EVALUATING THE ENERGY RETURNS OF INVESTMENT-BASED INCENTIVE PROGRAMS: THE CASE OF OREGON’S BUSINESS ENERGY TAX CREDITS

by

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Governments around the world provide financial incentives to encourage renewable energy generation and energy conservation. The primary goals of these efforts are to mitigate climate change and improve long-term energy independence by reducing reliance on fossil fuels. The consensus in the energy incentive literature is that performance-based incentives, which fund energy output, are more cost efficient than investment-based incentives, which fund capital input. This thesis uses a 30-year case study of Oregon's Business Energy Tax Credit (BETC) program to argue that investment-based energy incentives are moderately cost efficient relative to other state performance-based incentives and can be an effective driver of clean energy deployment. However, this analysis also finds that there are significant opportunities to improve the cost efficiency of investment-based energy incentive programs by targeting least cost projects. Namely, 50% of the first year kilowatt-hour electricity returns of the BETC program could have been achieved at 10% of the cost. These lessons from historical BETC spending should guide policymakers, NGO's, and businesses who aim to make targeted use of fiscally-constrained energy incentive programs.

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CHAPTER I

INTRODUCTION

The vast majority of the world's electricity and transportation network is built around three fossil fuel sources: coal, oil and natural gas (REN21, 2010). These fuel sources are finite—most notably oil, which is often imported at great cost—and produce significant greenhouse gas emissions contributing to global climate change. Governments have long recognized the long-term importance of transitioning to a "cleaner" energy economy. Clean energy sources are defined here as those that directly reduce fossil fuel consumption, such as energy efficiency and conservation (heretofore combined under the umbrella term "conservation"[1]), and those that indirectly offset fossil fuels, such as renewable electricity generation (solar photovoltaics, wind, etc.). The key follow-up question is which government policies are the most effective and cost efficient drivers of clean energy deployment.

Governments and public entities have enacted a wide array of policy tools to spur the development of renewable energy and conservation. These policy tools include quota-type mandates for renewable electricity and energy efficiency; research, development and deployment (RD&D); transportation initiatives; and other approaches that target clean energy indirectly, such as carbon pricing (DSIRE, 2011; IEA, 2011). One of the most widely-used tools among national and sub-national governments has been financial incentives—in the form of subsidies or tax credits—to entice clean energy developers to implement renewable energy and conservation projects.

The energy incentive debate is largely centered on which policy design structure induces the greatest clean energy deployment (policy *effectiveness*) at the least cost (policy *cost efficiency*) (Gan et al., 2007; Sovacool, 2010). The main categorical distinction is made between *performance-based* energy incentives, which fund projects based on the *output* of energy produced or conserved, and *investment-based* energy

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[1] The umbrella term "conservation" is used to denote both energy efficiency, which uses technology to produce the same end product while using less energy (e.g., weatherization), and conservation, which uses behavior or process change to use less energy (e.g., bicycle programs).

incentives, which fund projects based on the *input* of initial capital investment. Performance-based energy incentives are generally argued to be more effective and cost efficient than investment-based energy incentives at achieving clean energy outcomes (Sovacool, 2010; Loiter & Norberg-Bohm, 1999; Cox et al., 1991). This analysis provides evidence that investment-based tax credits can be an effective and cost efficient tool for stimulating clean energy activity in comparison to performance-based energy incentives.

In addition to evaluating the effectiveness and cost efficiency of investment-based programs in aggregate, this case study also examines the specific types of investments that have been most effective and cost efficient within an investment-based program. In the academic literature, little attention has been paid to the reform of existing investment-based energy incentive policies, despite the fact that hundreds of national and sub-national programs still exist (DSIRE, 2011; IEA, 2011). Through an investigation of historical public spending patterns on clean electricity, this paper offers evidence on which technologies are most cost efficient and effective. Foremost, waste heat recovery, wind, biomass and conservation provide the least cost annual electricity return on public investment. An even more granular assessment evaluates cost efficiency and effectiveness on a project-to-project level, which finds further room for the improvement of investment-based energy incentives. In this case study, roughly 50% of the annual clean electricity could have been achieved with 10% of the incentives, and about 90% could have been achieved with 50% of the incentives. These results suggest that there are significant opportunities to make investment-based energy incentives more effective and cost efficient, despite their relative advantages compared to a sample of performance-based energy incentives.

Oregon’s Business Energy Tax Credit (BETC) program is an ideal case study for this investigation: BETC is one the largest and longest-standing examples of an investment-based energy incentive program. The program began in 1979 as a modest response to the oil crisis, providing limited tax credit funding for business conservation and renewable projects. The program has grown substantially in size and scope over the last decade, which has led to increasing demands on the program to be effective and cost efficient (Kuehl, 2011, Esteve, 2011). This independent 30-year review of BETC spending provides much-needed evidence on the relationship between taxpayer energy incentives and energy policy goals. These lessons from historical BETC spending should guide policymakers, NGO's, and businesses who aim to make targeted use of fiscally-constrained energy incentive programs.

CHAPTER II

LITERATURE REVIEW

2.1. The Benefits of Clean Energy Deployment

Renewable energy generation and conservation provide many public benefits that make them economically, socially and ecologically desirable. The four most common benefits cited for clean energy development are: 1) environmental improvement; 2) energy security; 3) economic development; and 4) employment (Liao et al., 2011). This wide range of potential benefits has brought significant political weight to the issue of clean energy procurement in recent years.

The role of clean energy in the mitigation of global climate change deserves particular emphasis. The Intergovernmental Panel on Climate Change outlined in their 2007 report the predicted environmental consequences of business-as-usual greenhouse gas pollution: rising sea levels, desertification, extreme weather events and flooding, species extinction, ocean acidification and the loss of coral reefs. The Global Humanitarian Forum (GHF) argues that climate change is already causing significant harm to human populations at a 1 degree Celsius rise in temperature. GHF estimates that 300,000 perish and 325 million people are seriously affected by climate change annually, coupled with $US125 billion in economic losses (2009). Climate change impacts have already been observed in the United States, including increased frequency of intense downpours and reduced snow cover; future problems include more intense hurricanes and storm surges, and issues with human health, water supply, and agricultural stability (U.S. GCRP, 2009). Climate researchers have confirmed that at least some further harmful effects of climate change are inevitable (Eilperin, 2009), but that clean energy deployment has the ability to mitigate greenhouse gas emissions stemming from the energy system. The climate mitigation benefits of clean energy also coincide with local, national, and international climate obligations, such as statewide goals or the Kyoto Protocol (EEA, 2004). Reduction of greenhouse gases and environmental sustainability are generally considered to be the most important outcomes of renewable energy proliferation (Shen et al., 2010).

Other benefits of clean energy include net increases in energy security, employment and economic development. Since most regions must import a significant amount of their total energy portfolio, energy conservation and homegrown renewable supply stabilize energy prices and reduce the chance of external energy shocks (Liao et al., 2011). Domestic buildout also provides an opportunity for growing local energy technology markets and developing export industries. These industrial sectors can become dynamic and prosperous segments of regional economies. Clean energy can also increase economic production by reducing electricity costs and increasing reliability of the grid in the long term (Liao et al., 2011). These clean energy industries can also provide significant means for maintaining and catalyzing local employment needs; economies in transition are particularly amenable to these benefits of renewable deployment (Liao et al., 2011). The Center for American Progress argues that clean-energy investments create 16.7 jobs per $1 million in spending, compared to 5.3 jobs for fossil fuels (PERI, 2009). During periods of economic turmoil, these economic and employment benefits take on increasing political importance.

2.2. Policy Rationale for Promoting Clean Energy

Clean energy faces significant market barriers that prevent these economic, social and ecological benefits from accruing. The most relevant economic theory for incentivizing clean energy deployment is the concept of externalities (Metcalf, 2009). The production and consumption of fossil fuels produce pollution—air, water, and greenhouse gas emissions—that are borne by society-at-large rather than the individual producers and consumers of fossil fuels. Unpriced greenhouse gas emissions are arguably the greatest externality that the world has ever known (Stern, 2007). Since the market does not inherently account for these external costs of production, “only government can solve the failure of the market to account for [the] unintended consequences of market activity” (Mann, 2010, p. 400; Pigou, 1920). Economic theory concludes that social welfare can be improved through governmental action to internalize these external market costs.

Ideal conditions dictate that a “Pigouvian” tax be applied at the rate at which the pollution imposes costs on society (Tietenberg, 2006). However, political reality often requires that governments apply an economically imperfect Pigouvian subsidy to promote externality-reducing activity rather than taxing external costs directly (Metcalf, 2009). Subsidies incur two distortions on the market: first, they reduce energy prices, thereby creating a distortion on the margin between energy and non-energy consumption; second, "they generate distortions among the externality-reducing technologies in a way that raises the cost of achieving policy goals while doing so in a fairly opaque way" (Metcalf, 2009, p. 526). Financial incentives to spur clean energy, as a form of Pigouvian subsidy, are therefore an economically imperfect but political amenable policy tool for overcoming environmental externalities.

Similarly, environmental amenities such as climate stability and clean water, as well as the public health outcomes that result from their protection, are public goods subject to collective action problems (Hardin, 1968). Energy security, which is derived from the long-term stability of the energy system, is also a public good akin to national security. Without market signals dictating the protection of these public goods, Hardin's "Tragedy of the Commons" theory hypothesizes that these goods become degraded over time. Free riders benefit from the protection of public goods without personal cost, which stifles collective action that would benefit all. Thus, public recourse has the opportunity to improve public welfare by imposing or incentivizing the protection of public goods. In this vein, governments create incentives for renewable energy and conservation that promote the collective benefits of climate stability and other public goods (Tietenberg, 2006).

Technical gains that result in increased productivity of capital are themselves a public good. Individual firms under-invest in capital and technological improvement because they do not internalize the broader social gains from learning (Palmer & Burtraw, 2005; Arrow, 1962). The introduction of a new technology is a form of positive externality, whereby the benefits of the new technology are not entirely borne by the individual or firm (Tietenberg, 2006). Cox et al. examine how this played out in early wind turbine development in California:

> In 1980 a company that undertook the task of developing an economical wind machine could not ensure that it would receive an adequate return on

> its investment in research. If the technology is easily imitated, with slight variations to avoid patent infringement, competition would limit the financial return from research and development. […] the federal and California governments decided that the most appropriate way to overcome the roadblocks to wind power development was the establishment of generous tax credits and price guarantees for electricity sales. (1991, p. 349)

The government in the U.S. has a long history of using RD&D and other public subsidies to foster the technological development of industry, including railroads, aviation, microchips, and the Internet (Breakthrough Institute, 2009). The positive externalities and public good nature of technical gains are further justifications for incentives to promote clean energy development.

Energy incentives for clean energy, in addition to addressing externalities and public goods, allow clean energy to compete with direct government subsidies for fossil fuel production. According to Liao et al., "the first challenge to reach free market mechanism is to recognize the incentives/subsidies that are built into the supply systems of conventional fuels" (2011, p. 790). Distorting markets with clean energy subsidies to balance fossil-based market distortions is an imperfect solution for overcoming market barriers. The long-term aim is to remove all public subsidies and to tax external costs at the margin equal to the marginal costs imposed on society (Liao et al., 2011).

While these justifications for promoting clean energy are largely economic, one last argument is ethical in nature. The climate dilemma involves economic sacrifice in order to protect the well-being of future generations. Climate change, in ways unique from other policy motivations, requires a moral argument in defense of intergenerational equity. For further discussion of the ethical dimensions of climate mitigation, see: Weiss, 1990; Gardiner, 2006; and Caney, 2005.

2.3. Policy Alternatives to Energy Incentives

According to economic theory, subsidies in the form of financial incentives for clean energy deployment are an imperfect tool for reducing negative externalities and cultivating public goods. Direct taxes are more effective and cost efficient tools for achieving the benefits of clean energy—particularly when the goal is greenhouse gas reduction rather than energy deployment (Metcalf, 2009). Palmer & Burtraw (2005) investigate the ability of different energy policies to achieve cost-efficient carbon emissions reductions from renewable energy dissemination. These authors find that a carbon pricing scheme, such as a carbon tax or a cap-and-trade policy, is more efficient than either a quota-type mandate or a performance-based energy incentive for reducing carbon emissions. Hassett & Metcalf argue that energy subsidies are difficult to justify on economic grounds and that a carbon price would make energy incentives unnecessary (2006). However, Metcalf admits that political reality means "in large measure, we subsidize energy activities that we would like to encourage rather than tax activities that we would like to discourage" (2009, p. 523).

The debate on the efficacy and cost efficiency of quantity-based mechanisms versus price-based mechanisms is more unclear, both in terms of the ability to reduce carbon emissions and to deploy clean energy. Table 1 provides a summary of the common categories of quantity- and price-based energy policies.

Table 1: Fundamental Types of Regulatory Strategies

	Price-Driven	**Capacity-Driven**
Investment Focused	Rebates Tax Incentives	Bidding
Generation Based	Feed-In Tariffs Rate-Based Incentives	Quotas

Source: Haas et al., 2004

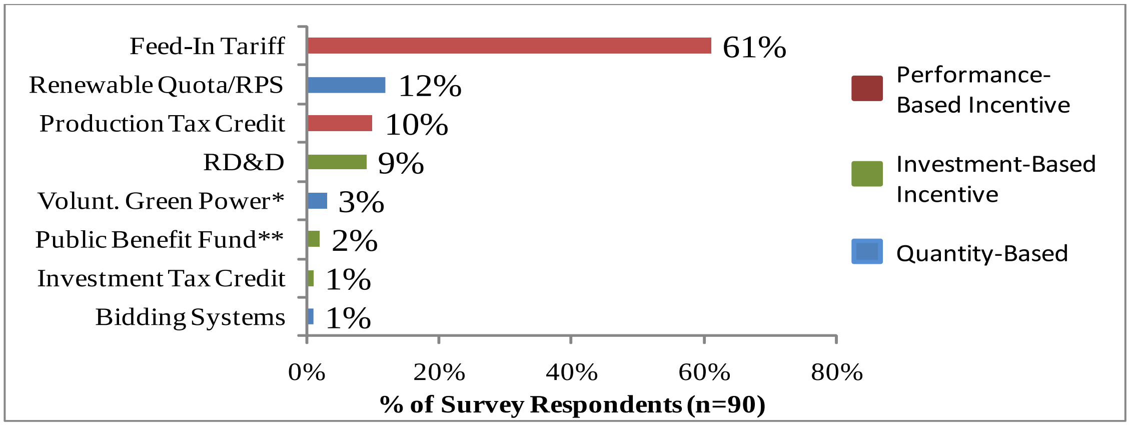
Quantity-based ("Capacity-driven") policies include quotas that mandate a percentage of energy come from renewable sources by a given deadline. In an assessment of wind policies in U.S. states, quotas were found to be more effective at driving wind power than financial instruments; however, financial instruments were also found to wield "a great deal of influence" (Bird et al., 2005, p. 1407). Other studies have also found price-based mechanisms to be either less effective than quantity-based mechanisms or not effective at all in driving renewable energy (Menz, 2005; Menz & Vachon, 2006; Loiter & Norberg-Bohm, 1999; Palmer & Burtraw, 2005). It is worth noting these studies favoring quantity-based mechanisms are based on existing policies within the United

States. Feed-In Tariffs (FITs), which have been common in the international community but not in North America, are a price-based policy that have been shown to be more effective and cost efficient than quantity-based tools in many studies (see: next section). The question is therefore not only of price-based versus quantity-based energy policies, but of designing energy incentives to be most effective and cost efficient.

2.4. Investment- Versus Performance-Based Energy Incentives

Performance-based energy incentives (labeled “Generation Based” incentives in Table 1) are generally found to be more effective and cost efficient than investment-based energy incentives, although there is significant variation based on the design of the program. In particular, feed-in tariffs (FITs) stand out as “the world’s most successful policy mechanism for stimulating the rapid development of renewable energy” (Singh & Sood, 2011, p. 661). A FIT establishes long-term, fixed price contracts for the purchase of renewable energy (including solar, wind, etc.). These incentives are most effective when they scale down gradually over time at the rate of technological cost reductions and differentiate based on region and resource intensity (Singh & Sood, 2011). A survey of electricity stakeholders in Southeast Asia found that FITs were the preferred policy mechanism of 61% of respondents (see: Figure 1) (Sovacool, 2010). FIT was the only policy to satisfy all of the analytical criteria of efficacy, cost effectiveness, dynamic efficiency, equity, and fiscal responsibility. The study cites evidence from Germany that the FIT “lowered the average market price of electricity, displaced inefficient and more polluting power plants, and reduced energy dependence and the costs of importing coal and other fossil fuels” (Sovacool, 2010, p. 1790). Investment tax credits (ITCs), one of the most common forms of investment-based energy incentives, were argued not to meet the criteria of efficacy (“ITCs have been subject to regulatory uncertainty and have frequently expired”), cost efficiency (“ITCs create little incentive to keep costs down”) or fiscally responsibility (“ITCs require continuous government funding”) (Sovacool, 2010, p. 1787). Production Tax Credits (PTCs), a form of performance-based energy incentive that funds renewable energy output on a per kWh basis, was found to be similarly flawed. However, PTCs were found to be more cost efficient than ITCs because they provide money for renewable production rather than investment (Sovacool, 2010). Gan et al. also found FITs to stand out as the most attractive energy incentive tool, while noting that upfront RD&D funding may be needed to develop long-term technological improvement and cost reduction (2007).

Figure 1: Most Preferred Policy Mechanisms Selected by Survey Participants



*Voluntary Green Power "provides no guarantee that additional renewable energy capacity will be built," only that a certain amount of renewable energy be delivered to consumers (1786)

**Public Benefit Funds usually, but not always, fund projects based on investment rather than performance

Source: Sovacool, 2010

Other analyses do not include FIT as a policy option, and focus on the comparison between ITCs and PTCs. PTCs have largely been found to be more effective and cost efficient at bringing renewable energy to market than ITCs because they fund energy outputs rather than capital inputs (Loiter & Norberg-Bohm, 1999; Cox et al, 1991; Mann, 2010). The explanation underlying the relative efficacy and cost-efficiency of performance-based energy incentives is intuitive: "the PTC is better than the ITC because it provides continuing incentives to produce renewable energy, rather than providing an incentive to invest capital in a renewable project" (Mann, 2010, p. 388). In India, the ITC spurred substantial wind power development, but because economic incentives were based on installation rather than capacity, turbine performance has been poor (Sovacool, 2010). In California, the problem of funding inputs was even more dramatic, as some companies installed non-functioning wind turbines to receive tax credits. The ITC system for wind became "a sort of lottery with developers hoping the benefits of getting credit for fake systems outweighed the chances of getting caught" (Sovacool, 2010, p. 1789).

These authors acknowledge that ITCs offer benefits beyond effectiveness and cost efficiency, including policy characteristics that make ITCs politically attractive. ITCs are less expensively and more easily administered than PTCs, because tracking project performance requires more complex monitoring of energy output over time than investment-based incentives. ITCs are also more advantageous for spurring developing technologies that still have high capital investment cost per unit of electricity output (Loiter & Norberg-Bohm, 1999). While PTCs favor lowest cost energy production and usually target a narrow band of technologies, ITCs are more flexible to technologies at different stages of development. This produces a greater diversification of project types, which is more dynamically efficient[2] and can often lead to long-term innovation and cost-reductions (Cox et al, 1991; Sovacool, 2010; Haas et al., 2004). Overall, however, the literature favors PTCs over ITCs for their clearly defined energy output. Policies should "incorporate incentives that encourage *production* of electricity by renewables rather than simply *investment* in renewable energy capital" (Loiter & Norberg-Bohm, 1999, p. 95).

As indicated by the efficacy and cost efficiency of FITs over PTCs—of one performance-based energy incentive over another—there are more nuanced policy design features that can have a significant impact on the effectiveness and cost efficiency of an energy incentive program. Researchers have provided general rules for successful energy incentive programs. Policies can best guarantee effectiveness if objectives and policy structure are stable and predictable over a long time horizon (Gan et al., 2007). Barradale (2010) articulates that reducing uncertainty is a key component of workable clean energy deployment strategies. Public policy uncertainty, such as the federal production tax credit lapses for wind in 2000, 2002, and 2004, deters long-term private-sector investment in renewable technologies. In other words, "stability—the antidote to uncertainty—is […] an important criterion for evaluating the effectiveness of policy incentives" (Barradale, 2010, p. 7706). Quantity-based energy policies are inherently more stable than PTCs and ITCs for achieving long-term stability; similarly, FITs are argued to be more effective than PTCs and ITCs in part because of the use of long-term, stable contracts (Barradale, 2010; Sovacool, 2010).

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[2] Dynamic efficiency refers to the ability for a policy to promote a diversification of renewable energy sources and technologies (Sovacool, 2010, 1785).

2.5. The Effectiveness and Cost Efficiency of Project Types

Few studies in the energy incentive literature have investigated returns on investment within an individual energy incentive program. Analysts typically compare policy types against one another to determine the overall effectiveness and cost efficiency. Admittedly, performance-based energy incentives guarantee the tax cost per unit of energy and thus provide few avenues for investigating variation in effectiveness and cost efficiency within a given program; PTCs, for example, establish definitive public costs per unit of renewable energy generation. On the other hand, investment-based energy incentives fund project inputs and therefore do not guarantee finite spending levels per unit of energy output. Investment-based tax credits therefore provide an opportunity to evaluate the effectiveness and cost efficiency of different investments within a singular program.

Although this appears to be the first paper on the effectiveness and cost efficiency of projects within an investment-based energy incentive program, there have been several studies that examine the potential of various project categories and technologies. These papers investigate the effectiveness and cost efficiency of project types independent of policy design. Shen et al. (2010) investigate six renewable energy sources (solar, biomass, geothermal, ocean, wind, and hydropower) for their deployment potential in Taiwan based on energy, environmental and economic considerations. The results of their 15-expert questionnaire favored hydropower, solar and wind technology (see: Table 2).

A report by McKinsey & Co. (*Unlocking Energy Efficiency in the U.S. Economy*) assesses both the cost efficiency and scalable potential of assorted energy efficiency project types (2009). The underlying idea is that certain project types are more ideal for public and private investment, or at least provide better opportunities for low cost energy returns in the short-term. For example, increasing the energy efficiency of refrigerators is found to be very cost efficient, while increasing the energy efficiency of freezers is found to be very cost inefficient. This cost curve is located in Appendix A and will be discussed in more detail in Section 3.3.

Table 2: The Optimal Non-Fuzzy Performance Value of Six Renewable Energy Sources

Goal	Criteria & Aggregate Weight		Solar	Biomass	Geo.	Ocean	Wind	Hydro
Energy	Energy Price Stability	0.050	4.47	4.49	5.22	4.03	4.85	5.76
	Security for Energy Supply	0.119	6.61	5.10	5.34	5.61	5.31	6.48
	Low Energy Prices	0.043	2.71	4.12	4.90	4.21	4.72	6.30
	Stability for Energy Generation	0.097	5.40	5.10	5.19	4.15	5.46	5.31
Env.	Carbon Emissions Reductions	0.122	5.47	4.45	5.52	5.38	6.66	6.80
	SOx and NOx Reductions	0.084	5.47	4.15	5.52	5.45	6.66	7.19
	Environmental Sustainability	0.143	6.24	4.46	6.31	5.19	6.25	5.95
	Low Land Requirement	0.028	3.41	3.44	5.59	6.69	3.78	4.62
Econ.	Local Economic Development	0.059	6.99	5.15	4.25	4.46	5.12	4.62
	Increasing Employment	0.041	6.39	4.85	3.95	4.21	4.63	3.74
	Technical Maturity	0.052	6.70	5.37	3.59	3.50	3.75	6.52
	Potential for Commercialization	0.059	6.67	5.19	4.67	3.82	6.04	5.70
	Market Size	0.075	7.62	6.43	4.37	5.43	6.43	5.43
	Reasonableness for Cost	0.051	2.56	4.37	3.84	2.90	4.74	5.00
Total			5.866	4.906	5.190	4.882	5.729	6.005
Rank			2	5	4	6	2	1

Source: Shen et al. (2010)

2.6. The Current Landscape of Investment-Based Energy Incentives

At the national and sub-national level, governments have instituted a substantial array of investment-based energy incentives that fund upfront capital and other project inputs. According to the Database of State Incentives for Renewable Energy (DSIRE), 22 states and the federal government have corporate tax incentives that invest in projects based on qualifying inputs (2011). As of 2011, the U.S. federal government provides a Business Energy Investment Tax Credit worth 30% of certified project costs for solar, fuel cells, and small wind facilities; 10% credits are available for geothermal, combined heat and power, and other technologies. The state programs vary significantly in size, scale, and eligible technologies. For example, as of 2011, North Carolina’s Renewable Energy Tax Credit funds 35% of project costs up to $2.5 million installations; New Mexico’s Advanced Energy Tax Credit funds only 6% of project costs but up to $60 million installations. Hawaii and many other states only qualify solar and wind, Indiana funds only energy conservation, and Missouri and Wisconsin subsidize only woody biomass (DSIRE, 2011).

Complementing these corporate investment tax credits are a series of related investment-based energy incentive policies at the statewide level. 29 states have property tax incentives for renewable projects, 27 have grant programs for renewable and energy efficiency programs, 26 have rebate incentive programs for clean energy investment, 26 have sales tax incentives for renewable energy and manufacturing projects, 19 states have public benefit funds, and 3 have green building incentives (DSIRE, 2011). These investment-based energy incentives can be found at the international level as well: China has tax reductions for biogas and wind energy development; Ghana has reduced import duties and sales taxes on solar and wind systems; and the Czech Republic has a five year tax exemption on a variety of renewable energy systems (IEA, 2011). All of these national and state-level energy incentive programs are based on technical project inputs rather than on energy output. These investment-based energy incentive programs broadly parallel the funding structure of Oregon's Business Energy Tax Credit system.

2.7. Oregon's Business Energy Tax Credit Program

Oregon's Business Energy Tax Credit (BETC) program is an ideal case study for analyzing investment-based energy incentive policies. The program that began as a modest response to the oil-based price shocks of the 1970's has expanded in size and scope over the course of the 2000's to become one of the largest energy incentive programs in the U.S (Kuehl, 2010). The high caps on incentives and the diversity of funded technologies provide significant evidence for the evaluation of investment-based energy incentive programs.

BETC began in 1979 to "encourage the conservation of electricity, petroleum, and natural gas by providing tax relief for Oregon facilities that conserve energy resources or meet energy requirements through the use of renewable resources" (Kuehl, 2010, p. 704). The program began with a $30 million program cap, and a 35% per project tax credit capped at $3.5 million (Kuehl, 2010). These energy incentives, in the form of tax credits, were intended to promote investment in conservation and renewable projects by allowing developers to recuperate a percentage of upfront project costs.

The restructuring of the ODOE in the 1990's coincided with a scaling back of the program, reducing the maximum tax credit for most projects from $3.5 million to

$100,000. However, in 1999, the legislature raised the cap on individual projects to $10 million (Kuehl, 2010). In 2001, the Oregon legislature expanded the “pass-through” option that allowed taxpayers to sell their tax credits to entities with larger tax liability; previously limited to utilities, the pass-through expansion allowed developers without the proper tax appetite to benefit from tax credit incentives, including non-profits, schools, government agencies, tribes, small businesses and individuals (ODOE, 2010). The pass-through option allows tax credits to become equivalent to cash subsidies for would-be clean energy developers, although at less than the face value of the tax credit[3]. The pass-through option has substantially increased the number and size of clean energy projects in Oregon (Esteve, 2009b). About 60% of projects utilized the pass-through option in 2008 (ODOE, 2009).

HB 3201 and HB 3619, enacted during the summer of 2007 and the spring of 2008, respectively, increased the tax credit for renewable facilities and manufacturing from 35% to 50% of certified project costs and raised the tax credit cap for large renewable manufacturing projects to $20 million (DSIRE, 2011; Esteve, 2009b; Kuehl, 2010). Caps for renewable energy and conservation projects remained at $10 million. Expected costs for the biennial period 2009-11 are estimated at $185 million in tax credits (Esteve, 2011). These taxpayer costs represent a significant portion of Oregon’s roughly $30 billion annual budget (Oregon Blue Book, 2011).

The budgetary increases have made BETC increasingly controversial. Critics of the BETC program have called the tax credits a big giveaway to business, claiming that costs have far outrun estimates and that the program includes major structural flaws. A series of articles in the *The Oregonian* detailed the controversy: program costs that were 40 times more than lawmakers expected ($40 million versus $1.2 million); liberal distribution of tax credits (such as three Klondike wind farms receiving a total of $33 million); prolific funding for botched projects; and a rubber stamp Department of Energy, citing that 97% of all applications have been approved since the BETC program began (Duin, 2010; Esteve, 2009a; ODOE, 2009). One commentator wrote: “Records show that

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[3] The pass-through rate for selling tax credits to other parties is governed by legislative rules. In January 2010, a tax credit could be sold for roughly 74% of the face value of the credit. A $10 million credit could be sold to another party for $7.4 million in cash—this would be the value of the tax credit to a developer without the tax liability to use $10 million in tax credits (O’Neill, 2009)

the [BETC] program […] has given millions of dollars to failed companies while voters are being asked to raise income taxes because the state budget doesn't have enough to pay for schools and other programs" (Esteve, 2009a).

Oregon implemented a series of changes to mollify demands for more clearly defined outcomes in the BETC program. HB 3680, which was codified into law February of 2010, placed new financial limits on the program and allowed more discretion for the ODOE director (OLA, 2010). Legislators reduced the eligible costs for larger wind facilities (over 10 megawatts) from 50% of total project costs to 5%, significantly reducing subsidies available for major wind farms. Other changes included more stringent operational requirements, elimination of credits for failing and indebted applicants and tightened restrictions on multiple tax credits for single projects (ODOE, 2009). Caps on BETC funding through June 2011 were set at $300 million for renewable energy facilities and $200 million for manufacturing facilities (Van't Hof & Powell, 2010). The legislative changes mandated a tiered priority system that forced larger projects to compete for these funds based on a series of criteria, including investment payback period, expected lifespan of the facility, environmental impacts, and employment effects (OLA 2010; Van't Hof & Powell, 2010). These changes have made the BETC program an investment-performance hybrid, that funds projects based on both capital inputs and projected outputs of a variety of indicators. However, since these legislative changes were not acted upon until November of 2010, this hybrid tiered priority system will have little if any influence on the 30-year history of the BETC program (1981-2010) evaluated in this paper.

CHAPTER III

METHODS

3.1. BETC Data

Oregon's BETC program is administered by the Oregon Department of Energy (ODOE). The data utilized in this study was obtained via a public records request from ODOE; this research is an independent investigation of the BETC program. This data documents the 20,000+ projects for which tax credits have been issued through 2010. The relevant fields parsed from the data set are on: 1) tax credits issued, 2) annual energy returns, and 3) project specifications.

The amount of tax credits issued by ODOE to the project developer are recorded in lump sum dollars ($), not adjusted for inflation. Also included in the data are projects' "final certified costs" that are eligible for funding, which are often but not always equivalent to total project costs. This analysis will focus only on total tax credit amount measured in $.

The energy data associated with BETC-funded projects is parsed into five separate classifications of energy: energy saved, energy displaced, electricity produced, thermal energy and biofuels produced[4] (ODOE, 2011). Related to these are 9 fuel types, which include electric, natural gas, petroleum, wood, etc. The bulk of this paper focuses on electricity produced and energy saved under the fuel type electricity, collectively termed "clean electricity." All analysis of clean electricity returns have been converted from million BTU to kilowatt hours (hereafter, kWh) [5].

ODOE records energy savings and generation as *first year estimates* for any given project. The "first year" designation equals the total amount of kWh generated or saved in the first full year of the project. This first year energy data serves as an adequate proxy for annual energy saved or generated over the lifetime each individual project. Since ODOE records annual energy returns, all energy figures will be labeled as kWh per year.

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[4] Electricity produced, thermal energy and biofuels produced are all based on the particular type of energy being produced. Energy displaced means trading the energy use of one fuel for another fuel (e.g., when a vehicle uses an alternative fuel). Energy saved is energy no longer used (e.g., when a vehicle is no longer used).

[5] 1 million BTUs (1 MMBTU) = 293.1 kWh

This indicates that that BETC-funded projects continue to produce these annual energy totals on a year-to-year basis as long as the project is in operation. Notably, no data exists on the expected project lifetimes of BETC-funded investments. Since the data captures annual energy returns rather than total energy returns over the lifetime of a project, there is a methodological disadvantage against projects that have extended lifetimes, such as hydropower and geothermal projects (30 year lifetime averages, rather than 20 for most other sources) (ECN, 2001). This limitation in the data is addressed throughout.

The term energy "estimates" is used because no energy output data is recorded. Energy estimates are made by the project developers and then evaluated and adjusted by BETC technical reviewers before being finalized (ODOE, 2011). To confirm the accuracy of the BETC estimates, this analysis uses a sampling of real world data on BETC-funded projects to compare the ODOE first year energy estimates with actual annual energy output. Specifically, this paper uses a sample of fourteen BETC-funded projects—nine large wind farms, one biomass plant, and four smaller-scale photovoltaic projects—to assess the accuracy of ODOE estimates. The goal is to substantiate the claim that ODOE estimates can be utilized for meaningful evaluation of the cost efficiency and effectiveness of the BETC program. Ultimately, these ODOE estimates serve as a proxy for the real world annual energy returns of BETC-funded projects.

The data set also includes important fields on project specifications that are used to evaluate the relationship between tax credit investments and energy returns. Of primary importance is the project category field[6]. *Project category* is a broad grouping of clean energy projects, including wind, solar and geothermal (for a complete list of project categories used in this analysis, see: Table 3). More detailed cost curves that parse these broad categories into more specific project types are located in Appendix B.

Not included in the analysis are a subset of three project categories that aim for non-energy based outcomes: manufacturing, recycling, and RD&D (see: Table 4). Oregon has spent over $50 million on solar manufacturing facilities to spur the growth of its statewide photovoltaic industry. Similarly, almost $50 million of BETC funds have gone towards recycling projects, with the intention of reducing material rather than

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[6] This field is recorded as "System Name" in the ODOE data

energy waste. Lastly, Oregon spent over $40 million on RD&D for long-term technological gains rather than shorter-term clean energy delivery.

Table 3: Included BETC Project Categories, with Tax Credits Received

Project Category	Tax Credits ($)
Biomass	$ 29,880,239
Conservation	$ 203,175,976
Geothermal	$ 2,562,761
Hydro	$ 9,757,250
Solar	$ 48,576,020
Waste Heat Recovery	$ 4,206,964
Wind	$ 95,050,475
Total	**$ 393,209,685**

Source: ODOE, 2011

Table 4: Excluded BETC Project Categories, with Tax Credits Received

	Project Category	Tax Credits ($)
Non-Energy	Renewable Manuf. Facilities	$ 50,998,064
	Recycling	$ 49,143,556
	RD&D	$ 14,570,696
	RD&D - Renewable	$ 14,065,777
	RD&D - High Efficiency Co-Gen.	$ 6,824,306
	Total	**$ 135,602,399**
Non-Elec.	Transportation	$ 87,173,738
	Biomass	$ 81,468,338
	Conservation	$ 60,609,631
	Co-Generation - Renewable	$ 39,457,400
	Sustainable Building	$ 14,051,879
	Waste Heat Recovery	$ 11,588,004
	Co-Generation	$ 5,457,724
	Solar	$ 1,618,742
	Geothermal	$ 1,328,744
	Homebuilder Projects	$ 160,008
	Total	**$ 302,914,208**

Source: ODOE, 2011

This analysis focuses only on those project categories that produce or save electricity, which eliminates certain project categories like transportation that offset non-electricity based fuels. Co-generation and sustainable buildings include multiple fuel types rather than just electricity and are thus not part of the quantitative analysis. Certain project categories can involve either electricity-based or non-electricity based projects, such as biomass. Only those projects that are electricity-based are included in the analysis. For a list of the non-electricity based project categories, see Table 4.

3.2. Research Questions & Evaluation Criteria

The primary research question that this paper seeks to address is whether investment-based energy incentives are cost efficient and effective relative to performance-based energy incentives. This portion of the analysis evaluates the BETC program both for internal cost inefficiencies and in relation to current performance-based energy incentives in the U.S. The secondary research question asks which project categories are most effective and cost efficient within an investment-based energy incentive program. This portion of the analysis compares BETC-funded project categories in relation to one another over the 30-year history of the program.

The two evaluation criteria of effectiveness and cost efficiency are derived from Gan et al. (2007) and Sovacool (2010). Gan et al. define *effectiveness* as “the extent to which the policy is able to meet quantitative objectives,” which is usually “simply to increase the share of renewable [or clean] energy generation” (146). Sovacool (2010) deems a policy effective (“efficacious”) if it “has resulted in a substantial increase in the amount of renewable [or clean] energy generation” (p. 1785). Effectiveness will be measured by the total annual energy, in kWh per year, that have been correlated with the BETC program. Gan et al. define *cost efficiency* as the “the increase in green electricity divided by the cost of the instrument” (p. 146). Sovacool divides cost efficiency into two separate criteria: cost effectiveness and fiscal responsibility. Cost effectiveness refers to reaching energy targets at the lowest societal cost, while fiscal responsibility refers to limited government cost (1785). From the perspective of policymakers and the taxpaying public, Gan et al.’s definition suffices for assessing the cost efficiency of the BETC program. Cost efficiency is measured in public cost per annual (first year) energy unit, measured in dollars ($) per kWh per year.

3.3. Modified McKinsey Cost Curves

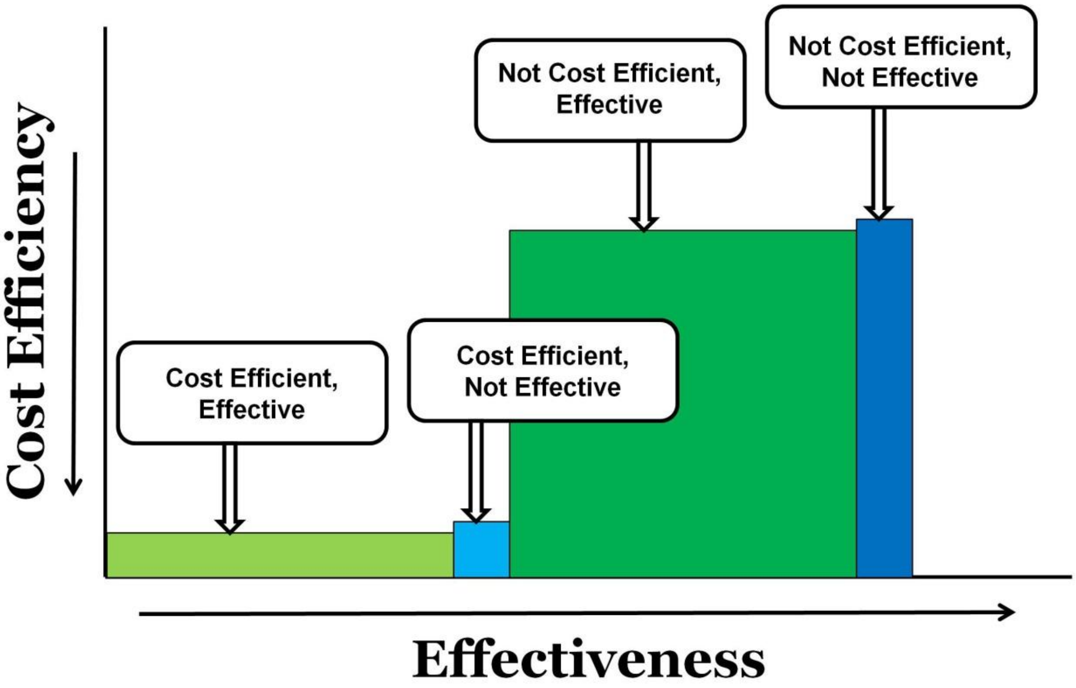
This paper first investigates the cost efficiency and effectiveness of different project categories within the BETC program. The methodological foundation for this research is a cost curve derived from a series of reports published by McKinsey & Company, which has investigated the carbon reduction and financial potential of various energy technologies. Most relevantly, McKinsey & Company have used cost curves to assess the viability of various energy efficiency project types for achieving cost efficient and scalable energy returns on investment (see: Appendix A). This cost curve serves as a template for much of the visual data presented here.

The McKinsey cost curve provides two valuable pieces of information that reflect the two relevant criteria for evaluating the BETC program: cost efficiency and effectiveness. In the cost curve, the y-axis serves as an indication of cost efficiency, whereby the height of the column denotes the cost per unit of energy delivered. Technologies are ranked most to least cost efficient, from left to right. The other piece of information is the effectiveness of these project types based on the scalability of each. No single technology has the potential to scale to achieve all necessary energy needs because projects are bounded by time constraints and supply chain limitations. Energy efficiency and conservation efforts, for example, are ultimately limited in their effective potential by the availability of energy reduction opportunities. The width of each column x-axis on the cost curve indicates the energy potential of each project type.

The modified McKinsey cost curve used in this analysis makes significant substantive changes in the way that energy returns on investment are presented. Primarily, whereas the McKinsey and other analyses used cost curves to assess the future potential of energy efficiency and renewable technologies, this analysis is rooted in historical energy outcomes. This research relies on historical data to illuminate similar questions about the cost efficiency and scalability of various clean energy technologies.

Figure 2 provides a summary for interpreting the clean electricity cost curve used in this analysis. Effectiveness is measured by the total annual energy that have been saved or generated by each project type. The x-axis on the cost curves represents the total first year energy returns by project type (measured in kWh per year). The width of each column signifies the amount of first year energy delivered by all BETC-funded projects within that category over the 30-year history of the program. Whereas the McKinsey cost curve investigated energy potential of certain technologies, this analysis looks at the total amount of energy that has been implemented historically.

Figure 2: Interpreting the BETC Cost Curve



Cost efficiency is measured in tax cost per annually-delivered kWh. The y-axis is measured in dollars per kWh per year, and is the basis for organizing project categories from most to least cost efficient, left to right. As mentioned in the previous section, this annual energy approach is disadvantageous to projects that have relatively long lifetimes, as the energy returned over the first year becomes multiplied over a longer time period. The intention of the project category analysis is to tease out which groups of projects have provided the greatest annual return on public spending over the life of the program.

3.4. BETC Evaluation

The evaluation of the BETC program in aggregate follows a two-pronged approach: an assessment of project-to-project spending on clean electricity to unearth the scale of cost inefficiencies within the program, and then a comparison of the cost efficiency and effectiveness of the BETC program relative to current U.S. performance-based energy incentive programs.

The first portion of this evaluation uses data on BETC-funded clean electricity between 2001 and 2010 to highlight avenues for achieving the same or greater clean electricity returns at less cost. The 10,000+ BETC-funded clean electricity projects are ranked from most to least cost efficient and plotted in a line graph; one line represents the total amount of tax credits issued and the other line represents the total amount of clean electricity corresponding with those credits. Since the most cost efficient projects correlate with greater amounts of clean electricity for less tax credits, the divergence between these two lines broadly summarizes the cost inefficiencies of recent clean electricity spending. The analysis then delves into the make-up of the most and least cost efficient individual projects to evaluate which technologies can be targeted to make investment-based energy incentives more cost efficient.

The second portion of this evaluation directly compares the BETC program to other state-level performance-based energy incentive programs around the country. Four technologies are isolated: solar photovoltaics (PV), biomass, hydro, and wind. A total of 67 U.S. performance-based energy incentives have been aggregated to determine the average annual cost per kWh and contract length for each of these four technologies. This data is used to determine the total program cost per annual kWh (kWh/year). Since the BETC program is an upfront investment[7], and the performance-based energy incentives are funded over time, a net present value calculation is performed to compare the two types of energy incentives on equal terms. The effectiveness of the BETC program relative to these performance-based energy incentives is assessed by investigating the relative scale of the largest programs in the sample. BETC is a state-level program, and

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[7] BETC funding for larger projects is issued over multiple years, but BETC will be assumed to fund projects entirely in the first year.

the performance-based energy incentives range from local- or utility-level to regional-level programs, which makes direct comparisons of effectiveness challenging.

3.5. Sensitivity Analysis & Additionality

One of the essential questions that arises when evaluating the relationship between energy incentives and the corresponding energy returns is whether the energy outcomes were *caused* by the energy incentives. There are a host of confounding variables that muddle the causal line between independent variable (energy incentives) and dependent variable (clean energy outcomes). Confounding variables include other energy incentives and regulations, market conditions, time, and resource availability. This paper approaches one particularly salient complication in assessing the energy returns of the BETC program: additionality.

Additionality is a term rooted in the carbon offset literature, and which addresses the question of whether a project would have occurred anyway without a particular policy mechanism. Additionality takes place when a policy mechanism incurs actions that are not required by law, would not otherwise be financially viable, and cannot be observed in other similar activities that do not utilize the policy mechanism (UNFCCC, 2008). An ECONorthwest study of the BETC program provides a general guideline for investigating additionality within the BETC program: 80% of projects would not have occurred without these investment-based energy incentives (2009). This analysis uses this figure as a baseline for teasing out the additionality impact of BETC on the various project categories being evaluated.

In this paper, the primary driver of additionality is assumed to be the payback period of individual projects. In this scenario, projects that have significantly longer payback periods are more likely to require energy incentives in order make a project financially viable; projects that have shorter payback periods are more likely to be independently financially viable without BETC funding. ODOE records a project payback period estimate for every project that receives BETC funding. Based on this data and ECONorthwest’s 80% figure, the section removes the 20% of projects with the shortest payback period that are assumed to have occurred without BETC funding. Two of the seven wind farms (about 20%) that received the maximum tax credit available are also assumed to be non-additional. Oregon’s major wind farms have run upwards of hundreds of millions of dollars, and, even with a payback of over 10 years, a BETC incentive covering 10% of costs is intuitively less likely to lead to an additional project . Collectively, this sensitivity analysis offers a slightly different picture of the cost efficiency and effectiveness of the different BETC-funded project categories.

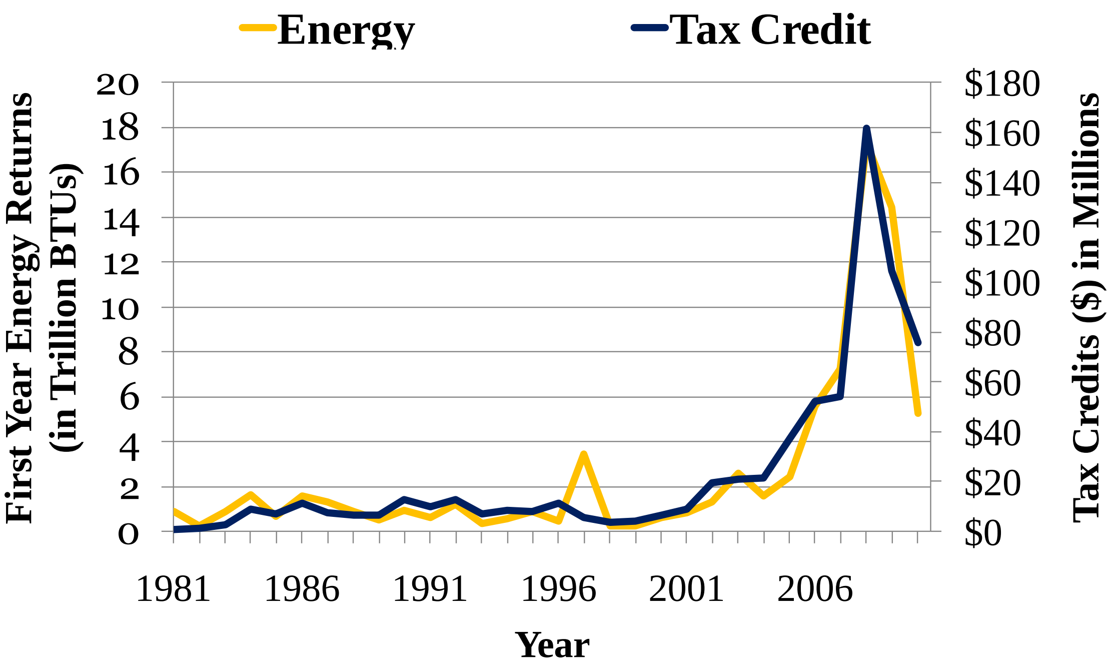
CHAPTER IV

RESULTS

4.1. Summary Statistics

Oregon's Business Energy Tax Credit (BETC) program constitutes one of the largest and longest-standing energy incentive programs in the U.S. Since the program's inception in 1979, over $700 million in conservation and renewable energy[8] tax credits have been issued (see: Figure 3).

Figure 3: BETC Spending and Energy Returns by Year



These $700 million in tax credits have coincided with over 75 trillion BTUs of first year clean energy deployment in the form of conservation and renewable projects[9]. For context, the average Oregonian uses 292 million BTUs of energy per year, including electricity, transportation and heating; the tax credits have therefore been estimated to correlate with enough energy to meet the annualized individual needs of over 260,000

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[8] Excluding Manufacturing, Recycling and RD&D

[9] All BETC-funded energy outcomes are estimates of annual returns provided by the ODOE (see: section 3.1)

Oregonians,[10] or almost 10% of the state's energy needs (EIA, 2011). As per project limits and tax credit percentages increased in the latter part of the 2000's, program costs skyrocketed. Almost twice as many tax credits were issued between 2005-2010 as were issued in all of the 25 years preceding.

The Department of Energy's issuance of investment tax credits has historically been based on the meeting of certain technical requirements and project deadlines to achieve project funding. Over the life of the program, a significant amount of the 26,000 applicants have been approved for tax credit subsidy (see: Table 5). Although *The Oregonian*'s claim that ODOE approved 97% of projects is an overestimate, a significant majority (78%) have been approved once initiating the application process (Esteve, 2009a; ODOE, 2011). A sizable percent have been revoked (12%) or denied (5%), while a smaller fraction have been withdrawn or remain inactive. It is the completed projects that are subject to cost efficiency and effectiveness assessment.

Table 5: BETC Applications by Status

Application Status	# of Applications	%
Completed	20,225	77.8%
Revoked	3,248	12.5%
Denied	1,321	5.1%
Inactive	667	2.6%
Withdrawn	492	1.9%
Rejected	42	0.2%
Grand Total	25,995	100.0%

Source: ODOE, 2011

4.2. Verifying ODOE Estimates

Since the BETC program is an investment-based energy incentive program, clean energy projects are funded based on upfront capital costs rather than the generation or saving of electricity over time. ODOE records energy saved and generated for BETC-funded projects as estimates of annual output. Before any meaningful analysis can take place utilizing these estimates, a verification of their accuracy needs to take place.

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[10] Annual savings not accounting for project lifetimes, which would reduce the total annual savings from funded projects over time

Finding good data on project output can be difficult. Using public data provided by the Northwest Power and Conservation Council and a local utility, this study has isolated real world data on fourteen BETC-funded projects: nine major wind farms, one biomass plant and four small business photovoltaic projects. This sample gives a rough snapshot of the diverse clean electricity projects that are funded under the BETC program. The result from this sample group of projects is that the BETC estimates hold up fairly accurately in relation to real world data (see: Table 6).

Table 6: Comparison of BETC Estimates to Real World Energy Output

		ANNUAL ENERGY ESTIMATES (BETC)		ANNUAL ENERGY OUTPUT		
Project Type	**N=**	**MMBTU/yr.**	**MWh/yr.**	**MW (Average)**	**MWh/yr.**	**ESTIMATE-TO-OUTPUT %**
Windfarm	9	7,660,685	2,245,125	244.1*	2,138,316	**95.2%**
Biomass	1	177,000	51,874	6.7*	58,692	**113.1%**
Photovoltaics	4	3,752	1,100		1046**	**95.4%**

*Source: Northwest Power and Conservation Council, 2011
**Source: EWEB, 2011
BETC Source: ODOE, 2011

ODOE estimates of annual energy output for these fourteen projects are recorded in million BTU per year (MMBTU/yr.), but have been converted to megawatt hours per year (MWh/yr.). Real world data on the larger wind and biomass projects are recorded in average megawatts (MW), which is the power of these energy plants averaged over the course of a year (taken over multiple years of operation). These average MW numbers have been converted to MWh per year to compare with the BETC estimates. The actual energy output for the nine BETC-funded wind farms falls about 5% short of the BETC estimates, while the annual energy output at the biomass plant exceeded BETC estimates by about 15%. The real world annual energy output of the four sample photovoltaic projects was taken from the most recent year, recorded in MWh per year. Similar to the wind farms, the photovoltaic projects fell about 5% short of ODOE estimates.

This sampling of BETC-funded renewable electricity projects provides some evidence that ODOE estimates of annual energy output for BETC-funded projects are accurate. Our sample suggests that real world annual energy output may fall about 5% below the estimates used in the remainder of this analysis. It is important to acknowledge that this is a small sampling of real world data and that there is no way to ensure that all annual energy estimates accurately reflect actual energy output. However, many of the conclusions from the quantitative analysis of these ODOE estimates are strong enough to overcome the potential for slight overestimates in the data.

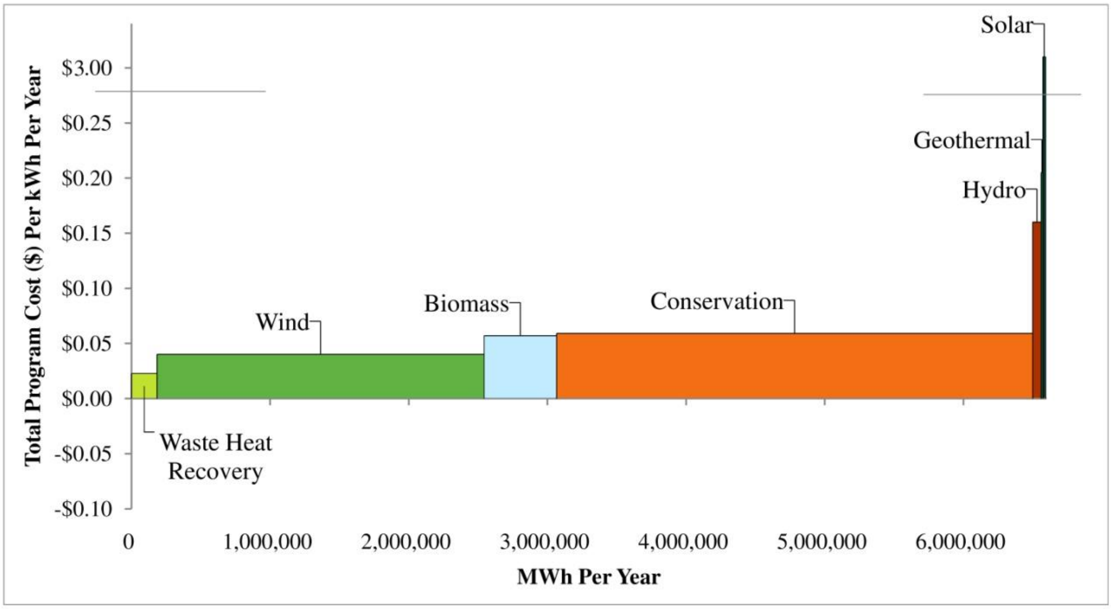
4.3. BETC Cost Curve on Clean Electricity

The investment-based nature of the BETC program has led to vastly different taxpayer investments per unit of energy returned. The basic visual tool for evaluating the cost efficiency and effectiveness of different project categories within the BETC program (wind, solar, etc.) is a cost curve of all spending on clean electricity dating back to the program's inception in 1979. Projects that reduce electricity, such as conservation, and those that generate electricity, such as wind power, are directly compared because both are measured in kWh units of clean electricity.

The vertical axis details the tax cost per annual kWh ($ per kWh per year) for each project category. This vertical axis is used to evaluate the cost efficiency of each project category; the cost curve is organized from most to least cost efficient, left to right. The horizontal axis is used to evaluate the effectiveness of each project category. This data is measured in annual kWh, or kWh per year, and the width of each column measures the total annual clean electricity deployed by each project category over the life of the BETC program. This data on effectiveness serves as a proxy for the ability of each project category to scale to future clean energy needs. The area of each rectangle is equal to the total tax credits in dollars ($) issued for each project category, given by multiplying the $ per kWh per year by the total kWh per year.

Figure 4 and Table 7 detail the BETC cost per annual kWh of seven clean electricity project categories: waste heat recovery, wind, conservation, biomass, hydro, geothermal and solar.

Figure 4: BETC Clean Electricity Cost Curve by Project Category (1981-2010)



Source: ODOE, 2011

Table 7: BETC Clean Electricity by Project Category (1981-2010)

Project Category		Total Program Cost ($)	Annual Energy (MWh/yr.)	Program Cost/ kWh/yr.	Program Cost/ kWh/yr. (2001-2010)*	Program Cost/ kWh/yr. (2006-2010)*	kWh/yr./ Program Cost
Waste Heat Recovery	🟩	$ 4,206,964	183,869	$ 0.02	$ 0.02	N/A	43.7
Wind	🟩	$ 95,050,475	2,359,095	$ 0.04	$ 0.04	$ 0.04	24.8
Biomass	🟦	$ 29,880,239	522,379	$ 0.06	$ 0.15	$ 0.15	17.5
Conservation	🟧	$ 203,175,976	3,433,292	$ 0.06	$ 0.06	$ 0.06	16.9
Hydro	🟥	$ 9,757,250	60,903	$ 0.16	$ 0.22	$ 0.22	6.2
Geothermal	🟩	$ 2,562,761	12,495	$ 0.21	$ 0.20	$ 0.19	4.9
Solar	⬛	$ 48,576,020	20,595	$ 2.36	$ 2.65	$ 2.72	0.4
Total		$ 393,209,685	6,592,626	$ 0.06	$ 0.06	$ 0.06	16.8

Source: ODOE, 2011

Immediately evident is the substantial difference in the effectiveness and cost efficiency of these project categories. Waste heat recovery, which involves capturing unused heat from industrial processes to generate electricity, is twofold the most cost efficient project category at $0.02 per annual kWh (i.e., a one-time taxpayer cost of $0.02 correlates with one kWh per year for as long as the project is operational). However, while highly cost efficient, waste heat recovery is limited in its effectiveness. These projects are founded on inefficiencies within the industrial system that are rare-but-inexpensive sources of clean electricity. Table 7 includes a column on the most recent five years of BETC funding (2006-2010); the lack of any large-scale waste heat recovery projects over this time period suggests that the 'low hanging fruit' of accessible waste heat recovery projects has been tapped.

Wind and conservation are both relatively cost efficient and scalable within the BETC program, at \$0.04 and \$0.06 per annual kWh, respectively. These two project categories collectively account for about 5.8 million of the 6.6 million annual MWh of clean electricity associated with the BETC program. As recipients of about three-quarters of all clean electricity tax credits over the last decade, wind and conservation have been the primary drivers of clean electricity within the BETC program. While conservation has been about 50% more effective than wind power, wind has been about 50% more cost efficient. Wind power achieved over two-thirds of the annual clean electricity of conservation while receiving only half as many tax credits (about \$100 million versus \$200 million, respectively). The cost efficiency of wind and conservation have remained steady in recent years and, thus, these technologies remain viable options within an investment-based energy incentive program.

Biomass falls between wind and conservation in terms of cost efficiency, at \$0.06 per kWh per year. Within the BETC program, biomass has received more tax credits for biofuel production than for electricity production, which has limited the effectiveness of biomass as a tool to deploy clean electricity. Also, the tax cost per annual kWh of biomass electricity has risen substantially in recent years, from \$0.06 averaged over the life of the program to \$0.15 over the last decade. Due to increasing demand on biomass for fuel production, as well as a reduction in supply of available biomass material (wood, organic waste, etc.), the potential for cheap biomass electricity projects is potentially limited. The curve thus overemphasizes the current cost efficiency of biomass for clean electricity production.

Small-scale hydro and geothermal are moderately cost efficient and effective within an investment-based energy incentive program. At \$0.16 and \$0.21 per annual kWh, respectively, these technologies are about three to four times more expensive than wind and conservation. These project categories also have not scaled particularly well in the BETC program, generating about 75 GWh of electricity per year in aggregate, or about one seventh of that generated by biomass. Hydro power has become less cost efficient in recent decades, rising to $0.22 per annual kWh; geothermal has become more cost efficient over recent years and is now roughly comparable to biomass ($0.19 versus $0.15 per annual kWh). Both hydro power and geothermal facilities can have long project lifetimes, of about 30 years compared to 20 years for the remaining project types, which gives them an advantage not captured in the cost curve (ECN, 2001). Thus, although the tax cost per annual kWh for hydro power and geothermal are greater than other sources, these technologies are likely to produce those annual kWh over a longer period of time. This slightly improves the cost efficiency and effectiveness of these project categories relative to other technologies in an investment-based energy incentive program.

Solar projects are neither effective nor cost efficient within the confines of the BETC program. Solar projects have a tax cost per annual kWh ($2.36 per kWh per year) over ten times that of hydro power and geothermal and over fifty times that of wind. The recipient of almost $50 million in tax credits, solar projects have generated roughly 20 GWh of annual electricity. In comparison, wind projects received $100 million in tax credits and generated 20,000 GWh of annual electricity. Most surprisingly, the cost efficiency of solar projects has *decreased* over the last decade, despite the sustained technological advances that have been made in photovoltaic technology over that time period. Thus, it cost more public dollars per unit of solar electricity between 2006-2010 ($2.72) than it did averaged over the life of the program ($2.36). This appears to provide lessons both on the nature of solar as a technology and the cost efficiency of investment-based energy incentive programs. One lesson is that solar is an expensive technology that still requires significant tax cost per unit of clean electricity delivered. However, the lack of solar cost efficiency improvements over time suggests that the upfront funding of the BETC program failed to incentivize the most optimal photovoltaic projects. The combination of expensive technology and an incentive structure based on capital costs rather than electrical output has hindered the cost efficiency and effectiveness of solar in the BETC program.

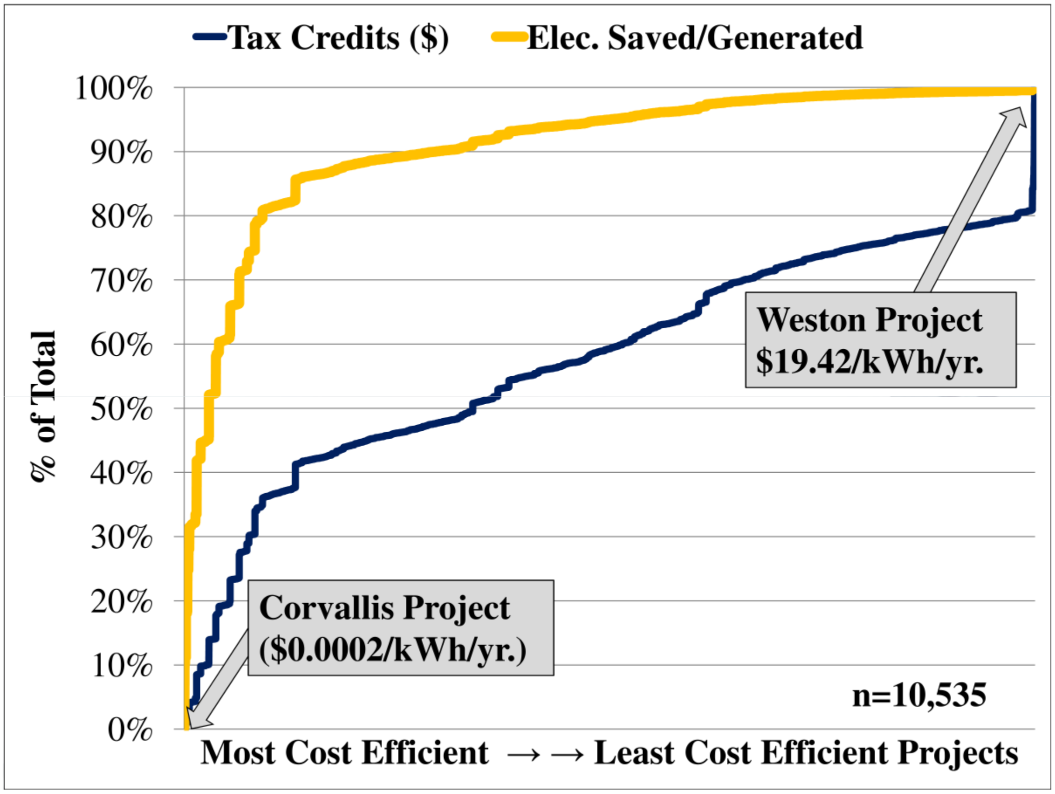
4.4. Internal Cost Efficiency Improvements

The previous section suggested possible avenues for improving the cost efficiency of an investment-based energy incentive program by shifting funding to those project categories that provide the lowest public investment per unit of energy (in kWh per year). This section investigates the BETC program on an individual project level to determine in more detail how the program could have been made more cost efficient. The broad lesson is that much of the clean electricity correlated with the program could have been achieved for less public funding.

Figure 5 is a summary of all tax credits issued for clean electricity projects between the years 2001-2010. Whereas the clean electricity cost curve evaluated BETC electricity returns by project category, this graph uses individual projects to tease out cost inefficiencies at even more granular level. There have been over 10,000 clean electricity projects funded by the BETC program over the 2000’s. The funding structure of an investment-based energy incentive program dictates that the public investment per unit of clean energy fluctuates from project to project, including within a single project category. For example, the most cost efficient BETC-funded electricity conservation project (a lighting modification project in Corvallis, at $0.0002 per annual kWh) is almost 100,000 times more cost efficient than the least cost efficient BETC-funded electricity conservation project (an industrial process modification project in Weston, at $19.42 per annual kWh). These internal variations within project categories can manifest significant program inefficiencies via the funding of least cost efficient projects.

In Figure 5, the 10,000+ BETC-funded clean electricity projects are sorted from most cost efficient on the left (the lowest tax cost per annual kWh, starting with the Corvallis project) to the least cost efficient on the right (the highest tax cost per annual kWh, ending with the Weston project). The blue line indicates the cumulative amount of tax credits that have been issued for these projects as a percentage of the total tax credits. Noticeable jumps in the blue line indicate larger tax credits, such as the $11 million for certain large wind farms (3.6% of total tax credits). The yellow line indicates the cumulative amount of clean electricity associated with these tax credits. The more cost efficient projects on the left are correlated with more clean electricity returns per tax credit than the less cost efficient projects on the right. The yellow line rises at a greater rate than the blue line because a greater percentage of annual clean electricity is deployed for less tax credit investment. The gap between the two lines indicates the degree to which cost efficient projects deployed more clean electricity for less taxpayer cost.

Figure 5: Electricity Saved/Generated as % of Tax Credits (2001-2010)



The figure indicates that certain projects funded by the BETC program were extremely cost efficient relative to the remainder of the projects. Specifically, 13.9% of the clean electricity tax credits were correlated with 52.1% of the program's annual clean electricity over this decade-long period (see: Figure 6). In broader terms, about 10% of the BETC incentives for clean electricity corresponded with half of the annual clean electricity returns. Receiving about $43 million of the $305 million in BETC tax credits for clean electricity, these projects total 2.6 annual tera-watt hours (TWh)[11] of electricity generated or saved, at a one-time public cost of $0.02 per kWh per year (see: Table 8). For low levels of public financial input, these top 10% most cost efficient projects were correlated with a substantial amount of the total clean electricity associated with the program.

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[11] 1,000,000,000 kWh = 1,000,000 MWh = 1,000 GWh = 1TWh

Figure 6: Electricity Saved/Generated as % of Tax Credits (2001-2010) v2

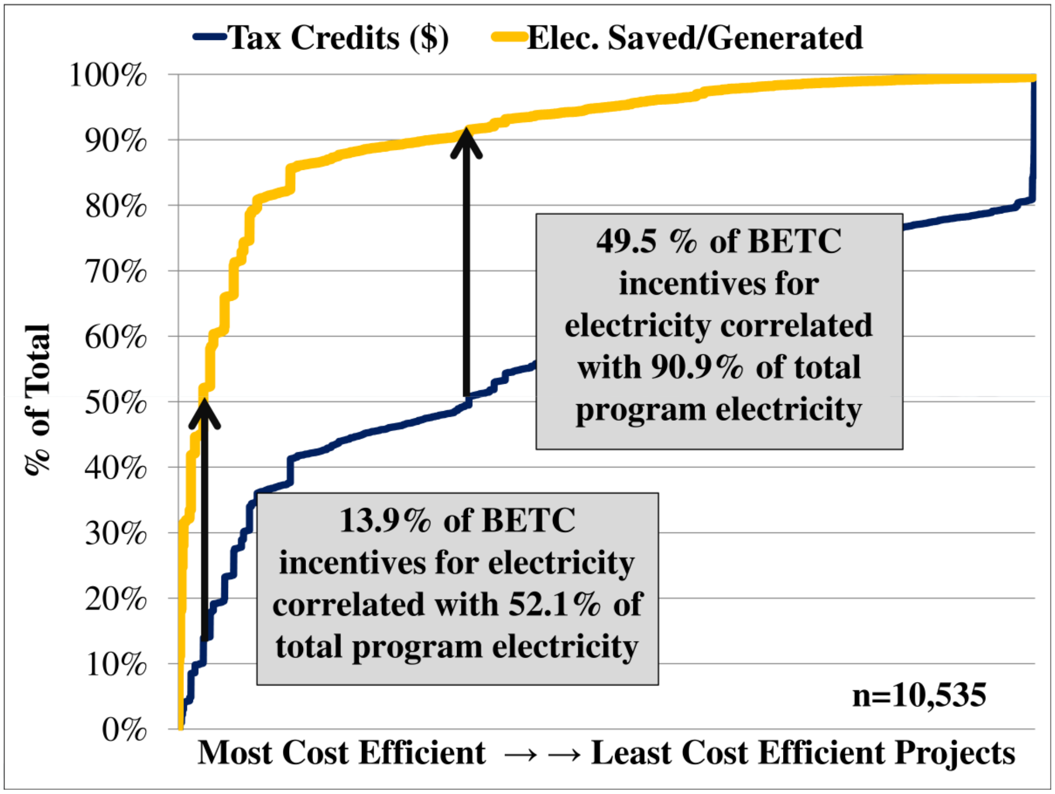


Table 8: Summary by Cost Efficiency Grouping

Cost Efficiency Grouping	Program Cost	MWh/Yr.	Program Cost /kWh/Yr.
Top 10%	$42,500,925	2,579,869	$0.02
Next 40%	$108,524,055	1,923,333	$0.06
Bottom 50%	$154,105,479	449,197	$0.34
Total	$305,130,459	4,952,399	$0.06

Source: ODOE, 2011

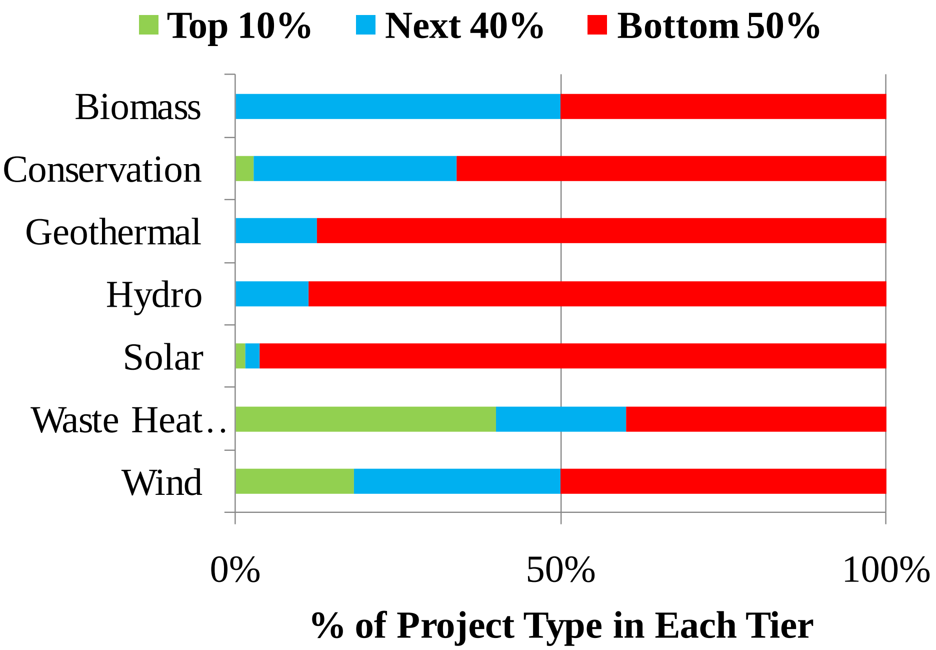
49.5% of the most cost efficient BETC-funded clean electricity projects were correlated with 90.9% of the annual clean electricity during this time period. Or, about half of BETC incentives for clean electricity between 2001-2010 corresponded with all but 10% of the total clean electricity delivered. This suggests that, in addition to the very cost efficient projects, there are another subset of projects (the “next 40%” in Table 8) that are moderately cost efficient recipients of BETC funds. These projects represent the “average” use of BETC spending, in that 1% of the tax credits are correlated with about 1% of corresponding clean electricity returns. These projects received $109 million in BETC funding and delivered 1.9 annual TWh of clean electricity, at about the BETC average for clean electricity of $0.06 per kWh per year.

These statistics also suggest that there are a significant amount of cost inefficient projects as well: the 50% least cost efficient tax credits are correlated with only 10% of the annual electricity savings and generation over this timeframe. $150 million in BETC funding corresponded with about one half TWh of annual clean electricity, at a rate of $0.34 per kWh per year. The retrospective lesson is that the BETC program could have derived a substantial portion of the electricity obtained by the program at half of the cost.

In order to understand the make-up of the most and least cost efficient individual projects, Figure 7 shows the project category ratio in the each segment of cost efficiency (top 10%, next 40% and bottom 50%). The lessons learned parallel much of what was gathered from the clean electricity cost curve. The top 10% most cost efficient individual projects are made up of 4 project categories: conservation, solar, wind and waste heat recovery. Wind and waste heat recovery have a significant fraction of their total projects in the top 10%. Conservation and, surprisingly, solar, have a small percentage of their projects in the top 10%. By retaining only these most 10% most cost efficient clean electricity projects, 50% of the total clean electricity in the BETC program could have been achieved.

Collectively, the top 10% and the next 40% of cost efficient projects are made up of all seven clean electricity technologies, although in varying degrees. This suggests that, within the BETC programs, projects of all types have been part of the high- and mid-range cost efficient projects that have made up the bulk of BETC annual clean electricity delivery. Half or more of the biomass, wind, and waste heat recovery projects fall into the top 50%. Conservation is heavily represented, followed by a smaller fraction of the moderately cost efficient geothermal and hydro power technologies. Solar, while present in the top 50% most cost efficient projects, is largely captured in the least cost efficient BETC-funded projects. By retaining only these top 50% most cost efficient projects, 90% of the clean electricity correlated with the BETC program could have been achieved. Or, from another perspective, a doubling in funding for projects akin to the 50% most cost efficient could have achieved an 80% increase in the clean electricity delivered (90% of clean electricity + 90% = 180% of annual clean electricity deployment).

Figure 7: Project Category Breakdown, by Cost Efficiency Grouping



Source: ODOE, 2011

The broader policy lesson is twofold. Firstly, investment-based energy incentive programs can be reformed to better account for these vastly diverging electricity returns on public investment. Section 4.3 outlined the divergence in tax cost per electricity return on a project category level, highlighting the technologies that can achieve the optimal clean electricity returns on public investment. This section explored cost inefficiencies within the program at an even more detailed level and found that certain individual projects are far more cost efficient than others. Although these cost efficiencies largely parallel those gleamed from the clean electricity cost curve, it is clear that there is a role for all technologies in optimizing clean electricity output. The goal should be to both emphasize cost efficient technologies and to incentivize the most cost efficient projects within each category. Solar, for example, while generally expensive, is also represented in the top 10% most cost efficient projects for delivering clean electricity in the BETC program. Second, these statistics may suggest that inefficiencies are embedded in the BETC program because of the funding structure of investment-based energy incentives more broadly. By funding capital investment rather than energy output, BETC funds both cost efficient and cost inefficient projects alike. To evaluate the cost efficiency of the BETC program as a whole, the next section compares the total program tax cost per kWh per year against other statewide performance-based energy incentive programs.

4.5. Comparing BETC to Performance-Based Energy Incentives

The previous sections have used internal spending patterns within the BETC program to evaluate the cost efficiency and effectiveness of different patterns of BETC spending. The significant cost efficiency disparities of individual projects called into question, but did not negate, the cost efficiency of the program as a whole. The lesson was more about the ability to make incentive-based energy incentives more cost efficient and effective, rather than evaluating these energy incentives as a whole. This section investigates the relative cost efficiency and effectiveness of investment-based energy incentives by comparing the BETC program against a sample of performance-based energy incentives from around the U.S.

Performance-based energy incentives tend to exist only for renewable electricity generation, so this section narrows the analysis to include only four sources of renewable electricity: solar photovoltaics (PV), biomass, hydro power and wind. There are a scattering of performance-based energy incentives for geothermal, but not enough to merit a full analysis. In all, the Database of State Incentives for Renewable Energy (DSIRE) contains 67 performance-based energy incentive policies spread amongst the four technology types. Any regional-, state- , local- or utility-level policy was included if the database included information on: a) qualifying technologies; b) dollars incentive per kWh; and c) contract term length. Although not all confounding variables are addressed directly (other renewable energy policies, resources availability, etc.), the regional diversity of the energy incentives counteracts much of the potential systemic influence of external variables. Using this sample of programs, dollars per kWh and contract term lengths were averaged for each of the four technologies (see: Table 9). An average total program cost per annual kWh was determined for each of these technologies by multiplying the annual program cost by the contract term length. Information on the size of each program, as a proxy for effectiveness, is included in some but not all of the performance-based energy incentive programs (addressed later in this section).

Table 9: Aggregated Performance-Based Cost Per Annual kWh

	Annual Program Cost/ kWh/yr.	**Terms (Years)**	**Total Program Cost/ kWh/yr. (Undiscounted)**
PV Average	$0.22	12.7	$2.79
Biomass Average	$0.18	10.3	$1.88
Hydro Average	$0.17	13.9	$2.40
Wind Average	$0.17	12.7	$2.10
Total Average	**$0.19**	**12.4**	**$2.38**

Source: DSire, 2011

The BETC program cost per kWh per year for each of these four project categories is included in Table 10. The only significant changes in these figures from the previous section is for solar PV, which is significantly less cost efficient when solar water heating projects are removed ($3.29 per annual kWh for PV versus $2.36 per annual kWh including solar water heating). Table 9 and the BETC data from Table 10 are measured in total program cost per kWh per year (i.e., total program cost per kWh delivered every year that the project remains in operation). Performance-based energy incentives have the advantage of guaranteeing that the projects remain in operation over the lifetime of the contract, which can range upwards of 20-25 years. However, the average contact length for these four technologies is 12.4 years, which is well within the range of assumed project lifetimes for renewable electricity projects (ECN, 2001). In order to compare the BETC program with the aggregated performance-based energy incentive programs, both must be put into net present value terms.

The BETC program is assumed to be an upfront cost, and therefore is already in net present value terms. In order to equalize this upfront cost with performance-based energy incentives, which are paid out over multiple years, a 6% discount rate is applied to future year spending over the contract length of each technology (see: Appendix C). The result is a decrease in the program cost of the performance-based energy incentive programs when put into net present value terms (see: Table 10). Both the BETC and the performance-based energy incentive figures are in total net present value program cost per kWh per year.

Table 10: Total Program Cost Efficiency Comparison, Net Present Value

	BETC Program Cost/ kwh/yr.	Performance-Based Program Cost/ kWh/yr. (Discounted at 6%)
Solar PV	$3.29	$2.03
Biomass	$0.07	$1.43
Hydro	$0.22	$1.69
Wind	$0.04	$1.53
Total	**$0.06**	$1.55

Source: ODOE, 2011

The cost efficiency of the BETC program is evident for biomass, hydro and wind technology. Historical data on the BETC program concludes that biomass electricity has had a tax cost of $0.07 per kWh per year. In the aggregated performance-based energy incentive programs, that same kWh per year has a net present value program cost of $1.43. Although biomass projects have become less cost efficient in recent years in the BETC program (about $0.15 per kWh per year), the technology still holds a cost efficiency advantage over the same technology in these other program. Hydro power is similarly cost efficient, at $0.22 per annual kWh within the BETC program versus $1.69 per annual kWh in the aggregated performance based energy incentive programs.

Wind is particularly cost efficient, at a onetime tax cost of $0.04 per kWh per year compared to $1.53 per kWh per year averaged over the performance-based energy incentive programs. Under the BETC program, Oregon’s nine largest wind farms received $83 million in tax credits (see: Table 11). Based on real world data obtained from Northwest Power and Conservation Council, these nine wind farms have collectively averaged 244 MW of power over the latter part of the 2000's. A simple conversion nets over 2.1 TWh of annual electricity generated by these wind farms. The BETC program's $83 million correlated with 2.1 TWh of annual electricity equates to a program cost of $0.039 per kWh per year.

Table 11: Cost Efficiency of BETC's Nine Largest Wind Farms

Tax Credits ($)	MW (Average)*	kWh/yr.	Program Cost /kWh/yr.
$ 83,000,000	244	2,138,316,000	$ 0.039

Source: ODOE, 2011

*Power plant energy output data comes from the Northwest Power and Conservation Council

In comparison, Indianapolis Light & Power Company offer $0.107 per kWh of wind electricity over 10 years. At this program cost of $1.07 per kWh per year, Oregon's nine largest wind farms would have had a tax cost of $2.3 billion. Only Duke Energy's performance-based energy incentive is comparable to the BETC program's large wind farms, at $0.006 per kWh over 10 years ($0.06 program cost per kWh per year). These nine wind farms would have had a tax cost of $128 million under the incentive structure of the Duke Energy program. For a list of the performance-based energy incentives used in this assessment, see: Appendix D.

Solar PV in the BETC program is less cost efficient than in this sample of performance-based energy incentive programs. At a tax cost per annual kWh of $3.29, BETC has program cost over 50% higher per annual kWh than in the aggregated performance-based energy incentives (net present value of $2.03 per annual kWh). The nearly $50 million in tax credits for solar PV in the BETC program would have generated more clean electricity under the incentive structure of these other programs. Overall, the BETC program, as a case study of investment-based energy incentives, can be said to be at least moderately cost efficient in relation to current U.S. energy incentive policies. Even accounting for the potentially slight overestimates of the ODOE data, and the fact that BETC funding does not guarantee long-term project operation, the historical data suggests that the program has cost efficiently delivered biomass, hydro and wind facilities in relation to this sample of performance-based energy incentives. The significant difference in cost efficiency allows for a large margin of error when forming this conclusion.

It is more difficult to assess the effectiveness of the BETC program in relation to these performance-based energy incentives. Many of the sample programs are recent, including pilot programs, while others are locally- or utility-based. However, a surface-level comparison of the BETC program to the largest performance-based energy incentive programs highlights the large amount of electricity correlated with the BETC program (see: Table 12). The BETC program's largest project was the equivalent of 130 MW, far greater than any project limit in the sample of large performance-based energy incentive programs. The BETC program has also averaged about 160 MW of grid-connected nameplate capacity per year over the last ten years. This is greater than most of the other programs aim to deliver over the course of their multi-year funding periods. The simple lesson is that BETC and investment-based energy incentive programs can be an effective driver of clean energy relative to performance-based energy incentives.

Table 12: Effectiveness Comparison Against Large Performance-Based Programs

Program Name	Tech.*	Project Limit (Nameplate kW)	Program Limit (Nameplate MW)
TVA - Mid-Sized Standard Offer Program	B, H, S, W	20,000	100
TVA - Generation Partners Program	B, H, S, W	200	200
Vermont Standard Offer Program	B, H, S	2,200	50
Biomass Energy Prod. Incentive (S. Carolina)	B	1,000	21
Community Based RE Prod. Incentive (Maine)	B, H, S, W	10,000	50
Large Performance-Based Program Avg.		**6,680**	**84.2**
BETC (Annual)**	**B, H, S, W**	**130,625**	**161.7**

*B=Biomass, H=Hydro, S=Solar, W=Wind

**Converted from kWh to kW Based on 32% Capacity Factor

Source: Dsire, 2011; ODOE, 2011

4.6. Sensitivity Analysis & Additionality

One assumption implicit in the comparison of BETC to performance-based energy incentives is that all policies are subject to equal considerations of additionality. The assumption is that there is no difference between the influence of investment-based energy incentives and performance-based energy incentives on the decision making process, only the total subsidy available. Thus, each policy is equally likely to subsidize non-additional projects that would have occurred without the energy incentive. Evaluating this assumption in more detail is beyond the scope of this analysis.

However, this analysis attempts to account for the varying impacts of additionality on project categories within the BETC program. The rationale is that certain project categories are more likely to be independently viable without BETC incentive funding, and are thus more likely to be non-additional projects that would have occurred without energy incentives. Additionality is notoriously difficult to isolate: of the 20,000+ projects funded over the 30-year history of the BETC program, which projects would have been developed independent of these energy incentives? In order to approach this question, this assessment will assume that non-additionality is rooted in the financial viability of individual projects. The assumption will be that those projects most likely to be non-additional are those that have the shortest payback periods according to ODOE data recorded at the time of project funding.

ECONorthwest estimates that 80% of BETC-funded projects would not have occurred without these investment tax credits (2009). Reversely, 20% of projects would have been deployed regardless of BETC incentives. These are the non-additional projects that this analysis seeks to remove. BETC-funded projects differ substantially in the payback period on investment, from under 1 year to more than 99 years. Using the 20% non-additional figure as a starting point, this sensitivity analysis removes the 20% of projects with the lowest payback periods and re-assesses the cost efficiency of each technology.

The 20% lowest project payback periods are those projects that recoup investment in under 4.3 years. Any project with a payback period of greater than 4.3 years will be assumed to be additional. Also included in the non-additional group are 20% of large wind farms, despite their average of 10 year payback periods. The rationale is that these projects range upwards in the hundreds of millions of dollars, and are thus less likely to rely on BETC funding to green light their projects. No other clean electricity project category was eligible for a maximum credit of $10 million.

The resulting table (Table 13) has two major changes that highlight the potential impact of additionality on the cost efficiency of the respective project categories. Conservation increases from $0.06 to $0.09 per kWh per year when the 20% least payback period projects are removed. This is equivalent to a 50% reduction in cost efficiency of conservation as a project category. The lesson is that many conservation projects pay themselves off over a shorter period of time and are more likely not to have needed BETC funding; the remaining conservation projects more accurately reflect the cost of additional projects. The impact on biomass is even more significant: a five-fold cost efficiency reduction from $0.06 to $0.31 per annual kWh suggests that non-additional biomass projects artificially increase the perceived cost efficiency of these projects. Many biomass projects within the BETC program have a very low payback period, and when these projects are removed biomass looks less attractive than moderately-cost efficient project categories like hydro and geothermal. Surprisingly, this sensitivity analysis does not affect wind, which remains both cost efficient and effective.

Table 13: Senstitivity Analysis for Additionality

Project Category	Total Program Cost ($)	Annual Energy (MWh/yr.)	Program Cost/ kWh/yr. (Adjusted)	Program Cost/ kWh/yr. (Unadjusted)
Waste Heat Recovery	$ 3,789,701	169,385	$ 0.02	$ 0.02
Wind	$ 73,050,475	1,748,792	$ 0.04	$ 0.04
Conservation	$ 167,050,699	1,826,150	$ 0.09	$ 0.06
Hydro	$ 9,695,202	60,367	$ 0.16	$ 0.16
Geothermal	$ 2,464,875	11,113	$ 0.22	$ 0.21
Biomass	$ 14,370,731	46,744	$ 0.31	$ 0.06
Solar	$ 48,530,604	19,706	$ 2.46	$ 2.36
Total	$ 318,952,287	3,882,256	$ 0.08	$ 0.06

Source: ODOE, 2011

CHAPTER V

CONCLUSION

In investigating the cost efficiency and effectiveness of different project categories within an investment-based energy incentive program, it is clear that there are avenues for improvement. Wind and conservation offer low cost, scalable technologies that can drive significant amounts of clean electricity at a low public cost per unit of energy delivered. These technologies have remained cost efficient well into the 2000's. Biomass, and particularly waste heat recovery, are cost efficient niche clean electricity options that should be considered when applicable. Waste heat recovery has not been effective over recent years, and biomass has become less cost efficient over time. Both of these characteristics limit the ability of these project categories to be primary targets for sizable clean electricity deployment. Hydro and geothermal power are moderately cost efficient, and offer other advantages such as longer project lifetimes relative to other project categories. These technologies may be somewhat limited in their ability to effectively scale, based on the low quantity of clean electricity delivered compared to other technologies. Solar is an expensive technology that has been neither cost efficient nor effective within the BETC program. Most strikingly, the tax cost per annual kWh for solar power has increased over the course of the decade, which suggests that solar does not perform well in an investment-based energy incentive program. Over-reliance on solar funding can overwhelm an incentive program and remove much needed funding for more cost efficient and effective technologies.

There is significant opportunity for cost efficiency improvements on a project-to-project level within the BETC program. Roughly 10% of BETC incentives for clean electricity are correlated with 50% of annual clean electricity returns, and 50% of BETC incentives are correlated with 90% of annual clean electricity returns over the last decade. The incentive structure of an investment-based program such as BETC is going to fund cost efficient and cost inefficient projects equally. The result is that certain projects produce far greater clean energy returns at less cost compared to other projects. In order to optimize the cost efficiency of the program, BETC funding should target the most cost efficient projects within each technology. All project categories have individual projects that fall within the top 50% of cost efficient clean electricity projects funded between 2001-2010. This suggests that cost efficiency criteria can be utilized to fund those projects with the greatest electricity returns on investment—ODOE has already moved to considering cost efficiency, amongst other criteria, in its funding decisions. One strategy is to screen projects so that the 50% least cost efficient projects do not receive BETC funding, which would have saved about $150 million of public funds over the last decade. Another strategy is to use those funds to redouble clean energy efforts, and target a balance of technologies based on cost efficiency to significantly increase the total clean electricity associated with the BETC program.

Despite these cost inefficiencies in the historical spending patterns of the BETC program, Oregon's public energy spending holds up well against a sample of performance-based energy incentives from around the U.S. For biomass, hydro power, and wind, BETC energy incentives are more cost efficient than relative performance-based energy incentive programs. Wind, in particular, requires much less total program cost per kWh per year than in comparable performance-based energy incentive programs; Oregon's nine large wind farms would have required significantly more public spending under the incentive structure of these other regional- and utility-based programs. Solar PV is the exception to the cost efficiency of the BETC program, requiring over 50% more cost per annual kWh than comparable programs. The lesson for other policymakers is that non-PV technologies, such as biomass and wind, may require less funding per kWh in a performance-based energy incentive program than is currently available.

The BETC program has undoubtedly been an effective driver of clean electricity in Oregon. Assuming that 80% of projects would not have occurred without BETC funding (ECONW, 2009), most of the substantial changes in the statewide clean energy landscape can be attributed to the BETC program. The challenge has been sustaining this effectiveness over a long period of time—a common critique of investment tax credits. Investment-based energy incentives require a significant amount of upfront public cost, which can make the programs more financially burdensome in the short-term than performance-based energy incentive programs. Thus, even a cost efficient program like BETC can become unsustainable if the scale of public spending becomes too large. Recent controversies over the BETC program and upcoming legislative changes likely to reduce its clean energy impacts suggest that effectiveness can be a double-edged sword. While driving significant amounts of renewable energy and conservation projects is a favorable policy goal, the extent of these goals are ultimately limited by the availability of public funds and political support. While more cost efficient than the sample of performance-based energy incentive programs, the scale and upfront incentive structure of the BETC program have threatened to derail its success.

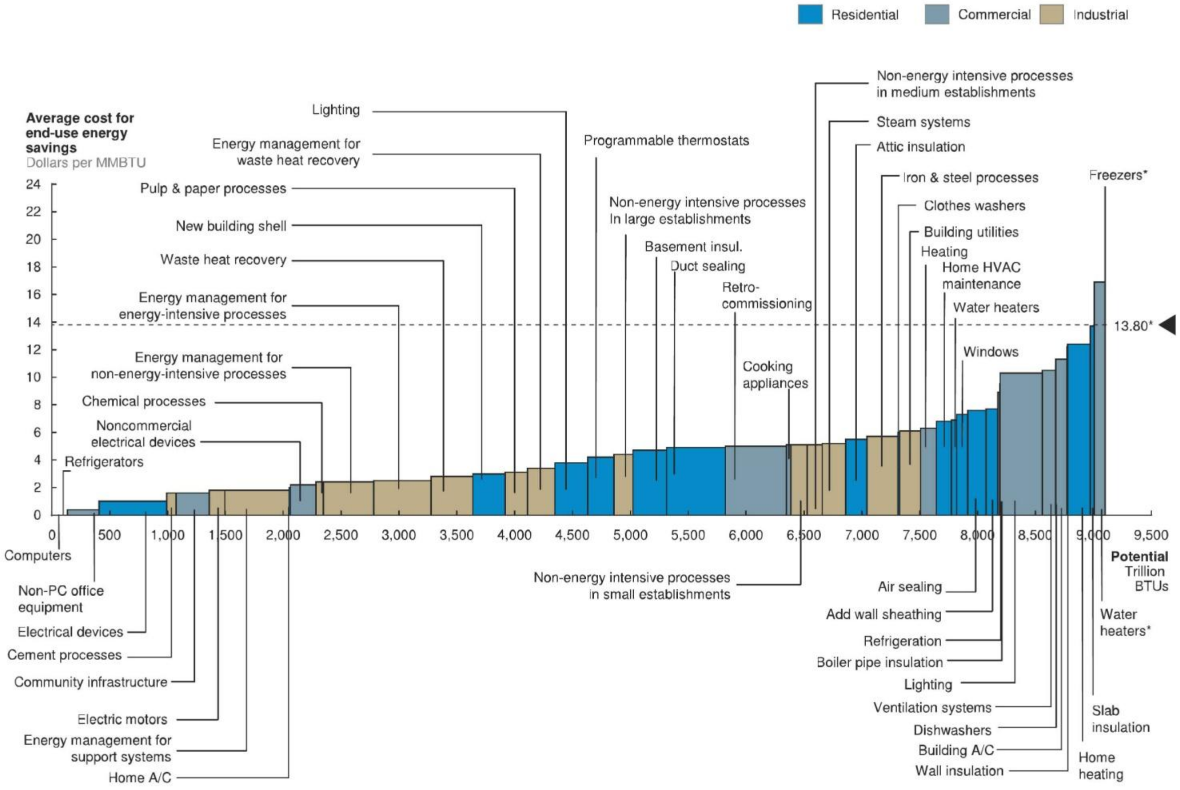
There are limitations to this analysis that should be considered. Assessing energy incentive programs and project categories based on clean energy returns is a simplification of the broader policy goals surrounding energy in the 21st century. Energy returns are only one of many available indicators that should be considered when making an energy-related policy decision. Also relevant are considerations of green jobs that can be created or sustained, the community ownership potential of these technologies, and the development of a diverse array of project categories rather than a singular technological focus. Recent experience with wind in Oregon highlights the importance of jobs as an area of political focus during economic stagnation; major wind farms create large amounts of clean electricity but few permanent jobs (Esteve, 2011). Wind electricity is also more complex than a simple kWh designation would indicate: there have been many challenges in the Pacific Northwest matching off-peak wind generation with the periods when people need electricity the most. Biomass has had its share of controversy as well, for the localized pollution and harmful ecosystem effects that it incurs. An assessment of tax cost per energy unit tells an important, but ultimately incomplete, side of the story.

More research needs to be done on the economic valuation of these different energy sources in Oregon and the Pacific Northwest. The external costs of biomass should be calculated and included in the per kWh cost of electricity whenever project decisions are made. More information is also needed on the impact of the time-of-day when electricity is delivered. How much of an impact does wind’s intermittency have on the cost per unit electricity versus the peak availability of a solar PV array? Energy systems need cost efficient kWh, but also certain kinds of cost efficient kWh that incorporate these other factors into the true cost of every unit of energy. More studies need to be done to substantiate the economic impacts of these factors so that more informed energy policy decisions can be made.

Lastly, it is important that energy incentives are focused on the long-term shift towards more a sustainable energy system in the Pacific Northwest. Uncertain and stop-start energy policy hinders the region's ability to foster sustained development of renewable energy and conservation industry. The relative cost efficiency of the BETC program shows that investment-based energy incentive programs work, but they require a significant amount of financial sacrifice in the short-term to achieve larger energy policy goals. Energy incentives are an investment in the many economic, social, and ecological benefits of clean energy proliferation. Stability, along with cost efficiency and effectiveness, needs to be harnessed to achieve these benefits of clean energy well into the 21st century.

APPENDIX A

MCKINSEY COST CURVE

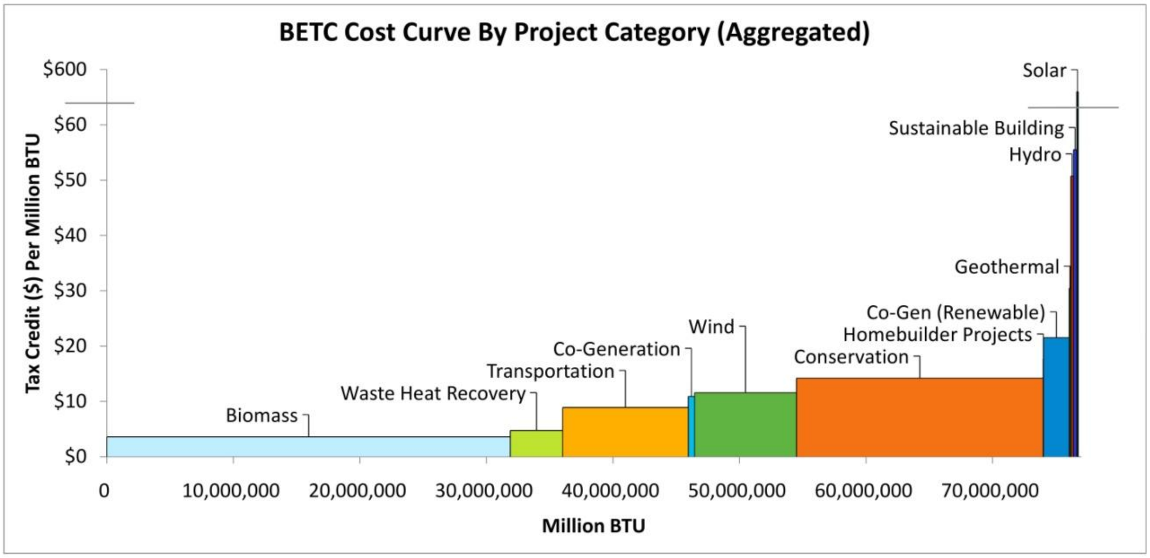


* Average price of avoided energy consumption at the industrial price; $35.60/MMBTU represents the highest regional electricity price used; new build cost based on AEO 2008 future construction costs

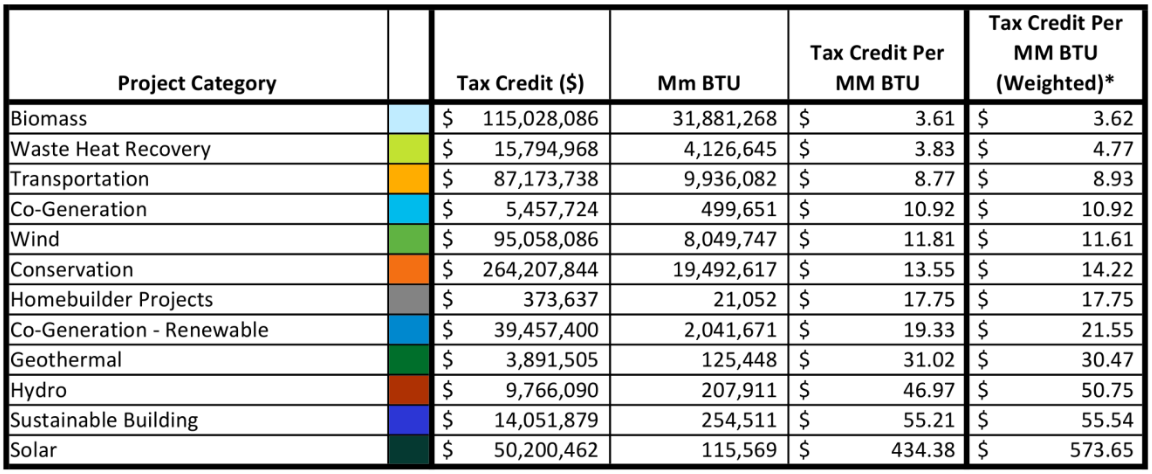
Source: EIA AEO 2008, McKinsey analysis

APPENDIX B

DETAILED BETC COST CURVES

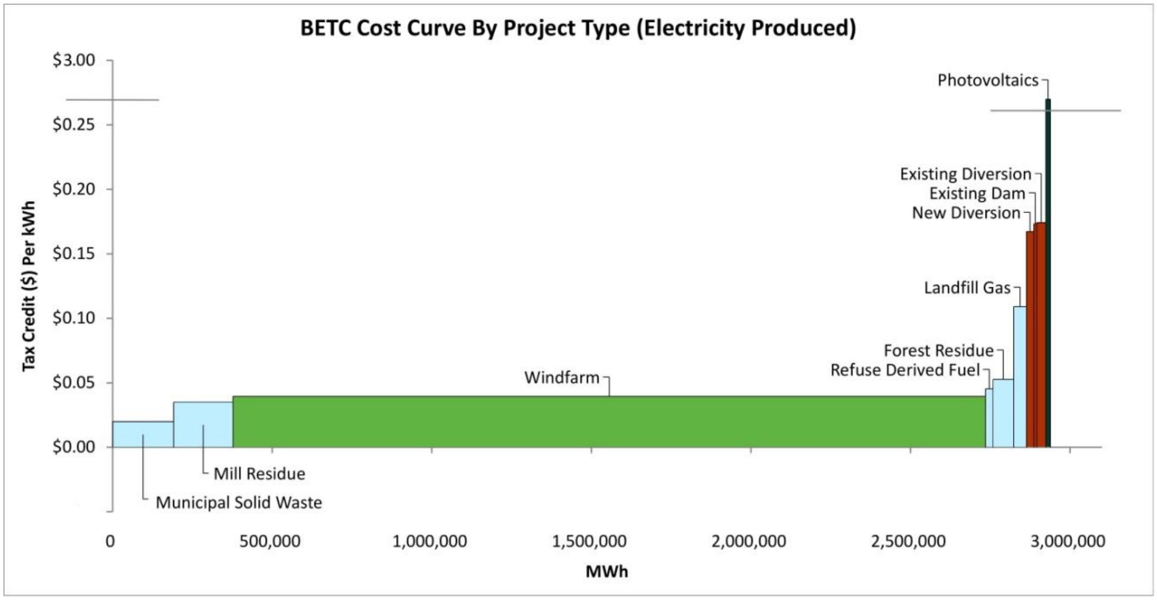


Source: ODOE, 2011



Project Category		Tax Credit ($)	Mm BTU	Tax Credit Per MM BTU	Tax Credit Per MM BTU (Weighted)*
Biomass	🟦	$ 115,028,086	31,881,268	$ 3.61	$ 3.62
Waste Heat Recovery	🟩	$ 15,794,968	4,126,645	$ 3.83	$ 4.77
Transportation	🟧	$ 87,173,738	9,936,082	$ 8.77	$ 8.93
Co-Generation	🟦	$ 5,457,724	499,651	$ 10.92	$ 10.92
Wind	🟩	$ 95,058,086	8,049,747	$ 11.81	$ 11.61
Conservation	🟧	$ 264,207,844	19,492,617	$ 13.55	$ 14.22
Homebuilder Projects	⬛	$ 373,637	21,052	$ 17.75	$ 17.75
Co-Generation - Renewable	🟦	$ 39,457,400	2,041,671	$ 19.33	$ 21.55
Geothermal	🟩	$ 3,891,505	125,448	$ 31.02	$ 30.47
Hydro	🟥	$ 9,766,090	207,911	$ 46.97	$ 50.75
Sustainable Building	🟦	$ 14,051,879	254,511	$ 55.21	$ 55.54
Solar	⬛	$ 50,200,462	115,569	$ 434.38	$ 573.65

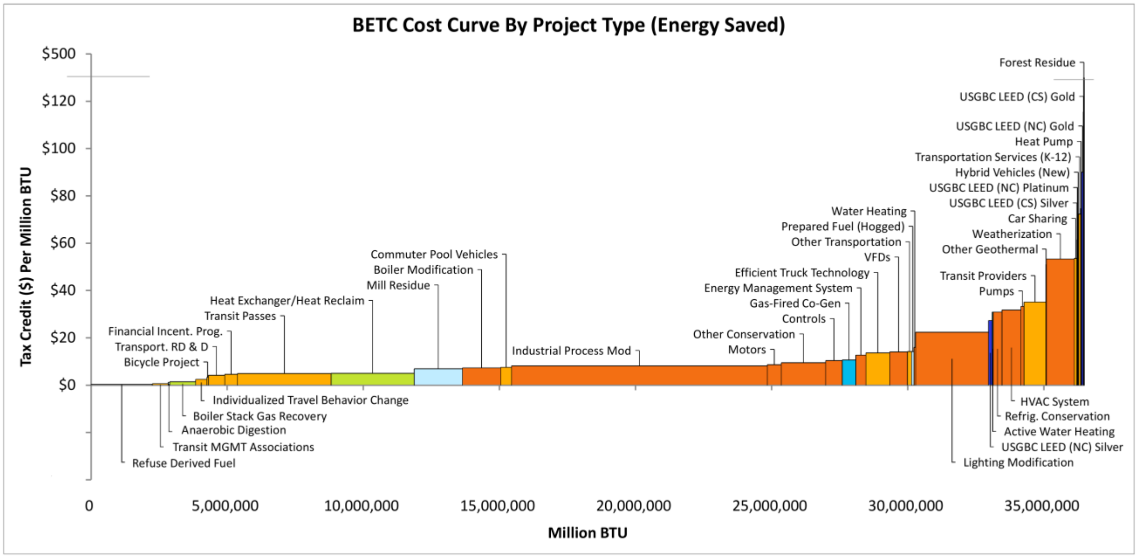
Source: ODOE, 2011



Source: ODOE, 2011

Project Type	Project Category		Tax Credit ($)	MWh	Tax Credit Per kWh	Tax Credit Per kWh (Weighted)*
Municipal Solid Waste	Biomass	🟦	$ 3,822,055	190,808	$ 0.02	$ 0.02
Mill Residue	Biomass	🟦	$ 6,506,620	185,931	$ 0.03	$ 0.04
Windfarm	Wind	🟩	$ 94,924,210	2,358,211	$ 0.04	$ 0.04
Refuse Derived Fuel	Biomass	🟦	$ 1,054,741	23,208	$ 0.05	$ 0.05
Forest Residue	Biomass	🟦	$ 3,403,649	64,623	$ 0.05	$ 0.05
Landfill Gas	Biomass	🟦	$ 4,059,320	40,314	$ 0.10	$ 0.11
New Diversion	Hydro	🟥	$ 3,809,120	22,770	$ 0.17	$ 0.17
Existing Dam	Hydro	🟥	$ 928,015	9,123	$ 0.10	$ 0.17
Existing Diversion	Hydro	🟥	$ 4,854,723	28,452	$ 0.17	$ 0.17
Photovoltaics	Solar	⬛	$ 47,303,503	14,364	$ 3.29	$ 3.31

Source: ODOE, 2011


BETC Cost Curve By Project Type (Energy Saved)

Project Type	Project Category		Tax Credit ($)	Mm BTU	Tax Credit Per MM BTU	Tax Credit Per MM BTU (Weighted)*
Refuse Derived Fuel	Biomass	🟦	$ 1,079,595	2,246,765	$ 0.48	$ 0.43
TMA (Transit Management Associations)	Transportation	🟨	$ 375,823	585,590	$ 0.64	$ 0.67
Anaerobic Digestion	Biomass	🟦	$ 67,443	52,544	$ 1.28	$ 1.28
Boiler Stack Gas Recovery	Waste Heat Recovery	🟩	$ 1,350,741	953,634	$ 1.42	$ 1.47
Individualized Travel Behavior Change	Transportation	🟨	$ 1,035,312	412,442	$ 2.51	$ 2.51
Bicycle Project	Transportation	🟨	$ 175,339	52,200	$ 3.36	$ 3.38
Transportation RD & D	Transportation	🟨	$ 2,541,162	603,149	$ 4.21	$ 4.20
Financial Incentive Programs	Transportation	🟨	$ 2,192,608	468,939	$ 4.68	$ 4.65
Transit Passes	Transportation	🟨	$ 16,706,588	3,439,928	$ 4.86	$ 4.96
Heat Exchanger/Heat Reclaim	Waste Heat Recovery	🟩	$ 13,004,770	3,051,438	$ 4.26	$ 5.06
Mill Residue	Biomass	🟦	$ 6,579,119	1,771,361	$ 3.71	$ 6.97
Boiler Modification	Conservation	🟧	$ 7,972,395	1,406,613	$ 5.67	$ 7.32
Commuter Pool Vehicles	Transportation	🟨	$ 3,025,485	397,212	$ 7.62	$ 7.59
Industrial Process Mod	Conservation	🟧	$ 77,196,396	9,395,463	$ 8.22	$ 8.21
Motors	Conservation	🟧	$ 4,226,471	514,301	$ 8.22	$ 8.70
Other Conservation	Conservation	🟧	$ 15,276,963	1,630,588	$ 9.37	$ 9.52
Controls	Conservation	🟧	$ 5,085,630	609,007	$ 8.35	$ 10.46
Gas-Fired Co-Gen	Co-Generation	🟦	$ 5,327,302	497,950	$ 10.70	$ 10.70
Energy Management System	Conservation	🟧	$ 4,910,722	371,039	$ 13.24	$ 12.73
Efficient Truck Technology	Transportation	🟨	$ 11,950,445	873,277	$ 13.68	$ 13.69
VFDs	Conservation	🟧	$ 9,516,237	654,264	$ 14.54	$ 14.11
Other Transportation	Transportation	🟨	$ 2,108,565	147,944	$ 14.25	$ 14.25
Prepared Fuel (Hogged)	Biomass	🟦	$ 1,282,500	89,858	$ 14.27	$ 14.27
Water Heating	Conservation	🟧	$ 810,952	58,814	$ 13.79	$ 16.02
Lighting Modification	Conservation	🟧	$ 52,242,317	2,677,465	$ 19.51	$ 22.40
USGBC LEED (NC) Silver	Sustainable Building	🟦	$ 3,732,056	137,389	$ 27.16	$ 27.35
Active Water Heating	Solar	⬛	$ 1,444,021	37,663	$ 38.34	$ 30.93
Refrigeration Conservation	Conservation	🟧	$ 8,970,913	319,988	$ 28.04	$ 30.94
HVAC System	Conservation	🟧	$ 20,985,149	697,657	$ 30.08	$ 31.82
Pumps	Conservation	🟧	$ 3,485,255	112,457	$ 30.99	$ 33.34
Transit Providers/Transportation Services	Transportation	🟨	$ 28,344,333	806,404	$ 35.15	$ 35.16
Other Geothermal	Geothermal	🟩	$ 746,117	15,886	$ 46.97	$ 51.06
Weatherization	Conservation	🟧	$ 52,111,059	1,028,532	$ 50.67	$ 53.38
Car Sharing	Transportation	🟨	$ 4,566,204	85,902	$ 53.16	$ 53.64
USGBC LEED (CS) Silver	Sustainable Building	🟦	$ 649,091	10,551	$ 61.52	$ 61.52
USGBC LEED (NC) Platinum	Sustainable Building	🟦	$ 1,920,929	28,672	$ 67.00	$ 67.00
Hybrid Vehicles (New)	Transportation	🟨	$ 1,966,098	27,715	$ 70.94	$ 70.37
Transportation Services for K-12 Students	Transportation	🟨	$ 5,736,323	79,303	$ 72.33	$ 72.33
Heat Pump	Geothermal	🟩	$ 1,800,513	28,230	$ 63.78	$ 74.76
USGBC LEED (NC) Gold	Sustainable Building	🟦	$ 5,876,901	65,500	$ 89.72	$ 90.04
USGBC LEED (CS) Gold	Sustainable Building	🟦	$ 1,354,959	11,724	$ 115.57	$ 115.57
Forest Residue	Biomass	🟦	$ 9,848,273	24,018	$ 410.04	$ 410.13

APPENDIX C

NET PRESENT VALUE CALCULATION

Net Present Value of Total Performance-Based Programs*

	Terms (Years)	**Annual Program Cost Per kWh, By Year**														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	**NPV**
PV Average	12.7	$0.22	$0.21	$0.20	$0.18	$0.17	$0.16	$0.15	$0.15	$0.14	$0.13	$0.12	$0.12	$0.11		$2.03
Biomass Average	10.3	$0.18	$0.17	$0.16	$0.15	$0.15	$0.14	$0.13	$0.12	$0.11	$0.11	$0.10				$1.43
Hydro Average	13.9	$0.17	$0.16	$0.15	$0.14	$0.14	$0.13	$0.12	$0.11	$0.11	$0.10	$0.10	$0.09	$0.09	$0.08	$1.69
Wind Average	12.7	$0.17	$0.16	$0.15	$0.14	$0.13	$0.12	$0.12	$0.11	$0.10	$0.10	$0.09	$0.09	$0.08		$1.53
Total Average	**12.4**	$0.19	$0.18	$0.17	$0.16	$0.15	$0.14	$0.14	$0.13	$0.12	$0.11	$0.11	$0.10	$0.10		$1.55

*Assume 6% Discount Rate

APPENDIX D

PERFORMANCE-BASED ENERGY INCENTIVES

Program Name	Tech.	Annual Program Cost/ kWh/yr.)	Terms (Years)	Total Program Cost/ kWh/yr.	Notes
NJ Board of Public Utilities (SRECs*)	PV	$0.60	15	$9.00	
OR Pilot Solar Volumetric Incentive Rate	PV	$0.41	15	$6.21	Averaged
Gainesville Regional Utilities - Solar FIT	PV	$0.29	20	$5.70	Averaged
TVA - Mid-Sized RE Standard Offer	PV	$0.56	15	$8.42	3% annual increase, Averaged
D.C. Public Service Commission (SRECs)	PV	$0.38		$4.84	Varies
Hawaii Feed-in Tariff	PV	$0.20	20	$4.08	Averaged
MD Public Service Commission (SRECs)	PV	$0.33		$4.20	Varies
DE Public Service Commission (SRECs)	PV	$0.31		$3.95	Varies
Golden Valley Electric Association (AK)	PV	$0.30		$3.82	Varies
Massachusetts DOER (SRECs)	PV	$0.30		$3.82	Varies
Indianapolis Power & Light Co.	PV	$0.22	10	$2.20	Averaged
Illinois Solar Energy Association (SRECs)	PV	$0.20		$2.55	
Farmers Electric Cooperative (IA)	PV	$0.20	10	$2.00	
Progress Energy Carolinas	PV	$0.18		$2.29	
El Paso Electric Company (SRECs)	PV	$0.14	12	$1.65	Averaged
TVA - Generation Partners Program	PV	$0.12	10	$1.20	Also $1000 Credit
California Feed-In Tariff	PV	$0.12	17.5	$2.01	Averaged
Marin Clean Energy - Feed-In Tariff	PV	$0.11	15	$1.67	Averaged
Community Based RE Prod. Incentive (ME)	PV	$0.10		$1.27	Varies
NC GreenPower Production Incentive	PV	$0.10		$1.27	
PNM - Performance-Based Solar PV (NM)	PV	$0.09	16	$1.44	Averaged
Xcel Energy - Solar*Rewards (NM)	PV	$0.11	11	$1.16	Averaged
EWEB - Solar Electric Program	PV	$0.09	10	$0.90	Averaged
Georgia Power - Solar Buyback Program	PV	$0.17	5	$0.85	
Orlando Utilities Commission - Pilot Solar	PV	$0.05	5	$0.25	
Duke Energy - Standard Purchase (NC/SC)	PV	$0.03	10	$0.30	Varies
PV Average		**$0.22**	**12.7**	**$2.96**	
TVA - Mid-Sized RE Standard Offer	Bio.	$0.56	15	$8.42	3% Annual Increase
Xcel Energy - RE Buy-Back Rates (WI)	Bio.	$0.73	10	$7.30	
WA Renewable Energy Prod. Incentives	Bio.	$0.33		$3.39	Averaged
Golden Valley Electric Association (AK)	Bio.	$0.30		$3.08	Varies
Chelan County PUD (Washington)	Bio.	$0.22		$2.26	
Vermont Standard Offer	Bio.	$0.12	17.5	$2.01	Averaged
We Energies - Biogas Buy-Back Rate	Bio.	$0.11		$1.11	Averaged
Community Based RE Prod. Incentive (ME)	Bio.	$0.10		$1.03	
Okanogan County PUD (Washington)	Bio.	$0.10		$1.03	
Indianapolis Power & Light Co.	Bio.	$0.09	10	$0.85	Also $6.18/kW/mo.
TVA - Generation Partners Program	Bio.	$0.03	10	$0.30	Also $1000 Credit

Program Name	**Tech.**	**Annual Program Cost/ kWh/yr.)**	**Terms (Years)**	**Total Program Cost/ kWh/yr.**	**Notes**
CVPS - Biomass Electricity Prod. Incentive	Bio.	0.04	5	$0.20	
Minnesota - RE Production Incentive	Bio.	$0.01	10	$0.13	Averaged
Duke Energy - Standard Purchase (NC/SC)	Bio.	$0.01	10	$0.06	
Biomass Energy Production Incentive (SC)	Bio.	$0.01	5	$0.05	
Biomass Average		**$0.18**	**10.3**	**$2.08**	
Chelan County PUD (Washington)	Geo.	$0.22		$2.20	
Duke Energy - Standard Purchase (NC/SC)	Geo.	$0.01	10	$0.06	
Geothermal Average		**$0.11**	**10**	**$1.13**	
Hawaii Feed-in Tariff	Hydro	$0.20	21	$4.22	Average
Vermont Standard Offer	Hydro	$0.12	17.5	$2.15	
Orcas Power & Light - Prod. Incentive (WA)	Hydro			$1.50	First Year Payment
TVA - Generation Partners Program	Hydro	$0.03	10	$0.30	Also $1000 Credit
TVA - Mid-Sized RE Standard Offer	Hydro	$0.56	15	$8.42	3% Annual Increase
Golden Valley Electric Association (AK)	Hydro	$0.30		$4.18	Varies
Community Based RE Prod. Incentive (ME)	Hydro	$0.10		$1.00	
Minnesota - RE Production Incentive	Hydro	$0.01	10	$0.13	Averaged
Duke Energy - Standard Purchase (NC/SC)	Hydro	$0.01	10	$0.06	
Chelan County PUD (WA)	Hydro	$0.22		$4.40	
Hydro Average		**$0.17**	**13.9**	**$2.23**	
TVA - Generation Partners Program	Wind	$0.03	10	$0.30	Also $1000 Credit
TVA - Mid-Sized RE Standard Offer	Wind	$0.56	15	$8.42	3% Annual Increase, Averaged
Golden Valley Electric Association (AK)	Wind	$0.30		$3.82	Varies
Hawaii Feed-in Tariff	Wind	$0.15	20	$3.00	Averaged
Indianapolis Power & Light Co.	Wind	$0.11	10	$1.07	
Farmers Electric Cooperative (Iowa)	Wind	$0.20	10	$2.00	
Community Based RE Prod. Incentive (ME)	Wind	$0.10		$1.27	
El Paso Electric Company (SRECs) (NM)	Wind	$0.05	12	$0.65	
Duke Energy - Standard Purchase (NC/SC)	Wind	$0.01	10	$0.06	
NC GreenPower Production Incentive	Wind	$0.09		$1.15	
Vermont Standard Offer	Wind	$0.17	17.5	$2.92	
Chelan County PUD (Washington)	Wind	$0.22		$2.80	
Okanogan County PUD (Washington)	Wind	$0.10		$1.27	
Orcas Power & Light - Prod. Incentive (WA)	Wind			$1.50	First Year Payment
Washington RE Production Incentives	Wind	$0.33		$4.20	Averaged
Xcel Energy - RE Buy-Back Rates (WI)	Wind	$0.07	10	$0.66	
Wind Average		**$0.17**	**12.7**	**$2.19**	
Total Average		**$0.17**	**12.1**	**$2.26**	

*SREC = Solar Renewable Energy Credits $0.19 $12.37 $2.53

Source: Dsire, 2011; HECO, 2011; CPUC, 2011; Marin Clean Energy, 2011

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