Appendix D: Benefit Cost Analysis: Economic Feasibility of Offshore Wind Energy Development on the California Central Coast

Photo Credit: Principle Power

Benefit-Cost Analysis:

Economic Feasibility of Offshore Wind Energy Development on the California Central Coast

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Introduction

The objective of the CalWind master's group project is to evaluate the feasibility of offshore wind (OSW) energy development in the central coast region of California (defined as Oxnard, Santa Barbara, and San Luis Obispo Counties). The project's clients are Infinity Wind and the Community Environmental Council (CEC). Evaluating the potential of OSW energy development requires a holistic assessment of socio-economic and environmental variables in the region of study. This process includes the following steps:

- Identification of stakeholders and the issues that concern them.
- Identification of the regulatory environment and associated externalities.
- Creation of a map of possible OSW development sites, informed by spatial tradeoff analysis incorporating stakeholder feedback, environmental impacts, regulatory constraints, and economic feasibility.

To inform ours clients' understanding of the economic feasibility of OSW development in the region of interest, CalWind has developed a benefit-cost analysis for several OSW scenarios. In the pages that follow, we will outline potential cost and benefit considerations, describe the range of benefit-cost ratios and their respective financial implications, and will conclude with the limitations of our analysis and areas for future research.

Assumptions

Currently, there are no OSW farms in the United States, and while there are developments in progress on the East Coast, there are no concrete plans for OSW development on the West Coast. Without domestic case studies to set economic precedents, CalWind has developed a list of assumptions to conduct a benefit-cost analysis for several hypothetical wind farm scenarios. The basic assumptions are as follows:

- Project perspective: Developer
  - All costs and benefits considered in this report are estimated from the perspective of a potential developer.
- Wind farm size: 500MW & 1000MW
  - 100 and 200 5MW turbine arrays, respectively. The 500MW size is approximately the same size as the proposed Cape Wind project off the coast of MA. A 1000MW scenario was included to see potential impacts of economies of scale.
- Distance from shore: 25 miles
  - Interviews with the wind industry and state and federal permitting agencies has led CalWind to conclude that OSW development is unlikely to occur in state waters. Due to the aesthetic importance of the coastal environment, we chose a 25 mile distance to minimize viewshed impacts from shore. Based on existing OSW projects planned for the East Coast, CalWind feels 25 mile is a realistic distance for this exercise.
- Floating turbine platform technology
  - Due to depth and financial limitations associated with OSW development on the outer continental shelf off the CA coast, traditional monopile or jacket foundations for wind turbines are not viable. Therefore, we assume the farm would use floating platform turbines. For the purposes of this exercise, we have created financial models using PelaStar's platform design.

A detailed discussion of assumptions is found in the cost and benefit consideration sections, below.

Cost Considerations

Without guaranteed subsidies, pursuit ofOSW development on the coast of California will only occur if costs to capture and transport that energy are less than the expected benefits. In an effort to calculate the costs associated with such a project, CalWind gathered information from multiple sources to determine the estimated cost of installing two wind farm scenarios. Every effort was made to gather accurate information within the scope of the project; however, since no floating offshore wind farm has been installed in the world, we can only base our numbers on pilot projects, industry claims, and historical data from other OSW projects.

Direct Costs Calculations

In order to determine the direct costs to a developer of installing an OSW farm, we consulted with our Group Project Client Infinity Wind Power, and adapted the process that they would follow to develop onshore wind power. The line items generated from that discussion are included in Table 1 of the Appendix.

Meteorological Data Acquisition

In order to determine the optimal equipment and arrangement of an OSW farm, a detailed site-specific wind profile is required. The profile is obtained by installing a tower at the proposed site location with specific equipment to capture meteorological data, including wind speed and direction. The cost to install a meteorological tower was calculated using the installation and anchoring costs for a floating turbine and half of the actual turbine cost. We also accounted for the cost of vessel mobilization, survey and engineering fees, and a contingency bonding sum roughly equal to the cost of project decommissioning.

Permitting and Lease Fees

The project begins by initiating the permitting process and obtaining a lease from the regulatory agency, in this case the Bureau of Ocean Energy Management (BOEM). The permitting process is highly variable based on the specific project location and attributes; therefore we included a range of 4 to 10 years to complete the permitting process. Based on conversations with Infinity Wind Power, we estimated that each year of permitting would cost $100,000 and that one-time agency permitting fees are estimated to be approximately $1,000,000.

In order to construct an OSW farm on the Outer Continental Shelf, a developer must acquire a lease from BOEM. Leases are obtained either through a competitive or non-competitive process, and to date only a handful of leases have been granted. The largest lease was for 164,750 acres offshore Rhode Island and Massachusetts in which Deepwater Wind paid $3,800,000 ($23.07 per acre) for the rights to start initial investigations and permitting.[1,2] In addition, the leasing party is responsible for an annual rent of approximately $500,000 until a wind farm is operational on the site.[2] For our project, we assumed that the scenarios would require 53,644 acres and 26,822 acres, respectively, based on standard wind farm spacing and a sizable buffer.[1] Therefore, we determined the approximate one time lease fees by multiplying the acreage estimates by the price per acre ($23.07). Federal rent fees, which are required every year until the project generates power, were dependent on the length of the permitting process plus 2 years for construction.

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[1]Please note: wind farm sizing and organization is highly dependent on site-specific details and gross estimates were used to determine an approximate with farm size.

Construction

Installation and Turbines

As mentioned above, floating wind turbine technology is unproven and difficult assign a cost. We used pricing data obtained from PelaStar, one of several floating wind turbine design and manufacturers, at an American Wind Energy Association (AWEA) conference. From the PelaStar information we were able to back calculate the cost per MW installed and apply that to each of our scenarios.

Electrical Infrastructure

The electrical infrastructure required includes turbine inter-connection cables, a substation, and transmission cable.The inter-connection cables in wind turbines transfer power from each generator to the charge controller or battery. The cables allow turbines to be connected or disconnected to the charge controller from a quick switch. Due to the limited information on offshore wind turbine in practice, the cost of inter-connection cables was estimated by doubling the price of on-shore turbine inter-connection cables ($35/foot), and we arrived at a price of $114.83/meter.

After the electricity being generated through wind turbines, substations(transformers) help collect power from groups of turbines and transport it to shore through transmission cables. It works as a back-up electrical generator and battery. Based on the data from National Renewable Energy Laboratory (NREL), the price for an offshore transformer is $2,618,000, and $5,600,600 for an onshore transformer.[2]It is also noted by NREL that three offshore transformers are required for a 500MW windfarm, and six transformers for a 1000MW installation. These transformers are in addition to an onshore substation, therefore the total cost for substation will include both onshore and offshore substation fees.

Transmission cables are what transport the electricity from offshore to on-land grid system and connect wind turbines to each other. For offshore wind farms, due to the further distance, long transmission cables are required. However, long transmission cables could also give significant influence on the power quality and stability. The transmission and array cable fee is composed of installation fees and cable fees. Installation fee is calculated by the cable vessel dayrate cost multiplying by the construction time. The total cable fee is equal to the unit price of cable multiplying by the distance.

Indirect Costs

There are numerous indirect costs that could be attributed to a project developer and how one calculates them is a function of where the system boundary is drawn. The group decided not to pursue the opportunity cost for other energy investments due to complete ambiguity of future energy costs as well as the opportunity cost for other investments being seen as being reflected in the discount rate used for the project.

The group did include indirect costs to commercial fisheries and whale watching for the two years of construction due to potential noise and traffic activities. It should be noted that, depending on the location of the OSW farm, there could be additional indirect costs to trawling fisheries, but since a specific cable route and project location was not explicitly chosen for this analysis, we excluded these costs. Indirect costs for impacts to birds and bats were used for the duration of the project to account for any mitigation activities that a developer would have to bare.

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[2]Jim Green et al., "Electrical Collection and Transmission Systems for Offshore Wind Power," in *Offshore Technology Conference*, 2007, http://www.onepetro.org/mslib/servlet/onepetropreview?id=OTC-19090-MS.

Present Value Calculations for Project Costs

In order to take the time value of money into account, present value calculations were included for the costs of each scenario, as outlined in Table 3 and Table 4 of the Appendix. A discount rate of 8% was used, following precedent set by a similar study examining wave energy.[3] Figure 1 compares the total vs. NPV of costs for each cost scenario analyzed.

Interestingly, the total present valuecost of the project is cheaper in Scenario B (long permitting) compared to Scenario A (short permitting). This is driven by the difference of discounted construction costs. For example, the 500MW wind farm in Scenario A has a present value of construction costs of approximately $850 million, whereas in Scenario B, the costs are about $625 million.

Benefit Considerations:

The benefits accrued from OSW development are more straightforward than the costs. With that said, costs are guaranteed to occur, benefits are not. Floating wind technology is unproven on the commercial scale. While power purchase agreements (PPA) provide some security to wind farm developers and owners, these contracts are not signed until utilities are certain companies can deliver dependable energy. This uncertainty will make investors hesitate to commit funds, and likely insist on higher returns than "conventional" energy investments. With that in mind, the CalWind team employed a 12% discount rate on all present value benefit calculations. Direct and indirect benefit considerations are detailed in the sections below.

Direct Benefits

Electricity Generation

Following OSW construction, the principal direct benefit realized by a developer is the revenue stream associated with electricity generation. To estimate these annual revenues, our group first multiplied wind farm size (500MW & 1000 MW) by a per turbine capacity factor of 37% across the number of hours in one year (8766). This capacity factor was taken from the U.S. Energy Information Association's (EIA) estimate of average marginal capacity for offshore wind technology. OSW electricity generation varies substantially by region, and EIA states that their, "…capacity factors should not be interpreted as representing EIA's estimate or projection of the gross generating potential of resources actually projected to be built."[4] This adjusted annual electricity generation potential was converted to kWh and multiplied by a Power Purchase Agreement (PPA) price of $0.187 per kWh.[5] The resulting product provides a raw PPA revenue stream estimate. Furthermore, speaking with CalWind client Infinity Wind, we learned that wind farm developers often receive a built in PPA Annual Escalation Rate of 3%. This annual escalation rate is reflected in the benefit present value calculation over the 25-year lifespan of the project.

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[3]Choong-Ki Kim et al., "Catching the Right Wave: Evaluating Wave Energy Resources and Potential Compatibility with Existing Marine and Coastal Uses," *PLoS ONE* 7, no. 11 (November 7, 2012).

[4]U.S. Energy Information Association, "Levelized Costs of New Generation Resources in the Annual Energy Outlook 2013" (U.S. Department of Energy, January 2013), http://www.eia.gov/forecasts/aeo/electricity_generation.cfm.

[5]Benefit value based on Cape Wind's PPA with National Grid. While this number would likely be different in California, it is the only domestic value available from which to make estimates.

Department of Defense Curtailment

Interviews with the Department of Defense (DoD) indicated that OSW developers operating in certain regions of military importance may encounter up to a 20% curtailment of operations. Given the location of DoD's Sea Range off the Santa Barbara coast, such a curtailment is a definite possibility. Therefore, we have included different benefit stream scenarios to reflect this potential benefit reduction.

Renewable Energy Credits

Another potentially realizable direct benefit for developers is revenue gained through carbon offsets. If this were to occur, developers would sell Renewable Energy Credits (RECs) to a party interested in offsetting their carbon emissions. To calculate this benefit, we multiplied the estimated carbon reduction (in tons) associated with 1 MW of wind energy by the adjusted capacity factor of our wind farms scenarios under curtailment and non-curtailment. This product was then multiplied by the most recent available market price per ton of carbon in California.[6]

Price Depression of Fossil Fuels

The last direct benefit we estimated is price depression of fossil fuels, which refers to the anticipated suppression of fossil fuel prices following the introduction of renewable energy to the grid. Here we are only looking at the prices of fossil fuels that are used to generate electricity, not other forms of fossil fuels such as liquid transportation fuels.

Studies examining impacts of additional large-scale renewable generation systems, such as offshore wind farms, on the price of electricity have indicated that an influx of electricity from these sources will reduce reliance on "peaker" plants, or generating facilities that are only used to generate electricity when demand is high. Similar to other U.S. states, California peaker plants are typically powered with natural gas and are more expensive per unit of electricity than the "baseload" power plants that are in operation 24/7. Peaker plants only typically operate during periods of peak loads; offshore wind patterns have been shown to peak roughly in sync with these loads, providing additional electrical supply when it is most needed, thus reducing reliance on peaker plants. Replacing expensive peaker plants with energy from offshore wind is anticipated to lower both the price of electricity, as well as the demand for natural gas.[7]

While it would be difficult for developers to capture this benefit, one could imagine a situation where a developer could leverage the knowledge of price depression from literature during PPA negotiations (i.e., a premium on PPA price due to price depression). For our benefit calculation, we incorporated hypothetical scenarios where developers received a 10%premium in PPA negotiations for anticipated price depression benefits. Recognizing the uncertainty of this calculation, we have included benefit calculations that include/do not include these values.[8]

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[6] "California 'Freebies' Drive Carbon to 2013 Low: Energy Markets - Bloomberg," accessed November 20, 2013, http://www.bloomberg.com/news/2013-08-21/california-freebies-drive-carbon-to-2013-low-energy-markets.html.

[7] Bruce Bailey, "Offshore Wind Resources and Their Load and Price Coincidence" (presented at the AWEA Offshore Wind Conference, Providence, RI, October 22, 2013).

[8] A reduced demand for natural gas is believed to reduce prices. Lowering electricity costs is a societal good that could also be measured as a consumer surplus, or an indirect benefit. Lowered natural gas prices may also encourage greater consumption of natural gas elsewhere, which could be considered an indirect societal cost/benefit.

Indirect Benefits

The indirect benefits of OSW construction discussed below were not included in the present value calculations or benefit-cost ratios. CalWind chose not to include these benefits because they are widely variable and/or uncertain. It would also be difficult, if not impossible, for the developer to capture the benefits into their revenue stream.

Social Cost of Carbon

Benefits associated with the social cost of carbon estimate the reduced cost of damage to the environment and human health resulting from the use of coal to generate electricity. Generating "clean" wind energy therefore reduces the need for coal generated power and creates societal benefits ($178.40/mWh).[9]

Artificial Fish Habitat

The creation of fish habitat stemming from artificial ocean structures is a potential indirect benefit of OSW development. Adding additional hard bottom habitat is believed to increase recruitment of certain fish species, as evidenced by oil platform staging. While recruitment increases are variable and contested in literature, these benefits could be realized by fishermen, and potentially used as a negotiating piece by developers during initial stakeholder engagement.[10]

Improved Air Quality

Improved air quality from a single wind project is hard to quantify, and associated societal benefits from improved health are too uncertain to value. On a larger scale (statewide OSW development, perhaps), it might be possible to calculate the societal benefits of improved health using the statistical value of life.

Present Value Calculation for Project Benefits

Following the approach taken for our cost calculations, CalWind projected a benefit stream across two different time horizons to reflect uncertainty in permitting timelines. Scenario A assumes 4 years of permitting and 2 years of construction before a developer receives electricity revenues. Scenario B assumes 10 years of permitting and 2 years of construction before a developer receives electricity revenues. Both scenarios incorporate a 12% discount rate and a 25-year operating period before decommissioning. Table 2 (see Appendix) summarizes these benefits. As mentioned previously, benefits may vary depending on DoD curtailment and the inclusion of highly uncertain benefits associated with price depression. With that in mind, we added categories within Scenario A and B to provide a range of possible revenue streams (See Tables 5&6, and Figure 2 in the Appendix).

Ignoring costs, a developer would be best off building quickly (expediting permitting), developing areas that avoid DoD curtailment, and negotiating a PPA that incorporates price depression benefits. This situation results in high-range values of $2,831,311,447and $1,415,655,724for 1000MW and 500MW farmsover the short permitting scenarios, respectively. Low-end benefit estimates assume a longer permitting period, DoD curtailment, and no developer realization of price depression benefits. The resulting values are $1,059,631,832and $529,815,916for 1000MW and 500MW farms, respectively.

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[9] Paul R. Epstein et al., "Full Cost Accounting for the Life Cycle of Coal: Full Cost Accounting for the Life Cycle of Coal," *Annals of the New York Academy of Sciences* 1219, no. 1 (February 2011): 73–98, doi:10.1111/j.1749-6632.2010.05890.x.

[10] Peter I Macreadie, Ashley M Fowler, and David J Booth, "Rigs-to-Reefs: Will the Deep Sea Benefit from Artificial Habitat?," *Frontiers in Ecology and the Environment* 9, no. 8 (October 2011): 455–461, doi:10.1890/100112.

Benefit-Cost Ratios

Calculations of Benefit-Cost (BC) ratios were conducted for each combination of benefit and cost values. Four benefit scenarios and two cost scenarios resulted in eight unique BC ratios for the 1000MW and 500MW windfarm schemes. BC ratios were calculated by dividing the NPV of calculated benefits by the NPV of calculated costs. A summary of these preliminary values is provided in the Appendix as

RESULTS: Cost-Benefit Ratios for Alternate Development Scenarios		
1000MW Windfarm	**Scenario A**	**Scenario B**
Without 20% DOD Curtailment	**1.36**	0.96
With 20% DOD Curtailment	1.09	0.77
No DOD Curtailment, No Price Depression	1.25	0.97
With DOD Curtailment, No Price Depression	1.00	0.71
500MW Windfarm		
Without 20% DOD Curtailment	1.30	0.92
With 20% DOD Curtailment	1.04	0.74
No DOD Curtailment, No Price Depression	1.20	0.85
With DOD Curtailment, No Price Depression	0.96	**0.68**
Benefit Discount Rate:		12%
Cost Discount Rate:		8%
PPA Price (per kWh)		$ 0.1870

6.

Interpretation of Benefit-Cost Ratios

BC ratios are consistently higher under Scenario "A" than Scenario "B", indicating sensitivity to permitting duration. BC ratios are consistently higher when DOD-related curtailment does not reduce anticipated benefits. Both of these results are unsurprising independently, however the magnitude of extended permitting time impacts (Scenario B) on the project were not anticipated. With the benefit and cost discount rates of 12% and 8%, respectively, no iteration of Scenario B results in a BC ratio above 1. Although many possibilities exist for the development of OSW on the central coast, Scenario B, with DOD curtailment and no benefit for price depression, is a very plausible scenario for future developers. The 0.68 BC ratio of this scenario indicates that costs must greatly diminish or benefits must increase significantly (e.g., substantial subsidies) to make OSW an attractive investment in this region.

Benefit-Cost Ratio Sensitivity Analysis

CalWindalso determined the sensitivity of BC ratios to discount rates and to the distance of the windfarm from shore. These analyses confirmed the sensitivity of BC ratios to permitting time, as indicated by the clear distinction of Scenario A and B sensitivity curves (See 4 in the Appendix).

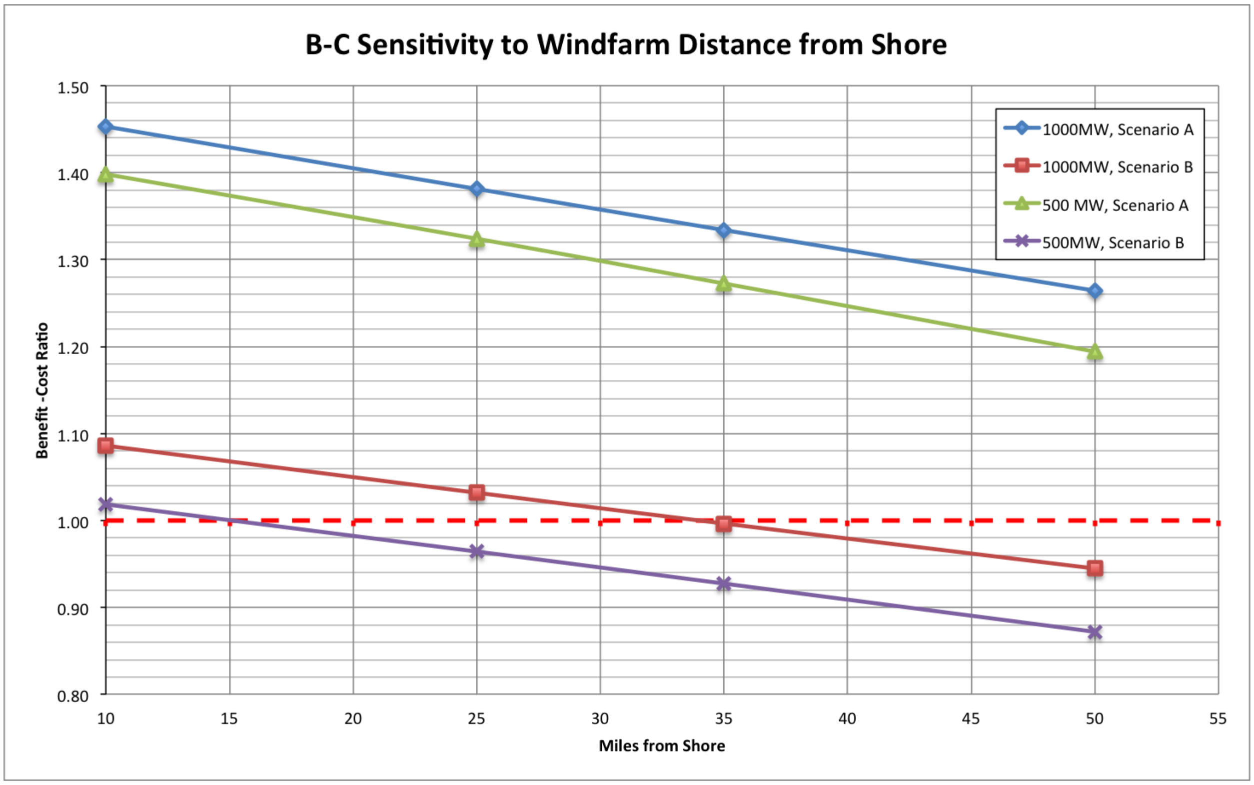


Figure 4: Sensitivity of B/C Ratios to Distance from Shore

In addition to illustrating BC sensitivity to the aforementioned factors, Figure 4 reveals that distance from shore has major implications for B/C ratios under Scenario B, with profitable development of 500MW and 1000MW windfarms limited to <15 and <35 miles from shore, respectively.

Conclusions and Areas for Future Research

Given the unproven nature of OSW floating technology at the commercial scale, and the uncertainty of future OSW PPA prices, large-scale investment in OSW development is unlikely to occur without substantial government subsidies. While CalWind's analysis has shown that OSW projects can be profitable without subsidies, such hypothetical scenarios would require a short permitting time horizon, realizable benefits from fossil fuel price depression, and minimal curtailment requirements from DoD. With these caveats in mind, CalWind would expect to see small-scale pilot projects launched before any concrete plans for commercial OSW development. Once the new technology is field-tested, and PPA prices can be estimated with greater accuracy, investors will be more willing to put forth the necessary capital for large OSW projects.

Without commercial scale case studies of floating OSW developments, CalWind had to make numerous cost and benefit assumptions for this analysis. The work outlined in this report could be significantly improved by incorporating research in the following areas:

- Impact of PPA prices on B-C ratio sensitivity
- Estimates of likely PPA prices in CA, as compared to MA (Cape Wind)
- Analysis of potential government subsides & their impact on OSW finances
- Impacts to consumer surplus as a result of widespread OSW deployment
- Indirect costs (e.g., anticipated local fishery impacts from possible OSW exclusion zones)
- Indirect benefits (e.g., fishery impact of artificial reef from floating OSW installments)

For the purposes of the CalWind master's group project, this benefit-cost assessment serves as a useful first approximation of the challenges associated with OSW development financing and profitability. Despite the limitations of our conclusions, our clients now have a foundation from which to assess the economic feasibility of OSW in central California.

Appendix

Cost Category
Pre-Construction Activities
MET Tower install & ops
Mobilization
Contingency / Bonding
Survey & Engineering
Permitting Fees
Agency Fees
Consultng Fees
Lease Fees
Construction Activities
Turbine Installation
Turbine Interconnection
Trans. Cable shipping
Transmission Cable
Array Cable Shipping
Array Cable Installed
Offshore Transformer (3reqd)
Onshore Transformer
Commissioning
Dock Upgrades
Operation Costs
Ops, Maint, Mgmt
Decommissioning

Benefit Category
Electricity Generation
PPA Price per kWh
Capacity Factor 37%
3% escalation / year
GHG Reductions
Using current AB32 Price
Price Depression
10% premium on PPA due to price depression.

Table 1: Direct Costsand Direct Benefits

Summary of Benefits (NPV)	No DOD curtailment, with Price Depression	No DOD, No Price Depression	DOD Curtailment, with Price Depression	w/DOD, No Price Depression
Scenario A, 1000 MW	$ 2,831,311,447	$ 2,614,406,685	$ 2,265,049,158	$ 2,091,525,348
Scenario A, 500 MW	$ 1,415,655,724	$ 1,307,203,342	$ 1,132,524,579	$ 1,045,762,674
Scenario B, 1000 MW	$ 1,434,430,493	$ 1,449,905,730	$ 1,147,544,394	$ 1,059,631,832
Scenario B, 500 MW	$ 717,215,246	$ 662,269,895	$ 573,772,197	$ 529,815,916

Table 2: Summary of Benefits

PRESENT	Scenario A: Short Permitting Duration			
Year	**Total Costs**	**Present Value**	**Cost of Elec/kWh (PV)**	**Activity**
1	$ 18,158,284	$ 16,813,226		Pre-Construction
2	$ 18,158,284	$ 15,567,801		Pre-Construction
3	$ 18,158,284	$ 14,414,631		Pre-Construction
4	$ 18,158,284	$ 13,346,880		Pre-Construction
5	$ 651,415,425	$ 443,342,393		Construction
6	$ 651,415,425	$ 410,502,215		Construction
7	$ 25,500,000	$ 14,879,005	$ 0.0352	O&M
8	$ 25,500,000	$ 13,776,857	$ 0.0345	O&M
9	$ 25,500,000	$ 12,756,349	$ 0.0338	O&M
10	$ 25,500,000	$ 11,811,434	$ 0.0331	O&M
11	$ 25,500,000	$ 10,936,513	$ 0.0325	O&M
12	$ 25,500,000	$ 10,126,401	$ 0.0320	O&M
13	$ 25,500,000	$ 9,376,297	$ 0.0315	O&M
14	$ 25,500,000	$ 8,681,757	$ 0.0310	O&M
15	$ 25,500,000	$ 8,038,663	$ 0.0306	O&M
16	$ 25,500,000	$ 7,443,207	$ 0.0301	O&M
17	$ 25,500,000	$ 6,891,858	$ 0.0298	O&M
18	$ 25,500,000	$ 6,381,350	$ 0.0294	O&M
19	$ 25,500,000	$ 5,908,658	$ 0.0291	O&M
20	$ 25,500,000	$ 5,470,979	$ 0.0288	O&M
21	$ 25,500,000	$ 5,065,722	$ 0.0285	O&M
22	$ 25,500,000	$ 4,690,483	$ 0.0283	O&M
23	$ 25,500,000	$ 4,343,040	$ 0.0280	O&M
24	$ 25,500,000	$ 4,021,333	$ 0.0278	O&M
25	$ 25,500,000	$ 3,723,457	$ 0.0276	O&M
26	$ 25,500,000	$ 3,447,645	$ 0.0274	O&M
27	$ 25,500,000	$ 3,192,264	$ 0.0272	O&M
28	$ 25,500,000	$ 2,955,800	$ 0.0271	O&M
29	$ 25,500,000	$ 2,736,852	$ 0.0269	O&M
30	$ 25,500,000	$ 2,534,122	$ 0.0268	O&M
31	$ 25,500,000	$ 2,346,409	$ 0.0267	O&M
32	$ 54,460,000	$ 4,639,994		decommissioning
33				
34				
35				
36				
37				
38				
	Cost	NPV		
Total	**$ 2,067,423,984**	**$ 1,090,163,594**	**$ 0.02975**	

Table 3: Project Costs Present Value Calculations, Scenario A, 500MW wind farm

PRESENT	Scenario B: Long Permitting Duration			
Year	Total Costs	Present Value	Cost of Elec/kWh (PV)	Activity
1	$ 6,807,860	$ 6,303,575		Pre-Construction
2	$ 6,807,860	$ 5,836,643		Pre-Construction
3	$ 6,807,860	$ 5,404,299		Pre-Construction
4	$ 6,807,860	$ 5,003,981		Pre-Construction
5	$ 6,807,860	$ 4,633,315		Pre-Construction
6	$ 6,807,860	$ 4,290,107		Pre-Construction
7	$ 6,807,860	$ 3,972,321		Pre-Construction
8	$ 6,807,860	$ 3,678,075		Pre-Construction
9	$ 6,807,860	$ 3,405,625		Pre-Construction
10	$ 6,807,860	$ 3,153,357		Pre-Construction
11	$ 757,901,175.11	$ 325,050,823		Construction
12	$ 757,901,175.11	$ 300,972,984		Construction
13	$ 25,000,000	$ 9,192,448	$ 0.0247	O&M
14	$ 25,000,000	$ 8,511,526	$ 0.0242	O&M
15	$ 25,000,000	$ 7,881,043	$ 0.0238	O&M
16	$ 25,000,000	$ 7,297,262	$ 0.0234	O&M
17	$ 25,000,000	$ 6,756,724	$ 0.0230	O&M
18	$ 25,000,000	$ 6,256,226	$ 0.0227	O&M
19	$ 25,000,000	$ 5,792,802	$ 0.0224	O&M
20	$ 25,000,000	$ 5,363,705	$ 0.0221	O&M
21	$ 25,000,000	$ 4,966,394	$ 0.0218	O&M
22	$ 25,000,000	$ 4,598,513	$ 0.0216	O&M
23	$ 25,000,000	$ 4,257,882	$ 0.0213	O&M
24	$ 25,000,000	$ 3,942,483	$ 0.0211	O&M
25	$ 25,000,000	$ 3,650,448	$ 0.0209	O&M
26	$ 25,000,000	$ 3,380,044	$ 0.0207	O&M
27	$ 25,000,000	$ 3,129,670	$ 0.0206	O&M
28	$ 25,000,000	$ 2,897,843	$ 0.0204	O&M
29	$ 25,000,000	$ 2,683,188	$ 0.0202	O&M
30	$ 25,000,000	$ 2,484,433	$ 0.0201	O&M
31	$ 25,000,000	$ 2,300,401	$ 0.0200	O&M
32	$ 25,000,000	$ 2,130,001	$ 0.0199	O&M
33	$ 25,000,000	$ 1,972,223	$ 0.0198	O&M
34	$ 25,000,000	$ 1,826,133	$ 0.0197	O&M
35	$ 25,000,000	$ 1,690,864	$ 0.0196	O&M
36	$ 25,000,000	$ 1,565,614	$ 0.0195	O&M
37	$ 25,000,000	$ 1,449,643	$ 0.0194	O&M
38	$ 54,460,000	$ 2,923,984		decommissioning
	Cost	NPV		
Total	**$ 2,263,340,955**	**$ 780,606,601**	**$ 0.02131**	

Table 4: Project Costs Present Value Calculation, Scenario B, 500MW wind farm

Present Value	Scenario A: Short Planning Time				
Year	PV, No DOD curtailment	PV, No DOD, No Price Depression	PV, DOD Curtailment	PV, w/DOD, No Price Depression	Activity
1	$ -		$ -		Planning
2	$ -		$ -		Planning
3	$ -		$ -		Planning
4	$ -		$ -		Planning
5	$ -		$ -		Construction
6	$ -		$ -		Construction
7	$ 133,225,009	$ 120,878,870	$ 106,580,007	$ 96,703,096	O&M
8	$ 122,142,157	$ 111,118,819	$ 97,713,726	$ 88,895,055	O&M
9	$ 111,990,313	$ 102,148,047	$ 89,592,251	$ 81,718,438	O&M
10	$ 102,690,334	$ 93,902,596	$ 82,152,267	$ 75,122,077	O&M
11	$ 94,169,898	$ 86,323,704	$ 75,335,919	$ 69,058,963	O&M
12	$ 86,362,912	$ 79,357,381	$ 69,090,330	$ 63,485,905	O&M
13	$ 79,208,962	$ 72,954,024	$ 63,367,169	$ 58,363,219	O&M
14	$ 72,652,819	$ 67,068,053	$ 58,122,255	$ 53,654,442	O&M
15	$ 66,012,326	$ 61,025,927	$ 52,809,861	$ 48,820,742	O&M
16	$ 60,555,391	$ 56,103,249	$ 48,444,312	$ 44,882,599	O&M
17	$ 55,553,285	$ 51,578,159	$ 44,442,628	$ 41,262,527	O&M
18	$ 50,967,711	$ 47,418,491	$ 40,774,168	$ 37,934,793	O&M
19	$ 46,763,635	$ 43,594,688	$ 37,410,908	$ 34,875,751	O&M
20	$ 42,909,007	$ 40,079,590	$ 34,327,205	$ 32,063,672	O&M
21	$ 39,374,501	$ 36,848,236	$ 31,499,601	$ 29,478,589	O&M
22	$ 36,133,281	$ 33,877,688	$ 28,906,625	$ 27,102,150	O&M
23	$ 32,837,613	$ 30,823,690	$ 26,270,090	$ 24,658,952	O&M
24	$ 30,137,335	$ 28,339,190	$ 24,109,868	$ 22,671,352	O&M
25	$ 27,660,637	$ 26,055,151	$ 22,128,510	$ 20,844,121	O&M
26	$ 25,388,848	$ 23,955,377	$ 20,311,078	$ 19,164,302	O&M
27	$ 23,304,869	$ 22,024,984	$ 18,643,895	$ 17,619,988	O&M
28	$ 21,393,046	$ 20,250,292	$ 17,114,436	$ 16,200,233	O&M
29	$ 19,639,042	$ 18,618,726	$ 15,711,233	$ 14,894,980	O&M
30	$ 18,029,726	$ 17,118,729	$ 14,423,781	$ 13,694,983	O&M
31	$ 16,553,070	$ 15,739,681	$ 13,242,456	$ 12,591,745	O&M
32	$ -		$ -		decommissioning
33	$ -		$ -		
34	$ -		$ -		
35	$ -		$ -		
36	$ -		$ -		
37	$ -		$ -		
38	$ -		$ -		
Total	**$ 1,415,655,724**	**$ 1,307,203,342**	**$ 1,132,524,579**	**$ 1,045,762,674**	

Table 5: Project Benefits Present Value Calculations, Scenario A, 500MW windfarm

Present Value	Scenario B: Long Planning Time				
Year	PV, No DOD curtailment, With Price Depression	"B" PV, No DOD, No Price Depression	PV, w/ DOD Curtailment, With Price Depression	PV, w/DOD, No Price Depression	
1	$ -	$ -	$ -	$ -	Planning
2	$ -	$ -	$ -	$ -	Planning
3	$ -	$ -	$ -	$ -	Planning
4	$ -	$ -	$ -	$ -	Planning
5	$ -	$ -	$ -	$ -	Planning
6	$ -	$ -	$ -	$ -	Planning
7	$ -	$ -	$ -	$ -	Planning
8	$ -	$ -	$ -	$ -	Planning
9	$ -	$ -	$ -	$ -	Planning
10	$ -	$ -	$ -	$ -	Planning
11	$ -	$ -	$ -	$ -	Construction
12	$ -	$ -	$ -	$ -	Construction
13	$ 67,495,935	$ 61,240,997	$ 53,996,748	$ 48,992,798	O&M
14	$ 61,881,018	$ 56,296,252	$ 49,504,814	$ 45,037,001	O&M
15	$ 56,737,778	$ 51,751,380	$ 45,390,222	$ 41,401,104	O&M
16	$ 52,026,119	$ 47,573,978	$ 41,620,895	$ 38,059,182	O&M
17	$ 47,709,401	$ 43,734,275	$ 38,167,521	$ 34,987,420	O&M
18	$ 43,754,139	$ 40,204,919	$ 35,003,311	$ 32,163,935	O&M
19	$ 40,129,725	$ 36,960,779	$ 32,103,780	$ 29,568,623	O&M
20	$ 36,808,179	$ 33,978,763	$ 29,446,543	$ 27,183,010	O&M
21	$ 33,443,899	$ 30,917,634	$ 26,755,119	$ 24,734,107	O&M
22	$ 30,679,245	$ 28,423,652	$ 24,543,396	$ 22,738,922	O&M
23	$ 28,145,023	$ 26,131,100	$ 22,516,018	$ 20,904,880	O&M
24	$ 25,821,828	$ 24,023,683	$ 20,657,463	$ 19,218,946	O&M
25	$ 23,691,913	$ 22,086,426	$ 18,953,530	$ 17,669,141	O&M
26	$ 21,739,038	$ 20,305,568	$ 17,391,231	$ 16,244,454	O&M
27	$ 19,948,347	$ 18,668,463	$ 15,958,678	$ 14,934,771	O&M
28	$ 18,306,245	$ 17,163,491	$ 14,644,996	$ 13,730,793	O&M
29	$ 16,636,557	$ 15,616,241	$ 13,309,245	$ 12,492,993	O&M
30	$ 15,268,512	$ 14,357,515	$ 12,214,809	$ 11,486,012	O&M
31	$ 14,013,740	$ 13,200,350	$ 11,210,992	$ 10,560,280	O&M
32	$ 12,862,780	$ 12,136,540	$ 10,290,224	$ 9,709,232	O&M
33	$ 11,806,972	$ 11,158,543	$ 9,445,577	$ 8,926,834	O&M
34	$ 10,838,383	$ 10,259,428	$ 8,670,706	$ 8,207,542	O&M
35	$ 9,949,750	$ 9,432,826	$ 7,959,800	$ 7,546,261	O&M
36	$ 9,134,420	$ 8,672,881	$ 7,307,536	$ 6,938,305	O&M
37	$ 8,386,301	$ 7,974,212	$ 6,709,040	$ 6,379,370	O&M
38	$ -		$ -		decommissioning
Total	**$ 717,215,246**	**$ 662,269,895**	**$ 573,772,197.20**	**$ 529,815,916**	

Table 6: Project Benefits Present Value Calculations, Scenario B, 500MW wind farm

RESULTS: Cost-Benefit Ratios for Alternate Development Scenarios		
1000MW Windfarm	**Scenario A**	**Scenario B**
Without 20% DOD Curtailment	**1.36**	0.96
With 20% DOD Curtailment	1.09	0.77
No DOD Curtailment, No Price Depression	1.25	0.97
With DOD Curtailment, No Price Depression	1.00	0.71
500MW Windfarm		
Without 20% DOD Curtailment	1.30	0.92
With 20% DOD Curtailment	1.04	0.74
No DOD Curtailment, No Price Depression	1.20	0.85
With DOD Curtailment, No Price Depression	0.96	**0.68**
Benefit Discount Rate:		12%
Cost Discount Rate:		8%
PPA Price (per kWh)	$	0.1870

Table 7: Benefit-Cost Ratios

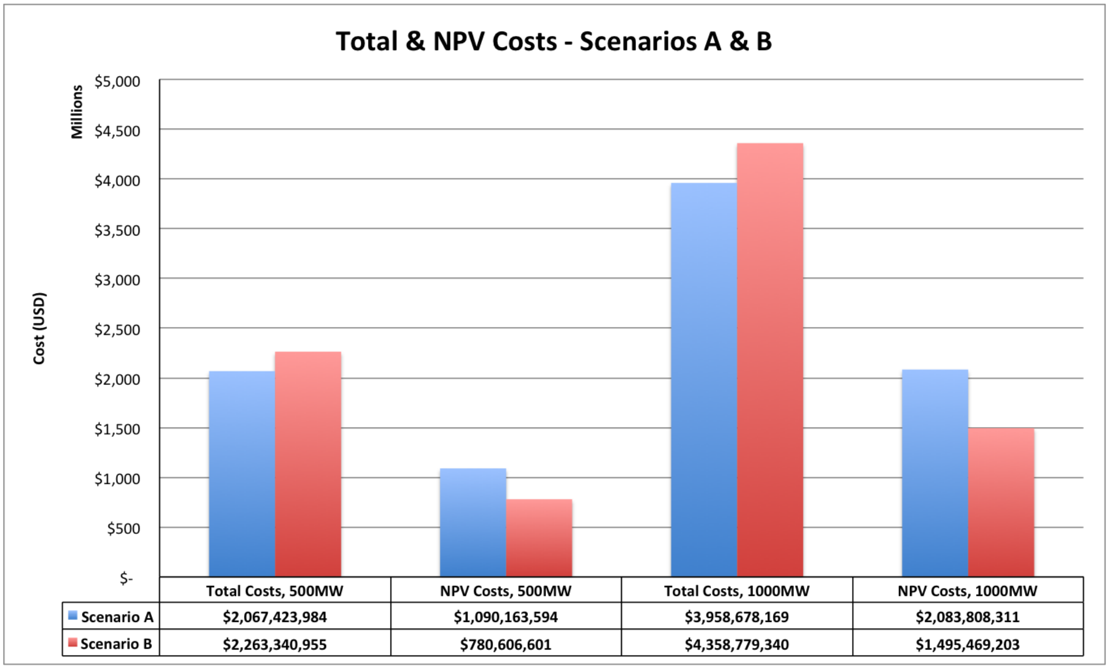
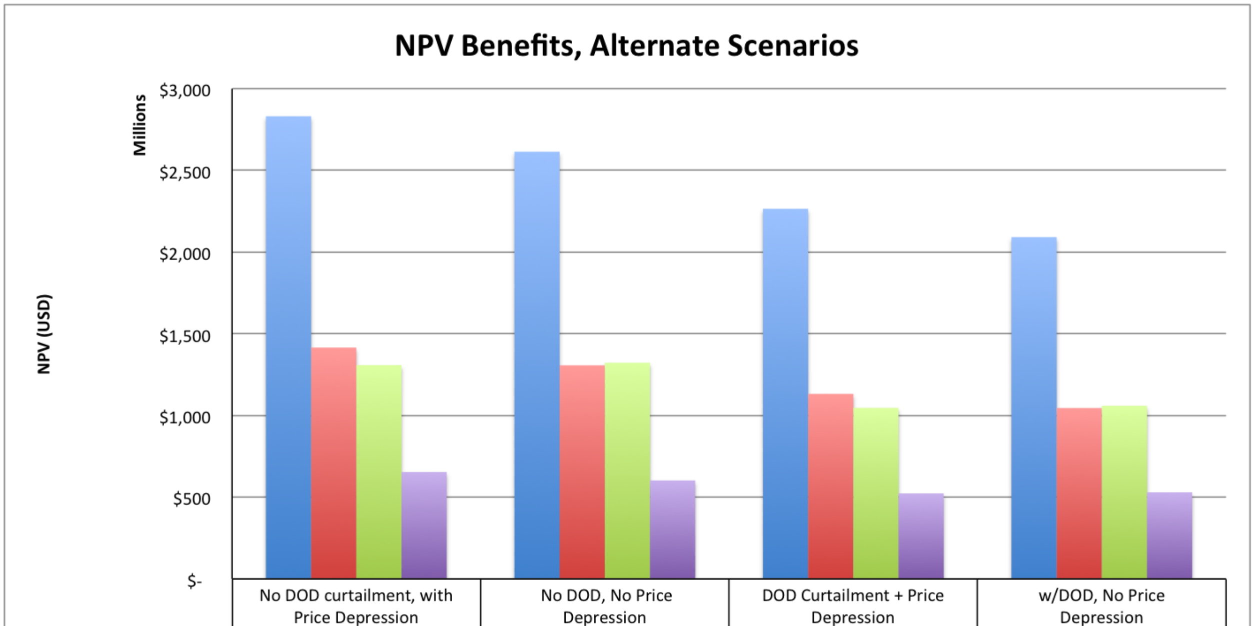


Figure 1: Total & NPV Costs, Scenarios A & B



	No DOD curtailment, with Price Depression	No DOD, No Price Depression	DOD Curtailment + Price Depression	w/DOD, No Price Depression
Scenario A, 1000 MW	$2,831,311,447	$2,614,406,685	$2,265,049,158	$2,091,525,348
Scenario A, 500 MW	$1,415,655,724	$1,307,203,342	$1,132,524,579	$1,045,762,674
Scenario B, 1000 MW	$1,308,473,283	$1,323,006,640	$1,046,778,626	$1,059,631,832
Scenario B, 500 MW	$654,236,641	$602,635,466	$523,389,313	$529,815,916

Figure 2: NPV Benefits, All Scenarios

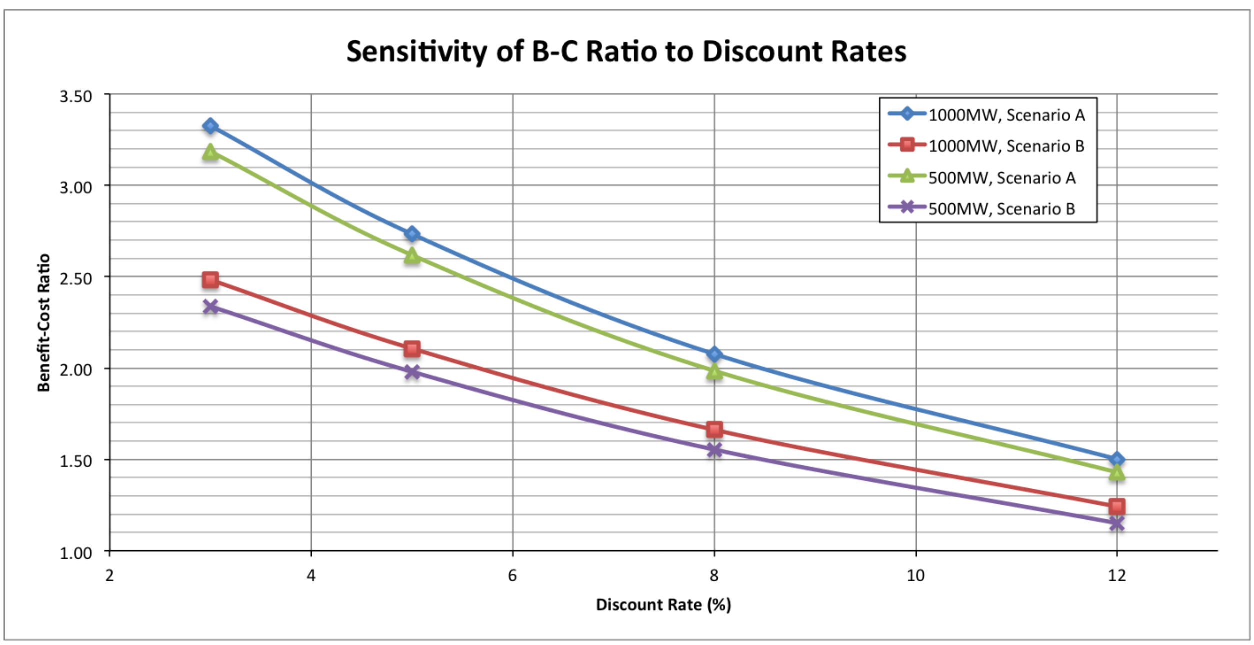


Figure 3: Sensitivity of B/C Ratios to Discount Rates

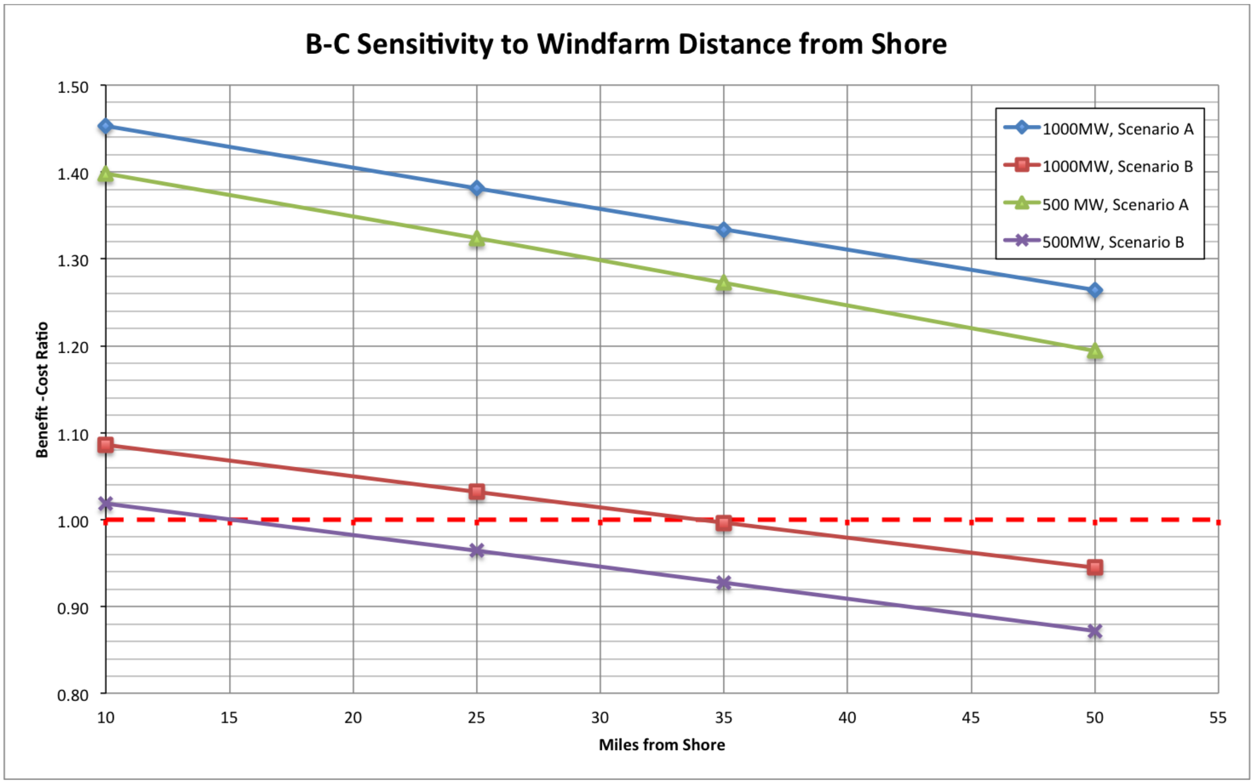


Figure 4: Sensitivity of B/C Ratios to Distance from Shore