Oregon Wave Energy Trust
Utility Market Initiative

Task 3.2.2: Price Support Alternatives Analysis

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About Oregon Wave Energy Trust

The Oregon Wave Energy Trust – (OWET) - with members from fishing and environmental groups, industry and government - is a nonprofit public-private partnership funded by the Oregon Innovation Council in 2007. Its mission is to serve as a connector for all stakeholders involved in wave energy project development - from research and development to early stage community engagement and final deployment and energy generation - positioning Oregon as the North America leader in this nascent industry and delivering its full economic and environmental potential for the state. OWET's goal is to have ocean wave energy producing 2 megawatts of power - enough to power about 800 homes - by 2010 and 500 megawatts of power by 2025.

Price Support Alternatives Analysis

Introduction

Wave energy is an emerging technology that is currently more expensive than other forms of renewable energy, such as wind and biomass. However, studies conducted by EPRI indicate that the cost of energy (COE) will decline as installed capacity increases and will ultimately be cost competitive with wind energy. However, much like the early days of the wind industry and other renewable energy technologies, the wave energy industry will require price support mechanisms to help bridge the gap from demonstration to commercialization. Price support mechanisms can make commercial projects more attractive through direct cost offsets or increase demand through policies that encourage development.

Purpose

To provide an overview of the existing and proposed types of price support mechanisms that may be used to overcome the difference between the cost of energy and the current market price. This document includes a brief description of each mechanism, the attributes and limitations, and an analysis of each option, as informed by the interests of the wave energy development and utility community.

The document is arranged in the following manner:

- Attributes of Wave Energy Industry
- Interests/needs of developers and utilities
- Summary of Existing Incentives
    - Federal Financial Incentives
    - Oregon Financial Incentives and Policies
- Proposed Price Support Policies
- Review of Price Supports against Interests/Needs
- Quantitative Review of Price Supports

Attributes of Wave Energy Industry

The following attributes of wave energy should be considered when evaluating the appropriateness and effectiveness of the proposed price support mechanisms.

- ***High Initial Capital Cost*** – much like other forms of renewable, wave energy is projected to have a relatively high capital cost even in commercial deployments.

- ***Uncertain Operations and Maintenance Costs*** – as there have been no sizable deployments of wave energy systems, the estimated operations and maintenance costs have not been confirmed.

- ***Unproven Technology*** – the early stage of the technology may make it difficult for projects to obtain conventional project financing. Many demonstration programs are funded with 100% equity or with a combination of grants. Need to consider how to transition to conventional project financing.

- ***Early Stage Developers*** – some of the companies developing wave energy projects may have insufficient balance sheets required to provide performance bonds or secure debt financing.

- ***Non-competitive Versus Other Forms of Renewables*** – wave energy is an emerging technology and may not currently be cost competitive with other forms of utility scale renewables such as wind and biomass. Therefore, it may be difficult for wave to be competitive in an RFP process.

Needs and Interests

The following table summarizes the needs and interests related to price support mechanisms of the utilities and wave energy developers. A review of each mechanism relative to these needs and interests is included on page 12 and 13.

Investor Owned Utilities	***Publicly Owned Utilities***	***Wave Energy Developers***
▪ Reasonable cost recovery is assured. ▪ Reflects ratepayer interests either through legislation or PUC direction. ▪ Maintains utility discretion in resource acquisition decisions. ▪ Does not influence real-time dispatch of resources. ▪ Utility actions required for national benefit be funded by national resources.	▪ Maintains ability to manage rates consistent with Board Direction. ▪ Maintains discretion in resource choice and acquisition method. ▪ Maintains utility discretion in resource acquisition decisions. ▪ Does not influence real-time dispatch of resources. ▪ Utility actions required for national benefit be funded by national resources.	▪ Reduces project capital costs. ▪ Subsidizes cost of energy. ▪ Supports a transition to conventional financing/market competitiveness. ▪ Creates incentive to purchase wave energy.

Existing Federal Financial Incentives

The Federal government has a broad array of existing programs that may be applicable to supporting the above market costs of the emerging wave energy sector. These include:

- Renewable Electricity Production Tax Credit (PTC);
- Business Energy Investment Tax Credit (ITC);
- Renewable Energy Grants;
- Federal Loan Guarantees;
- Clean Renewable Energy Bonds.

Production Tax Credit

The PTC is applicable to renewable energy producers that pay federal corporate taxes and is in effect for the first 10 years of electricity production. The PTC was introduced in 1992 as wind and other renewable technologies progressed.

Attributes	*Limitations*
• Provides a 10 year incentive based on the production of energy. • $11 per megawatt hour adjusted annually for inflation. • Requires a project partner that has a large federal tax obligation.	• Support level is insignificant relative to what is needed to help bridge the cost gap for wave energy. • Incents production without regard to the capacity or energy requirements of the existing system. • Only authorized through 2013. • Current value is only 50% of the PTC for wind. • Requires complex business structures to accommodate the tax equity partner. • Sporadically reauthorized which has historically deterred investors from the renewable sector. • Only applicable to investor owned facilities. Not applicable to public utilities.

Investment Tax Credit

The American Recovery and Reinvestment Act of 2009 (H.R. 1) allows a renewable energy project investor take the Business Energy Investment Tax Credit (ITC) in lieu of the PTC. A federal investment tax credit was used to help launch the early stages of the wind industry.

Attributes	*Limitations*
• Provides 30% of eligible project costs in the form of a federal tax credit. • Facility must be placed in service by 2013.	• Incents investment and not production. • Could incent deployment of unfeasible or maintenance intensive technologies. • Requires a tax equity partner with a large demand for tax credits. • Projects must use US manufactured steel.

Renewable Energy Grants

Under Section 1603 of the American Recovery and Reinvestment Tax Act of 2009 (Section 1603), the United States Department of the Treasury (Treasury) will make cash payments in lieu of the ITC or PTC. Finally, developers will have the option to forego tax credits and receive a check from the US Treasury for 30% of the project cost. This option will be available for projects placed in service in 2009 or 2010 or that start construction during 2009 or 2010 and are completed by is 2013 for marine energy projects.

Attributes	*Limitations*
• Provides a cash grant of 30% of eligible project costs in lieu of the ITC or PTC. • Avoids having to have a tax equity partner.	• Must apply and start construction by 2010 and be completed by 2013. • Unclear whether program will be reauthorized. • Only applies to for-profit companies. • Projects must use US manufactured steel.

Federal Loan Guarantees

The ARRA bill also authorizes the US Department of Energy to guarantee loans made to marine and hydrokinetic projects in an effort to overcome challenges with conventional project financing. The guarantees will also be available to support loans to pay for construction or expansion of US factories that produce equipment for renewable energy projects. Any projects helped by the new loan guarantees must be in a position to commence construction by September 30, 2011.

Projects that benefit from the guarantees will have to pay contractors and subcontractors at least the prevailing wages for the local area as determined by the US Department of Labor.

Attributes	*Limitations*
• Provides a cash grant of 30% of eligible project costs in lieu of the ITC or PTC. • Avoids having to have a tax equity partner.	• Must apply and start construction by September 30, 2011. • Unclear whether program will be reauthorized. • Only applies to for-profit companies. • Projects must use US manufactured steel.

Clean Renewable Energy Bonds

The Energy Improvement and Extension Act of 2008 (Div. A, Sec. 107) allocated $800 million for new Clean Renewable Energy Bonds (CREBs). In February 2009, the American Recovery and Reinvestment Act of 2009 (Div. B, Sec. 1111) allocated an additional $1.6 billion for new CREBs, for a total new CREB allocation of $2.4 billion. The Energy Improvement and Extension Act of 2008 also extended the deadline for previously reserved allocations ("old CREBs") until December 31, 2009, and addressed several provisions in the existing law that previously limited the usefulness of the program for some projects. A separate section of the law extended CREBs eligibility to marine energy and hydrokinetic power projects.

Clean renewable energy bonds (CREBs) are issued -- theoretically -- with a 0% interest rate. The borrower pays back only the principal of the bond, and the bondholder receives federal tax credits in lieu of the traditional bond interest. CREBs may be used by certain entities -- primarily in the public sector -- to finance renewable energy projects. The list of qualifying technologies is generally the same as that used for the federal renewable energy PTC. CREBs may be issued by electric cooperatives, government entities (states, cities, counties, territories, Indian tribal governments or any political subdivision thereof), and by certain lenders.

Attributes	*Limitations*
• Reduces the cost of capital to the developer	• Only applicable to coops and public utilities.

Review of Oregon Financial Incentives and Policies

Oregon has several programs that may be applicable to supporting the above market costs of the emerging wave energy sector. These include:

- Business Energy Tax Credit (BETC)
- Energy Trust Open Solicitation Program

Business Energy Tax Credit

Oregon's Business Energy Tax Credit (BETC) is for investments in energy conservation, recycling, renewable energy resources, sustainable buildings, and less-polluting transportation fuels. Any Oregon business may qualify, including, but not limited to, manufacturing plants, stores, offices, apartment buildings, farms, and transportation. The tax credit can cover costs directly related to the project, including equipment cost, engineering and design fees, materials, supplies and installation costs.

Attributes	*Limitations*
• Provide incentive for investment in new and emerging technologies. • Allows project owner to trade the tax credit to a third party that has an need for the credits at a predetermined price.	• Does not ensure production • Capped at $20 million in project cost. • Credit not paid until project is complete and operating, which creates a cash flow deficit for the project developer.

	• Subject to biennial review and modification by State legislature.

Energy Trust of Oregon's Open Solicitation Program

The Energy Trust of Oregon (ETO) is an independent, nonprofit organization dedicated to energy efficiency and renewable energy development in Oregon. The Open Solicitation Program opened in May 2002 and is designed to support renewable energy projects that do not already have an established Energy Trust incentive program. Energy Trust expects to reserve approximately $2 million annually for the Open Solicitation Program. Funding has historically been awarded in the areas of small hydro, geothermal electric, and emerging commercial technologies such as wave energy. Energy Trust may fund all or a portion of the above-market costs of a project, defined generally as the difference between the present value of the electricity produced by the project, and the present value of the costs and expenses incurred to generate that electricity. There is no fixed percentage for the amount of the above-market costs the Energy Trust will pay. Eligible projects must either be located in the Oregon service territory of Pacific Power or Portland General Electric, or have a power purchase agreement with one of those utilities. Off-grid projects are not eligible for Energy Trust support.

Attributes	*Limitations*
• Offsets the costs of project development.	• Limited to PGE and PacifiCorp purchase or service territory. • Support limited to smaller projects due to limited magnitude of the existing fund.

Price Support Policy Options

There are a wide range approaches subsidizing the above market costs of the early stages of wave energy development in Oregon, including:

- Declining Feed-in tariff
- Carve Outs
- REC Multipliers
- Legislative Direction to Public Utility Commission
- National Renewable Portfolio Standard

Declining Feed-in Tariff

A feed-in tariff is a pricing mechanism that sets a standard rate that will be paid for a specific type of renewable energy production. The premium between the established tariff and market prices could be paid by utilities, grid operators, or the government.

Under a declining tariff structure, the rate level declines as the cumulative capacity increases. If the technology is progressing down the cost curve, then the technology will mature and projects will be developed. The rate may differ among various forms of power generation. A feed-in tariff is normally phased out once the renewable reaches a significant market penetration, such as 20%, as it is not economically sustainable beyond that point.

Other early stage energy industries such as fuel cells and solar have utilized a declining feed-in tariff to stimulate the growth and transition from demonstration to commercialization. This approach has been successfully used in Portugal to stimulate the early adoption of ocean energy.

Attributes	*Limitations*
• The higher tariff rate helps overcome the cost disadvantages of renewable energy sources. • Developers are assured of the price they will receive at the time of production. • Only provides benefit if there is production. • Provides a strong incentive for developers to rapidly introduce new technology and drive costs down.	• Utilities are required to purchase at a specified price. • Utilities may not need the power. • Requires utilities to acquire resources in a manner that may be inconsistent with their plans. • If the tariff is set improperly it could create unintended consequences (if too high could produce too much resource). • Because local ratepayers pay the premium it serves as a local subsidy for a nationwide problem. • Unclear who pays for the interconnection and protection costs.

Modified Declining Feed-in Tariff

The following concept maintains all aspect of the declining feed-in tariff outlined above except for how the price support is funded. Similar to the approach described above, the power would be acquired by the utility at an established rate. However, the difference between the tariff and market prices would be provided to the utility by another entity: either a state or federal entity.

This approach protects utility rate payers from having to shoulder a rate burden associated with tariff price while still providing the developer with a long-term power sales contract at a rate that can cover productions costs.

Attributes	*Limitations*
• The higher tariff rate helps overcome the cost disadvantages of renewable energy sources. • Developers are assured of the price they will receive at the time of production. • Only provides benefit if there is	• Requires a long-term stable funding source; not one that is subject to appropriations or review on an annual basis. • May require a significant financial commitment.

production. • Provides a strong incentive for developers to rapidly introduce new technology and drive costs down. • A long-term power sales contract at a fixed price improves the developer's opportunities for conventional financing. • Does not require utility rate payers to cover the above market costs of the resource. • Minimizes the financial concerns associated with large development happening in one utility's service territory. • Although similar to a production tax credit, does not require a tax liability.	• If federally funded, certain parts of the country may benefit more than others.

Carve Outs

A carve out establishes a portion of a state's RPS requirement to be met by a specific renewable energy technology. In NJ, the legislature mandated that a certain percentage of the RPS requirement be met with solar and imposed higher penalties for not meeting the solar 'carve out' objective. The 2007 Oregon Legislature made it clear that they wanted the RPS to be technology neutral, however the 2009 session resulted in a bill (i.e. HB 3039) that established a carve for solar project. Therefore, it is possible that the RPS could be modified to incent wave energy with carve outs.

Attributes	*Limitations*
• Assures a certain amount of wave energy development	• Forces a specific resource type without regard to the capacity or energy requirements of the existing system • Puts the utility in a poor negotiating position on price. • There is no cap on prices that can be charged.

REC Multipliers

In Oregon utilities currently acquire 1 renewable energy credit (REC) for each megawatt hour of renewable energy produce. A REC Multipliers concept would incent utilities to buy wave energy by creating authorizing the accrual of 2 to 5 RECs for each megawatt hour produced by wave energy. REC multipliers have been successfully used in other countries to help stimulate the adoption of an emerging technology such as wave energy. REC multipliers are demand side incentives and would require state legislation.

Attributes	Limitations
• Provides an incentive for wave energy development without creating a mandate for a specific type of renewable energy development. • Depending on the utility's need to meet an RPS goal, a utility may be willing to spend more on wave energy • Caps can be set to limit the total available REC Multipliers. • Multiplier could decline as installed capacity increases.	• Some parties have a concern that it negatively impacts the effectiveness of the RPS.

Legislative Direction to Public Utility Commission

Some states have used state legislation to authorize the Public Utility Commission to approve the investor owned utilities to enter into above market rate contracts for emerging renewable energy projects. This was recently done in Delaware to allow a 400MW offshore wind project to proceed.

National Renewable Portfolio Standard (RPS)

A National RPS has been discussed for some time and has been recently introduced as a legislative concept in the new Congress. A National RPS will help diffuse the debate at a State level and put the emphasis on creative ways to meet the objective.

Attributes	Limitations
• Create a more consistent national market for utilities. • May further help legitimize renewable energy technologies in the capital markets.	• May not properly incent early stage technologies. • An RPS does not directly create price support mechanisms.

Review of Price Supports against Needs and Interests

	UTILITIES NEEDS AND INTERESTS				
	Common		***Investor Owned***		***Public Owned***
	Maintains utility discretion in resource acquisition	Does not influence real-time dispatch of resources	Reasonable cost recovery is assured	Reflects rate payer interests	Ability to manage rates through Board
Existing Federal Incentives					
Production Tax Credit	✓		✓	✓	✓ *if purchaser* *n/a if developer*
Investment Tax Credit	✓	✓	✓	✓	✓ *if purchaser* *n/a if developer*
Renewable Energy Grants	✓	✓	✓	✓	✓ *if purchaser* *n/a if developer*
Clean Renewable Energy Bonds	✓	✓	✓	✓	✓ *if purchaser* *n/a if developer*
Existing Oregon Financial Incentives					
Business Energy Tax Credit	✓	✓	✓	✓	✓
ETO Open Solicitation	✓	✓	✓	✓	*n/a*
Price Support Policy Options					
Declining Feed in Tariff			✓	✓	
Carve Outs		✓			
REC Multipliers	✓	✓	✓	✓	✓
Legislative Direction to PUC		✓	✓	✓	*n/a*
National RPS		✓		✓	✓

Review of Price Supports against Needs and Interests

	DEVELOPER NEEDS AND INTERESTS			
	Reduces project capital costs	Subsidizes cost of energy	Transition to conventional financing/market competitiveness	Creates incentive to purchase wave energy
Existing Federal Incentives				
Production Tax Credit		✓		
Investment Tax Credit	✓	✓		
Renewable Energy Grants	✓	✓		
Clean Renewable Energy Bonds	✓	✓		
Existing Oregon Financial Incentive				
Business Energy Tax Credit	✓	✓		
ETO Open Solicitation	✓	✓		
Price Support Policy Options				
Declining Feed in Tariff		✓	✓	
Carve Outs			✓	✓
REC Multipliers			✓	✓
Legislative Direction to PUC				✓
National RPS				✓

Quantitative Analysis

This following quantitative analysis has been conducted to analyze the various price support mechanisms to be considered for the early stages of wave energy development in Oregon. This analysis considers the following types of price support mechanisms:

1. *Feed-In Tariff*
2. *Carve Out*
3. *REC Multipliers*
4. *Hybrid Feed-In Tariff/REC Multiplier*

Other types of price support mechanisms, including Clean Renewable Energy Bonds and a National Renewable Portfolio Standard were not analyzed as part of this document. Clean Renewable Energy Bonds would help lower the capital cost (and fixed charge rate as explained in Appendix A) and result in an overall lower cost of energy. A National RPS would help stimulate the overall demand for renewable, but it is difficult to quantify the increase the demand or value to wave energy in Oregon.

Recognizing that the wave energy industry is in an early stage of development, the price support analysis has been done considering the following stages of development:

- Concept Validation – up to 1 MW
- Commercial Demonstration – up to 10 MW
- Commercial Deployment – up to 100 MW

Approach

In order to analyze the impacts of different approaches to price support, it was first necessary to make an estimate of the Cost of Energy for wave energy technologies at each stage of development. Many of the technology developers have provided approximate ranges for the cost of their systems, but very few have provided sufficient detail required to conduct a detailed cost analysis. As such, this analysis looks at a range of installed capital costs from $4000 to $8000 per kilowatt of rated capacity. The analysis is conducted using an approach utilized by the National Renewable Energy Lab (NREL) for onshore wind turbines. The approach is provided in further detail in Appendix A.

The cost of energy analysis was conducted for six cases:

Case IA: 1 MW with Business Energy Tax Credit and Renewable Energy Grant
Case IB: 1 MW with Business Energy Tax Credit and Federal Production Tax Credit
Case IIA: 10 MW with Business Energy Tax Credit and Renewable Energy Grant
Case IIB: 10 MW with Business Energy Tax Credit and Federal Production Tax Credit
Case IIIA: 100 MW with Business Energy Tax Credit and Renewable Energy Grant
Case IIIB: 100 MW with Business Energy Tax Credit and Federal Production Tax Credit

The analysis considered five Scenarios for each Case:

- Scenario I: Installed Cost = $4000 per kW of name rated capacity
- Scenario II: Installed Cost = $5000 per kW of name rated capacity
- Scenario III: Installed Cost = $6000 per kW of name rated capacity
- Scenario IV: Installed Cost = $7000 per kW of name rated capacity
- Scenario V: Installed Cost = $8000 per kW of name rated capacity

Appendix A provides a summary of the major cost elements used in the model. Appendix B provides the assumptions and a summary of each of the Cases. The table below summarizes the assumptions for each Case.

Assumptions	Case IA	Case IB	Case IIA	Case IIB	Case IIIA	Case IIIB
Federal Tax Incentive	Renewable Grant	Production Tax Credit	Renewable Grant	Production Tax Credit	Renewable Grant	Production Tax Credit
State Tax Incentive	BETC	BETC	BETC	BETC	BETC	BETC
Total Project Capacity, MW	1	1	10	10	100	100
Capacity Factor	35%	0.35	35%	0.35	35%	0.35
Availability	70%	70%	80%	80%	90%	90%
Annual Energy Production, MWh	2,146	2,146	24,528	24,528	275,940	275,940
Fixed Charge Rate	21.85%	21.85%	16.85%	16.85%	11.85%	11.85%
Levelized Replacement Cost, $/kW	64.2	64.2	42.8	42.8	32.1	32.1
Operations and Maintenance Cost, $/MWh	42.0	42.0	28.0	28.0	21.0	21.0
Ground Rent, % of Value of Base Power	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
Value of Federal Production Tax Credit,	21.0	11.0	21.0	11.0	21.0	11.0
Value of Power, $/MWh	120.0	120.0	120.0	120.0	120.0	120.0
Wholesale Power Price, $/MWh	62.4	62.4	62.4	62.4	62.4	62.4
Value of Additional REC, $/MWh	57.6	57.6	57.6	57.6	57.6	57.6

The balance of this document provides a summary of the analysis of each price support mechanism. Each Case and Scenario is summarized into one table to show how the required price support changes with technology maturity and installation cost.

Feed-In Tariff and Carve Out

A feed-in tariff is a pricing mechanism that sets a standard rate that will be paid for a specific type of renewable energy production. A carve out is a mandate under the RPS for the utilities to procure a certain amount of wave energy. The cost to meet the carve out requirement should be similar to that of the feed-in tariff. The table below summarizes the feed-in tariff that would be required to offset the above market costs of wave energy projects as a function of installed cost for each Case (1, 10, and 100 MW). For example, in Case II and Scenario III (10 MW and an Installed Cost of $6,000 per kW), the required feed in tariff or carve out cost is $289.1 per MWh. The green shaded areas indicate the likely scenarios.

	Scenario				
	I	II	III	IV	V
Installed Cost, $ per kW of Capacity	4,000	5,000	6,000	7,000	8,000
Required Feed-In Tariff, $/MWh					
Case IA: 1 MW with BETC & Renewable Energy Grant	262.7	310.1	357.5	**404.9**	**452.2**
Case IIA: 10 MW with BETC & Renewable Energy Grant	193.0	241.1	289.1	337.2	385.3
Case IIIA: 100 MW with BETC & Renewable Energy Gran	**151.2**	**181.3**	**211.3**	**241.4**	**271.4**

REC Multiplier

A REC Multiplier incents utilities to buy wave energy by authorizing the accrual of multiple RECs for each megawatt hour produced by wave energy. The table below summarizes the level of REC multipliers that would be required to cover the above market costs. For example, in Case II, Scenario III (10 MW and an Installed Cost of $6,000 per kW) a REC multiplier of 3.9 would be required to cover the above market costs. This assumes a power purchase price of $120. The green shaded areas indicate the likely scenarios.

	Scenario				
	I	II	III	IV	V
Installed Cost, $ per kW of Capacity	4,000	5,000	6,000	7,000	8,000
Required Number of RECs					
Case IA: 1 MW with BETC & Renewable Energy Grant	3.5	4.3	5.1	**5.9**	**6.8**
Case IIA: 10 MW with BETC & Renewable Energy Grant	2.3	**3.1**	**3.9**	**4.8**	5.6
Case IIIA: 100 MW with BETC & Renewable Energy Gran	**1.5**	**2.1**	2.6	3.1	3.6

Hybrid Feed-In Tariff/REC Multiplier

Recognizing that a REC Multiplier of greater than 5 may not be a viable solution, a hybrid approach was considered. For example, in Case II, Scenario III (Installed Cost - $6,000 per kW), the assumed Feed-In Tariff is $200 per MWh. And a REC multiplier of 2.5 would be required to cover the above market costs. The green shaded areas indicate the likely scenarios.

	Scenario				
	I	II	III	IV	V
Installed Cost, $ per kW of Capacity	4,000	5,000	6,000	7,000	8,000
Assumed Feed-In Tariff, $/MWh					
Case IA: 1 MW with BETC & Renewable Energy Grant	250.0	250.0	250.0	**250.0**	**250.0**
Case IIA: 10 MW with BETC & Renewable Energy Grant	200.0	**200.0**	**200.0**	**200.0**	200.0
Case IIIA: 100 MW with BETC & Renewable Energy Grant	**150.0**	**150.0**	150.0	150.0	150.0
Required Number of RECs					
Case IA: 1 MW with BETC & Renewable Energy Grant	1.2	2.0	2.9	**3.7**	**4.5**
Case IIA: 10 MW with BETC & Renewable Energy Grant	0.9	**1.7**	**2.5**	**3.4**	4.2
Case IIIA: 100 MW with BETC & Renewable Energy Grant	**1.0**	**1.5**	2.1	2.6	3.1

The table below presents a sensitivity analysis for the required REC multiplier as a function of feed-in tariff rate for Case IA, IIA, and IIIA. This analysis assumes an additional REC is worth $57.60 per MWh.

Case IA: Required REC Multiplier as a Function of Installed Cost and Feed-In Tariff Value

	Installed Cost, $/kW				
	I	II	III	IV	V
Feed In-Tariff, $/MWh	4,000	5,000	6,000	7,000	8,000
120	3.5	4.3	5.1	5.9	6.8
140	3.1	4.0	4.8	5.6	6.4
160	2.8	3.6	4.4	5.3	6.1
180	2.4	3.3	4.1	4.9	5.7
200	2.1	2.9	3.7	4.6	5.4
225	1.7	2.5	3.3	4.1	4.9
250	1.2	2.0	2.9	3.7	4.5

Case IIA: Required REC Multiplier as a Function of Installed Cost and Feed-In Tariff Value

	Installed Cost, $/kW				
	I	II	III	IV	V
Feed In-Tariff, $/MWh	4,000	5,000	6,000	7,000	8,000
120	2.3	3.1	3.9	4.8	5.6
140	1.9	2.8	3.6	4.4	5.3
160	1.6	2.4	3.2	4.1	4.9
180	1.2	2.1	2.9	3.7	4.6
200	0.9	1.7	2.5	3.4	4.2
225	0.4	1.3	2.1	2.9	3.8
250	0.0	0.8	1.7	2.5	3.3

Case IIIA: Required REC Multiplier as a Function of Installed Cost and Feed-In Tariff Value					
	Installed Cost, $/kW				
	I	II	III	IV	V
Feed In-Tariff, $/MWh	4,000	5,000	6,000	7,000	8,000
120	1.5	2.1	2.6	3.1	3.6
140	1.2	1.7	2.2	2.8	3.3
160	0.8	1.4	1.9	2.4	2.9
180	0.5	1.0	1.5	2.1	2.6
200	0.2	0.7	1.2	1.7	2.2
225	-0.3	0.2	0.8	1.3	1.8
250	-0.7	-0.2	0.3	0.9	1.4

The table below presents a sensitivity analysis for the required REC multiplier as a value of the additional REC for Case IA, IIA, and IIIA. This analysis assumes that the feed-in tariff is $250 per MWh for Case IA (1 MW), $200 per MWh for Case IIA (10 MW), and $150 per MWh for Case IIIA (100 MW).

Case IA: Required REC Multiplier as a Function of Installed Cost and REC Value					
	Installed Cost, $/kW				
	I	II	III	IV	V
Value of Additional REC, $/MWh	4,000	5,000	6,000	7,000	8,000
20	8.1	10.5	12.9	15.2	17.6
40	4.6	5.8	6.9	8.1	9.3
60	3.4	4.2	5.0	5.7	6.5
80	2.8	3.4	4.0	4.6	5.2
100	2.4	2.9	3.4	3.8	4.3
120	2.2	2.6	3.0	3.4	3.8

Case IIA: Required REC Multiplier as a Function of Installed Cost and REC Value					
	Installed Cost, $/kW				
	I	II	III	IV	V
Value of Additional REC, $/MWh	4,000	5,000	6,000	7,000	8,000
20	4.6	7.1	9.5	11.9	14.3
40	2.8	4.0	5.2	6.4	7.6
60	2.2	3.0	3.8	4.6	5.4
80	1.9	2.5	3.1	3.7	4.3
100	1.7	2.2	2.7	3.2	3.7
120	1.6	2.0	2.4	2.8	3.2

Case IIIA: Required REC Multiplier as a Function of Installed Cost and REC Value						
		Installed Cost, $/kW				
		I	II	III	IV	V
Value of Additional REC, $/MWh		4,000	5,000	6,000	7,000	8,000
	20	2.6	4.1	5.6	7.1	8.6
	40	1.8	2.5	3.3	4.0	4.8
	60	1.5	2.0	2.5	3.0	3.5
	80	1.4	1.8	2.1	2.5	2.9
	100	1.3	1.6	1.9	2.2	2.5
	120	1.3	1.5	1.8	2.0	2.3

Production Tax credit

Cases IB, IIB, and IIIB evaluated the feasibility of a PTC multiplier. This concept would rely on Federal legislation to increase the value of the PTC to help bridge the gap between the above market cost and the market price for other forms of renewable energy development. For example, in Case II and Scenario III (10 MW and an Installed Cost of $6,000 per kW), the required PTC value is $292.8. The green shaded areas indicate the likely scenarios.

	Scenario				
	I	II	III	IV	V
Installed Cost, $ per kW of Capacity	4,000	5,000	6,000	7,000	8,000
Required Number of RECs					
Case IB: 1 MW with BETC & Renewable Energy Grant	223.9	291.6	359.3	**427.0**	**494.7**
Case IIB: 10 MW with BETC & Renewable Energy Grant	155.4	**224.1**	**292.8**	**361.5**	430.2
Case IIIB: 100 MW with BETC & Renewable Energy Gran	**82.7**	**125.7**	168.6	211.6	254.5

APPENDIX A: COST OF ENERGY MODEL

The cost analysis is conducted using a model developed by the National Renewable Energy Laboratory using a simple model used for the comparison of various wind turbine technologies. A full description of the model can be found at http://www.nrel.gov/wind/pdfs/40566.pdf.

Cost of Energy is calculated by dividing the Annual Operating Expenses by the Annual Energy Production.

Annual Operating Expenses include the fixed charge rate, bottom lease cost, levelized O&M cost, and levelized replacement/overhaul cost (LRC).

Annual Energy Production is the product of the Total Project Capacity, the Capacity Factor, and the Availability, the number of days in the year (365), and the number of hours in the day (24).

Fixed Charge Rate (FCR) is the annual amount per dollar of initial capital cost needed to cover the capital cost, a return on debt and equity, and various other fixed charges. This rate is imputed from a hypothetical project, modeled using a pro forma cash flow spreadsheet model. For the current base model, FCR includes construction financing, financing fees, return on debt and equity, depreciation, income tax, and property tax and insurance, and is set to 16.58% per year. NREL normally uses 11.58% for wind turbines. An additional 5% has been added to account for a higher cost of capital that will likely be encountered when financing early stage project.

Levelized Operations and Maintenance Cost normally includes:

- Labor, parts, and supplies for scheduled maintenance
- Labor, parts, and supplies for unscheduled maintenance
- Parts and supplies for equipment and facilities maintenance
- Labor for administration and support

Levelized Replacement Cost distributes the cost of major replacements and overhauls over the life of the project and is expressed in $/kW machine rating.

Bottom Lease Costs are the rental or lease fees charged for leasing the ocean bottom for the project installation.

APPENDIX B: CASE STUDIES

Case IA: 1 MW with BETC and Renewable Energy Grant

Assumptions		
Total Project Capacity, MW	1	
Capacity Factor	35%	
Availability	70%	
Annual Energy Production, MWh	2,146	
Fixed Charge Rate	21.85%	Rate used by NREL for cost comparsison of wind technologies + 10% to account for increased risk of early stage projects
Levelized Replacement Cost, $/kW	64.20	Assumes 600% of rate used by NREL for onshore wind
Operations and Maintenance Cost, $/MWh	42.00	Assumes 600% of rate used by NREL for onshore wind
Ground Rent, % of Value of Base Power	1.0%	Typical rate used for onshore wind
Value of Federal Production Tax Credit, $/MWh	21.00	As provided by the IRS for 2009
Value of Power, $/MWh	120.00	Weighted average value of wind energy including the base REC as estimated by NPCC in the Sixth Power
Wholesale Power Price, $/MWh	62.40	Assumes levelized Mid-C rate for 2010 through 2029 as estimated by NPCC.
Value of Additional REC, $/MWh	57.60	Calculated as Value of Power less Wholesale Power Price. Assumes buyer is short.

	Scenario				
	I	II	III	IV	V
Installed Cost, $ per kW of Capacity	4,000	5,000	6,000	7,000	8,000
Capital Cost, $K					
Total CAPEX	4,000	5,000	6,000	7,000	8,000
less Federal Renewable Energy Grant	1,200	1,500	1,800	2,100	2,400
less OR Business Energy Tax Credit	938	1,173	1,407	1,642	1,876
Net CAPEX	1,862	2,328	2,793	3,259	3,724
percent of total	*46.6%*	*46.6%*	*46.6%*	*46.6%*	*46.6%*
Annual Operating Expenses, $K					
Fixed Charge Rate	407	509	610	712	814
Levelized Operations and Maintenance Cost	90	90	90	90	90
Levelized Replacement Cost	64	64	64	64	64
Bottom Lease Cost	3	3	3	3	3
Total Annual Expense	564	665	767	869	971
Annual Energy Production, MWh	2,146	2,146	2,146	2,146	2,146
Cost of Energy, $/MWh	262.7	310.1	357.5	404.9	452.2

Feed-In Tariff & Carve Out Models

Required Feed in Tariff, $/MWh	262.7	310.1	357.5	404.9	452.2
Power Purchase Price for Carve Out, $/MWh	262.7	310.1	357.5	404.9	452.2

REC Multiplier Model

Net Cost of Energy, $/MWH	262.7	310.1	357.5	404.9	452.2
Value of Power, $/MWh	120.0	120.0	120.0	120.0	120.0
GAP=Difference between Net Cost and Value	142.7	190.1	237.5	284.9	332.2
Number of RECs required to fill GAP	2.5	3.3	4.1	4.9	5.8
Required REC Multiplier	3.5	4.3	5.1	5.9	6.8

Hybrid Feed-In Tariff/REC Multiplier Model

Net Cost of Energy, $/MWH	262.7	310.1	357.5	404.9	452.2
Feed-In Tariff (Assumption)	250.0	250.0	250.0	250.0	250.0
GAP=Difference between Cost and Price	12.7	60.1	107.5	154.9	202.2
Number of RECs required to fill GAP	0.2	1.0	1.9	2.7	3.5
Required REC Multiplier	1.2	2.0	2.9	3.7	4.5

Case IIA: 10 MW with BETC and Renewable Energy Grant

Assumptions		
Total Project Capacity, MW	10	
Capacity Factor	35%	
Availability	80%	
Annual Energy Production, MWh	24,528	
Fixed Charge Rate	16.85%	Rate used by NREL for cost comparsison of wind technologies + 10% to account for increased risk of early stage projects
Levelized Replacement Cost, $/kW	42.80	Assumes 400% of rate used by NREL for onshore wind
Operations and Maintenance Cost, $/MWh	28.00	Assumes 400% of rate used by NREL for onshore wind
Ground Rent, % of Value of Base Power	1.0%	Typical rate used for onshore wind
Value of Federal Production Tax Credit, $/MWh	21.00	As provided by the IRS for 2009
Value of Power, $/MWh	120.00	Weighted average value of wind energy including the base REC as estimated by NPCC in the Sixth Power
Wholesale Power Price, $/MWh	62.40	Assumes levelized Mid-C rate for 2010 through 2029 as estimated by NPCC.
Value of Additional REC, $/MWh	57.60	Calculated as Value of Power less Wholesale Power Price. Assumes buyer is short.

	Scenario				
	I	II	III	IV	V
Installed Cost, $ per kW of Capacity	4,000	5,000	6,000	7,000	8,000
Capital Cost, $K					
Total CAPEX	40,000	50,000	60,000	70,000	80,000
less Federal Renewable Energy Grant	12,000	15,000	18,000	21,000	24,000
less OR Business Energy Tax Credit	6,700	6,700	6,700	6,700	6,700
Net CAPEX	21,300	28,300	35,300	42,300	49,300
percent of total	*53.3%*	*56.6%*	*58.8%*	*60.4%*	*61.6%*
Annual Operating Expenses, $K					
Fixed Charge Rate	3,589	4,769	5,948	7,128	8,307
Levelized Operations and Maintenance Cost	687	687	687	687	687
Levelized Replacement Cost	428	428	428	428	428
Bottom Lease Cost	29	29	29	29	29
Total Annual Expense	4,733	5,913	7,092	8,272	9,451
Annual Energy Production, MWh	24,528	24,528	24,528	24,528	24,528
Cost of Energy, $/MWh	193.0	241.1	289.1	337.2	385.3

Feed-In Tariff & Carve Out Models

Required Feed in Tariff, $/MWh	193.0	241.1	289.1	337.2	385.3
Power Purchase Price for Carve Out, $/MWh	193.0	241.1	289.1	337.2	385.3

REC Multiplier Model

Net Cost of Energy, $/MWH	193.0	241.1	289.1	337.2	385.3
Value of Power, $/MWh	120.0	120.0	120.0	120.0	120.0
GAP=Difference between Net Cost and Value	73.0	121.1	169.1	217.2	265.3
Number of RECs required to fill GAP	1.3	2.1	2.9	3.8	4.6
Required REC Multiplier	2.3	3.1	3.9	4.8	5.6

Hybrid Feed-In Tariff/REC Multiplier Model

Net Cost of Energy, $/MWH	193.0	241.1	289.1	337.2	385.3
Feed-In Tariff (Assumption)	200.0	200.0	200.0	200.0	200.0
GAP=Difference between Cost and Price	-7.0	41.1	89.1	137.2	185.3
Number of RECs required to fill GAP	(0.1)	0.7	1.5	2.4	3.2
Required REC Multiplier	0.9	1.7	2.5	3.4	4.2

Case IIIA: 100 MW with BETC and Renewable Energy Grant

Assumptions		
Total Project Capacity, MW	100	
Capacity Factor	35%	
Availability	90%	
Annual Energy Production, MWh	275,940	
Fixed Charge Rate	11.85%	Rate used by NREL for cost comparsison of wind technologies
Levelized Replacement Cost, $/kW	32.10	Assumes 300% of rate used by NREL for onshore wind
Operations and Maintenance Cost, $/MWh	21.00	Assumes 300% of rate used by NREL for onshore wind
Ground Rent, % of Value of Base Power	1.0%	Typical rate used for onshore wind
Value of Federal Production Tax Credit, $/MWh	21.00	As provided by the IRS for 2009
Value of Power, $/MWh	120.00	Weighted average value of wind energy including the base REC as estimated by NPCC in the Sixth Power
Wholesale Power Price, $/MWh	62.40	Assumes levelized Mid-C rate for 2010 through 2029 as estimated by NPCC.
Value of Additional REC, $/MWh	57.60	Calculated as Value of Power less Wholesale Power Price. Assumes buyer is short.

	Scenario				
	I	II	III	IV	V
Installed Cost, $ per kW of Capacity	4,000	5,000	6,000	7,000	8,000
Capital Cost, $K					
Total CAPEX	400,000	500,000	600,000	700,000	800,000
less Federal Renewable Energy Grant	120,000	150,000	180,000	210,000	240,000
less OR Business Energy Tax Credit	6,700	6,700	6,700	6,700	6,700
Net CAPEX	273,300	343,300	413,300	483,300	553,300
percent of total	*68.3%*	*68.7%*	*68.9%*	*69.0%*	*69.2%*
Annual Operating Expenses, $K					
Fixed Charge Rate	32,386	40,681	48,976	57,271	65,566
Levelized Operations and Maintenance Cost	5,795	5,795	5,795	5,795	5,795
Levelized Replacement Cost	3,210	3,210	3,210	3,210	3,210
Bottom Lease Cost	331	331	331	331	331
Total Annual Expense	41,722	50,017	58,312	66,607	74,902
Annual Energy Production, MWh	275,940	275,940	275,940	275,940	275,940
Cost of Energy, $/MWh	151.2	181.3	211.3	241.4	271.4

Feed-In Tariff & Carve Out Models

	I	II	III	IV	V
Required Feed in Tariff, $/MWh	151.2	181.3	211.3	241.4	271.4
Power Purchase Price for Carve Out, $/MWh	151.2	181.3	211.3	241.4	271.4

REC Multiplier Model

	I	II	III	IV	V
Net Cost of Energy, $/MWH	151.2	181.3	211.3	241.4	271.4
Value of Power, $/MWh	120.0	120.0	120.0	120.0	120.0
GAP=Difference between Net Cost and Value	31.2	61.3	91.3	121.4	151.4
Number of RECs required to fill GAP	0.5	1.1	1.6	2.1	2.6
Required REC Multiplier	1.5	2.1	2.6	3.1	3.6

Hybrid Feed-In Tariff/REC Multiplier Model

	I	II	III	IV	V
Net Cost of Energy, $/MWH	151.2	181.3	211.3	241.4	271.4
Feed-In Tariff (Assumption)	150.0	150.0	150.0	150.0	150.0
GAP=Difference between Cost and Price	1.2	31.3	61.3	91.4	121.4
Number of RECs required to fill GAP	0.0	0.5	1.1	1.6	2.1
Required REC Multiplier	1.0	1.5	2.1	2.6	3.1

Case IB: 1 MW with BETC and Federal Production Tax Credit

Assumptions		
Total Project Capacity, MW	1	
Capacity Factor	35%	
Availability	70%	
Annual Energy Production, MWh	2,146	
Fixed Charge Rate	21.85%	Rate used by NREL for cost comparsison of wind technologies + 10% to account for increased risk of early stage projects
Levelized Replacement Cost, $/kW	64.20	Assumes 600% of rate used by NREL for onshore wind
Operations and Maintenance Cost, $/MWh	42.00	Assumes 600% of rate used by NREL for onshore wind
Ground Rent, % of Value of Base Power	1.0%	Typical rate used for onshore wind
Value of Federal Production Tax Credit, $/MWh	11.00	As provided by the IRS for 2009
Value of Power, $/MWh	120.00	Weighted average value of wind energy including the base REC as estimated by NPCC in the Sixth Power
Wholesale Power Price, $/MWh	62.40	Assumes levelized Mid-C rate for 2010 through 2029 as estimated by NPCC.
Value of Additional REC, $/MWh	57.60	Calculated as Value of Power less Wholesale Power Price. Assumes buyer is short.

	Scenario				
	I	II	III	IV	V
Installed Cost, $ per kW of Capacity	4,000	5,000	6,000	7,000	8,000
Capital Cost, $K					
Total CAPEX	4,000	5,000	6,000	7,000	8,000
less OR Business Energy Tax Credit	1,340	1,675	2,010	2,345	2,680
Net CAPEX	2,660	3,325	3,990	4,655	5,320
percent of total	*66.5%*	*66.5%*	*66.5%*	*66.5%*	*66.5%*
Annual Operating Expenses, $K					
Fixed Charge Rate	581	727	872	1,017	1,162
Levelized Operations and Maintenance Cost	90	90	90	90	90
Levelized Replacement Cost	64	64	64	64	64
Bottom Lease Cost	3	3	3	3	3
Total Annual Expense	738	883	1,029	1,174	1,319
Annual Energy Production, MWh	2,146	2,146	2,146	2,146	2,146
Cost of Energy, $/MWh	343.9	411.6	479.3	547.0	614.7

Production Tax Credit Multiplier Model

Net Cost of Energy, $/MWH	343.9	411.6	479.3	547.0	614.7
Value of Base PTC, $/MWh	11.0	11.0	11.0	11.0	11.0
Value of Power, $/MWh	120.0	120.0	120.0	120.0	120.0
GAP=Difference between Net Cost and Value of Power and PTC	212.9	280.6	348.3	416.0	483.7
Number of PTCs required to fill GAP	19.4	25.5	31.7	37.8	44.0
Required PTC Multiplier	20.4	26.5	32.7	38.8	45.0

Case IIB: 10 MW with BETC and Federal Production Tax Credit

Assumptions		
Total Project Capacity, MW	10	
Capacity Factor	35%	
Availability	80%	
Annual Energy Production, MWh	24,528	
Fixed Charge Rate	16.85%	Rate used by NREL for cost comparsison of wind technologies + 10% to account for increased risk of early stage projects
Levelized Replacement Cost, $/kW	42.80	Assumes 400% of rate used by NREL for onshore wind
Operations and Maintenance Cost, $/MWh	28.00	Assumes 400% of rate used by NREL for onshore wind
Ground Rent, % of Value of Base Power	1.0%	Typical rate used for onshore wind
Value of Federal Production Tax Credit, $/MWh	11.00	As provided by the IRS for 2009
Value of Power, $/MWh	120.00	Weighted average value of wind energy including the base REC as estimated by NPCC in the Sixth Power
Wholesale Power Price, $/MWh	62.40	Assumes levelized Mid-C rate for 2010 through 2029 as estimated by NPCC.
Value of Additional REC, $/MWh	57.60	Calculated as Value of Power less Wholesale Power Price. Assumes buyer is short.

	Scenario				
	I	II	III	IV	V
Installed Cost, $ per kW of Capacity	4,000	5,000	6,000	7,000	8,000
Capital Cost, $K					
Total CAPEX	40,000	50,000	60,000	70,000	80,000
less OR Business Energy Tax Credit	6,700	6,700	6,700	6,700	6,700
Net CAPEX	33,300	43,300	53,300	63,300	73,300
percent of total	*83.3%*	*86.6%*	*88.8%*	*90.4%*	*91.6%*
Annual Operating Expenses, $K					
Fixed Charge Rate	5,611	7,296	8,981	10,666	12,351
Levelized Operations and Maintenance Cost	687	687	687	687	687
Levelized Replacement Cost	428	428	428	428	428
Bottom Lease Cost	29	29	29	29	29
Total Annual Expense	6,755	8,440	10,125	11,810	13,495
Annual Energy Production, MWh	24,528	24,528	24,528	24,528	24,528
Cost of Energy, $/MWh	275.4	344.1	412.8	481.5	550.2

Production Tax Credit Multiplier Model

Net Cost of Energy, $/MWH	275.4	344.1	412.8	481.5	550.2
Value of Base PTC, $/MWh	11.0	11.0	11.0	11.0	11.0
Value of Power, $/MWh	120.0	120.0	120.0	120.0	120.0
GAP=Difference between Net Cost and Value of Power and PTC	144.4	213.1	281.8	350.5	419.2
Number of PTCs required to fill GAP	13.1	19.4	25.6	31.9	38.1
Required PTC Multiplier	14.1	20.4	26.6	32.9	39.1

Case IIIB: 100 MW with BETC and Federal Production Tax Credit

Assumptions		
Total Project Capacity, MW	100	
Capacity Factor	35%	
Availability	90%	
Annual Energy Production, MWh	275,940	
Fixed Charge Rate	11.85%	Rate used by NREL for cost comparsison of wind technologies
Levelized Replacement Cost, $/kW	32.10	Assumes 300% of rate used by NREL for onshore wind
Operations and Maintenance Cost, $/MWh	21.00	Assumes 300% of rate used by NREL for onshore wind
Ground Rent, % of Value of Base Power	1.0%	Typical rate used for onshore wind
Value of Federal Production Tax Credit, $/MWh	11.00	As provided by the IRS for 2009
Value of Power, $/MWh	120.00	Weighted average value of wind energy including the base REC as estimated by NPCC in the Sixth Power
Wholesale Power Price, $/MWh	62.40	Assumes levelized Mid-C rate for 2010 through 2029 as estimated by NPCC.
Value of Additional REC, $/MWh	57.60	Calculated as Value of Power less Wholesale Power Price. Assumes buyer is short.

	Scenario				
	I	II	III	IV	V
Installed Cost, $ per kW of Capacity	4,000	5,000	6,000	7,000	8,000
Capital Cost, $K					
Total CAPEX	400,000	500,000	600,000	700,000	800,000
less OR Business Energy Tax Credit	6,700	6,700	6,700	6,700	6,700
Net CAPEX	393,300	493,300	593,300	693,300	793,300
percent of total	*98.3%*	*98.7%*	*98.9%*	*99.0%*	*99.2%*
Annual Operating Expenses, $K					
Fixed Charge Rate	46,606	58,456	70,306	82,156	94,006
Levelized Operations and Maintenance Cost	5,795	5,795	5,795	5,795	5,795
Levelized Replacement Cost	3,210	3,210	3,210	3,210	3,210
Bottom Lease Cost	331	331	331	331	331
Total Annual Expense	55,942	67,792	79,642	91,492	103,342
Annual Energy Production, MWh	275,940	275,940	275,940	275,940	275,940
Cost of Energy, $/MWh	202.7	245.7	288.6	331.6	374.5

Production Tax Credit Multiplier Model

Net Cost of Energy, $/MWH	202.7	245.7	288.6	331.6	374.5
Value of Base PTC, $/MWh	11.0	11.0	11.0	11.0	11.0
Value of Power, $/MWh	120.0	120.0	120.0	120.0	120.0
GAP=Difference between Net Cost and Value of Power and PTC	71.7	114.7	157.6	200.6	243.5
Number of PTCs required to fill GAP	6.5	10.4	14.3	18.2	22.1
Required PTC Multiplier	7.5	11.4	15.3	19.2	23.1