode, and a 63% 'participation rate' for the Internet panel. For each stratum, data were weighted separately using U.S. Census

[11] We would have sampled additional individuals in DE but were limited by the number in the SSI panel.

Bureau (2014-2015) American Community Survey demographics in Stata software on strata population, education, household income, age, and sex. Table 3.2 presents the sample's mean demographics.

Table 3.2: Mean, unweighted sample demographics (all sample modes: mail, mixed, and panel).

	Delaware			**Maryland**			
	State	*Coastal*	*Inland*	*State*	*Coastal*	*Central*	*Mountain*
N	345	126	207	628	78	450	82
Age (yrs)	55	63	51	51	59	49	54
Male	55%	64%	50%		67%	41%	50%
Income ($/year)	$50k-$74,999	$75k-$99,999	$50k-$74,999	$50k-$74,999	$50k-$74,999	$50k-$74,999	$50k-$74,999
Educational attainment	Associate degree	Bachelor degree	Associate degree	Associate degree	Associate degree	Associate degree	Associate degree
Second beach home ownership	21%	62%	7%	7%	34%	6%	3%
Seen a wind turbine in operation	71%	85%	65%	63%	82%	59%	79%

3.2.1 'New Energy Development': Choice Experiment for Offshore Wind Power

The second section of the instrument presented the instrument's wind power choice experiment. Respondents were asked to vote their preference in a 'real referenda' across three choice sets that proposed three choice sets between three potential electricity generation projects: two offshore wind projects and a third, 'opt-out' alternative to build a new natural gas project instead.

Development of the Preamble

Figure 3.4 displays the preamble that immediately preceded the choice sets. In it, respondents were presented with a new energy development scenario for their respective state and were prompted to vote for their most preferred development scenario. The preamble informed respondents that they would be asked to make three energy development decisions amongst possible choice sets of various technological characteristics that would vary across, and within, each set.

First, some important information:

- Like many new technologies, the earliest projects cost more than later ones; thus, electricity generated by the first offshore wind projects will cost more than you are paying now. Wind energy is sold to consumers in long-term contracts that are structured so that the price consumers pay remains constant or is tied to a set annual increase (such as 3% per year). The questions that follow assume that your monthly electricity bill will be greater than it is today, with a constant monthly increase (e.g., $3/month in 2015, 2016, 2017 … 2034) over the 20-year life of the wind project.

- The turbines could be in the North, South, or across the entire Wind Energy Area. The size of the project (such as the number of wind turbines) as well as the increase to your electricity bill may also vary.

- To give you an idea of scale, 50 offshore wind turbines (300 Megawatts) would generate enough electricity to power 75,000 homes.

Some things to think about before voting:

New offshore wind project	New natural gas project
• Can only be built after its potential effects are evaluated.	• Environmental and human health effects would be much greater.
Environmental effects: • Some negative effects on marine life; however, the long-term effects are expected to be minor for properly located projects. • Will displace existing coal- and natural gas-generated electricity resulting in environmental benefits.	Environmental effects: • Negative effects during exploration, drilling and extraction, pipeline transportation and combustion. • Negative effects on wildlife, water use/quality and climate.
Social effects include: • Negative effects on traditional users of the marine environment (such as commercial fishermen).	Human health effects include: • Asthma, bronchitis, cardiovascular and respiratory ills resulting in hospital visits, lost workdays and restricted activity days.

Continue on to vote →→→

Figure 3.4: Preamble proceeding the choice experiment to vote in a 'New Energy Development' scenario.

Development of Choice Attributes and Versions

Each wind project option tested a varied combination of critical project characteristics, including its location within the Maryland WEA (North, South or Central), wind project size, and a monthly electricity price premium, or bid. All varied choice set combinations, as well as the first choice question, were designed in a way in that the larger of the two projects presented was always paired with a larger price than the smaller project.

Table 3.3 displays the CE's project attributes and levels. North, south or central location with the WEA rather than distance from shore was tested given that MWEA has a relatively constant closest distance to shore (approximately 18 km), and the vantage of the project from Ocean City (MD residents) or Fenwick, Island (DE residents) changes markedly depending on the project's north-south location. Furthermore, this allowed us to test a specific attribute that was directly policy relevant as distance from shore is not an actual attribute given the specific WEA has already been spatially defined and leased. Project size was also an obvious additional attribute. Smaller projects with fewer turbines would have less visual impact, therefore potentially incurring a lesser visual disamenity. On the other hand, it was hypothesized that some respondents might favor larger projects at greater monthly expense with the rationale being that more renewable energy generation capacity would provide greater benefit to society (i.e., climate and health benefits). The final attribute—bid ($/household/month)—allowed us to capture the maximum premium an individual would be WTP for 'green' offshore wind power.

Table 3.3: Attributes and levels shown in energy development choice experiment.

Attribute	Description	Levels
Location	Location of the wind project within the 124 mi^2 (321 km^2) WEA.	North; South; Entire wind energy area (North + South).
Size of energy project	Wind project power capacity (megawatts, or MW) in the WEA.	200, 300, 500, 750, 1000 (MWs); also displayed to respondents in equivalent number of wind turbines, 6 MW each: ~33; 50; ~83; 125; or ~166 wind turbines.
Bid	Extra payment respondent would have to pay per month for either the wind power or natural gas (opt-out) selection they checked.	$0 (opt-out alternative only); $1.50; $5; $10; $20; $50; $75; $100.

Choice Questions

Each of the three choice sets displayed two offshore wind projects with varying project characteristics in the MWEA ~17.7 km (told to respondents as 11 miles) from shore. A third, "opt-out" alternative option assumed a new natural gas project would be built instead. The premium for the natural gas, out-out alternative remained a constant $0/month for all respondents across all choice sets. All respondents were first shown the same fixed choice question (Figure 3.5). This approach is typical for choice experiments when seeking to test an explicit choice tradeoff between two attributes. Here—size and bid—were tested. A second and third CE question was included with different project attributes that varied across respondents. Using SAS statistical software, a semi-orthogonal design blocked into 24 sets in 12 versions was employed to create enough variation in project characteristics across questions (and within choice referenda) to determine effects of each attribute and level (Table 3.4).

➤ *Keeping in mind your **monthly budget**, please respond as if you were actually faced with this vote and as if the options presented in each choice are the only available options.*

Choice 1: Please consider this set of options for Your State's energy future.

*Refer to the **Wind Energy Area Map*** and *to the insert for the **simulated views of the wind projects***. Each simulation indicates the viewing location of a given wind power project option.

11a. If the vote were held today, which option would you vote for?

	Wind Power		**Natural Gas**
	Option A	**Option B**	**Option C**
Location	South	South	N/A
Size of energy project	33 wind turbines (~200 MW)	125 wind turbines (750 MW)	Expansion of electricity generation from natural gas.
Increase to your electricity bill	$1.50/month	$5/month	$0/month
I would vote for… *(Check one)*	◻	◻	◻

Figure 3.5: First choice question in the 'New Energy Development' referenda (choice 1 of 3 per respondent).

Table 3.4: Attributes and levels shown across 12 instrument versions of the wind choice experiment.

			Attribute		
Instrument version	**Question number in choice set**	**Wind Option**	**Location**	**Size (MWs)**	**Bid ($/month)**
1	2	A	Central	1000	$50.00
		B	North	750	$20.00
	3	A	Central	750	$10.00
		B	North	500	$1.50
2	2	A	North	750	$20.00
		B	South	500	$10.00
	3	A	South	300	$50.00
		B	Central	1000	$100.00
3	2	A	Central	1000	$100.00
		B	South	300	$50.00
	3	A	Central	1000	$50.00
		B	North	500	$5.00
4	2	A	Central	1000	$50.00
		B	South	300	$20.00
	3	A	Central	1000	$50.00
		B	North	750	$5.00
5	2	A	North	500	$10.00
		B	South	300	$1.50
	3	A	North	300	$50.00
		B	Central	750	$100.00
6	2	A	North	750	$20.00
		B	Central	1000	$50.00
	3	A	Central	750	$100.00
		B	North	500	$10.00
7	2	A	North	500	$10.00
		B	Central	750	$100.00
	3	A	Central	1000	$100.00
		B	South	300	$5.00
8	2	A	North	300	$50.00
		B	Central	750	$100.00
	3	A	Central	1000	$50.00
		B	North	500	$5.00
9	2	A	Central	1000	$100.00
		B	South	300	$50.00
	3	A	Central	750	$100.00
		B	North	500	$10.00
10	2	A	Central	1000	$50.00
		B	South	500	$20.00
	3	A	North	750	$50.00
		B	South	300	$10.00
11	2	A	South	300	$20.00
		B	North	500	$50.00
	3	A	North	750	$20.00
		B	South	300	$5.00
12	2	A	North	500	$50.00
		B	South	300	$10.00
	3	A	Central	1000	$100.00
		B	South	200	$5.00

Measures to Eliminate SP Bias

Because SP data are not revealed in a marketplace, one of the largest concerns is that elicited values could be subject to significant bias. Extensive research has been carried out to test measures that help drive down hyper-inflated stated values. These include 'cheap talk' and similar language to remind respondents of their budgets and the realistic nature of the choice they are considering as well as follow-up debriefing questions immediately after the choice experiment, and others (Ladenburg et al., 2011).

Several approaches were employed to mitigate potential SP bias.[12] The preamble informed respondents that their responses were important and would inform state policies. They were also told to assume that the policy future receiving the most votes would be implemented. Immediately before each choice set, respondents were asked to keep in mind their monthly budget, respond as if they actually were faced with this vote, and assume that the presented options were the only available. Immediately following each choice set, respondents were asked to indicate their level of certainty in their vote between 1 and 10.[13] Several debriefing questions were asked immediately following the CE aimed to help discern protest bids, the rationale for selecting the natural gas option (i.e., whether the respondent did not like any of the offshore options or whether the natural gas option itself

[12] Although, some hypothetical bias could remain.

[13] Online respondents saw a certainty slider scale, ranging from 1-100%. Mail responses were converted from 1 to 10%, 2 to 20%, for common units.

was preferred), believability of the scenarios, and which attributes she cared most and least about.

3.3 Modeling Stated Preferences and Utility

Whether participants would be willing to pay premiums for offshore wind power, and we can infer the health and climate attributes associated with that electricity or some other symbolic characteristics, is a function of the wind project attributes tested in the choice experiment (project size in MW, location, and price premium) as well as the alternative opt-out choice; a respondent's income and other important demographic characteristics (i.e., education); additional respondent characteristics (beach-goer, beach place attachment, environmental scales, government attitudes); and random error that captures unobserved preference heterogeneity not controlled for in the model.

3.3.1 Discrete Choice Model

A respondent's discrete choice between a given offshore wind power project with particular fiscal consequences or a natural gas plant without a price premium—the business as usual alternative—is best analyzed within a multinomial logit or conditional logit framework.

Each respondent was faced with three choice sets, each containing three options. Rational actors are assumed to select their preferred electricity scenario, maximizing individual utility. Mechanistically, the model explains the probability that a given choice is selected. The theory and application of mixed logits to estimate discrete choices is well known, tested and applied, and limitations understood. In this conventional discrete choice framework, respondents' utility cannot be measured directly. Rather, theory assumes respondents select the choice that yields the highest utility. Thus, their preferences can be modeled as the probability of selection as their choices take a 0-1 format.

Respondent choices were specified using short and full conditional logit regressions in STATA. Econometrically, the model is specified using the equations:

(Eq. 1a) $$U_{ni} = \beta x_{ni} + \alpha y_n + \varepsilon_{ni}$$

$$(i = 1, 2)$$

(Eq. 1b) $$U_{n0} = \varepsilon_{n0}$$

where $U_{n,i}$ demonstrates an individual's utility for selecting (i =1,2) either offshore wind power development scenario; U_{N0} demonstrates the utility for selecting 'Option C' opt-out alternative (Natural Gas); x_n represents the vector of three offshore wind power attributes that may vary randomly; y_n represents a vector of respondent demographic characteristics that remain constant across given alternatives, i; β' and α' represent estimated parameters on the project and individual characteristic vectors, respectively; and a stochastic random error term, ε_n.

The binary logit takes the straightforward probabilistic relationship:

(Eq. 2) ______ $$Prob(yes) = 1 - \{1 + \exp\ [\beta_0 - \beta_1(\$bid)]\}^{-1}$$

where β_0 and β_1 are coefficients; \$bid is the monthly price premium. Then using the parameter estimates from equation 1a, WTP or implicit price can be derived to represent the non-market attribute that a respondent is willing to tradeoff for a unit of market value following the approach outlined in Hanemann (1989). This measurement is estimated using the derived parameter estimates by taking a ratio of β_o, a non-monetary coefficient estimate for a CE attribute or the grand constant, to the monetary coefficient on bid (price):

(Eq. 3)

$$WTP = -\frac{(\beta_o)}{(\beta_{bid})}$$

3.3.2 Parameters

Instead of pooling the data in a general population model, models were specified separately for the Delaware and Maryland samples due to their natural delineation in the data and difference view vantage points. Table 3.5 overviews the short (restricted) and full (long) model variables and definitions. A dummy model was also specified that contained unique project-size combinations for each location-size combination relative to the opt-out scenario. Likely heterogeneity characteristics related to coastal living and tested in the literature are included in the final models, including coastal residency and whether a respondent thinks she would be able to see a project from a primary or secondary beach residence. Because the location of a respondent's secondary (beach) house in relation to the proposed OSW projects could affect WTP, we also control for these characteristics in model specification. Descriptive statistics for short and full model variables are displayed in Table A.1.

Table 3.5: Variable definitions in conditional logit models.

Parameter	Coding	Definition
		SHORT
choice	dummy (1,0)	Selection in choice set occasion; 1=selected alternative in choice set, 0=alternatives not selected
choiceset_new	continuous	Unique value for each choice occasion; ascending order for all choices
perid	continuous	Unique value for respondent; ascending order for all respondents in dataset
bid	continuous ($/house/mo)	Price for each alternative. Levels: $0, $1.50, $5, $10, $20, $50, or $100
north	dummy (1,0)	Location attribute for project in the North of the WEA
south	dummy (1,0)	Location attribute for project in the South of the WEA
central	dummy (1,0)	Location attribute for project in the Central of the WEA
size	pseudo continuous	Power capacity size of wind project: 0 (opt-out), 200, 300, 500, 750, 1000 MW; North project can be as large as 750; South project can be as large as 500; Central project can be 750 or 1000 MW
sizeN	pseudo continuous	Size of project located in the North of the WEA (200, 300, 500 or 750 MW)
sizeS	pseudo continuous	Size of project located in the South of the WEA (200, 300, or 500 MW)
sizeC	pseudo continuous	Size of project located in the Central of the WEA (750 or 1000 MW)
		FULL
Variables from short model		
*Short model * view*	dummy (1,0)	Respondent thinks s/he would have a view of a 300 MW offshore wind project in the WEA from his/her primary or secondary beach residence=1; doesn't think, or not sure, s/he would have a view=0
*Short model * coastal*	dummy (1,0)	Respondent in coastal strata, as defined in mailing sample containing all Atlantic ocean-bordering block groups=1; all other strata=0
*Short model * secondh_coastal*	dummy (1,0)	Respondent has a secondary beach residence in the Atlantic ocean coastal zip codes=1; anyone otherwise=0

3.3.3 Conditional Logit

Conditional logits were estimated in STATA to explain the extent and direction of the choice experiment attributes' relationship to selected energy policy choices. It is common to first specify conditional logits to discern how the CE attributes affect decisions before moving to mixed logit specification. One major difference is that conditional logits assume the parameter coefficients, β, to be the same across respondents whereas mixed logits allow for heterogeneity *across* individuals, allowing researchers to generate a distribution of β estimates across the sample. Mixed, or random utility maximization (RUM), models were considered after the conditional logits, but ultimately not employed as this study lacks potential for significant unobserved heterogeneity outside the variables already controlled for in the full models.

Delaware and Maryland data were specified in distinct models due to their unique views of the wind projects shown in the photosimulations, their hypothesized differences in WTP for offshore wind power, and the fact that the magnitude of price premiums for ratepayers are germane to state level policies. First, we present the short, conditional logits to estimate how the choice set and OSW project attributes influence the probability for voting *yes* for an offshore wind future. Fully-specified conditional logits follow to then discern relevant coastal heterogeneity, such as second home-ownership status in adjacent zip codes and whether or not a respondent thinks they would have a view of a project from his or her primary or secondary home. Respondent-specific attributes (i.e., household income) were not tested explicitly within the specification but accounted for in weighting the models on the Delaware and Maryland sample weights.

3.4 Results

This section presents the results including general support for offshore wind development; descriptive statistics outlining the CE choices; debriefing questions; conditional short and full logit results; and welfare estimations. General descriptive results are presented by state and by coastal residency, second beach homeowner status, and frequency of beach visitation given their hypothesized heterogeneity in offshore wind preferences.

General Support for Offshore Wind Development in the Maryland WEA

Given responses to a question preceding the CE, weighted stated (and leaning) support for development of a 300 MW project in the MWEA support appears to be uniformly high, ranging from 89% for Delawareans, 87% for Marylanders, 81% for coastal residents, 75% amongst those owning a second beach home, 88% amongst beach-goers, and 82% amongst those who think they would have a view of the project from their primary or secondary beach residence.

3.4.1 General CE Question Descriptions

Question Response Rates and Responses for Offshore Wind vs. Natural Gas

Respondents were presented with three energy development choice sets, each having three choices, resulting in (N=2,737) valid choices (Table A.2). Depending on the sub-sample, choice questions nonresponse was 6% or less. Second homeowners exhibited the highest preference for gas (59% to 71%, depending on the choice question) (Table A.3). Generally, Marylanders and Delawareans choices are similar, although it is worth re-iterating that Marylanders and Delawareans were presented with the same varied choice sets, but saw views presented from Ocean City Maryland and Fenwick Island, Delaware, respectively. The unweighted, mean monthly price premium for selected offshore wind power options for all three choice occasions was $8.13/household/month (unweighted).

Question Response Certainty

As described, each choice set was followed with a certainty scale to elicit the extent to which respondents would vote the way they just stated if faced with that referendum in real life. Mean choice set response certainty (100% being absolutely certain) is shown in Table A.4. Respondents across the sample and strata are generally in alignment, albeit with those who visit the beach more than average being slightly less certain. The overall averages are 70% or higher–generally in range with expected given around 7 or 8 or higher (if not using a different form of post-weighting certainty correction) to minimize hypothetical bias (Champ et al., 2004; Parsons and Firestone, 2018).

3.4.2 Debriefing Questions

But perhaps what is most illuminating is the rationale for preferences among those who always voted either for a natural gas or an offshore wind project. Figure 6 presents self-reported attributes by electricity technology that these respondents cared most and least about. The largest share of respondents who always voted for offshore wind, just under fifty percent, stated they equally considered each of the project characteristics when stating their decisions. The monthly premium mattered the most: more than twice the number of respondents who always voted for natural gas selected this answer compared to offshore wind. One concern with CE is if respondents ignore all the attributes or information presented in the various scenarios and just pick choices at random; only five percent or less of the respondents stated they ignored all the attributes (Figure 3.6, Figure A.2).

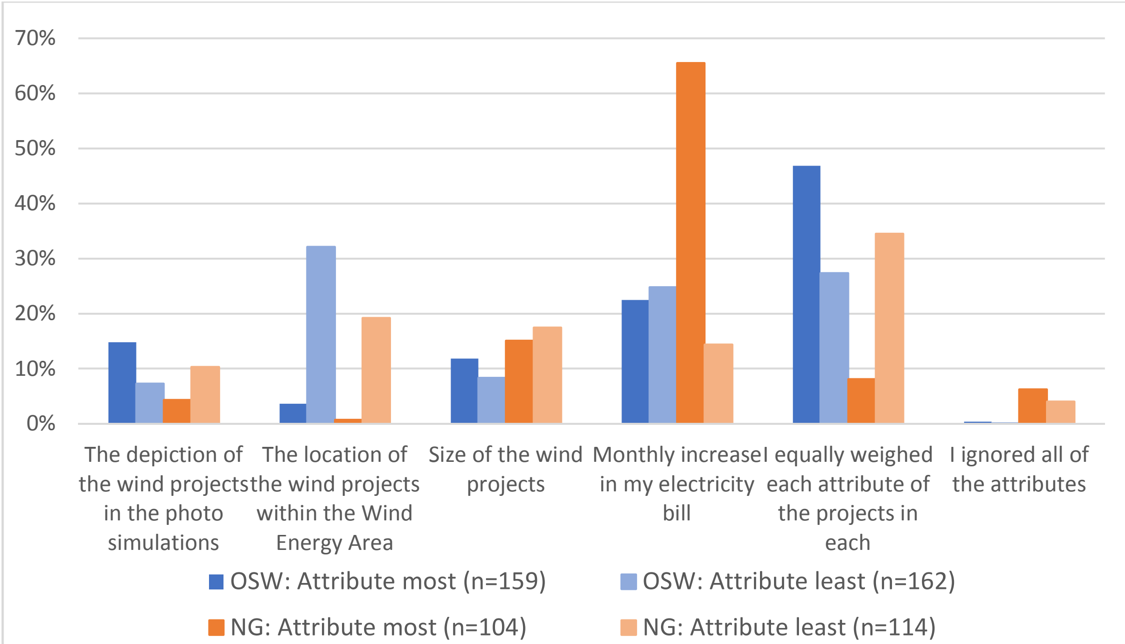

Figure 3.6: How respondents always voting for OSW or NG considered attribute characteristics (weighted).

Other debriefing questions offer insight into the reason respondents voted for natural gas one or more times (Figure A.1) and into which attributes they most considered when making their choices generally (Figure A.2). When voting for natural gas, coastal residents were nearly twice as likely not to believe the overall scenario compared to inland residents. Moreover, coastal residents were more likely to select natural gas (the status quo option) because they did not know which alternative was best. Second homeowners were more likely than primary homeowners to offer an additional 'Other' reason for choosing natural gas. When voting across the choice sets, generally speaking, respondents said they paid most attention to the monthly increase in their electricity bills, followed by equally weighing the OSW project's characteristics.

3.4.3 Beach Visitation and Second Beach Home Ownership

How, where and how often residents spend their time at the beach could substantively impact preferences for OSW development located nearby. Residents spent an average 11 days visiting the beach over the previous year, with 3% having visited the beach 300 days or more. On average, Delawareans spent approximately twice as many days (~20 versus ~10 days) at the beach as Marylanders during the previous year.

Table A.5 presents respondents' self-reported visitation behavior by beach over the year prior to taking the survey. Just under one in three Delawareans visited Rehoboth Beach, Delaware, followed by 14% at Cape Henlopen. Although Delaware has only about 40km of coastline, these two beaches are the furthest north, and thus the furthest from the MWEA. Thirteen percent visited Ocean City, Maryland or Fenwick, Delaware—that is, the beaches adjacent to the MWEA. A plurality of Maryland residents (49%), coastal residents (50%), residents who own a beach home (34%), and those who visit beaches more than average (34%)—recreated at Ocean City, Maryland, the beach that is directly adjacent to the MWEA. A total of 14% of the total sample noted they spent most of their beach days at a beach other than the Maryland and Delaware Ocean beaches. Eight percent of the entire sample, and just under forty-percent of the coastal stratum, own a second home at the beach.

3.4.4 Utility

Conditional Logit – Dummy Model

The most straight forward interpretation is to examine preferences for size-combinations relative to the natural gas opt-out alternative. In addition to the price (*bid*) variable, these models specify the probability of choice as a function of all possible project combinations presented to respondents in the CE. Each coefficient estimates the magnitude and sign of the effect for a given possible project on probability of selecting that option. Table A.6 presents these dummy models. As expected, price (*bid*) is negatively, statistically associated with project choice and of minor magnitude in both models with Delaware being more negative. For project size-location combinations, the only project that has a negative coefficient in Delaware is the central, 1000

MW project. Delawareans show the greatest decrease in utility for this size project, as do Marylanders. One thematic takeaway suggests a preference for project size and locations, as Delawareans exhibit the highest preference for smaller projects, from 200 to 500 MW, located in the South of the WEA, i.e., furthest away from those residents. Maryland residents also prefer smaller projects, but at this stage do not show evidence of a strong north or south preference.

Conditional Logit – Short Model

A preferred way econometrically to specify these CE models is to estimate the choices' attribute-level combinations, and their effect on utility, parsed out individually. This allows researchers to understand how each choice characteristic by itself influenced the respondent's preferred decision. Table A.7 reports conditional logit short model results for Delaware and Maryland with coefficients, robust standard errors, and *p*-values. In addition to the price (*bid*), the models specify dummy and continuous variables for project location and size, respectively.[14] For Delaware residents, locating the project in the South or the North of the WEA are statistically significant. The Central is not. Project sizes are also not significant. In the Maryland model, most attributes are statistically significant. All project locations are positive, with the central location having the largest coefficient. Both sizes for projects located in the South and the Central locations show a negative sign, like in Delaware, meaning a slight decrease in utility for a marginal increases in the number of turbines in those areas. But, only *sizeC* for Marylanders is statistically significant for all project sizes tested across both states. For both Delaware and Maryland, the association of project size, regardless of location within the MWEA, with energy choice is quite weak in magnitude.

Relative to the previous conditional logits with dummy specification, controlling for location and size separately allows understanding of how each of those characteristics contribute to respondents' choices while beginning to demonstrate a smoothing effect for the initial WTP calculations. Pseudo R^2's range 14% to 17%--arguably reasonable considering the short models lack coastal lifestyle or place-attachment heterogeneity controls that could influence utility.

Conditional Logit - Full Model

In addition to choice scenario characteristics influencing utility, the effect of additional heterogeneity to account for location and ownership attributes were tested in the full models. For example, residents that own a second home near the project might differ

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[14] We also specified the short models taking the natural log (ln) of project size. It produced similar results.

and would be willing to pay more or less (i.e., coefficient on *bid*) compared to permanent coastal residents. The full model incorporates whether respondents were in either state's coastal stratum; whether respondents own a secondary home in a coastal strata zip code; and whether respondents thought they would have a view of a 300 MW offshore wind project from their primary or secondary residence.

Table 3.6 presents the fully-specified conditional logit model for Delaware and Maryland. Columns one, two, and three display coefficient estimates, robust standard errors, and *p*-values for each. Relative to the short models, the full models are generally not robust, with the inclusion of the heterogeneity measures resulting in minor but statistical changes in the coefficients from those found in the short model (Table A.7). In Delaware, whether a respondent had a view from her primary/secondary residence mattered, but only for the northern project location. In contrast, all of the CE attributes were statistically significant for second home owners in coastal Delaware Atlantic zip codes, suggesting they view these offshore wind project characteristics, (i.e., where the project is located relative to them, and how big it is in the viewshed) differently than everyone else. For Maryland, being in the coastal strata, having a view, and/or owning a coastal Maryland second home separately were statistically significant. Interestingly, *coastal* price in Maryland was the only statistically significant interacted *bid* coefficient.

Table 3.6: Full conditional logit model for Delaware and Maryland.[15]

Variable	DELAWARE			MARYLAND		
Choice	**Coef.**	**Robust std. er.**	***p*-value**	**Coef.**	**Robust std. er.**	***p*-value**
bid	-0.042	0.007	0.000***	-0.023	0.004	0.000***
north	0.946	0.304	0.002***	0.428	0.193	0.026**
south	2.160	0.956	0.024**	2.068	0.662	0.002***
central	2.948	2.900	0.309	2.839	1.892	0.134
sizeN	-0.001	0.000	0.158	0.000	0.000	0.862
sizeS	-0.003	0.003	0.282	-0.004	0.002	0.027**
sizeC	-0.003	0.003	0.369	-0.004	0.002	0.064*
*view*bid*	0.001	0.014	0.942	0.001	0.007	0.893
*view*north*	-1.100	0.604	0.068*	-0.011	0.412	0.980
*view*south*	0.465	1.621	0.774	-2.965	1.416	0.036**
*view*central*	1.028	5.403	0.849	1.012	2.642	0.702
*view*sizeN*	0.002	0.001	0.103	0.000	0.001	0.749
*view*sizeS*	0.001	0.005	0.841	0.010	0.004	0.013**
*view*sizeC*	-0.001	0.006	0.864	-0.001	0.003	0.746
*coastal*bid*	0.003	0.015	0.823	-0.047	0.016	0.003**
*coastal*north*	0.193	0.651	0.767	1.305	0.730	0.074*
*coastal*south*	5.574	4.932	0.258	1.795	3.026	0.553
*coastal*central*	1.772	6.333	0.780	18.381	6.652	0.006***
*coastal*sizeN*	-0.001	0.001	0.576	-0.001	0.001	0.424
*coastal*sizeS*	-0.021	0.017	0.204	-0.003	0.010	0.780
*coastal*sizeC*	-0.002	0.006	0.693	-0.017	0.007	0.017**
*secondhc*bid*	0.023	0.020	0.242	-0.018	0.029	0.536
*secondhc*north*	-2.157	0.810	0.008***	-1.434	1.085	0.186
*secondhc*south*	-9.458	2.939	0.001***	-8.692	3.043	0.004***
*secondhc*central*	-16.462	5.164	0.001***	-17.820	4.863	0.000***
*secondhc*sizeN*	0.003	0.001	0.034**	0.001	0.002	0.757
*secondhc*sizeS*	0.030	0.010	0.002***	0.021	0.008	0.010**
*secondhc*sizeC*	0.016	0.006	0.004***	0.019	0.006	0.002***
Pseudo R^2		0.206			0.152	
Number of observations (choices)		2,175			4,602	
Log pseudolikelihood		-21643.3			-117037.7	

[15] *Note:* * Significant at the a = 0.1 level of confidence; ** significant at the a = 0.05 level of confidence; *** significant at the a = 0.01 level of confidence.

3.4.4.1 WTP, Implicit Prices and Welfare under Choice Certainty

Above we presented data on the extent to which project attributes and personal coastal living characteristics affect a respondent's likelihood to vote for offshore wind. WTP calculations for different project sizes and locations were then derived from the parameter estimates (Figure 3.7). This north-south comparison was selected because it represents a direct amenity tradeoff by state, and is the likely way the projects will be built, i.e., not across the entire designated area for development. Notably, the smallest project exhibits the largest WTP for both possible locations in each state. All WTP values are positive except for a 500 MW project in the south for Marylanders. For both states, WTP decreases markedly more in the south relative to the north as a function of project size. In other words, both Delaware and Maryland demonstrate an elevated elasticity in their WTP to project size for turbines located in the south of the WEA. Estimates suggest a substantively decreased willingness to pay for a project located in the south of the WEA as a function of increased project size, while WTP for a project in the north is invariant to size for Marylanders and decreases only minimally for Delawareans. Figures A.3-A.5 display mean WTP for coastal strata, expected view, and second home ownership in nearby coastal areas, respectively.

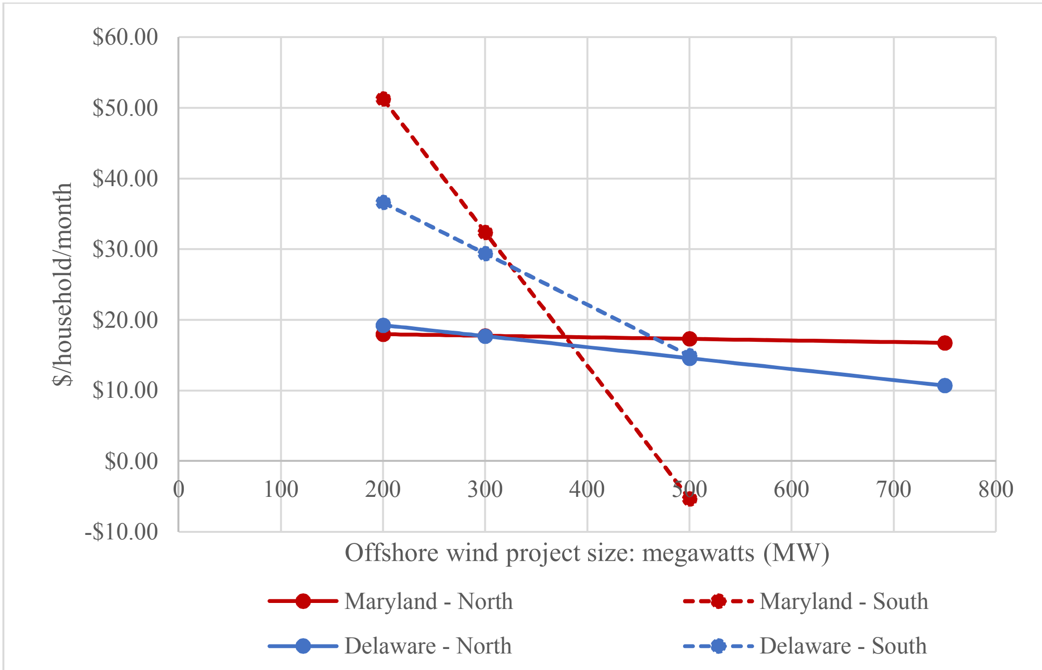

Figure 3.7: Delaware and Maryland mean WTP ($/household/month) for offshore wind power in the north or south of the WEA as a function of project size (short model, from full conditional logit results).

Generally speaking, residents in both states are WTP the most for small projects in the south. This erodes as projects are proposed having more turbines as Figure 3.7 illustrates with these baseline WTPs. As shown, implicit prices for an additional turbine can be simply calculated from continuous project size variables in each location of interest by taking the delta in WTP over the delta in size. Respondents in Delaware were willing to pay $.09 or $0.43 less per month in the north and south for one more 6-MW offshore wind turbine. In Maryland, respondents were willing to pay $0.01 and $1.13 less per month less in the north and south for one more 6-MW offshore wind turbine. Delawareans and

Marylanders would be WTP \$0.41 or \$1.00 less per month for an additional 6-MW turbine in the central location (not shown in Figure 3.7).

WTP Accounting for Choice Question Certainty

Following several approaches to correct for inherent SP biases as described earlier, we also tested how the models would perform under weighting by their choice certainty and using the cut-off approach in which only highly certain (>8 out of 10) responses were retained in the analysis (results not reported). Issues arose under both approaches. Weighting on respondents' choice certainty yielded highly unrealistic WTP estimates, which could indicate if the data are skewed to the highest who also exhibit very strong preferences for/against offshore wind. For the latter, the issue could be likely due to a low *n* in the coastal strata for our variables of interest (i.e., *view*).

3.5 Discussion

This analysis provides data that bolster the foundation for state energy policies by providing an empirical answer to the question of how much above current rates households are WTP for offshore wind power. We employ discrete choice experiment modeling to investigate how, why and the extent to which respondents made their decisions when offered energy development futures for the Mid-Atlantic region.

Respondents were asked to state their preference among two offshore wind power projects and a natural gas project, defined in the study as the no-cost, status quo option. A conditional logistic framework allowed estimation of the significance and magnitude of the main vectors of explanatory variables influencing discrete energy future decisions and associated utility. This study adds evidence to a growing body of offshore wind power literature that is also policy-ripe, given that the MWEA has been leased, project bids accepted and surrounding states have committed to an additional 8000 MW.

While we find high-level support for building offshore wind in the Maryland WEA of 75% or higher, general support might go only so far given above-market prices for offshore wind power that presently exist in the marketplace. As a result, nuances remain important. We find significant relationships between the project attributes and energy development choices, particularly with project location being important. There is some evidence to suggest that residents would desire large projects, but perhaps have concerns or fears about turbines being everywhere they look.

WTP results suggest an important tradeoff in desired premiums between size and location. While results suggest that residents in both states tout the highest baseline (200 MW) WTP for projects located in the South, WTP for that location is much more responsive to a build-out of size. The willingness to pay calculations for various project sizes located closer to Delaware (north) or closer to Maryland (south) illuminate findings that could be of direct use to developers. For instance, permitting stages might yield that a larger project could be more economically viable in the north, say, if there is a need to avoid deeper waters located in the southeast of the WEA. WTP calculations suggest that both Delawareans and Marylanders are most highly sensitive to project size in the south, particularly Marylanders, so doing so would be in line with public preferences.

Another aspect worth elaborating on is the various vantage points—straight-on from Maryland; and at an oblique angle from Delaware. This results in coastal Delaware residents and tourists at Delaware beaches being both physically further from the project (the length of the hypotenuse compared to the length of a side of a right triangle) and they will likely experience the project differently as the project is either in their periphery or requires them to turn their head toward the south. These effects will be more pronounced the further south a project is located and the further north (compare a beachgoer at Rehoboth to South Bethany, Delaware) a beachgoer is located.

Potential Limitations

Like other SP studies, these data are subject to caveats worth noting. There might be significant hypothetical bias, so follow-up studies using other methodologies, such as revealed preference could help corroborate estimates. This could be done by presenting the SP instrument then shortly after, presenting the same respondents with an experiment in which they are given the option to enroll in a utility program. While we investigated two germane projects attributes, at the project-level, distance (and others) are often tested in the literature. Unfortunately, we have no way of knowing if the project attributes would matter if the project were completely out of sight on the horizon. Also, while we have found the general survey attitudinal results differ only negligibly across survey modes, it remains unclear whether CE responses differ significantly across the survey mode in which they were elicited (Knapp and Firestone, 2018). These questions warrant follow-up analyses.

Possible Directions for Future Research

The effect of a wind project on tourism has not been quantitatively addressed here, nor has the effect on property value been monetized. Although marginal, yet minimal, negative impacts have been found on nearby housing prices for some, but not all *onshore* wind projects (Dröes and Koster, 2016; Gibbons, 2015; or see for example, Hoen et. al, 2015), the effect of *offshore* wind farms on coastal property values has been largely ignored. This is perhaps a needed avenue for research as attitudes toward proposed onshore wind farms have also been found to differ among second home owners (Janhunen et al., 2014).

3.6 Conclusions

The present study serves to address gaps for policy makers and federal agencies (Bureau of Ocean Energy Management, National Oceanic and Atmospheric Administration, Department of Interior) that in the coming years are tasked with undertaking complex analyses regarding the future use of coastal resources. While state-level policies offer a means to drive renewable electricity development, eastern US state energy policies suffer from a lack of empirical evidence on whether public ratepayers have an economic appetite for nascent offshore wind energy, and if so, to what extent. These findings are expected to be directly relevant not only for state and executive-branch policy-makers, but also coastal planners and other stakeholders, including existing users of the marine and coastal environment, boaters, fishermen and tourists. Nuanced aspects of making environmental decisions, that historically have received little attention, to extract coastal energy resources were explored, including several aspects related to spatial heterogeneity. Given the DOI has already leased or has plans to lease WEAs along the US Eastern Seaboard for offshore wind development in the coming decade, there is ample room for social welfare measures to be integrated into stakeholder discussion, policy analysis, and the like. Finally, it is important to reiterate the importance of locational issues and how they can influence welfare distribution. The project will likely have substantially implications for Delawareans (e.g., visual and cabling to the Delaware shore, along with price suppression benefits), although Maryland ratepayers will be paying the over-market price and the agreements with Maryland provide substantial economic benefits to Marylanders, but not Delawareans. Given electricity is regressive, and with the understanding that various sub-groups' desire to pay or support this technology vary considerably across space and demographic, this information could inform best practices for designing an efficient or fair state energy portfolio.

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Chapter 4

DOES ONE MODE FIT ALL: IMPACTS ON MEASURING PERCEPTIONS OF CLIMATE CHANGE AND RENEWABLE ENERGY POLICY FUTURES

Researchers carry out questionnaires to gauge public appetite for issues of societal importance. The objective of such surveys is to collect a sample large enough to undertake data analysis to report results that are representative of a broader population of interest. Doing so requires settling the dilemma of maximizing two goals that are often at odds: on one hand, maximizing the response rate, while on the other, implementing a low-cost survey. A greater response rate, and sample (N), minimizes survey error across individual responses, improving data validity (Dillman et al., 2014; Greenlaw & Brown-Welty, 2009). Researchers strive to achieve these goals at low unit-cost given limited resources, which ultimately depends on the method of data collection (Greenlaw & Brown-Welty, 2009) and requires expensive tradeoffs, trained researchers, proper timing, among other considerations (Dillman et al., 2014).

Traditionally, surveys are completed by mailing a questionnaire to a sample of households, or asking respondents to either give their responses to an interviewer or over the phone. Multiple rounds of contact are needed to achieve a desirable response rate as people forget, are weakly motivated, or misplace survey materials. The state-of-the-art protocol to achieve the largest, unbiased sample, said 'Dillman method', consists of contacting a sampled respondent with an initial pre-notification letter followed by another letter with the survey packet (including supplementary materials), a reminder post-card, a second packet, and a final postcard with typically two weeks in between, or some variation thereof (Dillman et al., 2014).

This widely-accepted Dillman method has been empirically supported with decades of studies discerning how a single aspect increases response rates (such as use of a real stamp), or, introduces bias (i.e., being too upfront about the research topic, increasing propensity for emotionally-invested respondents to ‘self-select’ into the sample) (Dillman et al., 2014). While the traditional mail sampling method can achieve high response rates up to 50%+, it comes with significant resource, material, and time expense. Mixed-mode surveys have been found to offer higher response rates relative to traditional mail-based or web-based surveys, but at an increased cost (Greenlaw & Brown-Welty, 2009). Mail surveys tend to reach an older, male and white demographic disproportionate to the general population (Christensen et al., 2012; Dillman et al., 2014), leaving perhaps need for a more effective means to reach marginalized or transient (e.g., millennials) populations.

Online surveys comprised of standing panelists paid to complete questionnaires have become increasingly common, and questions surrounding their data quality are becoming of interest, and, some concern (Shin et al., 2011). Individuals opt into an online ‘panel’ in which they are paid to complete surveys on relatively any topic by a survey firm. Outside of panel contexts, some researchers also send invitations to email addresses. Third party, Internet-based survey providers include GfK’s KnowledgePanel® (formerly KnowledgeNetworks), Harris Interactive, Survey Monkey, and Survey Sampling

International (SSI). These panels are not created the same, and findings cannot necessarily be generalized across probability-based (i.e., GfK) samples that are drawn from mail addresses with opt-in, 'convenience' samples in which participants self-select to participate (i.e., SSI and Qualtrics) (Berrens et al., 2003; Hays et al., 2015). Online panels offer an attractive option to researchers for several reasons, the largest perhaps being the extreme ease of administration and data collection with the potential to ensure a high data quality at reduced cost. Responses are compiled instantaneously into a database with no need for transcription, reducing the chance to inadvertently introduce error. These assurances though also come with phone surveys that can be programmed with similar controls (yet perhaps at a higher unit cost).

The proliferation of online surveys begets an increased understanding of the integrity of information collected—a critical research inquiry in social science disciplines, in particular for sensitive policy topics. We present results from a tri-mode, concurrent survey that investigated preferences surrounding development of offshore wind power carried out in 2015 across two states in the Mid-Atlantic, USA. Unlike similar, mail-only surveys of public perception of wind power undertaken in the region (e.g., Krueger, Parsons & Firestone, 2011), responses in the present analysis were elicited via identical questionnaires across a mail, mixed-mode, and internet panel, each containing functionally identical survey materials (photomontages created by Macro Works and map).

4.1 How Various Survey Mode Errors Can Influence Environmental Responses

For surveys that gauge (subjective) public opinions or support for potentially politically contentious environmental issues, it is unclear how mixed and panel modes perform relative to the mail approach. Even the most recent edition of Dillman et al. (2014) contains only a brief section detailing accepted online design and sampling methods. Factors that could influence estimates by mode concern coverage, nonresponse, measurement errors, and overall error.

Given its infancy, not much is definitively accepted regarding the representative coverage of online survey data collection methods, including the predictors of survey mode differences or preference (Ansolabehere & Schaffner, 2014; Smyth et al., 2014a). Those with high incomes, high education, and decreasing age have been found to preferentially prefer using the Internet (Smyth et al., 2014b; Verma et al., 2014), which is partially explained by familiarity and access to media types. This is exacerbated by the fact that 13% of American adults still did not use the Internet as of 2014 (Wormald, 2014). Ansolabehere and Schaffner (2014) found minor, yet significant, differences in response demographics by mode using a national Internet panel, telephone, and mail survey. Verma et al. (2014) offered an online or telephonic interactive voice response (IVR) option and found that relying solely on Internet responses led to statistically significant exclusions of certain populations, particularly of ethnic minorities or those with lesser education (Spanish speakers, those lacking college education and individuals who were Black, non-Hispanic). Because familiarity with a given mode is the highest predictor of completion of that mode, this suggests that particular populations might not have had access (Smyth et al., 2014b). These trends though might be shifting over time given that most web survey tools now work on smart phones or tablets with web access relative to just a few years ago.

If a younger, more tech-savvy demographic completes surveys online, web-based responses might not be representative. Given that people self-select (e.g., older males) into probability samples, many mail survey samples are also not representative of the broader population of interest, making post-sampling weighting of descriptive statistics critical. The more nuanced issue with online surveys then becomes the manner in which the sample is drawn (convenience vs. probability), with the former prone to bias.

Online surveys or mixed-modes can suffer from much lower response rates than their mail counterparts due to low recruitment rate of panelists and low response rate of email invitees (Jäckle et al., 2015; Shin et al., 2011). Most investigations into the differences in response rates across mail, Internet, telephone, and mixed-mode surveys have found that web-based modes yield lower response rates than mail (Converse et al., 2008; Greenlaw & Brown-Welty, 2009; Kaplowitz et al., 2004). For example, an early national study investigating perceptions of a watershed found a lower web-based response rate (42%) than mail (52%; *N*=19,890) (Kaplowitz et al., 2004). Yet some research suggests a well-implemented mixed- or web-based mode can offer higher response rates (Kiernan, 2005; Shin et al., 2012).

Allowing respondents to answer via their preferred mode has been shown to increase response rates (Smyth et al., 2014a). Using web-based, mixed-mode, and paper surveys, Greenlaw and Brown-Welty (2009) found that mixed-mode surveys (*N*=3,842) of American Evaluation Association members, while higher cost, resulted in members being significantly more likely to respond (52%) compared to the typical mail mode (42%); Dillman et al. (2009) demonstrated that switching to a different mode can increase response rates. The general consensus (Converse et al., 2008), though, maintains that traditional mail surveys still provide the highest, but also at the greatest per-unit cost—USD$4.78/response compared to USD$0.64/response for web-based (Greenlaw & Brown-Welty, 2009). It is worth mentioning many of these studies are of special populations and that specific subgroups might react differently to various survey mode options. There is also the question of how to best deploy modes, with compelling evidence suggesting sequential deployment augments response rates compared to a parallel approach, although that has since been debated (see meta-analysis for example, Medway & Fulton, 2012).

Another concern is whether online survey data have increased measurement error. Outside of investigation into response rate, little investigation of data validity across modes has been explored, but some nuances have emerged (e.g., Ansolabehere & Schaffner, 2014; Atkeson et al., 2011; Dillman et al., 2009; Shin et al., 2012). Shin et al. (2012) found lower question non-response. Audible modes—IVR and telephone—have elicited more extreme responses for satisfaction/dissatisfaction questions than web or mail (Dillman et al., 2009).

In particular, if a sampling strategy induced measurement error in opinions of sensitive or politically-charged issues such as climate change (Wang, 2017), it would be of noteworthy concern (Vannieuwenhuyze, 2014). However, although eliciting information on representativeness of political behavior has been found to differ, the differences have been negligible between parallel Internet and telephone surveys (Stephenson & Crête, 2011). Elsewhere, mixed-mode data has been found to show some minor differences but not of statistical importance (Cernat, 2015). Subjective or sensitive measures could be reported differently as well, as the assumption is that a respondent feels more comfortable, and social desirability bias might be less without an interviewer, but this not necessarily been borne out. For example, sensitive questions on crime victimization can be more difficult to answer via the telephone (Laaksonen & Heiskanen, 2014). Yet, while mobile web usage reporting of alcohol consumption reporting has differed PC versus mobile, other sensitive questions did not differ (Toninelli & Revilla, 2016). Moreover, subjective answers such as an evaluation of one's well-being have differed slightly across telephone and web platforms, although again with negligible statistical significance (Sarracino et al., 2017). Because of limited unanimity of best practices regarding web-based methods, researchers are hesitant to embrace an entirely new approach. Total survey error (TSE) does however provide a means to compare errors across measurements (Groves & Lyberg, 2010; Smith, 2011).

4.1.1 Does Mode Affect Politically Contentious Environmental Responses?

The present analysis employs several analytical comparisons to estimate differences or similarities among mail, mixed, and opt-in panel surveys. We first compare the raw response demographics for each mode to Census measures. Next, we examine weighted point estimates for additional demographics that were not used in weighting the data, calculating each mode's TSE. We then evaluate environmental responses across modes, estimating ordered Likert regressions to parse out mode differences that first control only for mode then introduce demographics, following similar previous studies (see for example, Ansolabehere & Schaffner, 2014; Groves & Lyberg, 2010; Sanders et al., 2007; Smith, 2011). Finally, we examine potential for biases by survey completion device and discuss how survey objectives should consider the tradeoff of cost, ease of administration, and other limiting factors.

4.2 Research Design for the Tri-mode Choice Experiment

Data for the present analysis are taken from an identical, tri-mode survey sent to respondents across three parallel treatment modes: (1) a traditional, mail mode where responses were mailed back via a survey booklet; (2) a mixed-mode version with an option to complete the identical survey either via mail *or* online; and (3) an online panel mode that consisted of opt-in, paid SSI panelists (total sample *N*=973). From January to April 2015, survey data regarding the opinions of and economic preferences for developing offshore wind power in the federally designated Maryland Wind Energy Area (hereafter 'MWEA', located ~18 km off the coast of Ocean City, MD) were collected across a stratified, random address-sample of all Delaware and Maryland households and from the online panel. Online panelists took the survey at the same time and were recruited from a separate, opt-in sample frame. For analytical purposes data effectively fall into sub-samples: (1) mail-mode completes; (2) all responses from the mixed-mode option, also broken up into respective (2a) mail and (2b) online completes; and (3) online, SSI panel completes.

4.2.1 Survey Development

The instrument underwent several iterations, and final versions were pre-tested among ~10 University of Delaware graduate students. A pilot test was then undertaken at a Delaware Division of Motor Vehicles location to ensure language was understandable and unbiased, the survey of appropriate length, and the choice scenarios realistic. Fifty complete or semi-complete surveys as well as general comments told to the researchers were recorded. Survey language was modified to reflect germane comments.

The survey was divided into four sections. Respondents were first asked about their opinions on wind power and developing an offshore wind project in the MWEA as well as its perceived environmental, social, and economic effects. The second section introduced the central focus of the survey, a choice experiment where respondents were prompted to vote for the energy development future they most prefer for the mid-Atlantic region. Questions followed regarding general and specific aspects about environmental attitudes and behavior, world views (e.g., climate change and government beliefs) and coastal activities. The survey concluded with detailed questions on respondents' second homes in coastal communities adjacent to the MWEA, and standard socio-economic and demographic questions.

4.2.2 Stratification

Delaware was bifurcated into two strata: coastal, which includes block groups and census tracts bordering the ocean, and inland comprised of everything else. Maryland was trifurcated into a coastal, mountain, reflecting the rural, western part of the state is regarded as Appalachia, and central. To ensure the sample of coastal and mountain residents was large enough to provide statistically significant results, they were oversampled in the mail and mixed mode cohorts (for the online sample as described below, we sampled everyone in the panel, and then post-stratified consistent with above). The sample frame was selected at random by SSI (N_{mail_total}=1,850).

4.2.3 The Mail and Mixed-Mode Surveys (Modes 1 and 2)

Within each stratum those individuals contacted by mail were randomly assigned in equal parts to modes 1 (mail-only) and 2 (mixed-mode). Individuals in mode 1 received a pre-notification letter notifying them that they would be receiving a mail survey packet in a couple of weeks. All those in mode 2 were notified of the same, but also given an immediate opportunity to complete the identical survey online via the survey platform Qualtrics instead of responding by mail. The cover letters differed slightly in that those in the mixed-mode (2) were provided an individualized web address and assigned a unique PIN to enter on the survey's Internet home-page.

Two weeks later, all individuals in modes 1 and 2 received a survey packet containing a cover letter, mail survey, offshore wind project photomontages printed on 11 x 17 paper, a graphical representation instructing the respondents how far to hold the images from their eyes, and a pre-stamped and addressed return envelope. Those in mode 2 were again presented with the option to take the identical survey online. The same bi-furcated process was carried out with a reminder post card and second survey packet.

To augment response rates, mail-mode respondents (1) at the very end were sent an additional post-card with a new option to complete the survey online. With the second post card, respondents in mode 1 in addition to those in mode 2 were provided with the option to take the survey online. This was done to boost responses and to test whether a late, online option could be effective. While it did increase response rates by adding $n=6$ more responses to mode (1) via online completes, these additional online data completed by the mail-mode respondents at the end are not analyzed here to ensure a direct mode, sub-sample comparison.

4.2.4 The Online Panel Survey (Mode 3)

SSI hosts a convenience panel of approximately 7 million people as of 2017, in which survey panelists are paid to answer surveys that they are invited to complete (F. Markowitz, personal communication, June 16, 2017). Panelists were recruited by SSI through a myriad of membership lists from over 3300 partner organizations (e.g., Amtrak, Apple, social networking, frequent flyers, readership clubs) with a consistent process over the past five years (F. Markowitz, personal communication, June 16, 2017). The Internet panel mode sample (3) was curated to reach a quota on age and gender that mirrors the general population and administered to all individuals in Maryland and Delaware that SSI had recruited into its panel database. Of those, 137 Delawareans and 424 Marylanders (N_{panel_total}=561), completed the survey.[16] We would have preferred more Delaware panelists, and more coastal panelists in both states (less than 20 in each state), but were limited by the number of persons successfully recruited by SSI. These limited numbers highlight a possible drawback of online panels within small states such as Delaware or when a portion of a state or a highly specific geography (here, the coastal region) is of particular interest. We contacted another panel vendor, and it was similarly limited.

[16] Possible panelists are recruited via email or pop-up and asked if they're interested in joining; they are then vetted using a battery of geographic and demographic questions. Panelists with consistent low participation rates are removed from the panel and are also required to take 'rest' periods to avoid cognitive overburden.

For respondents completing the survey online, the offshore wind power photomontages were stored on an external server and programming was accomplished by Macro Works to direct seamlessly between the photomontages and the survey. These images had to be properly projected using various operating systems (e.g., IOS and Windows) on desktops, laptops, and tablets and using various Internet browsers. All Internet users were given a test photomontage question early in the survey. If they could not view it properly, they were requested to terminate the survey. Less than 1% did so.

The analyses also explore data from non-mail responders regarding their *online* survey experience. The main question here is whether environmental responses differ by survey-taking device. All respondents who took the survey online were asked whether they would have taken it if a web-based option was not available; what type of device they used to complete the survey; and questions regarding the photomontages.

4.2.5 Response Rates

After accounting for undelivered responses and bad addresses, the final response rates[17] across Delaware and Maryland were 25% for the mail- (1) and 30% for the mixed-mode for surveys completed via mail or online (2a and 2b, respectively). Importantly, the mixed-mode (2) yielded an absolute increase of 5% in the response rate (or a 20% relative increase) compared to the mail-mode[18], providing evidence that allowing respondents to select their completion method is a possible way to increase response rates. The online

[17] Several mail and online respondents completed the survey twice; only the first response was used unless sparsely completed, in which case the second response was retained.

[18] Means are not significantly different before and after the second post-card (p=0.683).

panel (3) yielded a 63% "participation rate", which is not directly comparable to a traditional response rate.[19] The contact numbers in the first stage of a multi-source, recruitment process are unknown, though the number of panelists who initially start the survey is (here, *N=2070*). Both SSI and the American Association for Public Opinion Research (AAPOR) recommend for a non-probability, convenience panel to report a "participation rate"— number of completes divided by the number that started the survey (AAPOR N.d.; F. Markowitz, personal communication).

4.2.6 Weighting

Delaware and Maryland responses were weighted separately on five variables to reflect each state's strata population, education, household income, age, and sex. Demographic information were obtained online from the U.S. Census Bureau American Community Survey (2014-2015). Weighted data were used to calculate TSE and mean differences in attitudinal questions.

4.3 Analysis

4.3.1 Comparison of Unweighted Mail, Mixed, and Online Panel Survey Data to Census

First, we compared the sampled unweighted demographic data from mail, mixed, and panel mode respondents to Census estimates. Online panel respondents are less likely to be male and older, and to have high income and own a home than mail and mixed modes.

[19] According to SSI, it is near impossible to calculate the true response rate given the manner in which panels are selected.

Among the mixed-mode, the online respondents (2b) were more likely to have a college degree, were wealthier and more likely to be employed relative to the respondents that opted for mail completion (2a). We also discerned unweighted data differences (full results not reported) with Census estimates in the sample's coastal populations. Coastal residents' opinions are of particular interest given the questionnaire was focused on ocean energy development. Coastal panelists were less likely to own a home, have a high household income, be male, and be slightly younger relative to coastal mail and mixed-mode counterparts.

4.3.1.1 Statistical Differences in Unweighted Demographics

Table 4.1 reports t-tests of mean group differences between unweighted modes for the entire sample and coastal strata, indicating the mail-mode does not statistically differ from the entire mixed mode (mail plus online responses) for demographics of interest. However, the panel does statistically differ from other modes. The largest statistical deviations found are between the traditional mail-mode and the online panel; at least half of the unweighted demographics differ. It is however important to remember that these are for unweighted, descriptive data.

Table 4.1: T-tests of group demographic mean differences across unweighted modes (full and coastal samples).

SURVEY DEMOGRAPHIC	**DE and MD, entire sample (n=973)**					**DE and MD, coastal strata (n=203)**				
	(1) vs. (2)	**(1) vs. (2a)**	**(1) vs. (2b)**	**(2) vs. (3)**	**(1) vs. (3)**	**(1) vs. (2)**	**(1) vs. (2a)**	**(1) vs. (2b)**	**(2) vs. (3)**	**(1) vs. (3)**
Gender (male)	0.29	0.87	0.06	0**	0**	0.84	1.00	0.69	0.03*	0.048*
Age (years)	0.65	0.14	0.30	0**	0**	0.69	0.16	0.34	0.10	0.23
Education	0.66	0.22	0.007**	0.049*	0.18	0.57	0.08	0.15	0.30	0.14
Annual household income	0.20	0.62	0.001**	0**	0.0002**	0.33	0.69	0.16	0.001**	0.0005**
Employment										
Employed for wages or self-employed	0.96	0.08	0.011*	0.0002**	0.0003**	0.47	0.66	0.04*	0.58	0.32
Unemployed	0.26	0.24	0.45	0.0068**	0.0009**	0.12	0.26	0.04*	0.04*	0.0006**
Home ownership (own home)	0.25	0.31	0.4105	0**	0**	0.53	0.55	0.71	0.0003**	0.0042**

Note. $^{**}p < 0.001$, $^{*}p < 0.05$

4.3.1.2 Mixed-Mode, Early vs. Late Responders

We also examined the effect of providing the mixed-mode (2) respondents an option to complete the survey online (2b) two weeks prior to providing them with the mail packet. We find none as the early vs. late online respondents do not differ statistically (*p < .05)*. We also compared the early online respondents to the those in the mixed-mode sample that completed the survey later (either online or by mail), finding early responders with higher income (*p = .004*) and more education (*p = .04*).

4.3.2 Comparing Weighted Data to Additional Census Measures to Calculate TSE

We next compared weighted survey data to Census benchmarks that were *not* used in the weighting process such as homeownership; people (including themselves) living in their household; and employment status to generate individual estimates of differences and measures of TSE (Table 4.2).

Table 4.2: Weighted Delaware and Maryland point estimates, average difference, and total survey error (TSE) by mode.

	Mail (1)		**Mixed, all completes (2)**		**Mixed, mail completes (2a)**		**Mixed, Internet completes (2b)**		**Internet Panel (3)**		**Census ACS (2014, 2015)**	
	DE (n=81)	MD (n=83)	DE (n=109)	MD (n=91)	DE (n=68)	MD (n=53)	DE (n=39)	MD (n=35)	DE (n=123)	MD (n=401)	DE	MD
Home ownership												
Own home	0.83 *(.61)* *(.94)*	**0.87** *(.70)* *(.95)*	**0.96** *(.79)* *(.99)*	0.8 *(.63)* *(.90)*	0.94 *(.70)* *(.99)*	0.8 *(.63)* *(.91)*	1 *n/a*	0.79 *(.50)* *(.94)*	**0.59** *(.47)* *(.69)*	0.74 *(.68)* *(.79)*	0.72	0.69
People in household												
1 person	0.27 *(.15)* *(.45)*	0.2 *(.09)* *(.39)*	0.11 *(.04)* *(.26)*	**0.07** *(.02)* *(.19)*	0.17 *(.06)* *(.38)*	0.13 *(.04)* *(.36)*	**0** *(.00)* *(.01)*	0 *n/a*	0.22 *(.14)* *(.35)*	0.24 *(.19)* *(.30)*	0.27	0.27
2 people	0.33 *(.18)* *(.52)*	0.48 *(.27)* *(.70)*	**0.6** *(0.43)* *(.75)*	**0.54** *(.36)* *(.71)*	**0.64** *(.42)* *(.82)*	0.55 *(.29)* *(.78)*	0.53 *(.28)* *(.77)*	0.53 *(.26)* *(.78)*	0.36 *(.26)* *(.48)*	0.38 *(.32)* *(.45)*	0.37	0.32
3 people	0.19 *(.08)* *(.37)*	0.14 *(.06)* *(.31)*	0.22 *(.10)* *(.41)*	0.09 *(.02)* *(.31)*	0.14 *(.04)* *(.40)*	**0.03** *(.01)* *(.13)*	0.38 *(.15)* *(.67)*	0.15 *(.02)* *(.57)*	0.18 *(.11)* *(.26)*	0.18 *(.14)* *(.24)*	0.16	0.17
4+ people	0.21 *(.09)* *(.42)*	0.18 *(.08)* *(.35)*	**0.07** *(.02)* *(.17)*	0.3 *(.17)* *(.48)*	**0.05** *(.01)* *(.20)*	0.28 *(.12)* *(.53)*	0.09 *(.02)* *(.31)*	0.32 *(.13)* *(.62)*	0.24 *(.16)* *(.34)*	0.19 *(.15)* *(.25)*	0.21	0.17
Employment												
Employed for wages (self-employed)	0.44 *(.27)* *(.63)*	0.65 *(.40)* *(.84)*	0.61 *(.45)* *(.75)*	0.56 *(.37)* *(.74)*	0.51 *(.31)* *(.71)*	**0.32** *(.15)* *(.56)*	0.8 *(.58)* *(.92)*	0.83 *(.54)* *(.95)*	0.5 *(.39)* *(.62)*	**0.48** *(.41)* *(.54)*	0.58	0.63
Out of work (unemployed)	0.06 *(.01)* *(.27)*	0 *n/a*	0.07 *(.02)* *(.23)*	**0** *(.00003* *) (.002)*	0.11 *(.03)* *(.33)*	0 *n/a*	**0** *(.00)* *(.01)*	**0** *(.00005)* *(.003)*	**0.18** *(.10)* *(.31)*	0.07 *(.05)* *(.11)*	0.09	0.08
Average difference	0.017	0.08	0.109	0.096	0.097	0.127	0.068	0.12	0.049	0.046		
Total Survey Error (TSE)	0.005	0.01	0.024	0.019	0.023	0.031	0.042	0.028	0.005	0.004		

Note. Bolded figures denote a point estimate that significantly deviates from Census point estimate.

The first five column pairs display the Delaware and Maryland proportions for each of the main demographics not used to weight the data across mail-, mixed-, mail completes in mixed-, Internet completes in mixed-, and panel modes. The last column pair indicates each state's corresponding Census figure obtained from the U.S. Census American Community Survey (ACS) 2014 or 2015 estimates. We find some significant differences. Nine Delaware 95% confidence intervals fall outside (either above or below) their corresponding Census measure. The weighted mixed-mode mail (2a) and Internet (2b) sub-samples and the Internet panel each exhibit two individual point estimates that are statistically different, with the combined mixed mode (2), having three, and none in the mail. The panel mode does not perform as well as the mail-mode, having two point estimates slightly under- or over-representative—*home ownership* and *unemployed* population—although it is worth remembering that the *unemployed* point estimate is a small measure of the actual population (8.5% of Delaware adults are either unemployed or out of work). All modes accurately reflect the *employed* population.

In addition to weighted data point differences relative to the Census, we examined a mode's *average difference* of estimates against census benchmarks to glean overall mode performance. Average differences were estimated by calculating the absolute value of each point estimate's difference with its respective Census benchmark, then taking the average of the sum. The mail and panel modes are within the bounds of normal deviation (3-5 percentage points) compared to the Census measures (Ansolabehere & Schaffner, 2014). The panel exhibits a higher average difference of about 5 percentage points, but still within reason. The mixed mode and mixed- sub-samples exhibit a higher average difference than desirable.

Perhaps the best indicator of how closely the weighted data emulate Census estimates is mean squared error (MSE). Each MSE was calculated by taking the average of the sum of squared differences between each metric and the corresponding Census proportion. A low MSE indicates that the total survey error is reasonably under control in terms of overall accuracy of the estimates, even if individual variables exhibit some significant differences (Ansolabehere & Schaffner, 2014). Hereinafter the MSE will be referenced using the measure it represents, TSE.

In Delaware, the panel mode performs identically in terms of TSE as the long-used mail-mode. Both are quite low, each having an average error rate of approximately 0.5 percentage points, giving high confidence that the TSE is well under control. The mixed-mode (2) (mail plus Internet) offers roughly the same TSE as the mail-only response, but with a higher response rate. It is worth noting that the TSEs values obtained for the mail- and panel modes here are lower than some reasonable TSE estimates reported in the literature (Ansolabehere & Schaffner, 2014).

Eight Maryland point estimates fall outside the 95% confidence interval, though all modes exhibit overall reasonable average differences and quite low TSEs. Like Delaware, the Maryland mixed-mode (2) does not perform as well as the mail or panel modes, exhibiting a higher average difference and TSE. The panel performs the best out of all modes from a TSE perspective in Maryland at only a 0.4 percentage point difference from the true (estimated) Census, followed by the traditional mail-mode with a 1.0 percentage point difference (TSE). The panel shows only one estimate with a 95% confidence interval that does not contain the (*employed*) Census population proportion. The mixed-mode with Internet completes (2b) performs better than its counterparts in the Delaware sample (TSE=0.028). The mixed-mode (2) containing both mail and online completes has a TSE that is under control (1.9 percentage points) but less robust than both mail- and panel modes.

4.3.3 Whether Mode or Technology Choice Affects Environmental Question Response

In socioeconomic studies addressing issues related to climate change and renewable energy in particular, researchers are concerned with nuanced explanatory aspects related to attitudes, perceptions, and behaviors as factors that explain overall support. Whether answers to these important socioenvironmental factors differ across modes could have large policy implications.

We consider the three main socio-environmental questions: general support for building an offshore wind project; support for state renewable energy mandates (portfolio standards); and attitudes toward the cause of climate change. We first analyze mean differences and then present ordered logistical regressions, controlling for mode then accounting for demographics.

4.3.3.1 Offshore Wind, State Renewable Energy Policies, & Climate Change Opinions by Mode

We examined unweighted *and* weighted means and corresponding confidence intervals for Maryland (Table A.8) for the key environmental survey questions (Delaware produced similar results). The main question here is whether individuals vary in environmental ideology across modes, particularly once data are weighted. For each of the three environmental policy questions, the various mode sub-sample weighted and unweighted means exhibit overlapping confidence intervals at the 95-99% level.

We also tested for pairwise differences across the unweighted Maryland means (Table 4.3). The only significant difference is in the comparison of support for building an offshore wind project between the mail- (1) and panel modes (3), but weakly so ($p < 0.1$). T-tests indicate no other systematic statistical differences for the remaining unweighted, key environmental metrics.

Table 4.3: Results of Maryland mode sample differences for key environmental questions.

	Mode comparison pairs (unweighted MD sample)				
Environmental survey question	*(1) vs. (2)*	*(1) vs. (2a)*	*(1) vs. (2b)*	*(2) vs. (3)*	*(1) vs. (3)*
General (and leaning) to support an offshore wind project near Ocean City, MD	0.71	0.75	0.78	0.12	0.08*
Supports Renewable Energy Standard policy	0.90	0.96	0.86	0.44	0.60
Opinion towards cause of climate change	0.92	0.69	0.72	0.62	0.73

Note. *p < .10; **p < .05; ***p < .01.

4.3.3.2 Ordered Logit Regressions: Mode Differences for Environmental Questions

We employed ordered logit regressions (given the response outcomes were measured in Likert scales) to analyze whether and the extent to which mode differences appear across parameter estimates. Previous studies have employed similar analytical approaches (Smyth et al., 2014a) as well as general OLS models (e.g., Ansolabehere & Schaffner, 2014). The main advantage of this approach is that it estimates statistically significant relationships of explanatory factors with dependent measures for which the Census is unable to provide validated benchmarks.

4.3.3.3 Do Environmental Question Responses Vary By Mode?

The first suite of regressions (Model I) test for significant differences across modes (Table 4.4). Columns 1, 3 and 5 indicate individual models detailing parameter estimates for mixed (2) and panel (3) modes relative to the mail mode (omitted category), p-values and standard errors. For the offshore wind support and renewable energy policy models, statistically significant differences at the 99% and 90% levels, respectively, are present between the panel mode and mail-mode (1), with the online panel being significantly more supportive of wind power and borderline significantly less supportive of renewable energy policies (there is no statistically significant difference regarding climate change causes). After controlling for demographics (Model II, Columns 2, 4, and 6), the mixed-mode continues to be statistically indistinguishable from the mail-mode, indicating there is high confidence of no systematic bias between these two collection methods. We find a statistical difference remains between the panel and mail-mode after controlling for demographics for respondents supporting their state renewable energy policy at the 99% level, although not for offshore wind power support.

Table 4.4: Ordered logistic regression results for key attitudinal questions (unweighted) for constrained (Model I) and full models with demographic factors (Model II).

	General support for an offshore wind project		**Supports State renewable energy policy**		**Opinion toward cause of climate change**	
	Model I	Model II	Model I	Model II	Model I	Model II
	Coef. (SE)		Coef. (SE)		Coef. (SE)	
Mixed-mode (2)	0.212	0.42	0.076	0.067	0.011	-0.026
	(0.262)	(0.306)	(0.21)	(0.25)	(0.187)	(0.21)
Panel mode (3)	0.647***	0.453	-0.426*	-0.595**	0.1	0.204
	(0.228)	(0.22)	(0.175)	(0.21)	(0.16)	(0.174)
Age	-	-0.013	-	0.006	-	-0.006
		(0.007)		(0.01)		(0.004)
Male	-	0.183	-	-0.328**	-	0.272*
		(0.225)		(0.15)		(0.136)
Education						
2	-	-0.612*	-	0.171	-	0.057
		(0.361)		(0.2)		(0.193)
3	-	-0.771**	-	0.582**	-	-0.009
		(0.349)		(0.2)		(0.187)
Income	-	-0.002	-	0.003**	-	-0.001
		(0.002)		(0)		(0.001)
Politico_social						
1	-	0.262	-	0.651	-	-0.535
		(0.48)		(0.39)		(0.16)
2	-	0.885*	-	1.293***	-	-0.864**
		(0.477)		(0.39)		(0.187)
3	-	1.249*	-	2***	-	-1.62***
		(0.517)		(0.41)		(0.353)
N	941	815	930	832	885	794
Pseudo R^2	0.012	0.055	0.008	0.07	0.0002	0.023

Note. $^*p < 0.10$; $^{**}p < 0.05$; $^{***}p < .01$.

4.3.3.4 Survey Devices Used to Complete Online Survey

The survey inquired about the online device and whether a respondent would have taken the survey if they did not have an online option. Notably, 18% of the mixed-mode online respondents indicated that they would *not* have taken the survey if only offered a mail option, while an additional 30% responded ‘maybe’. Thus, it is perhaps unsurprising that the mixed mode yielded a relative increase in the response rate of 20% compared to the mail-only survey.

One implication of online surveying that requires consideration of a visual object, such as a photomontage of a hypothetical offshore wind power project, is whether responses are affected by the kind of device used to view the image. The majority of modes 2a and 3, respectively, used a laptop (41% and 57%), closely followed by a desktop computer (35% and 43%). Interestingly, about one-quarter of the mixed-mode online respondents (2a), used a large or small tablet, compared to less than 1% of those who were part of SSI’s online panel (3). Only one respondent completed the survey online using a cell-phone, which was strongly discouraged in the instructions. A t-test of differences in small vs. larger screen size indicates no significant difference ($p=0.08$) in general support for building an offshore wind project, suggesting that photomontages can be shown across a range of device type and sizes.

4.4 Discussion and Conclusions

The present analysis adds to the literature on how preferences or attitudes for politically sensitive issues compare when reported via different modern survey techniques.

Results investigate data from a 2015 tri-mode choice experiment across Delaware and Maryland to assess preferences for economic premiums for offshore renewable energy. We find some noteworthy differences but compelling evidence for mode similarities.

Most unweighted data measures fall well above or below their corresponding Census measure. This was perhaps to be expected given standard strata oversampling approaches and propensity for demographics to exhibit some self-selection bias. T-tests indicate that the mixed-mode did not statistically differ from the mail mode, no matter how the respondent chose to submit his/her responses, for all demographics. The panel does statistically differ from the mail-mode at nearly all the demographics, and the mixed-mode statistically differed from the panel for every demographic tested in the total sample. Interestingly, the unweighted coastal sample has fewer statistical deviations between modes, in particular the panel vs. mixed or mail.

While each of the mode samples are not perfectly representative of the population, the mixed mode yielded a demographic relatively similar to the mail-mode on age and income when considering the entire mode (both mail and web responses). Like Smyth et al. (2014b), these data provide evidence that when given an option, more educated respondents and those with higher household income are more likely to use the Internet as a response platform. This could reflect a relative preference or those demographics could be endogenous to the format choice, as those who are financially well-off may have more immediate access to Internet options while those with higher education may be more experienced with electronic devices.

Given the ever-wider use of different sampling modalities, it is more critical than ever to weight when presenting descriptive statistics to reflect the population. Calculations of mode-specific TSEs of *weighted* data compared to additional Census point estimates not used in the weighting do not deviate substantially, generally. While the mixed-mode does suffer some from low responses for the mail or web-only responders in a particular state, it has a higher overall response rate than the mail. The Maryland, mixed-mode subsample exhibits a weighted TSE that is under control, although notably higher than its counterparts for weighted panel and mail—each highly similar to the Census counterpart. These aggregate estimates of error give confidence that once weighted, the panel mode, especially, perform well in representing additional demographics of broader surveyed groups—and findings could reasonably be interpolated out to the broader population of interest. While it is perhaps not surprising that the panel emulates Census estimates the best, the mixed-mode's TSE only deviates from the Census by 2.4 and 1.9 percentage points (DE and MD, respectively).

An important question is how data perform for social and environmental questions after they are weighted. We find little evidence that means statistically differ for critical socioenvironmental indicators across modes, including support for renewable energy policies. Weighted data for environmental attitudes fall closely in-line with the same attitudinal measures when different methods of data collection are employed. There is some evidence of significant differences between panel and mail modes for key attitudes, perception, and support questions of interest. But given that we have established demographic differences between mode choice, the differing responses are not surprising.

Once we control for demographics, we find no differences across modes regarding offshore wind power support or climate change causes but do find that online panelists are significantly less supportive of government mandated renewable energy requirements suggesting, the possibility of error due to non-response bias, which cannot be fully corrected through weighting, or the possibility that online panelists perhaps have a more libertarian bent then the population as a whole.

While there has historically been little validation of panel data, overall we find it to be robust given both the comparison of weighted data to additional ACS measures and regression analyses, giving confidence panel data could be a comparable substitute for traditional mail surveys. The panel TSE out-performs the traditional mail-mode in some cases.

Other metrics might glean differences, including individual question response rates or time spent per question or survey. Given one primary focus of this study was to estimate preferences to pay economic premiums for offshore wind energy, whether heterogeneity across modes or survey-taking device influence willingness to pay could elicit insight on how to adjust the models (Mjelde et al., 2016). These answers are outside the scope of the present analysis.

All methods of sampling require trade-offs of time, cost and error. Randomly-sampled mail surveys (and variants thereof), with reliable response rates and coverage, have become the staple for social scientists. It is unlikely that mail surveys will fall out of favor entirely while important sub-groups still lack easy access to online surveys. Yet complex survey designs (choice experiment surveys) can take months and require multiple versions (>10), necessitating considerable resources devoted to logistical and administrative steps (i.e., printing and envelope stuffing) and subsequent data coding/data entry that give rise to heightened risk for human error.

Researchers will continue to seek measures representative of the broader population, or at least as much as from a traditional mail survey for politically sensitive environmental public policy preferences. We find strong evidence to suggest that low opportunity cost, web-based survey methods, to include opt-in online panels or invitations from a researcher to participate online, provide streamlined alternatives that should be considered if they can produce sufficient sample size. These options offer enhanced quality, as well as possible depth, of data as a result of the ability to employ advanced tools. Coupled with user access to laptops and tablets, web-based methods challenge traditional methods to collect socioenvironmental data, at perhaps a decreased cost and time duration.

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Chapter 5

CONCLUSION

No one electricity generation technology is a silver bullet. In the coming years when the United States is faced with the effects of climate change, offshore wind power development touts the potential to be a significant component of the larger energy equation. Offshore wind is poised to provide tangible benefits while also potentially incurring localized environmental disturbances or implications for current users of the coastal and marine environment, whether it be boaters, tourists or homeowners. The key to meeting climate goals while also moving toward a clean energy transition is through careful mitigation of these possible effects. This dissertation summarizes and dives in depth on several nuances at play: spatial heterogeneity, economic valuation, and survey methodology effects. Realizing a development path in which the WEAs are developed in a socially optical manner will likely require careful consideration of these factors as they pertain to the public's appetite for this technology.

In this dissertation, three articles are presented that examine issues for a 'true' measurement of the public as it concerns the future of offshore wind development in the US: spatial heterogeneity, economic valuation, and survey methodology. As when evaluating other proposed environmental improvements to inform development decisions, these aspects are set to fundamentally shape the social and regulatory path and therefor acceptance of this electricity generation technology. The regulatory process for such multimillion-dollar projects requires significant Federal consideration, while the goal to meet a clean energy future that includes arguably a novel technology necessitates a concurrent priority for its methodical analysis and consideration of rippling, societal implications.

The first essay reviews germane studies in the environmental economic valuation literature as they apply to economic preferences for offshore wind development. Public preferences for environmental improvements or goods, whether it be recreational opportunities or improved water quality, manifest in spatial patchiness depending upon their location to the respondent or other factors. The simple concept distance decay, for instance, informs us that the further respondents live from a proposed site in question for an environmental improvement, the lower their utility for that improvement, holding all else constant. Consider an angler that is choosing among water bodies in her home state. When making her destination decision, she will consider the attributes at each of these sites, with distance being one critical vector. Using water quality improvement as an illustration, said angler's utility will be a function of her physical proximity to a) the proposed water body under consideration for clean-up, b) substitute sites where she could go fishing instead, or c) the combined possibility for recreating at many of these sites. Aggregate utility estimates in several of these studies discussed in this review find biases in SP models that disregard these spatial factors.

This article applies this utility distance-dependent rationale to development for offshore wind in the US in terms of existing, proposed, and cumulative development across the Eastern OCS. We identify three spatial effects or dimensions that ought to receive heightened attention in the wind stated preference literature or related government studies—distance to a proposed wind project, distance to existing wind project(s), and cumulative effects. These dimensions are also supported through examples in the wind power acceptance and hedonic valuation literature. We argue that residents, users and non-users, might strongly exhibit preferences for future offshore wind depending upon where existing onshore or offshore wind projects are. This nuance might significantly play an increasing role as more projects are built offshore and others undergo permitting review. Welfare evaluation therefor we argue ought to be highly adaptive and iterative.

The second essay analyzes survey data from a choice experiment to discern consumer utility for potential offshore wind projects of varying size, extra cost to ratepayers each month, and specific location within a leased Federal WEA. A nascent offshore wind industry in the US faces steep LCOE for consumers, policy barriers to entry and incurs (local) disamenities and anticipated conflict with existing ocean use. While the value of offshore wind is expected to vary significantly along the Eastern Seaboard, the welfare implications could vary widely across areas of dense human use or habitation.

The results in this essay suggest that ratepayers across Maryland and Delaware not only highly support this technology, but also are willing to pay premiums for it. Respondents prefer, and tout the highest economic premiums for, the smallest project sizes across the various possible development segments within the Maryland WEA. That WTP decreases dramatically however, and at different rates, with additional proposed turbines and depending on the area in the WEA in which they are expected to be. Coastal residents also differ, and whether residents have a second home in the coastal area. This finding underscores the notion that a blanket one-sized fits all policy for ratepayer premiums—that is, all residents in Maryland should pay +$1.50/household/month if an offshore wind project is built as the means to cost share increased kWh-costs as a result of the new electricity generation facility—might be far too simplistic. This is particularly the case when considering the established differences in this spatially-explicit WTP, and that some residents are willing to pay far higher than that amount.

The final dissertation essay examined the tri-mode data to discern similarities or differences between traditional and newer survey modes for critical environmental and energy issues. There remains a gap between advancing data collection methods, including mixed-mode and online surveys, and an understanding of how mode choice might affect the measurement of perceptions of politically-sensitive environmental issues. While much of the survey literature on sensitive topics focuses on mode differences for issues from domestic violence to drug consumption, different methods of data collection could induce error for politically-charged issues, particularly those with evidence rupture across political party lines. The extent various online survey modes differ in gleaning measurements of public attitudes or economic preferences for renewable energy policies could have significant implications if used to inform their policy processes.

Results in various unweighted (demographics) and weighted analyses (demographics, TSE, and Likert regressions) suggest negligible statistically significant differences across modes concerning weighted support for offshore wind power development, attitudes toward state-level renewable energy standards or climate change perceptions. The online panel performs as well or better as the mail-based survey in many metrics, suggesting that researchers can have confidence in tapping into some of these private lists culled by firms to emulate the population. The findings in this essay highlight the potential for online mode data collection to be a viable alternative in some cases.

When carrying out any survey, a researcher's goal is to minimize errors to the extent possible and choose method(s) germane to the research questions of interest. However, a main takeaway from this essay is that researchers might weigh more heavily the tradeoffs for survey design such as cost, quality, time efficiency, and ease of implementation and data collection. As these findings from these data inform the decision processes for renewable energy or climate change policies at the Federal and state levels, careful optimization of these design considerations, let alone methodological effects, should remain of utmost priority.

5.1 Thematic Findings

The essays together speak to a similar theme that is relevant for policy making processes in that there is always a concern for data fidelity, accuracy and reliability—and the data here as they are used to inform decisions for offshore wind technology are no exception. Federal, state and local governments do not have years to carry out studies regarding this new technology. On the other hand, public officials need information to accurately and fairly inform OSW policy. Informing socially optimal policies for this technology ought to rely on the best-available data. While mail surveys have a long way to go before they approach obsolescence, rabidly available new modes such as online panels or mixed approaches could offer means to quickly supplement, relatively speaking, their mail counterpart. Findings here suggest ample opportunities for researchers to collect data via online panel or opt-in online modes for CEs applied to offshore wind or renewable energy projects. Findings also suggest that online and panel data could open the door to improving the CE models if it allows for ease of collecting a web of more locational information. While more data is not always the answer if it is for the sake of more data, online platforms offer a sophistication that will allow future related studies to augment the depth and breadth of data collected, on top of the ease of administration that can be streamlined to limit human-error. This could allow more Federal agencies to integrate these values into their decision-making processes, such as through creation of relevant tools.

5.2 Caveats

These essays offer robust findings to inform renewable energy policies. It is worth remembering though that all research requires context that could have implications on interpretation. First, these data were collected in 2015 and provide a static image under a previous political administration. The world is a different place in 2018; from a Federal perspective, the nation has shifted its national sociodemographic priorities. Second, the CE preamble and images underwent meticulous design before becoming finalized, and much of the CE wind power studies do not even include photomontages. That said, they do not include night-time images or moving blades to reflect their true nature that also might alter WTP estimates. Third, and along the same line, there are several bounds to the choice set and what it illuminates about consumer preferences. We do not know whether respondents would prefer onshore wind to offshore wind, nor whether respondents would prefer offshore wind projects to natural gas but only if it were located outside the MWEA (or elsewhere else entirely). One could make an argument that those are valid alternatives or referenda adjustments. Lastly, while we do have a sense as to respondent certainty given several design elements incorporated into the CE, we simply do not know the extent respondents would exhibit their behavior as expected if given this option in real life.

5.3 Future Research

Lessons learned and findings gleaned from this research offer ample opportunity for future inquiry. Fundamentally, the questions explored here could apply to other WEA areas that are leased or undergoing permitting. The dataset from this dissertation could also weigh in on other analyses for renewable energy perceptions literature, more broadly speaking. Possible research endeavors analyzing development futures for other WEAs could focus on housing price impacts for homes near offshore wind projects or include additional project characteristics in the CEs. Several tweaks for the preamble or how the photomontages are displayed could add additional realism in the electricity choice referenda in these studies, with examples such as moving images that host turbines at night with red lights or turbines with moving blades, or even a combined SP and reveled preference (RP) experiment. From a methodological perspective, these findings suggest compelling evidence to modernize how some non-market valuation studies are carried out. Findings in the third chapter suggest there is statistical robustness to tap into responses from online surveys, particularly from paid survey panelists as we find they can outperform mail surveys in some respects.

5.4 Implications for Policy

With WEAs leased throughout nearly in every corner of Atlantic OCS, it is likely additional projects beyond the Block Island Offshore Wind Project could come online adjacent to significant load centers. While the Atlantic OCS boasts considerable reliable and high wind resources, that alone has shown to not be enough. The extent of which these projects come to fruition will depend notably on local opposition, policy drivers, price competitiveness, and marine effects. How the public and effected stakeholders *think* and *behave* in response to these issues will ultimately play one of the most significant roles in informing the policy and regulatory thinking, and, outcome.

While numerous findings have been presented here, this dissertation can be summed up in several takeaway themes. First, while robust results are established, policy makers and researchers should heed caution when extrapolating these findings outside the Mid-Atlantic region. What is true for Maryland might not necessarily hold entirely for the Massachusetts or North Carolina WEAs. Second, the second chapter has established ratepayers would be willing to pay for electricity generation from a renewable source (i.e., the avoided negative externalities from fossil fuel electricity generation). While we know why respondents voted for natural gas given the debriefing questions, it is important to remember that we do not know directly (self-reported) why respondents voted for offshore wind. We can reasonably infer that an expressed WTP is for the positive externalities associated with renewable electricity generation, but it could include others such as a symbolic desire for his/her state to adhere to a sustainable energy path. This finding, as well as the specific details on the extent of their WTP, can be informative to state REC carve outs. Third, it cannot be underscored enough that the location of these projects matters for economic preferences, and social well-being, that will result from development of offshore wind projects and how that factors into the overall benefit-cost equation. For example, moving a project further offshore might mitigate visual disamenities but would also incur higher construction (i.e., cabling or substation) costs (Samoteskul et al., 2014). Therefore, optimization between the tradeoffs of these key benefits and costs will be up to the developer, the BOEM, and the public to resolve, particularly in an adaptive sense in a world where more projects are built and cumulative effects become more salient through time. This question will likely necessitate a societal answer, relying on substantive consultation from ratepayers and local residents. Finally, there are modern survey techniques available to policymakers that can be deployed at alleviated cost with potential to expeditiously collect germane information on public perceptions, economic preferences, or expected behavior. Dynamic socioeconomic data for future WEAs ought to be seriously considered to inform these development futures.

While it is as important as ever to move toward a clean energy transition with offshore wind power making up a notable share of the energy portfolio, doing so in a way that is least socially disruptive arguably ought to be the utmost priority. States will continue to take center stage in creating demand for the projects through their RPSs. The findings, methodological approaches, and recommendations presented here can inform an overall decision paradigm for offshore wind development.

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APPENDIX A

CHAPTER 3: APPENDICES

Table A.1: Choice model descriptive statistics for attributes and independent variables (unweighted). Variable definitions are presented in Table 3.5.

Variable	**Total**	
	Prop.	**Std. Err.**
	SHORT	
wind	33%	0.005
bid		
$0.00 (natural gas)	36.9%	0.009
$1.50	16.8%	0.007
$5.00	21.9%	0.008
$10.00	10.2%	0.006
$20.00	6.9%	0.005
$50.00	5.9%	0.004
$100.00	1.5%	0.002
north	41.7%	0.009
south	18.4%	0.007
central	3.0%	0.003
sizeN		
0	58.3%	0.009
200	13.4%	0.007
300	1.1%	0.002
500	10.5%	0.006
750	16.6%	0.007
sizeS		
0	81.6%	0.007
200	1.9%	0.003
300	14.2%	0.007
500	2.3%	0.003
sizeC		
0	97.0%	0.003
750	1.4%	0.002
1000	1.6%	0.002
	FULL	
view	22.8%	0.008
coastal	21.4%	0.008
secondh_coastal	8.9%	0.006

Table A.2: CE question responses/response rates (unweighted).

CE Question	Total		Delaware		Maryland		Coastal		Own beach home		Visit beach above average (11 days/yr)	
	N	Response rate	N	Response rate	N	Response rate	N	Response rate	N	Response rate	N	Response rate
13a.	912	94%	323	94%	589	94%	194	96%	88	98%	286	97%
14a. & 15a.	1825		647		1178		387		178		580	

Table A.3: If the vote were held today, share of respondents that would vote for each choice option in the choice experiment question set (weighted).

CE Question	Total			Delaware			Maryland			Coastal			Own beach home			Visit beach > average		
CE Option	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
13a.	39%	33%	28%	40%	32%	28%	39%	34%	28%	39%	38%	23%	25%	16%	59%	43%	35%	22%
14a. & 15a.	12%	45%	43%	12%	44%	44%	13%	45%	43%	15%	43%	43%	5%	24%	71%	16%	43%	41%

Table A.4: Mean response certainty for all choice questions and mean >=60%, >=70% and >=80% certainty (weighted).

	Total	**Delaware**	**Maryland**	**Coastal**	**Own beach home**	**Visit beach > average**
Mean CE question certainty	71%	70%	71%	72%	63%	65%
Share of responses >/= 60% certain	70%	68%	70%	67%	64%	62%
Share of responses >/= 70% certain	70%	56%	58%	60%	45%	50%
Share of responses >/= 80% certain	41%	38%	58%	50%	27%	31%

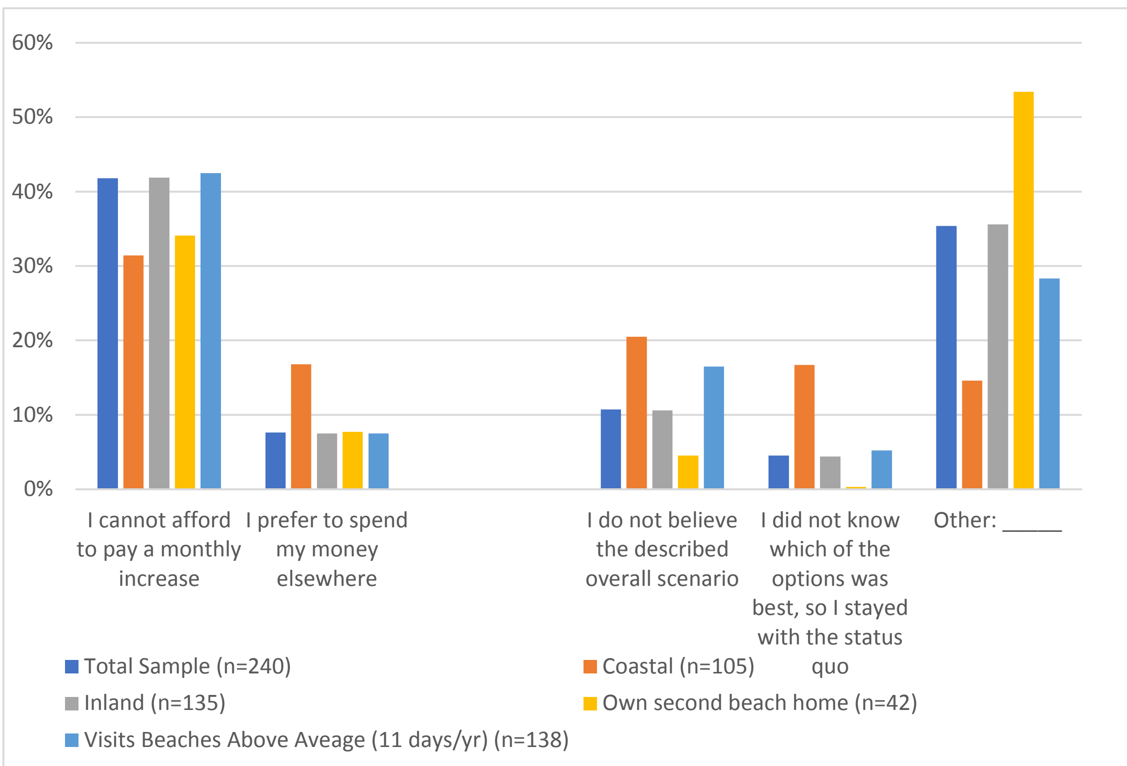

Figure A.1: Reason for voting for natural gas opt-out alternative one+> times (weighted).

Table A.5: Self-reported beach visitation over the previous year, presented south to north (weighted).

Beach	Delaware	Maryland	Coastal	Own beach home	Visit beach above average (11 days/yr)
Assateague National Seashore (VA)	0%	1%	0%	0%	0%
Assateague National Seashore (MD)	1%	4%	22%	7%	7%
Ocean City Beach (MD)	10%	49%	50%	34%	34%
Fenwick Beach	3%	2%	5%	7%	7%
Fenwick Island State Park	2%	0%	1%	0%	0%
South Bethany Beach	0%	1%	3%	1%	1%
Bethany Beach	6%	5%	3%	11%	11%
Delaware Seashore State Park	7%	0%	2%	0%	0%
Dewey Beach	11%	3%	3%	4%	4%
Rehoboth Beach	31%	9%	7%	18%	18%
Cape Henlopen State Park	14%	2%	4%	1%	1%
Other Beach	14%	24%	1%	17%	17%

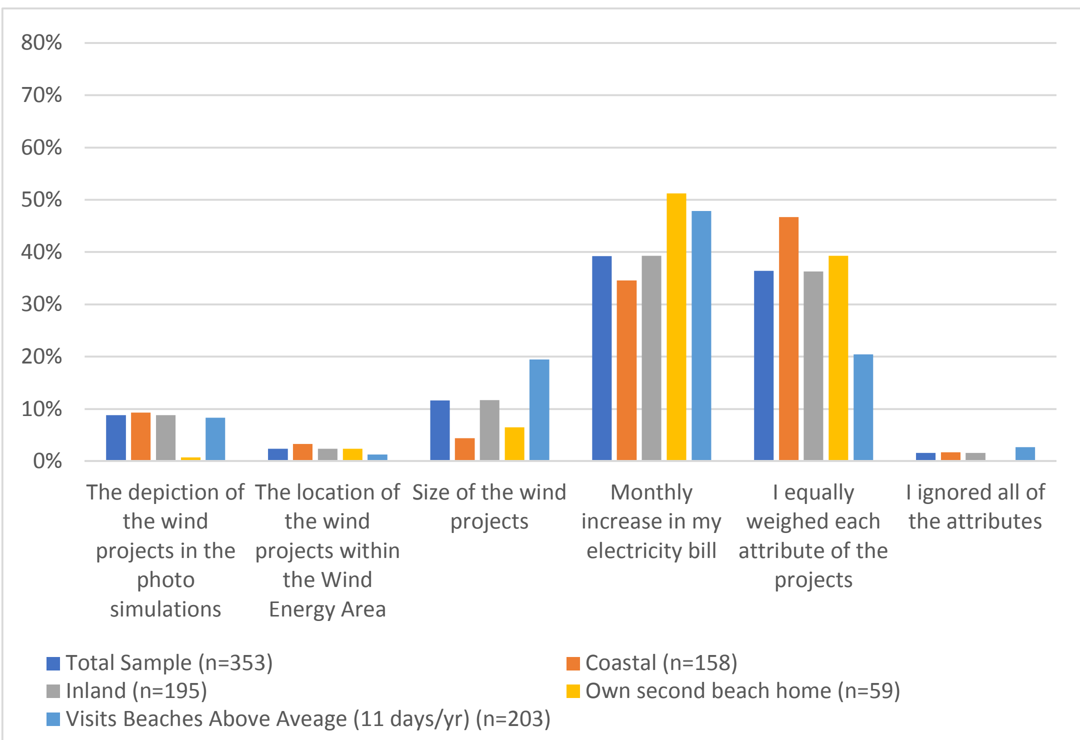

Figure A.2: CE attributes most considered by respondents when making votes (weighted).

Table A.6: Dummy conditional logit results for Delaware and Maryland.

Variable	DELAWARE			MARYLAND		
choice	**Coef.**	**Robust std. er.**	***p*-value**	**Coef.**	**Robust std. er.**	***p*-value**
bid	-0.036	0.006	0.000***	-0.021	0.003	0.000***
n200	0.319	0.192	0.096*	0.382	0.147	0.009***
n300	0.607	0.605	0.315	-0.304	0.379	0.422
n500	0.598	0.228	0.009***	0.503	0.163	0.002***
n750	0.156	0.224	0.486	0.298	0.155	0.054*
s200	1.985	0.887	0.025**	0.553	0.420	0.188
s300	1.181	0.245	0.000***	0.677	0.165	0.000***
s500	0.994	0.487	0.041**	0.143	0.339	0.674
c750	0.662	0.504	0.189	-0.120	0.334	0.719
c1000	-0.143	0.500	0.774	-1.230	0.330	0.000***
Pseudo R^2	0.176			0.140		
Number of observations (choices)	2,910			5,301		
Log pseudolikelihood	-24995.9			-127071.7		

Note. * Significant at the a = 0.1 level of confidence; ** significant at the a = 0.05 level of confidence; *** significant at the a = 0.01 level of confidence.

Table A.7: Short conditional logit results for Delaware and Maryland.

Variable	DELAWARE			MARYLAND		
choice	**Coef.**	**Robust std. er.**	***p*-value**	**Coef.**	**Robust std. er.**	***p*-value**
bid	-0.035	0.005	0.000***	-0.023	0.003	0.000***
north	0.520	0.240	0.031**	0.413	0.165	0.012**
south	1.678	0.746	0.025**	1.224	0.534	0.022**
central	2.585	2.150	0.229	3.347	1.395	0.016**
sizeN	0.000	0.000	0.367	0.000	0.000	0.767
sizeS	-0.002	0.002	0.464	-0.002	0.002	0.221
sizeC	-0.003	0.002	0.239	-0.004	0.002	0.004***
Pseudo R^2	0.173			0.137		
Number of observations (choices)	2,910			5,301		
Log pseudolikelihood	-25086.6			-127525.1		

Note. * Significant at the a = 0.1 level of confidence; ** significant at the a = 0.05 level of confidence; *** significant at the a = 0.01 level of confidence.

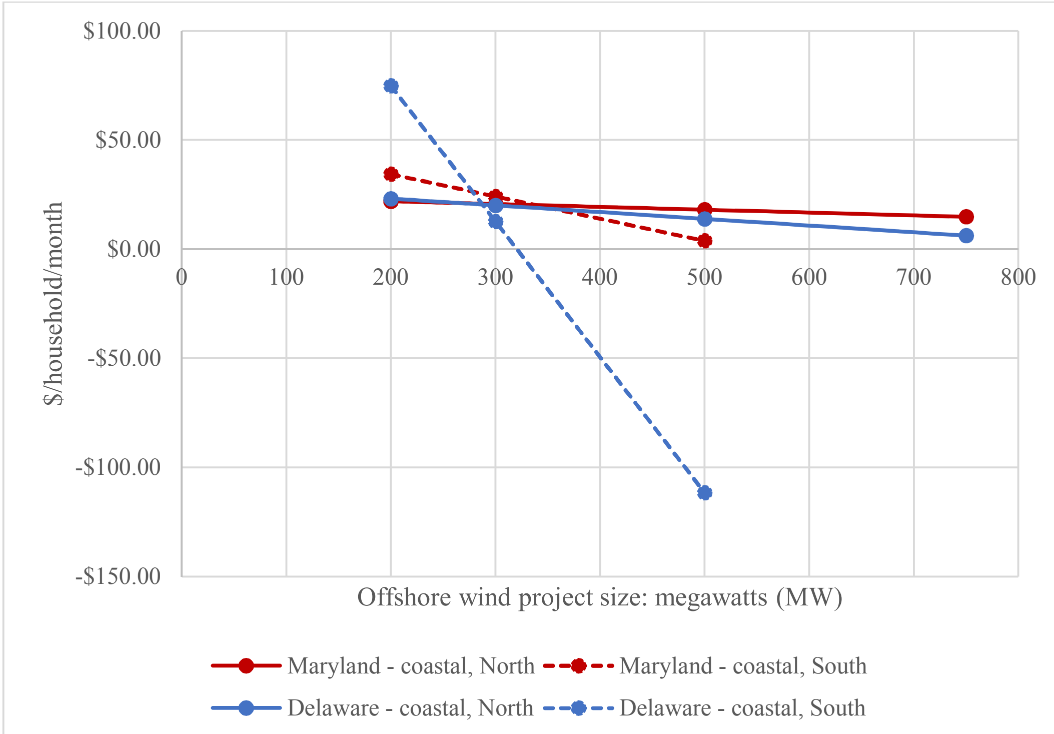

Figure A.3: Delaware and Maryland mean WTP ($/household/month) in coastal strata.

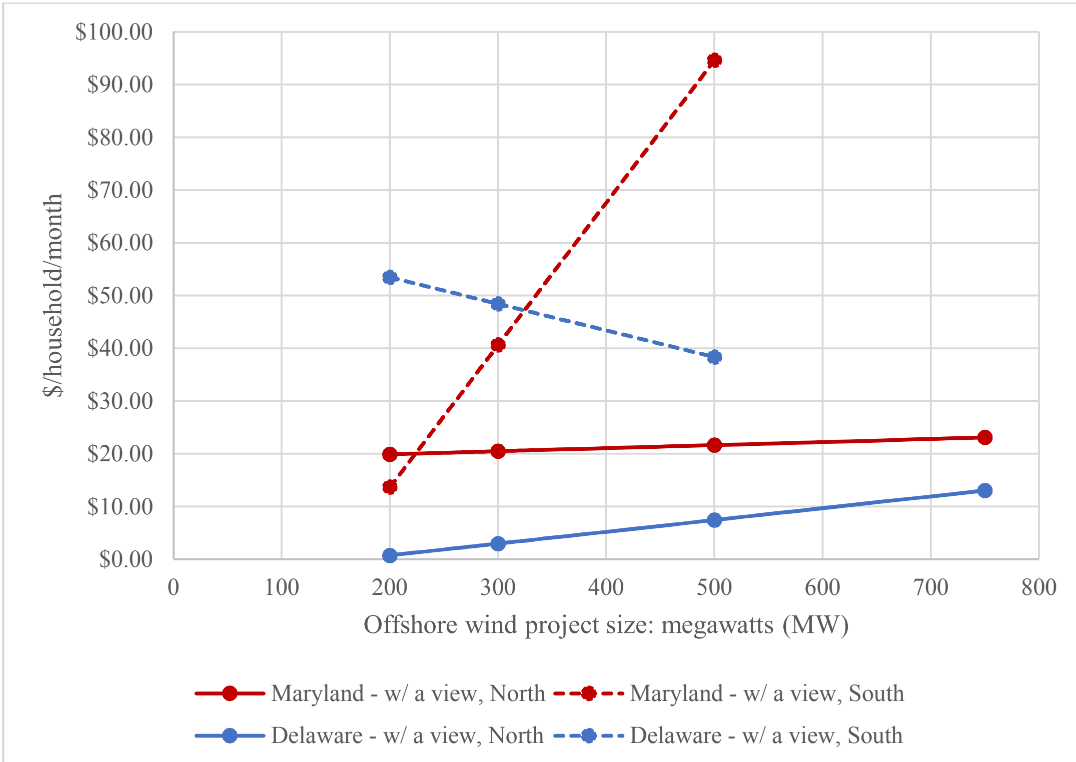

Figure A.4: Delaware and Maryland mean WTP ($/household/month) with an anticipated project view.

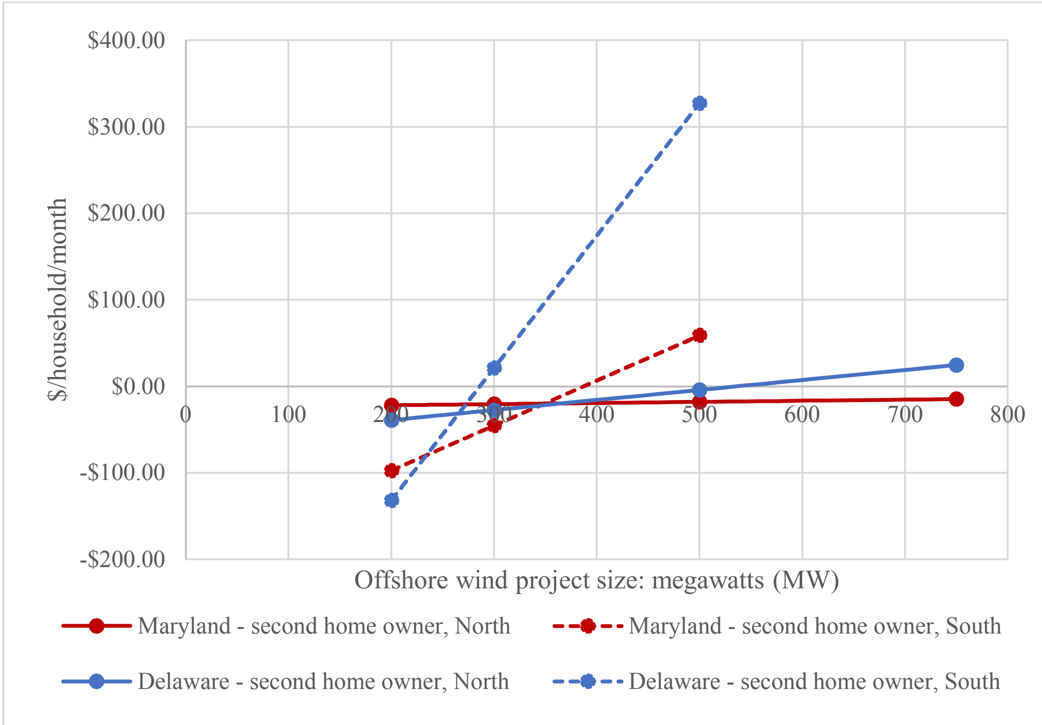

Figure A.5: Delaware and Maryland mean WTP ($/household/month) who own a secondary beach home in zip codes bordering the Delaware/Maryland Atlantic coastline.

APPENDIX B

CHAPTER 4: APPENDIX

Table A.8: Weighted and unweighted means for support for offshore wind development, state renewable energy policies, and climate change attitudes among Maryland residents.

	Mode and Sub-sample Means *(95% conf. interval)*				
Key environmental question in instrument	**Mail (1)**	**Mixed, all completes (2)**	**Mixed, mail completes (2a)**	**Mixed, Internet completes (2b)**	**Panel (3)**
	UNWEIGHTED				
General support (and leaning to support) for an offshore wind project	0.78	0.81	0.81	0.81	0.87
	(.70) (.88)	*(.73) (.89)*	*(.71) (.91)*	*(.68) (.94)*	*(.84) (.90)*
Supports his/her State having policies to promote renewable energy development (i.e., Renewable Energy Standard)	2.48	2.49	2.48	2.5	2.43
	(2.33) (2.62)	*(2.36) (2.62)*	*(2.31) (2.66)*	*(2.29) (2.71)*	*(2.38) (2.50)*
Opinion towards the cause of climate change	2.66	2.64	2.58	2.73	2.7
	(2.43) (2.88)	*(2.41) (2.86)*	*(2.27) (2.88)*	*(2.39) (3.07)*	*(2.59) (2.81)*
	WEIGHTED				
General support (and leaning to support) for an offshore wind project near Ocean City, MD	*0.91*	*0.86*	*0.82*	*0.91*	*0.88*
	(.83) (.99)	*(.73) (.99)*	*(.59) (1.05)*	*(.79) (1.02)*	*(.84) (.92)*
Supports his/her State having policies to promote renewable energy development (i.e., Renewable Energy Standard)	2.63	2.55	2.42	2.70	2.37
	(2.40) (2.86)	*(2.22) (2.89)*	*(1.85) (2.99)*	*(2.47) (2.93)*	*(2.3) (2.46)*
Opinion towards cause of climate change	2.91	2.51	2.42	2.63	2.74
	(2.30) (3.51)	*(2.23) (2.80)*	*(2.02) (2.82)*	*(2.24) (3.02)*	*(2.58) (2.91)*

APPENDIX C

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APPENDIX D

MAIL SURVEY: MARYLAND/DELAWARE (VERSION 1)

What will the future hold?

UNIVERSITY OF DELAWARE

You are one of 1,850 Delaware and Maryland residents randomly chosen to participate in this survey. Your help is voluntary and your answers are completely confidential. Your thoughts and opinions are important!

Instructions:

In addition to this survey booklet, you have been provided with an insert of photos of the ocean. Please refer to the photos when directed to do so. **To accurately view these photo-simulations, please hold the photo pages approximately 9 inches from your face, as instructed on the photo inserts.** When you are finished, please return the completed survey in the envelope provided. Please do not return the photo inserts.

If you have any concerns about this study, you may call Jeremy Firestone at (302) 831-0228 or email at jf@udel.edu

University of Delaware
College of Earth, Ocean, and Environment
373 ISELab
Newark, Delaware 19716

I. YOUR OPINIONS ON WIND POWER

1. Have you ever seen a wind turbine in operation?

□ Yes
□ No

2. What is your general attitude toward wind power?

□ Very positive
□ Positive
□ Neutral
□ Negative
□ Very negative

3. Overall, how familiar are you with offshore wind power?

□ Familiar
□ Somewhat familiar
□ Unfamiliar

4. Do you think that wind energy is a viable substitute for…

	Yes	To some extent	No
Nuclear energy?	□	□	□
Fossil fuel (coal/natural gas) energy?	□	□	□

5. How economical ($) do you think wind power is?

Not economical				***Economical***
1	2	3	4	5

1

For questions 6-12, suppose a private developer proposed to place 50 wind turbines (300 MW) in the ocean between Fenwick Island, Delaware, and Ocean City, Maryland, for electricity generation (*see map insert*). The project would be at least 11 miles from the nearest town and take up no more than a quarter of the Wind Energy Area depicted on the map.

6. Please refer to Photo Q6 only, which represents how the wind project might appear from shore. Would you support or oppose this project?

□ Support
□ Oppose
□ I have not yet made up my mind →

Which way are you leaning?

□ To support the project
□ To oppose the project

7. Do you think you would be able to see the wind project from your home or beach home?

□ Yes
□ No
□ Not sure

8. Do you think you would be able to see the wind project during your day-to-day routine?

□ Yes
□ No
□ Not sure

9. To what extent do you agree or disagree that the wind project would fit well with the landscape/seascape?

□ Strongly agree
□ Agree
□ Neutral
□ Disagree
□ Strongly disagree

10. Do you believe that the wind project would have a positive effect, no effect, or negative effect on each of the following:

Check one box for each statement below	**Positive**	**No effect**	**Negative**	**Unsure**
Local fishing industry	□	□	□	□
Tourism & related business	□	□	□	□
Local job creation	□	□	□	□
Air quality	□	□	□	□
Price of electricity	□	□	□	□
Stability of electricity prices	□	□	□	□
Aesthetics of ocean view	□	□	□	□
Property values	□	□	□	□
Marine life	□	□	□	□
Bird life	□	□	□	□
Recreational boating	□	□	□	□
Recreational fishing	□	□	□	□
Vessel navigation	□	□	□	□
U.S. energy independence	□	□	□	□
Military radar transmission	□	□	□	□

11. **In deciding whether you would support or oppose the wind project, please write in three issues you consider to be the most important, <u>regardless of whether mentioned in Question 10</u>, with 1 being the most important.**

#1 ______________________________________

#2 ______________________________________

#3 ______________________________________

12. **Which of the following do you think would be the most important factor in a public review process for such a wind project? *(Select one)***

□ The energy developer's financial and technical capabilities
□ Expert opinion
□ Environmental impact studies
□ Job impact studies
□ Public involvement, consultation, and participation

II. New Energy Development

For the following questions, assume **you have the opportunity to vote on your State's energy development future by selecting among offshore wind power and natural gas options to expand electricity generation.**

The federal government has designated a Wind Energy Area, which begins about 11 miles off the coast of Ocean City, Maryland and Fenwick Island, Delaware, for potential development (**<u>see Wind Energy Area Map</u>**).

- ***Your responses are important; they will inform state renewable energy policies.***
- *For each question, assume the option that receives the most votes will be carried out.*

First, some important information:

- Like many new technologies, the earliest projects cost more than later ones; thus, electricity generated by the first offshore wind projects will cost more than you are paying now. Wind energy is sold to consumers in long-term contracts that are structured so that the price consumers pay remains constant or is tied to a set annual increase (such as 3% per year). The questions that follow assume that your monthly electricity bill will be greater than it is today, with a constant monthly increase (e.g., \$3/month in 2015, 2016, 2017 … 2034) over the 20-year life of the wind project.

- The turbines could be in the North, South, or across the entire Wind Energy Area. The size of the project (such as the number of wind turbines) as well as the increase to your electricity bill may also vary.

- To give you an idea of scale, 50 offshore wind turbines (300 Megawatts) would generate enough electricity to power 75,000 homes.

Some things to think about before voting:

New offshore wind project	New natural gas project
• Can only be built after its potential effects are evaluated. Environmental effects: • Some negative effects on marine life; however, the long-term effects are expected to be minor for properly located projects. • Will displace existing coal- and natural gas-generated electricity resulting in environmental benefits. Social effects include: • Negative effects on traditional users of the marine environment (such as commercial fishermen).	• Environmental and human health effects would be much greater. Environmental effects: • Negative effects during exploration, drilling and extraction, pipeline transportation and combustion. • Negative effects on wildlife, water use/quality and climate. Human health effects include: • Asthma, bronchitis, cardiovascular and respiratory ills resulting in hospital visits, lost workdays and restricted activity days.

Continue on to vote →→→

➢ *Keeping in mind your **monthly budget**, please respond as if you are actually faced with this vote and as if the options presented in each choice are the only available options.*

Choice 1: Please consider this set of options for your state's energy future.

*Refer to the **Wind Energy Area Map** and to the insert for the **simulated views of the wind projects**.* Each simulation indicates the viewing location of a given wind power project option.

13a. If the vote were held today, which option would you vote for?

	Wind Power		**Natural Gas**
	Option A	**Option B**	**Option C**
Location	North	North	N/A
Size of energy project	33 wind turbines (~200 MW)	125 wind turbines (750 MW)	Expansion of electricity generation from natural gas.
Increase to your electricity bill	$1.50/month	$5/month	$0/month
I would vote for… *(Check one)*	□	□	□

13b. How sure are you that you would actually vote for the option selected if faced with this choice in real life? Please select a number from 1 to 10, with 1 indicating "very unsure" and 10 indicating "very sure".

	Very Unsure								Very Sure
Certainty	1	2	3	4	5	6	7	8	9	10

6

Choice 2: Now, please consider this set of options for your state's energy future.

Refer to the ***Wind Energy Area Map*** and *to the insert for the* ***simulated views of the wind projects***. Each simulation indicates the viewing location of a given wind power project option.

14a. If the vote were held today, which option would you vote for?

	Wind Power		**Natural Gas**
	Option A	**Option B**	**Option C**
Location	Central	North	N/A
Size of energy project	166 wind turbines (~1000 MW)	125 wind turbines (750 MW)	Expansion of electricity generation from natural gas.
Increase to your electricity bill	\$50/month	\$20/month	\$0/month
I would vote for… ***(Check one)***	□	□	□

14b. How sure are you that you would actually vote for the option selected if faced with this choice in real life? Please select a number from 1 to 10, with 1 indicating "very unsure" and 10 indicating "very sure".

	Very Unsure								**Very Sure**
Certainty	1	2	3	4	5	6	7	8	9	10

7

Choice 3: Finally, please consider this set of options for your state's energy future.

Refer to the ***Wind Energy Area Map*** and *to the insert for the* ***simulated views of the wind projects.*** Each simulation indicates the viewing location of a given wind power project option.

15a. If the vote were held today, which option would you vote for?

	Wind Power		**Natural Gas**
	Option A	**Option B**	**Option C**
Location	Central	North	N/A
Size of energy project	125 wind turbines (750 MW)	83 wind turbines (~500 MW)	Expansion of electricity generation from natural gas.
Increase to your electricity bill	\$10/month	\$1.50/month	\$0/month
I would vote for... ***(Check one)***	☐	☐	☐

15b. How sure are you that you would actually vote for the option selected if faced with this choice in real life? Please select a number from 1 to 10, with 1 indicating "very unsure" and 10 indicating "very sure".

	Very Unsure								**Very Sure**
Certainty	1	2	3	4	5	6	7	8	9	10

8

Please answer some follow-up questions regarding your votes.

If you selected a "Natural Gas" option one or more times → Answer 16
If you always selected a "Wind Power" option → Skip to 17

16. Select the *primary* statement that most closely described your reasoning when you chose to vote for natural gas: *(Select one)*

- □ I cannot afford to pay a monthly increase
- □ I prefer to spend my money elsewhere
- □ I do not believe the described overall scenario
- □ I did not know which of the options was best, so I stayed with the status quo
- □ Other: ________________________________

17. Of the attributes listed below, the attribute you *most* took into account when making your choices was: *(Select one)*

- □ The depiction of the wind projects in the photo simulations
- □ The location of the wind projects within the Wind Energy Area
- □ Size of the wind projects
- □ Monthly increase in my electricity bill
- □ I equally weighed each attribute of the projects
- □ I ignored all of the attributes

18. Of the attributes listed below, the attribute you *least* took into account when making your choices was: *(Select one)*

- □ The depiction of the wind projects in the photo simulations
- □ The location of the wind projects within the Wind Energy Area
- □ Size of the wind projects
- □ Monthly increase in my electricity bill
- □ I equally weighed each attribute of the projects in each option
- □ I ignored all of the attributes

19. The landscape/seascape impact of offshore wind turbines is__________ compared to the health/environmental impact of fossil fuel power generation?

Minor		***About the same***		***Major***
(1)	***(2)***	***(3)***	***(4)***	***(5)***
□	□	□	□	□

20. **Are you aware of the recent announcement by the federal government that U.S. Wind Inc./Renexia was the high bidder in an auction to lease the offshore Maryland Wind Energy Area for development?**

□ Yes
□ No
□ Unsure

III. GENERAL QUESTIONS

21. Select the following natural environment that you *most* enjoy: *(Select one)*

□ Oceans
□ Mountains
□ Forests
□ Bays/lakes
□ Deserts
□ None of the above

22. Please answer each of the following:

Check one box for each statement below	**Agree**	**Somewhat Agree**	**Neither agree nor disagree**	**Somewhat disagree**	**Disagree**
The ocean beach I most often visit is one of my favorite places.	□	□	□	□	□
I feel attached to the ocean beach I most often visit.	□	□	□	□	□
The ocean is part of my identity.	□	□	□	□	□

23. Have you ever written a letter, email or text to a public official to increase support of environmental protection or conservation efforts?

□ Yes □ No

24. In the last year, have you contributed financially to an environmental organization?

□ Yes □ No

25. Do you save energy at home (for example, by turning lights off when not in use, using energy efficient light bulbs, and watching how much you heat and cool)?

□ Yes □ No

26. Please check one box for each statement in sets A, B, and C below:

A.	**Agree**	**Somewhat agree**	**Neither agree nor disagree**	**Somewhat disagree**	**Disagree**
Humans have a responsibility to protect and preserve the environment for the benefit of future generations.	□	□	□	□	□
Humans have the right to modify the natural environment to suit their needs.	□	□	□	□	□
Humans are seriously abusing the environment.	□	□	□	□	□
Human ingenuity will ensure that we do not make the Earth unlivable.	□	□	□	□	□
Humans will eventually learn enough about how nature works to be able to control it.	□	□	□	□	□
The balance of nature is very delicate and easily upset.	□	□	□	□	□
If things continue on their present course, we will soon experience a major ecological catastrophe.	□	□	□	□	□

B.	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree
I use environmentally friendly products at home (for example, cleaning or gardening supplies).	□	□	□	□	□
I try to shop at natural food stores when possible.	□	□	□	□	□
I support the U.S. moving away from (traditional) incandescent light bulbs.	□	□	□	□	□
I live my life in a way that's good for the environment.	□	□	□	□	□

*****

C.					
I support government programs to reduce poverty.	□	□	□	□	□
Government regulation of business usually does more harm than good.	□	□	□	□	□
In my ideal society, all basic needs (food, housing, health care, and education) would be guaranteed by the government for everyone.	□	□	□	□	□
Our government tries to do too many things for too many people. We should just let people take care of themselves.	□	□	□	□	□
The government interferes too much in our everyday lives.	□	□	□	□	□

27. To what extent do you agree or disagree with your state having policies that facilitate a portion of electricity coming from renewable energy sources?

□ Agree
□ Neutral
□ Disagree
□ Not sure

28. Thinking about climate change, which of the following best describes your opinion?

□ It is entirely caused by natural processes.
□ It is mainly caused by natural processes.
□ It is partly caused by natural processes and partly caused by human activity.
□ It is mainly caused by human activity.
□ It is entirely caused by human activity.
□ I don't think climate change is occurring.
□ Not sure

29. How concerned, if at all, are you about climate change?

□ Concerned
□ Somewhat concerned
□ Not very concerned
□ Not concerned
□ Not sure

30. How many days have you spent at the beach in the last 12 months? ______ *(If 0 days* ⟶ *Skip to 32a)*

31. The ocean beach that I visited *most often* was: *(Select one)*

- □ Cape Henlopen State Park
- □ Rehoboth Beach
- □ Dewey Beach
- □ Delaware Seashore State Park
- □ Bethany Beach
- □ South Bethany Beach
- □ Fenwick Island State Park
- □ Fenwick Beach
- □ Ocean City Beach (MD)
- □ Assateague National Seashore (MD)
- □ Assateague National Seashore (VA)
- □ Other: ______________________

32a. Please indicate how important the following activities are to you:

	Extremely Important	Important	Somewhat Important	Not Important
Activities in the ocean (Swimming, surfing, snorkeling, boogie boarding, kayaking, skimming, and so on...)	□	□	□	□
Shore and pier fishing in the ocean	□	□	□	□
Activities on the sand (Sunbathing, reading, walking, shell collecting, playing with children, beach volleyball...)	□	□	□	□
Activities on the boardwalk and in nearby communities (Going to restaurants/bars/amusements, shopping, sightseeing...)	□	□	□	□
Activities in water bodies near the ocean (Nature viewing, fishing/crabbing/boating, swimming, kayaking, paddle boarding, wind surfing...)	□	□	□	□
Pleasure boating activities in the ocean	□	□	□	□
Recreational/commercial boat fishing in the ocean	□	□	□	□

32b. Which of the previous activities do you engage in? *(Select all that apply)*

□ Activities in the ocean
□ Shore and pier fishing in the ocean
□ Activities on the sand
□ Activities on the boardwalk and in nearby communities
□ Activities in water bodies near the ocean
□ Pleasure boating activities in the ocean
□ Recreational/commercial boat fishing in the ocean

33. How often do you use a boat for pleasure or fishing in the ocean?

□ Never
□ Rarely
□ Occasionally
□ Frequently

IV. HOUSEHOLD QUESTIONS

Finally, a few questions about yourself and your household to help us interpret the results of the survey.

34. Approximately how much is your monthly electricity bill, on average, in the summer? $ __________

35. Approximately how much is your monthly electricity bill, on average, in the winter? $ __________

36. What is the name of the company, cooperative or municipality that provides you with electricity service? _________________

37. Do you have electric heat? □ Yes □ No

38. On average, at what temperature do you set your thermostat in the winter? (degrees Fahrenheit) _______

39. How many persons, including yourself, live in your household?
_______ Persons

40. Are you male or female? □ Male □ Female

41. What is your age? _______

42. What is the highest degree or level of school that you have completed? ***(Select one)***

- □ Grade school
- □ Some high school
- □ High school graduate
- □ Some college credit
- □ Associate degree
- □ Bachelor's degree
- □ Graduate degree/ Professional

43. A. Where is your primary residence? Town _______________
Zip Code ____________

B. Do you own or rent your home? □ Own □ Rent

C. Is your primary residence in a beach community?
□ Yes → *Skip to E*
□ No ↓

D. Do you own a second home in a beach community?
□ Yes ↓
□ No → *Skip to G*

E. Town _______________ Zip Code _______

F. How long have you/your family had a residence in that beach community? ________ Years ________ Months

G. What is the approximate distance from your home or second home (if you own one) to the ocean, *whichever is closer*?

□ Less than 50 miles → ________ Mile(s)
□ More than 50 miles

44. What is your current employment status?

□ Employed for wages
□ Self-employed
□ Out of work
□ Homemaker
□ Student
□ Retired

45. Are you:

□ Socially liberal
□ Socially moderate
□ Socially conservative
□ Libertarian

46. Regarding U.S. policy, do you consider yourself to be:

□ Fiscally liberal
□ Fiscally moderate
□ Fiscally conservative

47. Which category best describes your <u>household</u> 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-$249,999
□ $250,000 and above

If you would like to make additional comments, please provide them in the space below:

Your contribution to this effort is greatly appreciated.

Please return the survey booklet in the enclosed envelope. Please do not return the photo insert. If the envelope was misplaced, return the survey to the address on the inside front cover.

Thank you!

APPENDIX E

INSTITUTIONAL REVIEW BOARD (IRB) APPROVAL: EXEMPT

Subject: IRBNet Board Action
Date: Thursday, January 5, 2017 at 10:10:14 AM Eastern Standard Time
From: Nicole Farnese-McFarlane
To: Lauren Knapp, Meryl Gardner, Jeremy Firestone

Please note that University of Delaware IRB (HUMANS) has taken the following action on IRBNet:

Project Title: [565033-4] Social Dimensions of Offshore Wind Power Development off the Delaware Peninsula
Principal Investigator: Jeremy Firestone

Submission Type: Continuing Review/Progress Report
Date Submitted: January 3, 2017

Action: EXEMPT
Effective Date: January 5, 2017
Review Type: Exempt Review

Should you have any questions you may contact Nicole Farnese-McFarlane at nicolefm@udel.edu.

Thank you,
The IRBNet Support Team

www.irbnet.org