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March 2010 — March 2011

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NATIONAL RENEWABLE ENERGY LABORATORY

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List of Acronyms

Act 45	2009 Vermont Energy Act
ADEME	French Environment and Energy Management Agency (Agence de l'Environnement et de la Maîtrise de l'Energie)
COE	cost of energy
CREB	clean renewable energy bond
CREST	Cost of Renewable Energy Spreadsheet Tool
CRF	capital recovery factor
DCF	discounted cash flow
DOE	U.S. Department of Energy
DSIRE	Database of State Incentives for Renewable Energy
ECCR	economic carrying-charge rate
ECN	The Energy Research Centre of the Netherlands (Energieonderzoek Centrum Nederland)
FCR	fixed-charge rate
FIT	feed-in tariff
GETEM	Geothermal Electricity Technology Evaluation Model
GRU	Gainesville Regional Utilities
H2A	DOE Hydrogen Analysis
IRR	internal rate of return
ITC	investment tax credit
kWh	kilowatt-hour
LCOE	levelized cost of energy
NARUC	National Association of Regulatory Utility Commissioners
NPV	net present value
NREL	National Renewable Energy Laboratory
O&M	operations and maintenance
PI	profitability index
PIM	profitability index method
PPA	power purchase agreement
PSB	Vermont Public Service Board
PTC	production tax credit
PV	photovoltaic
REPI	Renewable Energy Production Incentive
RESOP	Renewable Energy Standard Offer Program
RETI	Renewable Energy Transmission Initiative
ROE	return on equity
SAM	Solar Advisor Model
SPEED	Sustainably Priced Energy Enterprise Development Program (Vermont)
T&D	transmission and distribution infrastructure
ZSW	Zentrum für Sonnenenergie- und Wasserstoff-Forschung

Executive Summary

Policymakers across the United States continue to explore and consider a wide range of renewable energy (RE) incentive structures. Consideration of these policy alternatives is typically driven by either proposed or adopted legislative or regulatory mandates and often draws on input from diverse stakeholder groups. One of the key policy questions is the approach to setting the incentive level. Different approaches to setting incentive levels include: competitive policies (such as requests for proposals and auctions), value-based policies (in which incentive payments may differ by time of production or location), and cost-based policies (which may be performance- or capacity-based and are sized relative to the cost to install and operate a particular subcategory of renewable energy assets).

The advantages and disadvantages of each type of incentive must be considered with the applicable jurisdiction's policymakers' objectives in mind. In this context, cost-based policies have been the garnering increased attention and are currently implemented widely throughout Europe and North America. As a result, this report focuses on renewable energy cost modeling and possible techniques, tools, and approaches for establishing cost-based incentives in the United States.

From an historic and international perspective, the feed-in tariff (FIT) is one of the most commonly used cost-based incentive tools. A FIT is a policy that typically provides eligible renewable generators with guaranteed access to a predictable, long-term revenue stream from a creditworthy buyer. FITs are generally cost-based in design and performance-based in execution (i.e., the FIT payment is sized to cover both installation and operating costs, but the tariff is only paid for actual energy production). FITs and other cost-based incentives are currently offered in over 50 countries worldwide. Similar policies have recently been implemented in Florida[1] and Vermont.

This report is intended to serve as a resource for policymakers who wish to learn more about establishing cost-based incentives. The report will identify key renewable energy cost modeling options, highlight the policy implications of choosing one approach over the other, and present recommendations on the optimal characteristics of a model to calculate rates for cost-based incentives, FITs, or similar policies. These recommendations will be utilized in designing the Cost of Renewable Energy Spreadsheet Tool (CREST). Three CREST models will be publicly available and capable of analyzing the cost of energy (COE) associated with solar, wind, and geothermal electricity generators. (The CREST models and user manual are now available for download at http://financere.nrel.gov/finance/content/CREST-model.)

The CREST models will be developed for use by state policymakers, regulators, utilities, developers, and other stakeholders to assist them in current and future rate-setting processes for both FIT and other renewable energy incentive payment structures and policy analyses.

Taxonomy of Calculation Methodologies

The report defines and qualitatively compares different methodologies for calculating the COE in order to identify a preferred methodology for the CREST model. COE methodologies can be

[1] In the Gainesville Regional Utility service territory.

broadly grouped into cash flow forecasts and recovery factor analyses. The discounted cash flow (DCF) method is the primary example of a cash flow forecast. The recovery factor analysis methods include the capital recovery factor, fixed-charge rate, and economic carrying-charge rate. Other investment analysis tools include simple payback and the profitability index method (PIM), which is used to compare projects based on the net present value created per dollar of investment.

The report finds that the DCF approach is the preferred methodology for the CREST model. A DCF model is the most versatile tool for calculating after-tax cash flows and can take into account U.S. federal tax incentives, which play a significant role in renewable energy finance and market development. A DCF model also provides a transparent year-by-year analysis that can foster stakeholder participation and support.

Survey of Existing Renewable Energy Cost Modeling Tools

The report reviews existing cost modeling tools in order to identify relevant industry best practices and enable the CREST model to build upon previous work. Included in the survey are:

- California Renewable Energy Transmission Initiative (RETI) model (Black & Veatch Corp.)
- The State of Vermont, Standard Offer models
- The RETScreen model (Canadian government)
- The Gainesville Regional Utilities Feed-In Tariff model
- The System Advisor Model (SAM) (National Renewable Energy Laboratory)
- The European Union's Photovoltaic (PV) Technology Platform
- The Vote Solar Initiative model
- The Geothermal Electricity Technology Evaluation Model (GETEM) (U.S. DOE).

No single publicly available analytical tool was found to be both simple to use and robust enough to take into account the wide array of existing incentives when designing cost-based FITs or similar incentive payment structures. However, a variety of useful features were found in these models and subsequently integrated into the Cost of Renewable Energy Spreadsheet Tool (CREST) model. These features include a "quick-start guide," "notes" in the spreadsheet cells to guide users, user-driven selection of different levels of analysis detail, inputs for the most common federal and state tax incentives, and graphic representation of results. A table summarizing the survey of existing models can be found in Appendix A.

Industry Experience with Feed-In Tariff Calculation Methodology

Because FITs are one of the most common cost-based renewable energy incentives in use today, this report reviews the FIT rate-setting methodologies and processes in five jurisdictions that designed their own FIT calculation models. These markets include Germany; the Netherlands; Ontario, Canada; Gainesville, Florida; and Vermont. The report finds that there are common approaches to FIT rate-setting methodologies internationally, even if the inputs and assumptions used in models vary across the jurisdictions surveyed. With few exceptions, the models are characterized by comparative simplicity, DCF after-tax analysis, assumed private commercial ownership, the use of IRR as an evaluation metric, an assumption that other incentives are taken into account when calculating the rate, and the aggregation of cost inputs. These commonalities, as well as areas of divergence, are a useful benchmark for the development of the CREST model. A table summarizing the survey of international rate setting approaches can be found in Appendix B.

Model Inputs

The report discusses different approaches to structuring COE model inputs and the types of inputs that are typically employed in COE models. The report highlights that models need to balance simplicity and ease of use; accuracy, precision, and representativeness; and data granularity. The report finds that the preferred design for the CREST model would accommodate a wide range of inputs and levels of complexity. Specifically, the preferred design for the CREST model would:

- Allow for simple, intermediate, or complex installed cost inputs so that the model is useful in the full range of potential policymaking processes
- Enable the analysis of different ownership and financing structures
- Enable recognition of the full range of typical financing and development costs
- Focus on after-tax returns, assuming that investors can monetize tax incentives
- Enable consideration of the most common federal and state incentives.

Policy Decisions

The report highlights the fact that both the approach to building a COE model and the approach to modeling itself involve policy decisions that can have important implications for renewable energy incentive development and implementation. These choices include, for example, the type and detail of input data gathered, the degree of technology differentiation, and the comparative aggressiveness or conservativeness of the approach used to set rates. The report also discusses factors that could shape the modeling process, such as legislative constraints on the rate-setting process, whether the process is adjudicatory or based on stakeholder engagement, the familiarity of the regulators or stakeholders with cost methodologies, and the availability of accepted tools.

Conclusion

The report concludes by outlining the preferred design criteria for the CREST model. In order to create a flexible, easy-to-use, and robust rate-setting tool, the CREST model would:

- Be designed to accommodate a range of policymaking processes
- Utilize a DCF approach with the COE calculated based on after-tax returns and take into account the availability of available federal and state incentives
- Include key features observed in other models:
    - An introduction worksheet embedded in the model, which serves as a "quick-start guide"
    - Descriptive, embedded notes providing an explanation of the appropriate use of many input cells, as well as the typical range of values for some inputs

    - Frequent use of "check" cells, which provide visual cues to help ensure that the user populates all cells required to operate the model
- Provide users the option to enter inputs at one of three levels of detail
- Allow tariff differentiation based on size, resource quality, or other factors
- Model both private and public ownership scenarios
- Allow a range of capital structures
- Promote graphic representation of results
- Promote transparency and simplicity in the rate-setting process wherever possible.

The preferred CREST model design would utilize the after-tax DCF approach with the internal rate of return (IRR) as a target input in order to calculate the COE. This COE would be used to inform the rate-setting process. In contrast to the models used in other jurisdictions, however, the CREST model design would support a greater degree of cost input detail, enable analysis of both publicly and privately owned projects, and allow the inclusion of all or a portion of various incentives. The preferred design would not be so complex as to render the CREST model difficult to use across different regulatory decision-making contexts in numerous states.

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1 Introduction

1.1 Background

From an historic and international perspective, the feed-in tariff (FIT) is the most commonly used cost-based incentive tool. A FIT is a policy that typically provides eligible renewable generators with guaranteed access to a predictable, long-term revenue stream from a creditworthy buyer. While FITs are generally cost-based in design, they are regularly performance-based in execution (i.e., the size of the FIT payment is based on the development and operating costs, but the FIT is only paid in response to energy production).

Cost-based tariff policies have spread rapidly throughout the world during the past several years, and the number of countries with national FIT policies increased from 37 in 2007 to more than 50 in 2009 (DB Climate Change Advisors 2010; Martinot 2008; Martinot and Sawin 2009).Cost-based incentives, such as FITs, have been slow to emerge in the United States. Unlike Europe, the United States historically has used tax incentives to spur renewable energy development; however, there has been a sharp increase in interest in FIT policy development during the past few years. At the beginning of 2006, FIT policy activity was limited to exploratory regulatory proceedings and workshops in a handful of states (Rickerson and Grace 2007). As of October 2009, however, FITs were being considered at the federal, state, local, and utility levels (Couture and Cory 2009).

At the regional and local levels, some cities and utilities have been exploring cost-based incentives using FITs. Gainesville Regional Utilities (GRU) (GRU 2009) established the nation's first municipal FIT in February 2009 and provides photovoltaic (PV) generators a 20-year payment of $0.32/kWh. The Sacramento Municipal Utility District in August 2010 announced a FIT for up to 100 MW of either renewable energy or combined-heat-and-power generators (SMUD 2010), and CPS Energy in San Antonio, Texas, in September 2009 announced a solar FIT similar to Gainesville's (CPS 2010). Several other cities also have been exploring municipal FITs.[2]

In Michigan, Consumers Energy launched a pilot FIT for solar in 2009 (Consumers Energy 2009),[3] and the Indiana Utility Regulatory Commission approved a FIT rate for Indianapolis Power and Light service territory in 2010 (Indiana Utility Regulatory Commission 2010).[4]

In response to the sharp increase in U.S. FIT development, a number of recent studies have sought to catalog international FIT policy best practices and discuss potential U.S. FIT designs (Ahn et al. 2009; Burgie and Crandall 2009; Couture et al. 2010; DB Climate Change Advisors 2009; Grace et al. 2009; Grace et al. 2008; KEMA 2008; Pollock and McNamara 2010;

[2] Both Santa Monica, California, and Palm Desert, California, announced plans to pursue FITs, but state legislation submitted to develop FITs for each city [S.B. 523, 2009–2010 Sess. (Ca. 2009) and A.B. 432, 2009–2010 Sess. (Ca. 2009), respectively] has not been passed. The City of Los Angeles also has proposed to develop FITs to deploy 150 MW of PV.

[3] The program had a cap of 2 MW, and the queue for the incentive was filled quickly.

[4] Several utilities around the country have established programs under which they purchase electricity and renewable energy certificates from their customers under long-term contracts to supply their voluntary green power programs. These include several Wisconsin utilities (i.e., WE Energies, Alliant, and Madison Gas and Electric) and the Tennessee Valley Authority. These policies are similar to FITs but tend to be limited in size and are tied to voluntary green power demand.

Rickerson et al. 2007). A common theme to most of these studies is the importance of setting the "correct" FIT rate. As stated in a recent National Renewable Energy Laboratory (NREL) report (Cory et al. 2009, p. 11):

> Detailed analysis is required to properly set the payment level at the outset. The payment level must ensure revenues will be adequate to cover project costs. If the FIT payments are set too low, then little new RE development will result. And if set too high, the FIT could provide unwarranted profits to developers.

FIT rates set and maintained at too high a level can lead to overpayment by ratepayers and taxpayers. In turn, this results in abrupt changes in the policy, undermining the very investor security and market growth that the policy was intended to encourage.

Although some U.S. industry commentators have expressed anxiety about the lack of established FIT rate-setting methodologies,[5] policymakers might find just the opposite—there are too many policy options and rate-setting methodologies to choose from. During the past several decades in the United States and abroad, a wide range of formal analytical approaches has been employed to estimate the cost of electricity and set incentive levels for both renewable and fossil-fueled generators. As a result, policymakers can choose different approaches to discovering generation data, building quantitative models, and engaging industry stakeholders—approaches that vary considerably in complexity and transparency.

This report is intended to serve as a resource for policymakers who wish to learn more about establishing cost-based incentives. This report provides insights into the process, analytical tools, and policy and modeling decisions that state policymakers must undertake if they wish to apply such cost-based incentives to support renewable energy development.

1.2 Report Purpose and Design of CREST Model

State utility commissions, in conjunction with the National Association of Regulatory Utility Commissioners (NARUC) and the U.S. Department of Energy (DOE) Solar Energy Technologies Program, have asked NREL for assistance in devising a calculation methodology that helps determine cost-based tariff or incentive levels that might be used to support expended adoption of a variety of renewable energy technologies. The agencies seek a framework for how to set payment levels for FITs or other incentive payment structures, as well as a model and instruction manual to assist the states and participating stakeholders in current and future rate-setting processes.

The purpose of this report is to identify key renewable energy cost modeling methodological options, highlight the policy implications of choosing one approach over the other, and present recommendations on characteristics of a model to be made available for use by a broad target audience. This report catalogs and analyzes several approaches to cost-based tariff rate setting and discusses the approaches most likely to satisfy the objectives of U.S. policymakers.

The analysis contained in this report has informed the design of a model that can be used to calculate FIT rates or other incentive payment structures—the Cost of Renewable Energy Spreadsheet Tool (CREST). The CREST models are a series of publicly available spreadsheet

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[5] See, e.g., Barclay (2009, p. iii), "Feed-In Tariffs: Are They Right for Michigan?"

tools capable of analyzing the cost of energy (COE) from solar, wind, and geothermal electricity generating facilities.

The primary output of CREST will be the modeled project's COE—the revenue (in cents per kilowatt-hour) necessary for the project to cover all expenses, debt (if applicable), and its equity investors' required after-tax rate of return. This COE can be used to establish—for example—the FIT rate in the project's first year of commercial operation. It is recommended that the CREST model include the option to specify a tariff escalation rate, as well as the opportunity to define what percentage of the tariff is subject to such escalation. The FIT rate in subsequent contract years is the year-one COE adjusted by these two additional factors, if applicable. If no escalation is specified, then the CREST model would produce a levelized[6] cost of energy (LCOE) value, which is the same for each FIT contract year.

The CREST models are intended as tools for use by state policymakers, regulators, utilities, and stakeholders to assist them in rate-setting processes for implementing cost-based incentives and other renewable energy policies. The CREST models will be available for download from the NREL renewable energy project finance website.[7] The CREST models will be accompanied by an instruction manual that provides an overview of how the models can be utilized, interpreted, and modified. The instruction manual will also be available for download from the NREL CREST Web page. (The CREST models and user manual are now available for download at http://financere.nrel.gov/finance/content/CREST-model.)

1.3 Orientation of This Report: Cost-Based Incentive Mechanisms

FITs are the most common example of cost-based renewable energy incentives, although many of the modeling and implementation issues associated with other cost-based incentives (such as gap payments and targeted production incentives) are similar to the analytical requirements of FIT design. Renewable energy incentive mechanisms can be structured in many ways, including:

- As a function of the fixed and operating costs of eligible renewable energy technologies (a cost-based tariff)
- As a function of the value of the commodities produced by eligible generators, akin to an avoided cost benchmark (a value-based tariff) (Grace et al. 2008).

Incentives can also be structured as fixed payments, premiums greater than conventional energy prices, or as variable payments that cover the gap between a target incentive rate and the price of conventional energy (also called a "spot market gap" payment) (Cory et al. 2009; Couture and Gagnon 2010).

For purposes of this analysis, we evaluate only cost-based incentive mechanisms. Specifically, this analysis focuses on incentives that are paid on a cents-per-kilowatt-hour basis, called production-based incentives. It is also possible, however, for cost-based incentives to be implemented on a per-kilowatt basis, called capacity-based incentives. It is not the goal of this

[6] The LCOE is the single value, expressed in cents per kilowatt-hour, that has the equivalent economic effect over the analysis term as the year-one rate with an escalation factor.
[7] See http://financere.nrel.gov/finance/content/CREST-model.

report to define a model incentive mechanism, nor is it the goal to opine about the relative merits of one policy design over another. However, cost-based incentive structures are currently under significant consideration by a number of state and municipal entities. Therefore, this report focuses on the factors relevant to cost-based incentives.

1.3.1 Differentiated Cost of Eligible Resources

Different FITs, or other cost-based incentives, are assumed to be made available to generators falling into different categories of eligibility, which can be defined by such factors as technology, size, resource quality, and location.

1.3.2 A "Fixed-Price" Payment Schedule Measured in Nominal Dollars

The payments under the FIT are assumed to be fixed at a constant rate in nominal dollars (often referred to as "nominal levelized") or with a fixed initial rate in the first year of operation and annual escalation thereafter according to an agreed-upon index (such as an inflation index) applied to all or part of the initial rate in subsequent years.

1.3.3 An All-In "Bundled" Payment Structure

In return for the payment from the interconnecting utility, the FIT is assumed to require the delivery of all commodities produced (i.e., energy, capacity, and renewable energy certificates). This, by far, has been the predominant model of FIT established or proposed in the United States. The model therefore focuses on establishing estimates of the all-in COE or revenue requirement, including an assumed required return to investors. Accordingly, the generator is not expected to require an alternative revenue stream to cover its costs and return to investors.

1. Applying Model Results to Different Feed-In Tariff Structures

Although a cost model will, by its nature, calculate the total revenue requirement of a generator (equivalent to an all-in fixed FIT rate), policymakers might choose to adopt a cost-based FIT structure that is not fixed-price or does not convey all commodities. Examples include:

- A premium payment approach (the payment is meant to convey an amount greater than forecasted energy and capacity revenues)
- A spot-market-gap or contract-for-differences payment structure (the payment represents the difference between the cost-based all-in rate and the actual spot market energy revenues available to a generator)
- Unbundled (e.g., energy only or REC only, assuming that the generator sells all commodities not covered under the tariff elsewhere).

If an alternative FIT structure is adopted by policymakers, then estimating the appropriate FIT payment requires first assessing the total cost of renewable generation (as under a cost-based FIT payment). The actual payment under these alternative approaches then can be calculated as the difference between the calculated total revenue requirement and the applicable actual or estimated alternative revenue streams. It is important to note, however, that these decisions can have implications on the availability of financing for projects receiving FIT payments.

1.3.4 Long-Term Payments

FITs for fixed-price resources are assumed to have long-term contracts of between 15 and 25 years. This is the most common contract range internationally (e.g., Klein et al. 2008) and also is the most common contract range of the current and proposed FITs in the United States. Longer terms are favorable for renewable electricity generators such as wind and solar because they reduce re-contracting risk (Corfee et al. 2010) and enable lower FIT rates by decreasing levelized generation costs. It should be noted that the spreadsheet models will be capable of being modified to accommodate both shorter-term and longer-term contracts (up to 30 years) as well.[8] This will enable policymakers to explore the trade-offs between tariff duration and incentive level.

1.3.5 100% of Output Sold to the Interconnecting Utility

The conventional concept of a FIT reflects payments for energy (and associated commodities, such as renewable energy certificates) delivered into the local utility distribution system—with which interconnection is guaranteed. This report therefore focuses on the sale of 100% of generator output to the interconnecting utility.[9] This denotes a direct physical interconnection to the utility distribution system. FITs theoretically could be applied to generators whose output is partially consumed on-site by a retail host and partially sold to the interconnecting utility. There are complexities associated with reconciling this model with rate-setting approaches based on generation cost as well as interaction with net-metering policies, both of which are beyond the scope of this report. The CREST model associated with this report, therefore, should not be constructed to value or otherwise differentiate production that can be consumed on a retail customer's side of the meter.

1.4 Structure of this Report

Section 2 provides a cost-modeling taxonomy, characterizing the range of possible modeling approaches and assessing their strengths and limitations. Section 3 presents the results of a survey of existing renewable energy cost modeling tools in widespread use in the United States. Section 4 summarizes a representative sampling of industry experience with FIT cost-modeling approaches to date and compares different FIT rate-setting processes. The purpose of the survey was to identify relevant industry best practices and to build on existing models rather than duplicating previous efforts. Section 5 reviews the types of input assumptions required for FIT cost modeling and discusses the range of options, particularly with respect to level of complexity and associated trade-offs. Section 6 explores the policy objectives, processes, and decisions that influence the choice of modeling approaches, methodologies, inputs, and output uses. Section 7 lays out the characteristics of the CREST models based on the information and analysis in the previous sections. This methodology is applied to the development of FIT spreadsheet models for wind, solar, and geothermal electricity and used to calculate the COE from each generating technology. The appendices include:

- Appendix A. Summary of Survey of Existing Models
- Appendix B. Survey of Industry Experience with FIT Calculation Methodology.

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[8] Although it is rare for FIT contracts to be more than 25 years, there are exceptions such as the 40-year FIT for hydropower in Ontario (Ontario Power Authority 2009).

[9] Although a material portion of the U.S. electricity marketplace operates under a competitive retail model, FITs require a one-to-one correspondence of generator to buyer, which is not present if the competitive retail electricity supplier were to be designated as the buyer (Grace et al. 2008).

2 Taxonomy of Calculation Methodologies

To set cost-based FIT rates or other cost-based incentives, first the COE for the target technologies must be calculated. The purpose of this section is to identify, in a clear and organized manner, the most commonly used methodologies for calculating the COE from a renewable energy facility. The intention is to create a taxonomy of methodologies: naming, defining, and classifying the approaches in common use for establishing a COE estimate for renewable energy generators and drawing clear distinctions among the different approaches.

These methodologies vary significantly in detail and complexity, and their usefulness greatly depends not only on whether they adequately capture the key economic drivers of renewable energy projects, but also whether they reflect the goals and objectives of policymakers. As a result, there might not be a single FIT rate calculation methodology that is ideally suited to all situations. The descriptions that follow are intended to be detailed enough to provide an understanding and comparison of each calculation methodology and to determine its usefulness to a specific context.

2.1 Overview of Calculation Methodologies

The range of methodologies used to calculate the COE from a power generating asset can be placed into one of two broad categories, cash-flow forecasts or recovery factor analyses. The first category provides for the annual estimation of all project revenues, expenses, tax obligations or benefits, and repayments to all capital providers. These individual annual net cash flows subsequently are discounted to a single net present value (NPV) and internal rate of return (IRR). This generally is referred to as a discounted cash flow analysis. The FIT rate can be established by calculating the revenue per kilowatt-hour and escalation factor (if applicable), which results in a zero NPV using the project's assumed cost of equity and satisfies other applicable cash-flow constraints[10] or an IRR, which meets or exceeds the equity investors' requirements for a specified period.

The second COE methodology relies upon a single factor (i.e., a multiplier) to convert capital investment-related costs to an annual figure that estimates tax benefits or obligations and repayments to all capital providers over the life of the project. Using this latter methodology, the COE (whether nominal or real levelized) is calculated by multiplying the initial investment by the recovery factor, dividing this value by the estimated annual production, and adding a simplified estimate of operating expenses in a representative year. A number of alternative methodologies fall into the recovery factor analysis category. Table 1 summarizes several different cash flow forecast and recovery factor methodologies. This table also includes two additional investment analysis tools—the simple payback method and the profitability index method (PIM). Although not suited to the estimation of an appropriate FIT rate on their own, the simple payback and PIM can be used in conjunction with detailed COE analyses. Detailed descriptions of each of the methodologies follow the table.

[10] The NPV might have to be slightly greater than zero to both meet the required return and satisfy cash-flow constraints (such as minimum debt service coverage ratios).

Table 1. Summary of Calculation Methodologies

Method	Summary Description	Calculation	Cost of Energy
Cash-Flow Forecast Methodology			
Discounted Cash Flow	Discounts to present value the estimated annual cash flows to equity investors; provides either before-tax or after-tax results	Initial equity investment plus NPV of free cash flow to equity over the life of the project; internal rate of return of investment and cash flows for a specified period	Cents per kilowatt-hour revenue assumption yielding target weighted average cost of capital; can be in nominal levelized dollars, real levelized dollars, or increasing from an initial value at a defined escalation rate
Recovery Factor Analyses			
Capital Recovery Factor	Amortizes an investment into a stream of equal annual payments; provides pretax results; also called "annuity method"	Sums weighted average cost of capital and depreciation annuity	((CRF * Total Installed Cost) + Total Annual Variable Cost) / Annual Production; the CRF method typically calculates COE in nominal dollars
Fixed-Charge Rate	Calculates the percent of a project's year-one revenue requirement attributable to fixed costs; provides after-tax results	Sums annual weighted average cost of capital, tax, depreciation, and fixed overhead	((FCR * Total Installed Cost) + Total Variable Cost) / Annual Production; the FCR method typically calculates COE in nominal dollars
Economic Carrying-Charge Rate	Amortizes all fixed costs to produce a stream of annual payments that increase at a constant rate; provides after-tax results	Sums year-one weighted average cost of capital, tax, depreciation, and fixed overhead to derive year-one COE	((ECCR * Total Installed Cost) + Total Variable Cost) / Annual Production; the ECCR method typically calculates COE in real dollars;this value is escalated annually
Other Investment Analysis Tools			
Simple Payback	Estimates the number of years necessary to recover an initial equity investment; provides before-tax results	Initial equity investment/annualized cash flow to equity	Cents per kilowatt-hour revenue assumption yielding payback in targeted year
Profitability Index Method	Indicates the efficiency of invested capital; used to rank projects based on NPV per dollar invested	NPV/total installed cost	PIM does not set a FIT rate; it is a universal scale for comparing profitability of investments

2.2 Discounted Cash Flow Analysis

A discounted cash flow (DCF) analysis is a method of calculating the NPV and IRR on a potential renewable energy investment by estimating future free cash flows to equity on a periodic (i.e., annual, quarterly, or monthly) basis, taking into consideration the time value of money. According to *Corporate Finance*, "conventional NPV analysis discounts a project's cash flows estimated for a certain project life" (Ross et al. 2002, p. 213). A DCF analysis can be used to calculate a project's IRR both before and after tax. Cash flows are estimated using project-specific revenue and expense forecasts, debt service obligations, depreciation schedules, and income tax assumptions (as applicable). A DCF analysis takes a project's operational and financing milestones—including evolving tax obligations—into account when estimating its NPV and IRR. The DCF method also is capable of recognizing constraints on project financing, such as minimum debt service coverage ratios, and time-sensitive operational events, such as major equipment repairs or replacements (e.g., inverter for solar and gearbox for wind). It is the most detailed methodology discussed here.

2.3 Recovery Factor Analyses

Recovery factor analyses replace the year-by-year free cash flow estimates of the DCF method with a simplifying formula. The simplification combines the expected levelized annual operating expenses[11](or year-one expense plus escalation) with the product of (i) the estimated installed costs and (ii) a constant percentage factor intended to represent the portion of a project's initial investment and fixed costs recovered each year. Due to the tax-oriented nature of renewable energy investments, however, the simplifying assumptions of a recovery factor analysis result in less precision compared to a year-by-year after-tax DCF analysis. Several of these methodologies are identified and described below.

2.3.1 Capital Recovery Factor

The capital recovery factor (CRF) is a value between 0 and 1 designed to calculate the annual dollar amount required to fully amortize an investment over a specified period. The CRF "converts a present value into a stream of equal annual payments over a specified time, at a specified discount rate (interest)" (Khatib 2008, p. 39). The CRF is derived by combining a project's weighted average cost of capital with the depreciation annuity. The depreciation "is based on the concept that funds must be accrued during the lifetime of a project that will equal the original cost of the plant, thereby allowing for its replacement" (Kahn 1991, p. 44). The CRF approach also sometimes is referred to as the equivalent annual cost or the annuity method because, when multiplied by the total capital costs of the project, it yields the amount of money that must be collected annually to recover the initial investment at a specified rate and over a specified number of years.

2.3.2 Fixed-Charge Rate

The fixed-charge rate (FCR) is "a fraction between 0 and 1 which expresses the sum of annual requirements for return, taxes, depreciation, and sometimes other fixed overhead costs" (Kahn 1991, p. 42). In this approach the annual return requirements consolidate debt and equity returns into a single figure, such as a weighted average cost of capital. Other fixed overhead costs can include insurance, project management, and debt principal. To calculate the portion of a project's year-one revenue requirement attributable to these fixed costs, the FCR is multiplied by the project's total installed cost.

2.3.3 Economic Carrying-Charge Rate

Like the FCR method, the economic carrying-charge rate (ECCR) (sometimes referred to as the real carrying charge) "represents all of the costs associated with a new unit, including the depreciation of and return on the initial investment, and property taxes and fixed operating and maintenance costs over the life of the unit" (GE Power Systems Energy Consulting 2003, pp. 2–3). The ECCR differs from the FCR in that it is used specifically to calculate a project's cost of energy in the first year. This year-one value then is escalated by an assumed inflation rate to approximate the cost of market entry over time. Therefore, the ECCR "method of allocating capital costs over time produces a stream of payments that increase at a constant rate" (Kahn 1991, p. 168). The present value of the escalating payment stream calculated via the ECCR is equal to the present value of the constant stream calculated in the FCR methods. According to

[11] Depending on the recovery factor method selected and the detail orientation of the individual performing the analysis, the estimated annual operating expenses might or might not account for major equipment repairs and replacements.

Edward Kahn's *Electric Utility Planning & Regulation*, "this approach is still an approximation to a detailed multi-year optimization" (Kahn 1991, p. 171).

2.4 Other Investment Analysis Tools

2.4.1 Simple Payback

Simple payback is a commonly used yet often misunderstood method of estimating how long it takes to recover an investment. Applied to the electric-generator context, the simple payback period is calculated by dividing the initial equity investment by the estimated annual cash flow to equity. The value of simple payback is a conceptually easy-to-grasp description of the return of invested capital and typically is utilized by entities that plan to finance a project using internal funds and not incur project-level debt. The simple payback method is limited in its applicability and insight, as it ignores the cash flow benefits to the equity investor after the initial investment is recovered and provides no means to measure project profitability. Furthermore, simple payback analyses can be misleading for several reasons. One is that they do not take into account the time-value of money. Another reason is that payback analyses either ignore or over-simplify the annual variability in cash flow due to depreciation expense and other tax-related considerations. These factors dramatically influence annual cash flows and project profitability—particularly for renewable energy projects, which can offer investors important tax advantages. For these reasons, payback targets and payback analyses are more communication tools than financial analysis. They are not recommended for use in establishing FIT rates and are not discussed further in the present report.

2.4.2 Profitability Index Method

The PIM creates a metric that "indicates the efficiency of invested capital" (Chabot 2009, p. 12) and is a scale on which a range of projects can be equitably compared. The profitability index (PI) is calculated by dividing a project's expected NPV by the initial equity investment.

The numerator in the PIM is the project's NPV, which can be calculated using an underlying DCF, a fixed-charge rate, or a CRF analysis. The PIM pioneer, Bernard Chabot, uses the CRF approach. Therefore, the PIM is not an alternative to the DCF, FCR, or CRF analyses described above but can be used in conjunction with one of these analyses to help the participants in a regulatory process set FIT rates that provide for a similar level of profitability across a range of project sizes and technology types. For example, a project with an NPV of zero will generate a PI of zero because NPV is the numerator of the PI formula. This result denotes a project rate of return that is expected to meet—but not exceed—the investor's weighted average cost of capital and, implicitly, its threshold equity-return target.

The PI is intended to be a "universal profitability scale based on investor strategies" (Chabot 2009, p. 8), whereas NPV and IRR are profitability metrics that vary based on term. According to Chabot, FIT rates that result in a project profitability index between 0.1 and 0.3 are appropriate if the policy objective is to promote "fair and efficient tariffs" (Chabot and Saulnier 2001, p. 4). If scaled technology deployment and industry growth are the objective, Chabot opines that the target PI range should then be between 0.3 and 0.6. To this end, industry regulators and participants could elect to include a PI calculation in the quantitative modeling process and could target a PI range for each technology (or technology subcategory) that is commensurate with their policy objectives. Although policymakers intend to encourage all eligible projects equally, a single PI score could be targeted for all tariffs. If the objective is to increase technology diversity or promote adoption of specified technologies, for example, then different PI scores could be targeted for each category.

The PIM's creators conceived the method as a simplified analysis to quickly measure a project's potential profitability. To this end, a CRF is used to calculate a pretax NPV. Although simplified, this approach nonetheless is reasonable in European or other markets in which returns are predominantly cash-based and the tax implications are relatively uniform for investors. In the United States, however, where renewable energy investing is defined by complex structures to maximize the use of a multitude of tax incentives, a PI calculated based on a pretax NPV (or any other pretax analysis) is insufficient to draw actionable conclusions about project profitability. To apply the PIM concept in a useful manner in the United States, the NPV used in the numerator must be calculated based on a detailed after-tax DCF or FCR analysis. Admittedly, this impairs the simplicity objective of the PIM; however, it provides a mechanism for making the PIM a potentially useful tool for comparing the profitability of a range of renewable energy projects.

2.5 Conclusion: Applying the Discounted Cash Flow Model

It is recommended that the CREST models utilize the DCF method of calculating the NPV and after-tax IRR on a renewable energy investment. This is based on several factors. One is that any FIT rate calculation should incorporate all broadly available tax incentives. In the United States, tax incentives are an important component of investing in renewable energy projects, and the efficient monetization of all tax incentives is important even for smaller projects. Although the 2009 American Reinvestment and Recovery Act created a program that converts a portion of these tax benefits into cash, these provisions are set to expire for projects not under construction by the end of 2010. Unless there is permanent migration to cash-focused returns, renewable energy investing in the United States will remain strongly motivated by tax benefits. The DCF models easily can be structured to accommodate (and switch between) scenarios that involve tax impacts and those that do not. In other words, the DCF model provided in this report is a tool that can adapt with U.S. renewable energy policy over time.

Importantly, a successful, stakeholder-driven FIT design process requires a substantial degree of transparency. This is especially important with respect to the assumptions that drive the rate-setting modeling process. The year-by-year analysis in the DCF method provides for transparency regarding the impact of these assumptions throughout the life of the project.

The FIT rate-setting process also should be flexible and should allow for a range of complexity in modeling assumptions and calculations. The DCF method allows for a range of complexity in the level of input detail and modeling calculations that either surpasses the other methodologies available or would otherwise necessitate a separate modeling effort to inform the applicable recovery factor analysis.

A DCF model also supports the analysis of project returns for different types of investors. It is problematic to assume that all investors will be able to fully monetize the available tax incentives, therefore it is helpful to be able to assess the range of FIT rates required for different types of investors to achieve a defined rate of return (e.g., monetizing only a portion of the tax benefits). The DCF model accommodates a range of tax appetites and can approximate the utilization of tax benefits on an annual basis. This also is an important consideration for government entities or non-profit agencies that do not have a tax basis to which to apply the tax credits.

Additionally, state legislators and regulators also might wish to develop FIT rate models that recognize the strengths and limitations of local investors. The DCF method is flexible and can be customized to suit a range of state-specific conditions. This enables policymakers to adapt their programs over time to account for changing federal incentives as well as overall conditions in the renewable energy market. Lastly, as noted in Section 4, a survey of cost-modeling methodologies in other jurisdictions revealed that the DCF method is used in many jurisdictions with FITs.

3 Survey of Existing Renewable Energy Cost Modeling Tools

3.1 Survey of Existing Financial Models

This section surveys publicly available financial models in common use for estimating the COE from renewable energy generators and identifies the features most useful and applicable to a state-by-state cost-based incentive rate-setting process. Some of these models also are identified during the discussion of industry experience in Section 4. The most useful features are summarized in Appendix A and, as appropriate, are incorporated into the CREST models provided with this analysis.

The calculation methodologies and features—as well as the summaries of inputs and outputs—used in renewable energy project financial models vary widely in detail and complexity. The level of granularity of inputs and modeling calculations should take into account the intended use of the model. For example, a project-specific economic feasibility analysis could estimate tax benefits as a percentage of total project costs and assume complete monetization of all incentives. By comparison, a detailed project finance model intended for use with potential lenders and equity investors likely would determine the eligibility of project costs for the investment tax credit (ITC) (if applicable) on a line-by-line basis and calculate each partner's tax benefits based on individual tax appetite and capital account balances. In other words, model developers can match the complexity of inputs, calculations, and outputs to stakeholders' needs and preferences. In this case, the survey of models was conducted to identify the types of input and output summaries, calculation methodologies, and other features or details that could be useful to consider.

All of the models surveyed are publicly available. Each model is used to estimate a project's COE per kilowatt-hour based on estimated (or actual) project costs and financial parameters. Some of these models are in widespread use and others have been applied more narrowly. An informal but broadly cast survey of available models yielded the following prospects for examination, and each is discussed in detail below.

- The California Renewable Energy Transmission Initiative (RETI) model (Black & Veatch Corp.)
- The State of Vermont's Standard Offer models
- The RETScreen model (Canadian government)
- The Gainesville Regional Utilities Feed-In Tariff model
- The Solar Advisor Model (SAM) (NREL)
- The European Union's Photovoltaic Technology Platform
- The Vote Solar Initiative model
- The Geothermal Electricity Technology Evaluation Model (GETEM) (U.S. DOE).

3.2 Renewable Energy Transmission Initiative Cost of Generation Model[12]

The RETI cost of generation spreadsheet model[13]—designed by Black & Veatch Corp. for the State of California—is a simple yet versatile DCF model. The purpose of the RETI model is to calculate the cost of generation for multiple renewable energy technologies. It has been used for developing a supply curve of renewable energy generation resources in both the California RETI and the Western Renewable Energy Zones to explore policies relating to construction of new transmission to reach these zones. The model's simplified level of input detail might not be sufficient for some users, but the model includes all inputs necessary to conduct an introductory COE analysis for a variety of fuel-based and non-fuel-based technologies, making RETI a useful and effective tool. The RETI model can calculate a project's minimum year-one COE subject to user-defined equity return requirements, debt parameters, and other inputs. If escalation assumptions are provided, then the model calculates the LCOE. The user-friendly interface allows users to compute these values without being required to understand and operate Microsoft Excel's manual "goal seek" or "solver" optimization functions. The RETI model presents the strongest candidacy for using a publicly available model for exploring FIT rate calculations. Based on this report's analysis of the policymaking process in other jurisdictions, however, a model with greater input detail and project design flexibility is necessary to support the stakeholder processes associated with most FIT policy development.

3.3 Vermont Standard Offer Models[14]

In late 2009, the Vermont Public Service Board (PSB) opened two related, non-contested dockets[15] to examine the current COE from various renewable energy technologies and inform the board's decision on standard offer rates under the Sustainably Priced Energy Enterprise Development Program (SPEED). The model used throughout the stakeholder process followed a standard DCF format and initially was developed by Green Mountain Power Corporation, a Vermont utility. Although the original model was not designed to calculate FIT rates, the model provided a starting point for stakeholders to estimate the COE from a range of renewable energy technologies. Separate models ultimately were established for solar, wind, landfill gas, hydro, and farm-methane projects to support the board's consideration of technology-differentiated standard offer contracts. Complete transparency with respect to the model formulae fostered a collaborative process in which both developers and regulators gained comfort with the calculations and were able to focus their energy on trying to achieve consensus on inputs. The model can be used to calculate the input power purchase agreement (PPA) price that satisfies all cost estimates and financing conditions by using Microsoft Excel's "goal seek" or "solver" function. Useful features in this model include the estimated funding of reserve accounts, state tax incentives (in addition to federal), and the ability to refinance project debt after an initial five- to seven-year debt tenor. This last feature reflects the limitations in the debt market as of late 2009 and early 2010.

Due to a number of instances in which inputs have been embedded in formulas, however, the Vermont models are not user-friendly enough to recommend for widespread use in evaluating

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12 The RETI cost of generation spreadsheet is available at http://www.energy.ca.gov/reti/documents/index.html. Accessed August 17, 2010.

13 RETI materials are available at: http://www.energy.ca.gov/reti/documents/index.html.

14 The Vermont Standard Offer Models are available at: http://psb.vermont.gov/docketsandprojects/electric/7523/finalprice. Accessed April 7, 2011.

15 Docket No. 7523; Docket No. 7533.

cost-based FITs. Additionally, a COE model intended for use in many different states and under a variety of circumstances might need additional flexibility and functionality with respect to the level of detail of cost and operating inputs.

3.4 RETScreen

The Canadian government has widely distributed its RETScreen clean energy project analysis software. The purpose of the software is to evaluate energy production, costs, and financial viability—among others elements—for various types of renewable energy technologies. According to the RETScreen International website, the model has been used by more than 240,000 people in 222 countries and is part of the curriculum at more than 250 universities worldwide.[16] It has been used not only in support of renewable electricity projects (e.g., wind, solar, hydro, and geothermal) but also to calculate the potential savings associated with renewable heating and cooling, energy efficiency, and combined heat and power projects. Although the model's well-designed user interface might facilitate operation by users who do not possess detailed knowledge of renewable energy finance, the model's lack of transparency could pose a problem for developers who must ensure the proper treatment of all project attributes or for regulators with rate-setting responsibility. A limitation on utilizing RETScreen for the purposes of a general U.S. cost-based FIT model is the fact that it does not easily incorporate the U.S. tax incentives, which, as noted, are material to the finances of most U.S.-based renewable energy projects. The RETScreen software has several other useful features of note, including the option to select alternative levels of input detail in several categories, the sensitivity and risk analysis features, and a built-in help function for each model input.

3.5 Gainesville Regional Utilities FIT Model[17]

The Gainesville FIT model is a DCF model used to establish this Florida utility's solar FIT rate. As was the case in Vermont, the model inputs were informed through a stakeholder process. Compared to other publicly available models, the inputs are greatly aggregated and might not provide sufficient detail and flexibility for a tool to be applied across a wide variety of circumstances. The model's formatting also does not clearly define the inputs or the project-level and system-level outputs. The model's useful features include a calculation of the estimated impact on the utility's annual fuel cost adjustment to ratepayers.

3.6 System Advisor Model[18]

SAM is the result of a partnership between NREL, Sandia National Laboratory, and the DOE Solar Energy Technologies Program (NREL 2010). SAM is robust, offering many detailed sets of input options to evaluate multiple solar electric technologies. The tool is available for download on the NREL website. This model has an advanced graphic interface and offers a comprehensive set of output metrics and sensitivity analyses but can be daunting for entities such as policymakers who are unfamiliar with complex renewable energy systems. Among SAM's outputs are cash flow statements, which can be exported to Excel and reveal SAM to be a DCF model. The calculations associated with the cash flow statements exported from this version of SAM are neither transparent nor available to the user for review. Functional, Excel-based SAM cash flow models are available in draft form and without the graphic user interface from NREL's

[16] The RETScreen model is available at http://www.retscreen.net/ang/home.php. Accessed August 17, 2010.
[17] The Gainesville FIT Model is available from Gainseville Regional Utilities.
[18] SAM is available at https://www.nrel.gov/analysis/sam/. Accessed August 17, 2010.

website.[19] This is a limiting factor in SAM's potential application in a rate-setting process where a premium is placed on transparency. The ability to view all calculations is a likely requirement to get both policymaker and developer buy-in during the regulatory process. SAM, while highly robust, is also very complex and requires a high level of knowledge with respect to weather and resource data, system costs and function, and economic evaluation. Further, SAM currently offers no option to incorporate reserve requirements for debt, working capital, and replacement components such as inverters. These reserve accounts are very regularly required of renewable energy developers and represent a real cost of renewable energy production.

Among its many output options, SAM calculates the year-one PPA price, the LCOE in nominal dollars, and the LCOE in real dollars. Depending on policymakers' preferences regarding inflation of the revenue stream, one or more of these metrics would provide information useful to establishing FIT rates. Other useful features include SAM's ability to generate an array of sensitivity and optimization analyses, as well as graphical representations of many of the model's outputs. Graphics and sensitivity analyses can facilitate more efficient communications in a consensus-driven stakeholder process.

3.7 European Union Photovoltaic Technology Platform[20]

The European Union's Photovoltaic (PV) Technology Platform was designed specifically as a FIT rate calculator by the French Environment and Energy Management Agency (ADEME). The model is based on the DCF method, simplified by using the project owner's assumed weighted average cost of capital rather than project-specific debt service assumptions. Although well-suited to the European markets, the PV platform does not accommodate the accelerated depreciation and tax-credit benefits that drive renewable energy investing in the United States. Nonetheless, this model offers several useful features, including the clear definition of output metrics and a worksheet dedicated to the explanation of each input parameter—and often including a range of potential values to help new users get started. If inputs are dependent on other project-specific decisions, then an explanation of the process to determine the input is provided. One caveat is that these sample inputs must be updated periodically to remain useful. Further, a geographic area as diverse as the United States requires location-specific sample inputs.

3.8 Vote Solar Incentive Comparison Model[21]

The Vote Solar Initiative is a California-based group that has the goal of fostering the economies of scale necessary to reduce the installed cost of new solar installations.[22] Among its online resources, Vote Solar offers an Excel-based incentive comparison model—developed by Crossborder Energy—that calculates the incentives necessary to provide the same project-based economic results under three policy scenarios: an upfront incentive, a performance-based incentive, and a FIT. This DCF model's useful features include a description of the model's purpose, key inputs, key outputs, and model operations. Acting as a "quick-start guide," this feature can provide substantial value to policymakers or stakeholders who do not work with financial models on a regular basis. Additionally, the Vote Solar model calculates the cumulative

[19] Excel-based SAM cash flow models are available at https://www.nrel.gov/analysis/sam/support.html#fin_spread. Accessed August 17, 2010.
[20] The European Union PV Platform model is available at http://www.eupvplatform.org/. Accessed August 17, 2010.
[21] The Vote Solar model is available at http://votesolar.org/resources/incentive-model/. Accessed August 17, 2010.
[22] http://votesolar.org/who-we-are/. Accessed August 17, 2010.

program incentives paid based on estimates of total capacity installed under—or electricity generated as a result of—the program. The level of detail in the model, however, is insufficient for widespread use. For example, the model is limited to the use of a single dollar-per-watt input for the estimation of total capital costs.

3.9 Geothermal Electricity Technology Evaluation Model[23]

GETEM is "a detailed model of the estimated performance and costs of currently available U.S. geothermal power systems" (Entingh 2006, p. 1). The GETEM model "was developed to aid the [DOE] Geothermal Technologies Program in understanding the performance and the cost of the technologies it is seeking to improve" (Entingh 2006, p. i). Whereas most of the models surveyed rely on external resource assessments and power-conversion analyses (in the case of solar and wind resource estimates, for example), an evaluation of the efficiency and cost of different geothermal resource capture technologies is one of the core features of GETEM.[24] The GETEM model was built to help geothermal technology researchers gain insights into how particular improvements in performance, changes in technology, or reductions in the cost of subcomponents impact the facility's total cost of power.

By comparison, the CREST model seeks to support a FIT rate-setting discussion among stakeholders—many of whom might not possess the engineering background necessary to fully comprehend the GETEM model. For geothermal resources to be effectively included in the FIT rate-setting dialogue, such a model must succeed at bringing regulators, developers, and investors together in a discussion of what it takes to create successful geothermal electricity projects. This report and its associated model are intended to support the rate-setting process and are not designed to rank or otherwise compare the "pros and cons" of different geothermal technologies. If the COE from different geothermal technologies varies widely, then participants to the FIT process could explore whether it makes sense to differentiate geothermal FIT rates by technology, size, or other criteria.

3.10 Additional Models

The existing models surveyed in this report were collected by NREL and the authors via a renewable energy industry peer group that had expertise in the analysis and application of FITs worldwide. In addition to the models individually described above, the survey resulted in the identification of two more models, which—although related to FITs in some instances—take different approaches to the calculation of FIT rates. These models are described briefly below.

3.10.1 ECN Financial Gap Calculation Model

The Energy Research Centre of the Netherlands (ECN) model is used to establish FITs in the Netherlands. Similar to many of the other models surveyed in this analysis, the ECN model uses the DCF methodology to determine the COE. Rather than setting the tariff rate based solely on this COE analysis, however, the ECN model also incorporates a long-term electricity price forecast to calculate what the model refers to as the "financial gap." The financial gap is the difference between the initial equity contribution and the NPV of after-tax cash flow to equity, divided by the discounted electricity production. The resulting per-kilowatt-hour value sets the

[23] The GETEM model is available at http://www1.eere.energy.gov/geothermal/getem.html. Accessed August 17, 2010.
[24] One notable exception is that SAM's automation includes the integration of production estimates generated by PVWatts. See http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/. Accessed August 17, 2010.

FIT. The Dutch FIT assumes that eligible facilities deliver all electricity to the grid, are paid the market-based value of production, and then collect an additional FIT payment that reconciles the total revenue per kilowatt-hour with the COE. This analysis and the associated CREST models take the approach that the FIT is set equal to the COE in its entirety. Although the CREST models take into account the market-based revenues that are available to the project after the FIT contract expires and before the end of the project's useful life, the CREST models do not endeavor to calculate a financial gap similar to the ECN model. Nonetheless, policymakers still have the option to calculate the expected market value of production[25] from different types of renewable energy generators and subtract this value from the COE calculated with CREST and then use this gap to set a FIT rate in the Dutch style.

3.10.2 Hydrogen Analysis Production Cash Flow Analysis Tool

The DOE Hydrogen Analysis (H2A) model is a DCF analysis tool intended to calculate the cost of hydrogen produced (by a variety of different renewable energy technologies) over the analysis period at a specified after-tax equity cost of capital. The model is well conceived and constructed, however its focus on the cost of hydrogen as the output rather than the cost of electricity prevents further consideration of its use as a model to develop a cost-based FIT. The H2A model nonetheless was reviewed and its input and output formatting taken into account when considering design options for the CREST models that will be developed in association with this whitepaper.

3.11 Conclusion

This survey of existing financial models suggests that there is no single publicly available and recognized tool in widespread use that can be readily and easily applied to the task of calculating cost-based FITs for a variety of generation technologies in the United States. The survey, however, revealed a number of useful models from which best practices and features can be borrowed to create a spreadsheet financial model for use by renewable energy policymakers and stakeholders across the country. Such a model must be straightforward enough to be used effectively by a diverse set of participants, flexible enough to accommodate a consensus-driven process for identifying inputs that can vary in detail from state to state, and transparent enough to be useful in a public process. The key features observed in other models and proposed for incorporation into the CREST models include:

- An "Introduction" worksheet embedded in the model that serves as a quick-start guide
- Descriptive, embedded "notes" providing an explanation of the appropriate use of many input cells as well as the typical range of values for selected inputs
- Frequent use of "check" cells, which provide visual cues to help ensure that the user populates all cells required to operate the model
- The option to provide inputs at one of three potential levels of detail, chosen by the user and based on need
- Inputs for major federal and state tax incentives

[25] The wholesale market clearing prices are not transparent in all U.S. electricity markets; therefore, the financial gap approach might be easier to implement in some regions than in others.

- Graphic representation of results.

The survey also identified important limitations of publicly available models. In general, these limitations relate to:

- The level and flexibility of input detail
- Transparency with respect to model formulae (calculations are hidden)
- Consideration of the financial impact of major federal and state tax incentives.

A summary of the key characteristics of each surveyed model, as well as its applicability to FIT rate setting, is provided in Appendix A. The lessons learned from this review of existing models are applied to the development of the model accompanying this report and are described further in Section 7.

4 Industry Experience with FIT Calculation Methodology

Different approaches to setting FIT rates based on generation cost have been employed by jurisdictions both within the United States and abroad. Previous studies and reports have either described FIT rate-setting methodologies for specific countries (BMU 2007), compared FIT rate-setting processes across different countries (KEMA 2008), or compared general modeling approaches and advocated for a certain approach over others (Chabot et al. 2002; Gipe 2008). To date, however, there has not been a detailed, comprehensive comparison of FIT rate-setting approaches internationally. This section reviews and compares a representative sampling of cost-based FIT rate-setting approaches used in the United States and abroad. The goal is to establish a set of benchmarks for use in developing a general-purpose cost-modeling methodology for use in the United States. Specifically, the section identifies the type of model utilized in each jurisdiction, the type and complexity of model inputs, and other key assumptions that shaped the model structure. By surveying the model design options currently used and identifying designs that are common across jurisdictions, this section provides a point of comparison for the specific design recommendations discussed in Section 5.

Additionally, this section reviews and compares

- The rate-setting processes (e.g., how data is gathered, who gathers it, how data is verified, and how stakeholders are involved in the process)
- The rate-setting approval process (e.g., by regulatory order and by law).

Although these processes and procedures are not as directly relevant to the CREST model as the review of comparative model designs, they are included to give policymakers a better sense of how FIT rates are developed and codified.

4.1 Survey Methodology

A survey of FIT rate-setting methodologies was conducted, and key criteria for comparing FIT rate-setting methodologies were identified. The goals of this survey were to develop a common language and framework for comparing different rate-setting approaches and to identify common or best-practice approaches against which to benchmark current and future U.S. FIT rate-setting efforts. Another key goal of the survey was to directly inform the development of general-purpose CREST models that could be used by stakeholders in the United States to set FIT rates.

After surveying different FITs around the world, five jurisdictions were chosen for in-depth analysis and comparison: Germany; the Netherlands; Ontario, Canada; Vermont; and Gainesville, Florida. These jurisdictions were chosen because they represent a diverse sample of different generation cost-based FITs. They include a mix of well-established and relatively new policies, tariffs from both Europe and North America, and policies established at the national, state, and local levels. Moreover, each of the jurisdictions used a different approach to building customized spreadsheet models rather than using any of the pre-existing tools. The customized Vermont and Gainesville models were included in Section 3. Other jurisdictions did not use publicly available tools, however, and either are not yet willing to make the customized models available or have not yet released an English language version of the model.

The comparison between the jurisdictions was conducted through a literature review, comparisons of the modeling spreadsheets, and interviews with government officials, utilities, or consultants involved with design. Interviews for each jurisdiction were conducted with the following individuals during the period from fall 2009 to spring 2010:

- Germany: Maike Schmidt, Zentrum für Sonnenenergie- und Wasserstoff-Forschung (ZSW)
- Netherlands: Hans Cleijne, Principal Consultant, KEMA B.V.
- Ontario, Canada: Jim MacDougall, Manager, FIT Design, Ontario Power Authority
- Vermont[26]: Matt Karcher, Principal, Deacon Harbor Financial[27]
- Gainesville, Florida: John Crider, Planning Engineer, GRU.

As described below, some of the spreadsheet models are available online, whereas others are confidential and not available to the general public. Detailed reviews were conducted of the available spreadsheets, supplemented by in-depth interviews with the models' designers. In cases where the models were not available for direct review, the analysis was completed through the use of a detailed questionnaire and follow-up interviews with program managers.

Broadly, the comparison revealed that there are significant differences in the approaches that the selected jurisdictions have used for FIT rate setting. These differences primarily derive from the different regulatory and political systems present across the jurisdictions and the processes established to gather cost data for renewable energy generation technologies. The comparison also revealed, however, that there are clear commonalities among the rate-setting processes, particularly among the spreadsheet models that were developed and employed.

4.2 Comparing the Spreadsheet Models

In each of the case study jurisdictions, the FIT designers relied on spreadsheet-based financial models to calculate the FIT rates for target technologies. As discussed in greater detail in Section 5, the spreadsheets employed can range from simple financial models with only a few inputs to highly complex models that require hundreds of inputs and assumptions. There are trade-offs inherent in the relative complexity of spreadsheet modeling, and different levels of complexity might be preferred depending on the spreadsheets' intended purpose or audience. Project developers, for example, could find that more complex spreadsheets are required by potential project financiers to predict project cash flows to a degree sufficient to evaluate investments. Policymakers, on the other hand, could prefer to use less complex, more generalized models for policy-design purposes. Simpler models can be more transparent and accessible to stakeholders and can be designed to be representative of a broad range of potential projects (rather than tailored exactly to match a specific project).

Generally, the models used to set the rates for the case study FITs tended to be less complex than the full financial pro formas required by prospective capital providers. For the models used both in the United States and abroad, inputs tended to be aggregated (e.g., one or a few inputs for

[26] The authors of this report also were directly involved in the Vermont rate-setting proceedings.
[27] Karcher served as an expert witness for Renewable Energy Vermont in the proceedings and supported the development of a model that was adopted by the parties.

installed cost instead of 20), and the models tended to be limited to one or two worksheets. This section compares the spreadsheet models used in the case study jurisdictions in greater detail but does not attempt to discuss the drawbacks and benefits of different approaches. More in-depth discussion of pros, cons, and policy implications of different modeling approaches, levels of detail (i.e., granularity), and other factors can be found in Section 2, Section 3, and Section 5. More detailed descriptions of each jurisdiction's approach to rate setting are included in Appendix B.

4.2.1 Calculation Methodology

As described in Section 2, several standard types of calculation methodologies can be employed. Most of the jurisdictions studied utilized a DCF methodology (see Section 2.2). The one exception was Germany, which used a type of FCR methodology (see Section 2.3.2) for most resource types. A FCR model initially was proposed for use in Vermont (Vermont Public Service Board 2009a). This methodology was replaced by a DCF model early in the proceedings, however, after stakeholders suggested that a model that included a detailed pro forma would be more appropriate for the decision-making process (Vermont Public Service Board 2009a).

4.2.2 Tax Treatment

Tax treatment refers to whether potential tax impacts on project economics (i.e., income taxes on power sales, income tax credits for installation or production, and accelerated depreciation) are taken into account by the model. Most of the models analyzed use after-tax data, meaning that the impacts of tax benefits and losses are taken into account when calculating the COE. The exception to this is Germany, where the FIT rate typically is based on project economics before taxes are applied. The German government opted for a pretax calculation because tax benefits available to renewable energy generators are not significant and because tax liabilities vary across ownership types and are difficult to generalize.

Although most of the case study jurisdictions employed after-tax analysis in their models, some important differences were noted in their approaches. Most of the jurisdictions assumed that generators could and would depreciate their eligible property according to the available schedules.[28] Vermont's model added an extra layer of complexity, however, by assuming that future capital expenses (e.g., replacing the PV inverter) also would be depreciated. Another difference between the after-tax models was the treatment of tax credits. The United States relies more heavily on tax incentives at the federal, state, and local levels than do European countries; as a result, the treatment of tax credits in the U.S. models has important implications. Not all of the individual costs that comprise an aggregate "installed cost" figure, for example, are necessarily eligible for depreciation or tax credits (Bolinger 2009), but individual models approach this differently. The Vermont model allows for the percentage of costs eligible for depreciation to be specified, whereas the Gainesville model does not provide this level of detail.

4.2.3 Assumed Ownership Structure

Closely related to the issue of tax treatment is the issue of assumed ownership structure. Ownership structure can have important implications for tax incentives and liabilities and the

[28] Ontario, for example, assumes that 60%–80% of project costs will be depreciated under the Class 43.2 Capital Cost Allowance, with the remainder of capital costs depreciated according to an 8% declining balance schedule (Ontario Power Authority 2009).

availability of additional incentives. As discussed further in Section 5, FITs can be established based on an assumed ownership structure. A conservatively set tariff might assume the most efficient (lowest-cost) structure and a more aggressive tariff model might assume a less optimized ownership structure, thereby allowing a broader range of ownership structures to thrive.

Another option to account for the differences is to differentiate the FIT payment levels based on ownership. Due to the differences in applicability of tax-based incentives, as well as the ability for government bodies to utilize tax-free bonding or similarly advantaged financing mechanisms, the assumed ownership structure can have a material impact on the revenue needs, or COE, for a renewable energy project. This observation suggests that calculation methodologies and their corresponding spreadsheet models might be built to accommodate both taxable and tax-free ownership structures (Green Mountain Power 2009; Tregilus 2010). None of the models surveyed, however, were specifically built to model ownership by non-taxpaying entities.

All of the case study jurisdictions used models that assume commercial, private-sector ownership, except the Netherlands' model, which assumes that small-scale PV is owned by a residential homeowner. Ontario's FIT rate setting differentiates between three different corporate tax schedules (i.e., different project sizes are assumed to be owned by different corporation types[29]) but does not assume residential ownership of any system type or size (Ontario Power Authority 2009).

4.2.4 Evaluation Metrics for Return on Invested Capital

Each of the models is constructed to solve for one or more evaluation metrics. These metrics are not merely model "outputs"; however, they represent minimum thresholds or constraints that must be met for the renewable energy project to achieve the financing necessary for construction and operation. The models then adjust the FIT level until each constraint is met and the evaluation metrics demonstrate an economically feasible project—keeping all other inputs constant. The most common evaluation metrics in the jurisdictions studied include the IRR (which can be calculated on either before- or after-tax cash flows to equity providers) and the NPV. The IRR metric reports the percentage return on equity for the analysis period (likely to be the length of the proposed FIT contract in this case). By comparison, the NPV assumes a target percentage return on equity requirement and uses this target to calculate the present dollar value of the investment. A resulting NPV that is equal to or greater than zero denotes an investment that meets or exceeds the investor's minimum required return. An NPV of less than zero represents an investment that fails to meet the investors required return.

4.2.5 Assumed Capital Structure

Sources of capital to finance generation projects generally consist of equity and debt and also could include grants or other incentives. As a practical matter, not all projects use the same financing vehicles. For example, individual project financings could differ with respect to the obligations of, and rights granted to, equity providers. If leverage is used, then project owners must select one or more lenders, establish payment priorities, and determine whether the lender has recourse beyond the generator assets if the project company is unable to service the loan. In

[29] For example, General Corporation—General Corporate Income Rate; Canadian-Controlled Private Corporation—Small Business Rate; Canadian-Controlled Private Corporation—General Active Business Rate.

some cases, more complex capital structures are desired; for example, to facilitate changes in ownership allocations at various times during the project's useful life (Harper et al. 2007) or to make use of more sophisticated financing instruments that enable the conversion of debt into equity. Spreadsheet models used for policy analysis typically utilize capital structures on the simple end of the spectrum, assuming a single source of equity and a single source of debt. In these cases policymakers must identify the equity investor's target return on equity (typically after-tax dollars) and, if debt is used, the total loan amount, tenor, and interest rate.

Based on assumptions about market conditions and the type of debt applied to the project (e.g., with or without recourse beyond the assets of the project),[30] different debt terms were assumed by different jurisdictions. These terms include the amount of debt available to the project as a percentage of total capital contributed, the tenor, the interest rate, and the required average and minimum annual debt service coverage ratio.[31] Almost all of the models allow for modeling of a single conventional debt instrument and assume that projects will take advantage of some degree of leverage. The exception to this is the Gainesville model, which assumes that projects will be paid for with 100% equity. Both Ontario and the Netherlands generally assumed that the same debt-to-equity ratio applied to all technology types (i.e., 80/20 in the Netherlands;[32] 70/30 in Ontario). In both Germany and Vermont, each of the different technologies was assumed to have different debt-to-equity ratios, which generally reflected their different risk profiles and type of debt. Most jurisdictions assumed that the debt term was equal to the FIT term.[33]

4.2.6 Treatment of Incentives

Incentives for renewable energy generation can take many forms, including tax credits and accelerated depreciation deductions, production incentives, rebates, and grants (both taxable and non-taxable). Applicability can depend on availability or the developer's tax liabilities. Such incentives typically fall into two broad categories, "generally available" or "of limited availability" (e.g., budget limited, set to expire, or accessed only by winners of competitive processes). Additionally, the full value of generally available incentives that depend on tax appetite—the presence of sufficient tax liabilities to monetize tax incentives—might not be realized. Generally speaking, each of the jurisdictions took other available incentives into account in determining the FIT rate. The most significant variance was the degree to which incentives were presumed to be available or monetized.

The Netherlands model explicitly incorporates the national energy investment allowance incentive[34] where available. In the United States, both Gainesville and Vermont took the 30%

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[30] In Vermont, the PSB assumed that most project debt was recourse except for PV, which was assumed to be project financed (Vermont Public Service Board 2010).

[31] A debt service coverage ratio is a fraction that uses earnings before interest, taxes, depreciation and amortization (EBITDA) (operating cash flow) as the numerator and the sum of principal and interest owed for the same period as the denominator. The debt service coverage ratio is one of several tools used by lending institutions to assess the risk that a project will not be able to repay its loan.

[32] The exceptions to this are the Dutch small PV tariff, which is assumed to be 100% debt financed through a residential mortgage and the Dutch waste-to-energy tariff, which is set assuming corporate finance.

[33] The exceptions to this were for hydropower in the Netherlands, which assumes a 30-year debt term but only a 15-year FIT life; in Vermont, where the PSB found that the model should assume a "loan tail" for each generator—that is, assume that the loan term would be shorter than the contract term.

[34] Known in Dutch as the *Energie-investeringsaftrek*, or EIA.

federal income tax credit into account for eligible generators.[35] There was controversy in Vermont over whether state incentives—which included a state grant and state tax credits—should be taken into account. The law states that "reasonably available" incentives should be included in the FIT calculation. Some stakeholders argued that the limited availability of the state grant and the limited state tax equity available to monetize the tax credits meant that those incentives did not pass the "reasonably available" test. Additional guidance from the state clarified that generators could not take both the state grant and the FIT, but it was ultimately assumed that the state tax credits could be claimed against a portion of the capital costs for most generators (Vermont Public Service Board 2010). In Ontario, the FIT rates do not assume that generators can take advantage of the federal ecoEnergy incentive because it is available on a first come, first served basis and is already oversubscribed.

4.2.7 Tariff Rate Escalation

Another important FIT policy design decision is whether to allow all or a portion of the tariff rate to escalate over time. The options for this policy issue range from establishing a fixed FIT rate that remains constant for the duration of the contract to setting a rate that automatically adjusts each year—by multiplying either with a fixed escalation factor or with a designated inflation index such as consumer price index or gross domestic product implicit price deflator. The models examined vary in their approach to escalation. In Germany, the Netherlands, and Gainesville, Florida, the FIT rate remains fixed over the term of the policy. Ontario escalates 20% of the tariff rate each year at an assumed 2.25% inflation rate, and Vermont escalates 30% of the FIT rates annually for inflation.[36] Where applied, tariff-rate escalation is intended to serve as a risk-mitigating tool,[37] at least partially protecting the project investor from the uncertainty associated with the future cost of owning and operating the renewable energy facility.

4.2.8 Accounting for Operating Cost Inflation

Separate from (but not unrelated to) tariff-rate escalation, operating-cost inflation represents another decision point in the FIT rate-setting process. The question of whether to inflate operating costs typically is encountered at the cost-modeling stage. Some models assume a rate of inflation that is applied to all annual operating expenses. Some models apply inflation rates or indices to only a subset of annual operating costs. Some models assume no inflation at all, setting the FIT rate based on a static assessment of project capital and operating costs. Both Germany and the Netherlands assume a fixed inflation rate in their respective modeling of operating costs. By contrast, the Gainesville model does not include inflation in its calculation of the FIT rate, nor does it escalate its FIT rate.

4.2.9 Granularity of Cost Input Detail

Each of the models included comparatively aggregated inputs for costs, except for Germany's model, which included detailed capital and operating cost inputs. All of the other models included more simplified cost inputs, with the Netherlands, Gainesville, and Ontario each aggregating capital costs as a single input. Vermont, by contrast, distinguished initial financing

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[35] The exception to this was farm methane generators in Vermont. For farms, neither the federal nor the state tax credit was taken into account when calculating the FIT rate because it was assumed that farms did not have the tax appetite to take advantage of either incentive.
[36] In both Ontario and Vermont, the PV rate remains fixed and is not adjusted for inflation.
[37] The Ontario Power Authority (2009), for example, stated that "20% is generally consistent with the proportion of project costs that vary with inflation and provides protection against changes in the rate of inflation" (p. 32).

costs, such as debt and operating reserves, from hard capital costs. Most of the jurisdictions' models also require operating cost inputs,[38] which tend to be more differentiated than the capital cost inputs (e.g., three to five inputs, divided between fixed and variable operating costs).

4.2.10 Key Observations from Comparison of Spreadsheet Models

The case study jurisdictions have employed similar approaches to structuring their rate-setting models, even if the exact inputs and assumptions employed differed. With a few exceptions, the models generally are characterized by:

- Comparatively simple inputs (see Section 5)
- DCF, after-tax analysis
- Assumed private sector, commercial ownership
- The use of IRR as an evaluation metric
- An assumption that other available incentives are taken into account before the rate is calculated
- Aggregated cost inputs.

4.3 Comparing the Rate-Setting Process

Although there is commonality among the spreadsheet models employed, there are significant differences in how the case study jurisdictions structured and managed their rate-setting processes—including differences in data gathering, stakeholder engagement, and approval processes. Although these processes and procedures are not as directly relevant to the CREST model as the review of comparative model designs, they are included to give policymakers a better sense of how FIT rates are developed and codified. Sections 4.3.1 and 4.3.2 discuss the extent to which the data gathering and stakeholder engagement shape model design. Section 4.4 on the approval process highlights the fact that the outcomes of a rate-setting analysis could be exposed to additional amendments by policymakers.

4.3.1 Data Sources

Different jurisdictions used different sources of data to develop assumptions for their models. A significant differentiating factor among the case studies is that the European countries generally have more data on recent and local project costs to inform rate setting. This largely is a result of Europe's lengthier experience with FIT policies and because of requirements that generators receiving FITs must provide cost and performance data to subsequent rate-setting processes. As a result, European data-gathering processes tend to be more robust. Germany employs eight different research institutes to analyze bottom-up cost data from both published industry studies and from an analysis of costs reported by generators receiving FITs. The Netherlands employs both private sector and public sector research consultancies to create initial estimates, which are cross-referenced with industry cost data through a transparent, public engagement process (KEMA 2008). Each of the North American data-gathering processes was focused primarily on surveys of top-down data (i.e., average installed costs) rather than on bottom-up research processes (i.e., researching the costs of individual components). Ontario relied on published cost

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[38] The exception to this was Gainesville, which automatically populated O&M cost assumptions as a function of the installed cost input into the cash flow model.

estimates from recent consulting studies as well as experience from the 2006 Renewable Energy Standard Offer Program (RESOP). Gainesville and Vermont both relied on publicly available data gathered from regional programs, published studies, and input from industry.

4.3.2 Process Transparency and Stakeholder Involvement

The process by which cost data were gathered and ultimately integrated into the spreadsheet models shaped the amount and type of stakeholder input permitted in the rate-setting process. Germany and Ontario published descriptions of their calculation methodologies, rate-setting approaches, and data sources and also permitted some stakeholder comments and participation. The rate-setting models themselves, however, are not publicly available.

Both the Netherlands and Vermont utilized highly participatory processes featuring transparent spreadsheet models posted online. Stakeholders were encouraged to submit their own datasets to inform the model. Gainesville's process also provided an opportunity for stakeholder input through city commission workshops, but the process was not as extensive as those used in the Netherlands or in Vermont. The spreadsheet model is not available online from GRU but is available upon request. In some instances the nature of the stakeholder process informed the development of the model. In both the Netherlands and in Gainesville, for example, the rate-setting models were developed with simplicity in mind to accommodate and focus stakeholder input on key assumptions. As discussed in greater detail in Section 6, there are trade-offs in administrative costs, process length, and process complexity inherent in the amount and type of data gathered, the transparency of the rate-setting approach, and the degree to which stakeholders are involved.

4.4 Approval Process

The approval process determines the degree to which policymakers can influence or shape the rate-setting process subsequent to cost modeling. A key question here is whether the modeling exercise is the final step in the rate-setting process or whether the rates are developed as data points for use by policymakers and therefore are subject to further change. Across the case study jurisdictions there was little commonality among the processes by which the FITs were approved. This largely is a function of the different legal systems and regulatory processes of each jurisdiction. In all cases, however, the outputs informed policymakers, who then had authority to make the final decision to adopt the rates or alter them. In Germany and the Netherlands, for example, the FIT rate development process is managed by the responsible government ministry, but the final rates are proposed to the national legislature for adoption. During the parliamentary process, there are opportunities for the proposed rates to be amended before they are passed into law. In 2008, for example, the German legislature increased the wind rates rather than adopting them as proposed. In Vermont, by contrast, the FIT rate-setting process was initiated by a law that directed the PSB to examine what reasonable rates should be. The board used its authority to set the final FIT rates, following a formal regulatory proceeding. In Gainesville, the utility managed the development of the rates, which were then formally adopted in an ordinance approved by the city commission.

4.5 Conclusion

As described in Section 4.2.10, the comparison of different jurisdictions' spreadsheet models reveals that there are clear commonalities between the rate-setting approaches employed both in the United States and abroad. Each of the spreadsheets also contains distinct design features that reflect the different regulatory frameworks, analytical philosophies, and policy objectives present in the different jurisdictions. These findings provide a frame of reference for the recommended design of the CREST model described in Section 5. Some of the common design decisions, for example, could be appropriate for direct integration into CREST, whereas some might not enable the full range of function and flexibility envisioned for the CREST model.

5 CREST Model Inputs

This section provides a clear pathway to determining the set of inputs that must be defined to calculate a FIT rate for each technology-differentiated tariff and can be used to inform the structure of the CREST model.

5.1 Model Inputs and Their Context

In determining the ideal characteristics of a spreadsheet model to be used in support of FIT policy development and implementation context matters, the three categories of issues that should be considered are the policymaking process, policy objectives, and trade-offs among competing objectives.

5.1.1 Implications on Cost Modeling Dictated by the Process

As discussed in Section 6.1, the process of deriving and collecting inputs has implications for modeling choices. If the policymaking process relies on surveys of installers or developers to determine the "top-down" all-inclusive installed costs or total operating costs of a particular renewable energy technology, then few input cells would be required. Some FIT development processes have sought to develop detailed "bottom-up" cost estimates based on the costs of individual components. In such instances, a more detailed set of inputs could be required in the model.[39] A model intended to accommodate a range of processes should be designed to accommodate a greater variety and granularity of inputs than one using only greatly aggregated, top-down inputs. Conversely, a model with numerous minutely detailed input cells (i.e., high-input granularity) could prove confusing and cumbersome for users and could be prone to user errors such as leaving costs in detailed input cells that are already incorporated into aggregate numbers entered into another cell. A spreadsheet model able to accommodate both highly granular inputs and highly aggregated inputs is most useful within a wide range of policymaking processes.

5.1.2 Implications of Policy Objectives on Model Characteristics

Policy objectives also influence FIT cost model design. As discussed further in Section 6, there are numerous policy decisions to be made in FIT design, many of which have modeling implications. For example, is a single rate calculated for each technology or are costs further differentiated by project size, location, or another characteristic? Do policymakers wish to encourage a diversity of ownership structures or locations? Are policymakers seeking to develop an aggressive price point that might support a wide range of projects or a conservative price that might only support the most cost-effective project sizes or configurations? These choices could influence whether the costs of individual components (which might be sensitive to scale) can be varied in the model, whether the model can accommodate varying tax consequences and incentive eligibility, and whether the model is able to consider a variety of ownership structures.

5.1.3 Implications of Model Use

Another factor to consider is how the model results will be used. Will the result be used directly to set the FIT rate, for instance, or be used to guide a process of rate setting informed by the modeling? A model able to produce results for a range of inputs enables good consideration of the range of potential costs for a particular technology, enabling policymakers to make more

[39] Although these inputs could be aggregated external to the model, doing so has the potential to introduce some inaccuracy.

informed decisions regarding where to place the FIT rate on the aggressive-conservative continuum (discussed further in Section 6).

5.1.4 Finding the Right Balance Among Trade-Offs in Model Design

There are many trade-offs to be considered in the art of modeling. These usually fall along the spectra of simplicity versus complexity and of perceived accuracy versus ease of use.

- **Simplicity and ease of use**. For a model to be used within a policymaking context, it must be both readily understood by users who do not create financial models professionally and difficult to "break" or cause to malfunction. The more complex the model, the more likely it is that it will violate these criteria.
- **The trade-off between high-level and detailed analysis.** There will be a natural inclination among some users to seek greater detail and resolution in the name of accuracy. Clearly, the more features and options included, the more case-, technology-, or site-specific analysis a model can handle. Conversely, some users might seek a simplified model to estimate project costs. For policy-analysis purposes, it might be overkill to require the same level of detail as a model designed to support project financing.
- **Accuracy, precision, and representativeness.** Allowing for detailed cost inputs might provide a more accurate estimate of COE by increasing resolution. A more detailed set of model inputs, however, also can lead to false or "illusory" precision. This can occur if many of the inputs must be estimated because data are not readily available at that level of detail or if the range of cost variations among installations of the same technology is greater than the degree of precision gained.[40] Sometimes a representative estimate is sufficient.

  On the other hand, common methods used to simplify financial calculations—for example the "recovery factor" methodologies described in Section 2—can introduce imprecision (in this example, the inability to accurately model depreciation, applicability of tax incentives, and cash flow constraints). When it comes to model inputs, the right level of detail for a spreadsheet tool is influenced by such factors as the availability of reliable input data, the representativeness of that data for the applicable technology as a whole, and the policymaker's inclination to differentiate tariffs. As a result, a flexible model design might be more amenable to the range of anticipated CREST model uses than a one-size-fits-all set of model inputs.

  - **Level of data granularity.** As discussed, there exists a wide range of potential granularity of input data. A project's total installed cost, for example, could be either (1) input as a single value that implicitly includes items such as construction interest, permitting costs, developer's fees, and financing expenses, or (2) input as multiple values with equipment- and installation-specific detail. The process for collecting and compiling data, the

[40] For example, even for a single technology, costs can vary widely based on factors such as scale economies, resource quality, distance from transmission, whether or not a substation is required, and other site-specific factors. Further, changes in costs over time (before a FIT rate might be reset) can also outstrip the precision of a specific model result.

sophistication of the users, and the desire to vary specific components to explore tariff differentiation or the aggressive-conservative decision all influence the decision about this trade-off.

- **Ease of model use**. Depending on the timeline for the rate-setting process, a complex model with a significant degree of granularity could be less practical to utilize, as learning, explaining, populating, and debating it might take more time than is available.

Given the range of policy objectives and policymaking processes throughout U.S. electricity markets, the analysis in this section takes the above factors into account in developing recommended inputs for a spreadsheet modeling tool that is both easy to use and flexible enough to account for a variety of policy-design choices.

5.2 Total Installed Cost

Renewable energy installations are complex and capital-intensive projects. A diverse combination of equipment, labor, and service providers is required to bring each project to completion. Therefore, a project's true installed cost—those costs collectively aggregated for permanent financing—includes not only the cost of equipment and installation labor but also those associated with arranging financing, construction interest paid, conducting investor due diligence, establishing necessary operating reserve accounts, negotiating PPAs, designing and implementing utility interconnection, completing a resource assessment, and a plethora of development and permitting tasks. Equipment and associated installation expenses typically are referred to as "hard costs." The costs of financing and due diligence are referred to as "soft costs." All work related to studying project feasibility, engineering and design, obtaining permits, and negotiating power sales are referred to as "development costs." The treatment (for modeling purposes) of each of these cost categories was studied during the survey of modeling tools described in Section 3 and the review of industry experience with FIT modeling found in Section 4. The recommendations for modeling total installed costs in the CREST model are based on these analyses.

Total installed costs can be modeled many different ways. Some project stakeholders tend to speak of and analyze installed costs in aggregate dollars per kilowatt installed, and others require detailed lists of equipment and service costs. For some purposes, the component-level detail is necessary; for example, regarding the eligibility of costs for the ITC or for depreciation classification. The level of installed-cost detail included in a financial analysis helps to determine the level of complexity in other areas of the model. If installed costs are broken down in great detail, for example, then assignments of depreciation schedules and incentive eligibility could be done on a line-by-line basis. In the absence of such detail, depreciation allocations and incentive eligibility can be assigned for the purpose of estimating the COE from the proposed facility, using rules of thumb based on the composition of project costs. Table 2 summarizes the range of complexity in installed-cost modeling options.

Table 2. Summary of Total Installed Cost Inputs

	Range of Complexity in Total Installed Cost Inputs		
	Simple	**Intermediate**	**Complex**
Total Installed Cost Inputs	✓ Total dollar ✓ Dollar per kilowatt	✓ Generation equipment ✓ Balance of plant ✓ Interconnection ✓ Development costs ✓ Financing costs	✓ Each piece of equipment and service provided has its own input

The list of installed cost inputs is the primary example of an area in which policymakers can elect to have calculations made either within or external to the cost model. The financial model must have a reliable estimate of total installed cost, but it need not include a detailed breakdown to be able to calculate a defensible estimate of the COE for a specified project.

2. The Intersection of Modeling Inputs and Consensus-driven Stakeholder Processes

Although not essential to the modeling process, a detailed discussion of the composition of installed costs nonetheless could be helpful to the stakeholder consensus process. In this case, policymakers might wish to derive a detailed list of installed cost inputs (and arrive at a final representative installed cost number) through a collaborative process but only enter a single input—or defined set of aggregated inputs—into the rate-setting model. Doing so allows a more transparent consideration of some of the underlying assumptions or policy preferences. For instance, explicitly considering how much cost to include for such items as interconnection, line extension, and substation costs aligns with decisions on whether a FIT is intended to encourage project location at the most efficient locations to minimize these costs or over a more geographically diverse footprint. Conversely, such detail requires a level of data maturity and depth not necessarily available in the United States, as well as sufficient time for stakeholder debate on installed-cost components.

A financial analysis also can be constructed to allow the user to select the single input (simple), a categorical approach (intermediate), or a detailed level of granularity (complex). With such functionality, policymakers and stakeholders together can determine how much installed-cost transparency is desired. The specified line-items vary from project to project in the most detailed analysis, so it is impractical to attempt to develop a model that predicts all of the necessary inputs. Therefore, for the complex approach to be useful, its structure must allow for a user to specify a custom line-item detail. By definition, FITs are rates intended to be representative of a category of resources, and not a single project or the simple or intermediate approaches appear to be better tools to accomplish state objectives. Nonetheless, the complex structure can provide for those situations where highly granular cost detail is available or desirable.

Assessment. For the purposes of this project, an intermediate level of complexity for modeling the total installed cost of renewable energy projects appears to be most appropriate. This level of granularity allows for a reasonable amount of cost allocation among major categories yet maintains focus on ease of operation, which is a critical component to its value to policymakers. As discussed in Section 6, however, the specific policymaking process and the nature of the data sources can dictate whether a more highly aggregated or more detailed set of cost inputs is desired. For a model with the goal of being useful in a wide range of contexts, including a user-defined option to select simple, intermediate, or complex cost-input granularity is ideal.

5.3 Operating Costs

Although the cost of many renewable energy projects is dominated by initial capital expenditures and not by operations, the annual fixed and variable costs also impact a project's economics. Annual charges often are casually referred to as "operations and maintenance" (O&M); however, this term paints an incomplete picture of a facility's annual cost obligation. The full annual cost to operate a renewable energy facility also includes project management, insurance, property taxes (or payments in lieu thereof), permit maintenance, site maintenance, land lease or royalty payments, and other potential fixed and variable costs. A minimum level of specificity that accounts for these costs must be achieved to set FIT rates appropriately. As with total installed costs, operating costs can be estimated either individually or in aggregate. The presence of fixed operating costs that are independent of production, however, makes it difficult to accurately model all operating costs as a single value (i.e., in cents per kilowatt-hour) when production is expected to vary from year to year. As a result, the CREST model at minimum should include inputs for both fixed operating expenses (in dollars per kilowatt per year) and variable operating expenses (in cents per kilowatt-hour). The recommendations for modeling operating costs in the CREST model are based on the survey of modeling tools discussed in Section 3 and the review of industry experience with FIT modeling found in Section 4. Table 3 summarizes the range of complexity in modeling operating cost inputs.

Table 3. Summary of Operating Inputs Options

	Range of Complexity in Operating Cost Inputs		
	Simple	**Intermediate**	**Complex**
Operating Cost Inputs	✓ Variable operating costs (¢/kWh) ✓ Fixed operating costs ($/kW-year)	*Fixed Costs* ✓ Fixed O&M[41] ✓ Insurance ✓ Project management ✓ Property taxes *Variable Costs* ✓ Variable O&M ✓ Royalties ✓ Fuel or other consumables (if applicable)	✓ Line-item inputs for individual non-capital cost components

Assessment. Depending on the situation, either the simple level or the intermediate level of operating cost detail could be appropriate. As a result, it is recommended that the CREST model provide the flexibility to employ either the simple or intermediate approach. At a minimum, the user will define both fixed and variable operating expenses. The intermediate option allows for further specificity in the categories shown in Table 3. The intermediate approach is intended to offer enough detail to address important issues raised during stakeholder processes yet maintain focus on ease of use. If further granularity in operating cost inputs is desired, policymakers and stakeholders can elect to compile a more detailed list external to the model. Once complete, the detail list can be partially aggregated to fit into the limited number of fixed- and variable-cost categories offered within the model. Because FITs are intended to be representative of a category of resources and not a single project, the categorical approach appears to be a better tool to accomplish state objectives.

[41] This input could be used to model a long-term service agreement.

Additionally, it is recommended that CREST also take into account major equipment repairs or replacements likely to occur during the project's expected useful life. This would include, for example, inverter replacements for solar generators, gearbox repairs, replacements for wind projects, and make-up wells for geothermal facilities. Although these costs could be thought of categorically as ongoing maintenance, from a modeling perspective they should be treated as capital expenditures and depreciated accordingly.

5.4 Government Incentives

In this report, the term "government incentives" refers to the range of financial support mechanisms available to electricity-generating projects from federal, state, and (potentially) local governmental bodies. Due to the substantial and continually evolving variety of incentive programs available to renewable energy generation across the country, it is impractical to design and construct a rate-setting tool capable of modeling every conceivable state and local incentive. It is both important and feasible, however, to establish FIT rates that take into account both the broadly available federal incentives and the most common structures for both state and federal incentives and assume their efficient utilization. The recommendations for modeling government incentives in the CREST model are based on the survey of modeling tools undertaken in Section 3 and the review of industry experience with FIT modeling found in Section 4. Table 4 identifies each major category of government incentive and describes three levels of complexity at which each incentive can be modeled.

Table 4. Summary of Modeling Options for Federal, State, and Local Incentives

Modeling Options for Federal, State, & Local Incentives	Range of Input Complexity in Modeling Renewable Energy Incentives		
Federal Incentives			
Federal Production Tax Credit (PTC)	✓ PTC value ✓ Duration (10 years) ✓ Eligibility: Y/N		
	Simple	**Intermediate**	**Complex**
Federal ITC	✓ Single input ✓ Percent of total installed cost	✓ Cost eligibility modeled categorically	✓ Applicability determined line by line for detailed capital costs inputs
Utilization of PTC or ITC[42]	✓ Full ✓ Single input at 100%	✓ Partial ✓ Single input between 0% and 100%	✓ Partial ✓ Based on investor-specific tax obligations
Accelerated Depreciation (Federal)	✓ Total project cost is allocated across several depreciation categories using % inputs	✓ Total project cost is divided into categories and then allocated across depreciation schedules	✓ Assignments made for each cost line item

[42] Although many models assume that the full value of such incentives can be utilized, in practice that often is not the case. For example, in bringing in third-party equity investors, developers often have to give up some of the value in the deal. In other cases, the value of tax credits is fully realized only when the owner has sufficient tax liability to offset with the credits. Over the course of a project life it often is the case that, in some years, owner tax liabilities are insufficient to monetize the full value of the tax credits. The recent recession, for example, has resulted in shrinking profits and corresponding federal income tax liabilities for many of the traditional tax equity investors.

Modeling Options for Federal, State, & Local Incentives	Range of Input Complexity in Modeling Renewable Energy Incentives		
Utilization of Annual Net Operating Losses (Federal)	✓ All tax losses monetized as generated	✓ User defines whether tax losses are used as generated or carried forward	✓ Tax losses allocated across partnership
State & Local Incentives			
State ITC	✓ Single input ✓ Percent of total installed cost	✓ Cost eligibility model categorically	✓ Applicability determined line by line for detailed capital costs inputs
Utilization of State ITC	✓ Full ✓ Single input at 100%	✓ Partial ✓ Single input between 0% and 100%	✓ Partial ✓ Based on investor-specific tax obligations
State Grant, Rebate, or Capacity-Based Incentive	✓ Single, dollar-value input ✓ Dollar value calculated external to model	✓ Dollar value calculated internally	✓ Look up table of available incentives by state
Production-Based Incentives	✓ Dollar per megawatt-hour ✓ Duration ✓ Escalation	✓ Dollar per megawatt-hour ✓ Duration ✓ Escalation ✓ Funding cap, if applicable	✓ Look up table of available incentives by state
State Property Tax Exemption	✓ Ignore property taxes	✓ Create entry for fixed annual payments in lieu of taxes (PILOT);[43] populate as necessary	✓ Model using tax rate and basis; populate as necessary
State Sales Tax Exemption	✓ Reflect exemption through lower installed-cost estimate	✓ Break-out sales tax calculation categorically; zero out tax rate as applicable	✓ Apply sales tax calculation line by line; zero out tax rate as applicable

It is important to note that a project's eligibility for any individual incentive could depend on the technology deployed as well as on the project's ownership composition, capital structure, off-take arrangements, and other factors. Table 5 provides a high-level summary of eligibility for federal incentives by technology and ownership structure. The presence and applicability of state incentives are too diverse to include in a single table. A good source for information on state incentives is the Database of State Incentives for Renewable Energy (DSIRE) website, located at http://www.dsireusa.org.

[43] If PILOT is not applicable, the user can estimate the equivalent average annual property tax payment and enter it in the cell for the PILOT input.

Table 5. Summary of Eligibility for Federal Incentives

	Selected Eligibility Criteria for Federal Renewable Energy Incentives				
	By Technology			By Ownership	
	Solar	Wind	Geothermal	Private	Public
PTC		Through 12/31/12	Through 12/31/13	√	
ITC	Through 12/31/16	Through 12/31/12	Through 12/31/13	√	
U.S. Treasury Grant[44]	√	√	√	√	
Accelerated Depreciation	√	√	√	√	
Clean Renewable Energy Bonds (CREBs)	√	√	√		√
USDA Grants & Loans	√	√	√	√	
Renewable Energy Production Incentive (REPI)[45]	√	√	√		√

Notwithstanding the general rules described and summarized in Table 5, the ability to make efficient use of the tax-oriented incentives depends on the tax status and appetite of project investors. As a result, the impact of incentives on any FIT rate-setting exercise is representative and not specific to the individual investors in a specific renewable energy project.

Assessment. It is recommended that the CREST model include the most widely available and commonly used federal and state incentive programs. The survey of models and review of FIT experience in other jurisdictions is used to inform the list of incentives included in the CREST model.

5.5 Ownership and Capital Structure

Ownership and capitalization structures also can influence a project's COE or revenue requirements. This section defines a range of potential ownership and capital-structure options that could be assumed when modeling FIT rates. Policymakers' ultimate FIT design choices will have a significant impact on the availability and terms of financing for eligible renewable energy generators. The recommendations for modeling ownership and capital-structure options in the CREST model are based on the survey of modeling tools in Section 3, and the review of industry experience with FITs is found in Section 4.

5.5.1 Ownership Structure

A project's owners are responsible for both providing the initial investment and meeting any ongoing cash obligations. The owners also gain from a project's cash flow benefits. Ownership structure refers to the types of entities with a defined percentage ownership interest in the project, as well as their respective tax status. For example, a project described as a private joint-venture denotes ownership by two or more taxable entities. As a practical matter, one of these owners likely is without the tax liability necessary to utilize all of the project's available benefits. This circumstance is the basis for most private partnerships and represents the most commonly used structure in today's market for utility-scale project financing. In contrast, a public project refers to ownership by a non-taxable government entity. Public-private partnerships are a hybrid of the two types of structure. The selected ownership structure has important implications for

[44] Available to projects under construction by December 31, 2010, and meeting all PTC or ITC eligibility criteria.
[45] REPI is subject to annual appropriation and historically has been underfunded as compared to outstanding REPI commitments.

taxation and the project's eligibility for federal and state incentives. Table 6 summarizes these issues and their impact on FIT rate setting.

Table 6. Summary of Ownership Structures and Financial Modeling Implications

Tax Status Issue	Private Ownership (Income Taxable)	Public Ownership (Not Income Taxable)	Implications
Income Taxes	Yes	No	Due to the importance of tax incentives in the United States, FIT rates should be set based on after-tax returns
Depreciation	Yes	No	Can provide up to one-third of NPV benefit
Federal PTC, ITC, ITC Cash Grant	Yes	No	Can provide up to one-third of NPV benefit
Other Incentives *State Rebates* *Other Grants*	 Yes Yes	 Yes Yes	Depreciation basis likely reduced by 50% of rebate or grant amount; basis could be reduced 100% if incentives are not taxable
Performance-Based Incentives *PTC* *REPI* *State Performance-Based Incentives*	 Yes No State specific	 No Yes State specific	PTC available to eligible private-sector owner during first 10 years of operation; REPI subject to appropriation
Property Tax	Yes	No	Can be a fixed or variable amount
Sales Tax	State specific	No	Impacts total installed cost

3. Which Ownership Structure "FITs?"

Another question likely to confront policymakers is determining what ownership structure, or structures, to assume when setting FIT rates. The answer depends—once again—on each jurisdiction's policy objectives. If the policy is to prioritize least cost ahead of the pace and diversity of development, regulators will be driven to find what is believed to be the most cost-effective ownership and financing design. If this were universal and known ahead of time, then the spreadsheet model would have no need for flexibility in this area and would offer only one financing option. By comparison, if having a diversity of project owners (including cooperatives and government entities, for example, in addition to the private sector) is equally important, regulators are more likely to set FIT rates in a manner that accommodates a broader range of capital structures. As described in Section 5.5, ownership and financing structures impact the COE. One reason is that an owner's tax status impacts the availability of significant federal and state incentives (Table 6). Although arguably incentives are available for both private (e.g., ITC/PTC) and public (e.g., tax-free debt) project owners, there are many possible financing configurations, and these incentives should not be thought to universally level the playing field.

Assessment. For the purposes of this project, enabling analysis of projects utilizing different ownership (public and private) and financing structures (combinations of debt and equity) recognizes the variety of ownership structures—and associated range of COE—that policymakers and stakeholders might wish to consider. The CREST model should set limits on the complexity of ownership structures by assuming in the private ownership case that a single equity investor will provide both cash and tax equity investment and that the assumed equity return requirement is the combined IRR requirement for both the cash and tax equity.

5.5.2 Modeling Options for Determining Capital Structure

Capital structure refers to the proportions and sources of funds invested in a project and can include a variety of equity and debt instruments. In some cases projects are funded entirely by equity investors. This is more common among the largest developers with balance sheets that can support an all-equity[46] project financing but is not an option available to many of the smaller (and less well-capitalized) market participants also likely to participate in a FIT program. In other cases, debt is incurred at the project level as a way of reducing the amount of equity at risk for a single project and concurrently reducing the project's weighted average cost of capital. Some (typically public) entities even might pursue projects funded mostly—or entirely—with debt. A project's capital structure can remain constant for the life of the project or it can evolve with changes in ownership. Table 7 summarizes the range of complexity in capital structure options. For the purposes of this project, input assumptions allowing for a capital structure, which includes both equity and debt investments and which remains constant until the project debt is fully repaid, appear most practical.

Table 7. Summary of Capital Structure Options

	Range of Complexity in Capital Structure		
	Simple	**Intermediate**	**Complex**
Capital Structures Employed by Renewable Energy Projects	✓ 100% equity	✓ Both equity and project-level debt ✓ Debt-to-total-capital ratio either fixed or determined by available cash flow and a constant debt service coverage ratio	✓ Capital structure changes during project life due to refinancing, change in project ownership allocation, or sale of project

Table 8 summarizes a capital structure's key components and provides a brief explanation of the industry's standard practices for quantifying the values and constraints associated with each type of capital.

[46] Although it is common for large developers to fund projects using cash on hand (sometimes termed "using its balance sheet"), it also is relatively common for these same entities to group multiple projects funded in this manner and then seek financing to leverage the entire portfolio. The practice is referred to as "back-leverage financing" or corporate-level financing.

Table 8. Summary of Capital Structure Components

Source of Funds	Percent of Total Project Cost	Cost of Capital	Term	Constraints
Debt	Sized relative to expected operating cash flows	Based on the risk-free rate for a similar tenor, plus the lender's margin—based on the project's perceived risk profile	The length of the loan is no more than the length of the PPA and usually is a year or two less than the term of the PPA	Debt payments are sized to be less than the total available cash flow; the ratio of PV-adjusted earnings before interest, taxes, depreciation, and amortization to debt service is the debt service coverage ratio; lender sets a minimum debt service coverage ratio
Equity	Balance of capital required beyond loan	Based on alternative investment opportunities	Return sought by target year	Need for long-term revenue certainty; use of proven technology; project's overall financial outlook
Other	Grants might be available to buy-down the total installed cost and reduce the burden on other capital providers			Can restrict power sales or impose other requirements

If project owners seek to finance using a combination of debt and equity, then the amount of debt modeled can be either defined by the user with a single percentage value or derived through a formula that calculates the maximum sustainable debt subject to available cash flow (specifically EBITDA) and a constant debt service coverage ratio. The defined capital structure method (a single fixed input) results in a "mortgage-type" amortization. The maximum sustainable debt method results in debt service obligations that vary with the project's expected operating cash flows.

Assessment. Although commercial banks typically favor a detailed calculation of sustainable debt, such complexity might not be helpful, necessary, or appropriate for the type of projects affected by the FIT rate-setting process. By comparison, setting the debt-to-total-capital ratio with a single fixed input is likely to be intuitive to policymakers and other users, making it a practical solution for the need to model debt as an important financing tool for FIT projects. The recommended approach utilizes the fixed-input method to define capital structure. Model users, however, must be aware that the defined capital-structure method requires the user to monitor the resulting minimum annual and average debt service coverage ratios to ensure that the project's variable cash flow is sufficient to meet its ongoing debt service obligation. These ratios serve as modeling constraints. For users who understand and favor the maximum sustainable debt method, the total loan amount can be calculated external to the model and then entered as a single equivalent percentage value. Both methods require the maintenance of a debt service reserve account.

5.5.3 Sources of Capital

The specific sources of capital available depend on factors including, but not limited to, the project owner's tax status and credit rating, the terms of the PPA, the operating history of the selected technology, and the availability of federal and state incentives at project completion. The type and availability of capital also depends on whether the project is seeking development capital or permanent capital. Development capital is cash equity provided by entities with the appetite to take on permitting, power sales, and other development risks. For the purpose of cost modeling for establishing FITs, it is reasonable to include the return on development capital (which also can be referred to as a “development fee”) in the build-up to total project cost. Investors of development capital are assumed to be repaid at the closing of the project’s permanent financing. Permanent capital (also referred to as project capital) can be obtained from a much broader range of equity investors and lenders.

Table 9 summarizes the types of capital regularly available for renewable energy projects and categorizes them into simple, intermediate, and complex project financings. Although raising equity for a significant portion of project costs is commonplace, equity does not always mean simplicity. The tax-motivated nature of renewable energy investing is responsible for the market’s development of multiple complex project finance structures, which include shared ownership and combinations of cash and tax equity.

Although the recent recession has restricted project-level (as well as corporate-level) debt financing (Schwabe et al. 2009), project-level debt historically has been a component of the financial structure of many independent power projects. Trends and innovations, however, have resulted in a reduced role of project-level debt financing over time. Federal loan guarantees and economic recovery are expected to stimulate debt financing and, as lenders begin to reengage the market, one or more layers of project debt also can be included in certain circumstances. The nature of FITs as a long-term guaranteed revenue stream with known access is highly compatible with debt financing as a tool to create leverage for more projects to be viable under a fixed rate. Additionally, policymakers (whose objectives could include supporting renewable energy but minimizing the ratepayer costs) might expect the use of leverage to minimize project revenue requirements. If so, allowing CREST to reflect the benefits of such leverage supports these policymaker expectations regardless of whether debt is applied at the project or corporate level.

Table 9 lists several types of equity and debt. In general, equity refers to the capital invested by a project’s owner that the owner seeks to recover—plus a targeted return—over the lifetime of the project. A tax equity investor earns its return by offsetting its income tax liability from other business activities using the tax benefits generated by the project. Such benefits could include either the PTC or the ITC, depending on the project’s ability to meet IRS-established eligibility criteria and accelerated depreciation.

Table 9. Summary and Categorization of Sources of Capital Available for Project Financing

	Range of Complexity in Sources of Capital		
	Simple	**Intermediate**	**Complex**
Types of Capital Available to Renewable Energy Projects	*Potential Sources of Capital* ✓ 100% equity (“unlever-aged”); assumes single owner able to efficiently monetize all tax benefits	*Potential Sources of Capital* ✓ Cash equity ✓ Tax equity ✓ Term debt	*Potential Sources of Capital* ✓ Cash equity ✓ Tax equity ✓ Development sponsor equity stays in project ✓ Senior debt ✓ Subordinated debt

In contrast, debt refers to invested capital, which must be repaid in calculable amounts (regardless of, and prior to, returns to equity investors). The amounts typically include both principal and interest and are paid at specified intervals over a predetermined period. Different debt instruments are used at different stages in a project’s life cycle. Construction debt generally applies to the relatively short period from ground-breaking to commissioning but also can be used to finance long-lead-time items like equipment deposits. Term debt is the vehicle used to finance the project's total installed cost and is repaid out of operations. When debt is used in a project's capital structure, term debt often is used to refinance construction debt. If multiple term loans exist, one loan assumes senior status and the rest receive subordinate status. This senior and subordinate relationship refers to the priority with which the cash flows available for debt service are directed to various lenders and the security interest each has in the project (i.e., senior lenders have a first lien on the property). Project loans can have fixed or variable repayment structures, including balloon repayments. For example, during the recovery period following the recent financial crisis, the availability of debt generally was limited to mini-perm structures. A mini-perm sizes the loan amount and first several years of payments based on the same amortization as a term loan (e.g., 15 years) but requires the amount outstanding at approximately the fifth to seventh year to be repaid in full at that time. This lump-sum repayment is referred to as a balloon payment.

Assessment. The recommended approach assumes a single provider of both cash equity and tax equity and includes inputs that enable the recognition of a development fee, interest on a construction loan, and the utilization of permanent project debt.

5.5.4 Cost of Capital

The cost of capital is the required return on the funds spent—in this case to construct a renewable energy project. This concept applies to both debt and equity. The cost of debt capital is the interest rate. The cost of equity capital is the investor's targeted rate of return. Returns can be calculated both before and after tax. Pretax returns are a useful comparison metric for an investor considering multiple potential uses for the same capital. This is especially true when each investment has a different tax consequence. For investments that are within a single industry and subject to the same tax obligations and incentives, an after-tax return provides insight that is more useful for the project's cash flow implications.

Assessment. Given the tax-oriented nature of renewable energy investing in the United States, this project focuses on after-tax, project-level returns assuming that investors have sufficient tax liability to efficiently monetize all (or a specified fraction of) available federal and state tax incentives. There also is the secondary option for the project to monetize the tax incentives based on the cash flows in the project itself over a longer period.

The cost of capital inputs is another example of an area in which policymakers can elect to have calculations made either internal or external to the model. If calculations are made internally, then the inputs section of the model must capture the percentage and cost of equity as well as the percentage and cost of debt. These inputs are used to calculate the project's repayment obligations and determine whether the rates meet investor requirements. The alternative is to calculate the project's weighted average cost of capital externally and use this single simplifying input to model the portion of the FIT rate necessary to cover the project's cost of financing.

Assessment. The CREST models enable a user to define the key terms of a project's equity and debt (if applicable) investments. This method, shown in the "Intermediate" column of Table 10, is intended to provide a level of detail sufficient to approximate the cost and terms of capital most likely to be available to projects subject to the tariff.

Table 10 summarizes the modeling inputs required by each approach.

Table 10. Summary of Cost of Capital Modeling Options

	Range of Complexity in Modeling the Cost of Capital		
	Simple	**Intermediate**	**Complex**
Cost of Capital Modeling Options	*Cost of Capital Inputs* ✓ Weighted average cost of capital ✓ Calculated external to the FIT rate-setting model	*Cost of Capital Inputs* ✓ Cost of debt ✓ Percentage of debt ✓ Cost of equity ✓ Percentage of equity ✓ All used within the FIT rate-setting model	The cost of capital inputs do not become more complex but might become more numerous if a complex capital structure is used

5.5.5 Term

In the context of a discussion on capital structure, term refers to the period over which a return on investment is realized. For equity investments, the term either can be the project's expected useful life or be only as long as it takes for the investor to realize the targeted rate of return. Investors seeking the tax benefits generated by a renewable energy project, for example, are less motivated to remain invested after these benefits are fully realized than is a cash-based investor that is dependent on the continuing cash flows to earn its return. It is important to note that the United States IRS requires tax equity investors to meet minimum investment-duration requirements before it can exit an investment without triggering the recapture of some of its tax benefits. Once these requirements are met, the tax equity investor can sell its ownership share in the project without incurring a penalty.

For debt investments, the term is the number of years over which the loan must be repaid. Like the overall amount of debt, the tenor available is based on the length of a project's PPA and the creditworthiness of the buyer. The tenor typically is a year or two shorter than the term of the PPA. To this end, policymakers contemplating FIT design (including the tariff duration) have a great deal of influence over the terms—and ultimate feasibility—of renewable energy project financing through their ability to establish a stable, long-term source of revenue. FIT programs are under consideration in many jurisdictions as a way to meet the market needs for stability and creditworthy long-term contracts. The long-term revenue certainty associated with a FIT also could lead to longer debt tenors than typically seen in other contracting circumstances.

Financing structures for FIT projects are not yet well defined in the United States. In the near term, project owners are expected to adopt structures that make effective use of existing federal and state tax incentives. In most cases, this requires the integration of a tax equity investor. Some projects might be able to monetize enough of the tax benefits internally (e.g., at the project level) to use either a simple all-equity or a traditional cash-equity plus term debt project finance approach.

5.6 Conclusion

The research and analysis performed in support of this section demonstrates that the selection and organization of modeling inputs for any cost-based tariff calculation is inextricably linked to the identification and prioritization of clear policy objectives. When this defined set of inputs is deployed within a functional model, the architects also must consider the end-user of the model and the purpose for the model's use. Based on the answers to these questions, the model's architects then must build a model that balances ease of use and the presence of complex functionality. In the end, any spreadsheet tool will be successful only if it enables policymakers to be well informed during the rate-setting process without exerting undue effort.

6 Policy Decisions

In many cases, the objectives of the users and the policymaking process can dictate the model methodology and structure, the nature of the inputs, and how those models and their outputs are used. The purposes of this section are to articulate the connection between policy-driven decisions and modeling choices, help the model user understand the decisions required to utilize the model, and discuss how to integrate the model into the FIT policymaking and rate-setting processes. The text box examples in this section illustrate the connection between policy objectives and modeling approach and provide some guidance for model users.

The CREST models are targeted for use by state policymakers, utilities, and developers or other stakeholders participating in the regulatory process. The need to make the CREST models useable by state policymakers such as public utility commissions or legislative staffers drives some degree of simplification relative to SAM or the highly detailed spreadsheet models used by developers, lending institutions, and tax equity investors to support the financing of specific projects. The need to make the CREST models useful for utilities and developers who participate in the rate-setting process, however, requires that the model have sufficient depth and accuracy to both gain acceptance and to accommodate material factors that influence renewable energy project cost. The nature of the policymaking process, then, suggests the following ideal characteristics of a spreadsheet cost model.

- Usability—For example, limited number of "levers" to pull; well-documented; easy to use; inputs and choices clearly identified; robust (i.e., checks for errors in inputs)
- Transparency—"Black boxes" do not engender trust and stakeholder buy-in
- Credibility across the range of stakeholders—Familiarity with respect to approach, look, and feel; lack of inherent bias; limited degree of error introduced when simplifications are used
- Adaptability—Functions in a range of policymaking and rate-setting processes.

Section 5.1 introduced a number of policy considerations that could impact the modeling approach, the model's level of detail (or input granularity) and how this affects precision, and the model's comparative complexity or simplicity. Policy goals also can influence the choice of input assumptions and how the results are used to set FIT rates. This section explores how policy decisions related to data sources, the policymaking process, and policy objectives can influence cost-modeling decisions.

6.1 Cost-Modeling Factors Dictated by Data Sources

As noted in Section 5.1, the policymaking process can dictate a number of modeling choices. If the policymaking process relies on gathering top-down[47] installed and operating cost information, a more simplified set of inputs could be required than if the process relied on a bottom-up[48] survey of individual component or subsystem costs. A top-down process does not

[47] A top-down approach utilizes data and assumptions about the aggregated cost of a project; for example, wind projects cost $2,400/kW installed.
[48] A bottom-up approach utilizes data and assumptions about the cost of components of a project; for example, identifying the cost of a wind turbine tower, nacelle, and blades.

require a model with extremely detailed cost inputs. A process that gathers detailed bottom-up information will benefit from a model that can accommodate such data directly. Such model features are not mandatory, however, as component-level costs can be aggregated prior to being entered into the model. Attention should be paid to the fact that ITC and accelerated depreciation could apply differently to cost subcomponents. If aggregation includes a weighted averaging of component-level details on ITC and depreciation method distinctions, then such preprocessing need not compromise accuracy. Alternatively, a sufficiently accurate "rule of thumb" for this weighted averaging also can bypass the need for a more detailed set of inputs.

Data source options can be constrained by the rate-setting timetable. For instance, a tight and mandatory legislatively driven timetable could preclude a detailed analytical approach to gathering representative cost data, forcing reliance on existing studies or stakeholder surveys. Policymakers also should consider how the data gathered might need to be filtered, adjusted, or interpreted prior to being inserted into a cost model. Some key questions that are likely to arise include the following:

- **What if cost data gathered are described as *generic*, *representative*, or *national average*?** In such cases, it could be necessary for state policymakers to adjust these figures to reflect their location-specific cost profile. It is common for the cost of doing business to vary in the different parts of the country. This results from factors such as prevailing labor costs, land costs, permitting environments, and state or local taxation. Any generic data available for these factors should be used to make region-specific adjustments to generic costs. For example, the cost of doing business is greater in the northeast than in the central plains region. Cost differences also can result from differences in resource quality, landscape characteristics, or site accessibility. Care should be taken to understand how these factors compare between the data sources and the local environment. Policymakers also should identify the degree of interconnection-related and transmission-related costs included in such figures so that appropriate adjustments for the local context can be made as needed. If policymakers fail to take the steps necessary to ensure that the data used is applicable to the local context, then the probability of FIT rates being set either too low or too high increases.
- **How will costs be collected or estimated for emerging technologies?** In the case of emerging technologies, there is a smaller base of experience and directly applicable data to rely upon. Consider, for example, the difficulty of estimating the cost of offshore wind projects in the United States when, to date, not a single project has been built in the country and the cost data from Europe reflects mature installation and maintenance infrastructure that is not in place in the United States. In the absence of actual project data, there is little choice but to more heavily rely on studies, engineering estimates, and attempts to translate information on the few sample European installations to the local context. The risk increases that the price set based on cost modeling could be too high or too low. In such cases, FIT rate-setting policy decisions—such as choosing a point along the aggressive-conservative spectrum and determining the applicability of degression—are of heightened importance. These issues are discussed further in Section 6.3.

6.2 Cost-Modeling Factors Dictated by the Policymaking Process

Other aspects of the policymaking process influence the choice of modeling methodology as well as input granularity, including the nature of the rate-setting process, the participants in the process, and the participants' defined roles. Experiences to date in FIT development (as discussed in Section 3) and similar policy processes suggest that the starting point for asserting the modeling methodology is likely to be influenced by a number of factors such as those listed below.

- Whether there are legislative constraints on the rate-setting process, such as establishing how cost data will be collected and from where
- Whether the process is a consensus stakeholder process or an adjudicatory process
- Who is driving the process and what that entity puts forth as a proposed or mandated process, level of data granularity, or modeling methodology
- Whether the process requires, or a tight timeline dictates, that a proposal be put forth (for instance, by commission staff), or alternatively, whether all options are open for consideration (which might include offering dueling models)
- Familiarity among regulators or stakeholders with cost methodologies or precedents set in similar settings
- The availability of widely used and accepted tools (the objective of this project).

Finally, public policymaking processes benefit from model transparency. Even if a user cannot change all the formulas, being able to see how the data flows from input to result is more likely to be accepted than a model perceived as a "black box."

6.3 Cost-Modeling Factors Dictated by Policy Objectives

Many of the factors described in the previous two sections have implications for the model structure, methodology, or level of granularity, but specific policy objectives can shape the choice of inputs to use in the model and how the modeling results are used to set FIT rates.

6.4 Range of Cost of Energy Variance Associated with Technology-Specific Input Assumptions

Among other factors, a renewable energy project's COE is sensitive to project size (due to scale economies), resource quality (due to capacity factor and production profile), and infrastructure availability (e.g., proximity to transmission, need for step-up transformer or substation, roads to a mountain ridge, and repower versus greenfield project). As a result of these factors and others, the COE for projects using the same technology at two different locations can vary widely. This can lead to overpayment or underpayment if the two projects are eligible for the same (undifferentiated) FIT payment level. Text Box 4 uses a basic wind LCOE model[49] to illustrate hypothetical examples of wind power installations and the sensitivity of COE to a variety of factors.

[49] Developed by Sustainable Energy Advantage, LLC. Such sensitivities can be explored using the CREST models once completed.

4. Simplified Example of Cost of Energy Range for Illustrative Wind Projects

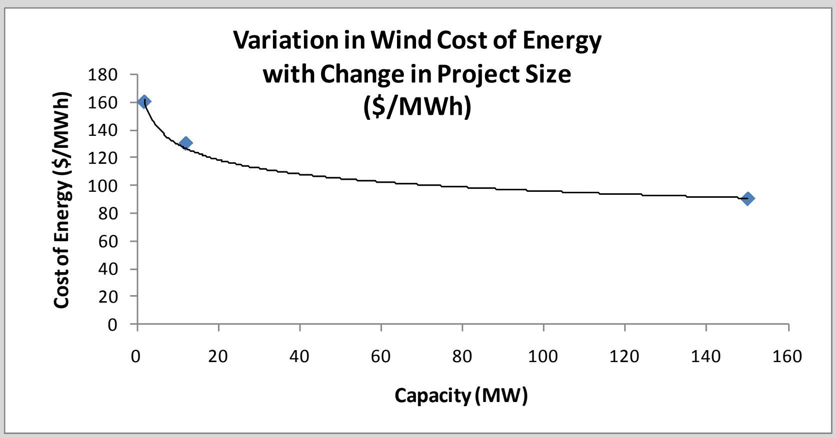
This example shows the range of potential values within a given technology and is used to illustrate how policy decisions can influence the inputs used to estimate COE and how such results can be used to establish FIT rates.

- **Sample Plant #1:** Single 1.8 MW turbine, 26% capacity factor, interconnecting to local distribution system without the need for a new substation.
- **Sample Plant #2:** 12 MW, 31% capacity factor, with a new mountain-access road, multi-mile generator lead, and a new substation.
- **Sample Plant #3:** 150 MW, 35% capacity factor, existing roads need only modest upgrades, need new multi-mile generator lead, and a new substation.

Modeled LCOE uses consistent financing and other key assumptions. These figures are for illustrative purposes; the absolute value of the costs should not be used for any particular purpose, as it might not be illustrative of local and current conditions.

- **Sample Plant #1:** $160/MWh
- **Sample Plant #2:** $130/MWh
- **Sample Plant #3:** $90/MWh

What is the "correct" FIT rate for wind? The answer depends on the project objectives.



6.4.1 Feed-In Tariff Rate Differentiation

As noted in Section 4 and in Appendix B, FIT rates for the same generation type (e.g., wind and solar) often are differentiated, meaning that FIT rates are defined for different subcategories of generators based on such distinguishing factors as technology (e.g., solar PV versus high-temperature geothermal), project size, resource quality, location (e.g., onshore versus offshore wind), or ownership type (e.g., public versus private). If policymakers have started with the presumption or legislative imperative to differentiate tariffs, then the key design questions could include the following.

- How many subcategories should be used?
- How are the subcategories defined?

- What payment level should apply within each subcategory?

Policymakers could also decide to differentiate tariffs if modeling results indicate a wide range of COE for a particular technology.[50] This might be the case for any eligible technology with a wide range of project sizes, a steep scale-economy function, or a wide range of resource intensities. Without differentiation, projects can experience a wide range of return on investment. Differentiation enables policymakers to target more similar returns to investors in projects with different characteristics. The answer to these questions regarding how to differentiate a tariff largely will be dictated by policy objectives.

5. Examples of Policy Objective Implications for Tariff Differentiation Within Resource Type

If the Policy Objective is to Encourage . . .	Then the Tariff should be Designed to…
✓ Variety of technologies (e.g., PV and solar thermal, enhanced and low-temperature geothermal, and commercial-scale and small wind turbines) or applications (e.g., building integrated PV or biomass CHP)	✓ Create differentiated tariffs open to the specific technologies or applications to be encouraged
✓ Best (lowest cost) ownership structure, technology, application, resource quality, and scale	✓ No differentiation, so long as the rate is set towards the conservative end of the spectrum
✓ Wide variety of ownership structures, technologies, applications, resource qualities, and locations, with less concern about cost containment	✓ No differentiation, with rate set at the more aggressive end of the spectrum
✓ Development in a variety of locations	✓ Create tariffs differentiated by resource (i.e., wind or solar resource), by geographical region, or by availability of transmission
✓ Different ownership structures or investor types	✓ Create differentiated tariffs that align with the ownership structure the policymakers wish to encourage

A critical observation is that even if policymakers wish to differentiate by such factors as project or equipment size or resource quality, they must make an aggressive/conservative decision within each subcategory—a concept discussed in more detail in the next section.

6.4.2 Aggressive Versus Conservative FIT Rate Setting

A conservatively set FIT is one that is designed to create a market for, and encourage, only the most efficient (low-cost) projects.[51] Its rate would be based on the generation costs of the most competitive developers or the most competitive project scale or resource quality. In Ontario, Canada, for example, the 2006 RESOP PV tariff level was too low (roughly equivalent to \$0.41/kWh) for all but the largest systems effectively excluding small and mid-size projects. A more aggressive FIT would establish rates sufficiently high to accommodate a broader range of systems of different sizes, types, resources, and ownership structures. In Germany, for example, biogas FITs are set relatively high to encourage small farm digesters (Grace et al. 2008). Given the infinite variety of specific project-cost factors, the conservative versus aggressive options form a continuum, and where a FIT rate is established along the conservative-aggressive spectrum is (or should be) a function of the policymaker's objectives.

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[50] For a detailed discussion of FIT differentiation, see "A Policymaker's Guide to Feed-in Tariff Policy Design" (Couture et al. 2010) at http://www.nrel.gov/docs/fy10osti/44849.pdf.

[51] In this context, the terms conservative and aggressive are used from the perspective of the policymakers establishing the FIT. "Aggressive" connotes a tariff intended to aggressively promote renewable energy development, and "conservative" connotes a more measured approach tilted towards supporting the best, most cost-effective projects.

Furthermore, setting a FIT rate to achieve policy objectives can be challenging. If the price is set too high, there is the risk of overpaying individual projects, overstimulating the market, and greatly impacting ratepayers—particularly when a tariff is open to large projects where ample resource potential is present.[52] Conversely, if the price is inadequate to attract investment, a FIT might be ineffectual. The policy choice of setting a FIT rate aggressively or conservatively alone or in combination with tariff-rate differentiation also can manage the trade-off between a FIT's effectiveness at increasing the quantity of renewable energy and its ratepayer impact.

As discussed in Section 6.4.1, FIT differentiation often is used when there is a wide range of COE for a particular technology. The more subcategories into which a technology is differentiated, the more accurate a price can be determined—meaning the smaller the variance in cost of the generators eligible for the tariff. Nonetheless, even within a differentiated tariff—for example, different prices established for larger and smaller generators—policymakers still must decide where to set the tariff along the aggressive-conservative spectrum. A key consideration is how "representative project" costs are determined for each subcategory. Options might include selecting an average project within the technology/size subcategory, selecting a project from the greater end of the bracket to encourage cost effectiveness and economies of scale, or choosing a project of the 75th percentile of project costs for that technology/size bracket to support a wider range of projects. Text Box 6 describes the aggressive versus conservative decision-making process, examining both tariffs that are differentiated by size, location, or other factors and tariffs that are not differentiated other than by technology.

[52] As described in Section 2, the profitability index method (PIM)—a technique used to create a universal profitability scale on which to compare projects with different characteristics—could be utilized to help policymakers select and substantiate a FIT rate at a level along the conservative-to-aggressive continuum, which is most consistent with the jurisdiction's stated policy objectives. Recall that a profitability index (PI) of zero denotes a project that meets, but does not exceed, the assumed cost of capital. To this end, how the PIM is used depends on whether the target rate of return applied in the rate-setting process is the minimum value that the market is assumed to be willing to bear or is something greater. In the modeling context where the target after-tax IRR is set at the absolute minimum, FIT rates that result in a PI of 0.0 to 0.3 comprise the conservative spectrum, and rates resulting in a PI of 0.3 to 0.6 represent more aggressive tariffs. Based on this approach, a PI greater than 0.6 represents an overstimulation of the market.

**6. Considerations in Aggressive Versus Conservative FIT Rate Setting—
Single (Undifferentiated) Tariff**

If policymakers are focused on encouraging the most cost-effective projects or are otherwise concerned about the risk of overpayment, then they can establish a conservative (lower-priced) FIT rate based on a modeled COE consistent with a low-cost proxy plant. For example, this could be represented by a wind project with scale economies, near transmission, in a location with strong winds, and with a relatively simple, low-cost financial structure. Under a single wind FIT rate that was not differentiated by such factors as project size, resource quality, or ownership, the most cost-effective projects are the most likely to get built. Large projects with good wind resources that are able to take advantage of scale economies or greater capital-cost projects, with the exceptional wind resources, might be able to attract financing and be viable under this type of FIT.

A more aggressive policymaker perspective might be to establish a FIT rate based on the modeled COE of less competitive proxy projects. (Policymakers might pursue such an approach if they desire to encourage, for example, a variety of project ownership structures, sizes, or locations.) Projects might have some combination of smaller-scale slower wind, a greater distance from transmission, or a less-than-optimal ownership structure—and therefore a greater COE—than the more conservative FIT rate described above. In establishing the FIT rate, policymakers either must model an idealized higher-cost single proxy plant or be informed by modeled COEs associated with the range of potential conditions they seek to encourage. A more aggressive FIT rate would be made available to projects that have a lesser calculated COE, thus encouraging scale economies but implicitly permitting those projects that are more cost effective than the selected proxy plants to realize higher profits. Based on the wind COE graph in Text Box 4, a conservative single-payment tariff rate could be $85–$90/MWh, and a more aggressive tariff might be from $100–$150/MWh, depending on the nature of tariff differentiation and other policymaker decisions.

Considerations in Aggressive Versus Conservative FIT Rate Setting—Differentiated Tariff

If a resource type can be developed over a wide range of size, technology, resource strength, or other factor that results in either a steep scale economy or steep supply curve (a steep curve suggests scarcity of the “best” sites and a wide variety of costs among the resources plotted, with a limited number of lower-cost sites and diminishing economics for subsequent developments), and policymakers wish to encourage some degree of diversity among project size, location, or ownership type without offering above-market returns to the lowest-cost projects, then a differentiated tariff can be used. Differentiating a tariff requires decisions on the number of differentiated rates (subcategories), the eligibility characteristics of those subcategories, and the FIT rate that applies to each subcategory. There is no precise formula for determining the number of differentiated rates. The choice is influenced by both the policy objectives and the shape of the supply curve or scale-economy functions. Consider the illustrative wind supply curve in Figure 1 (the data was received in spreadsheet form corresponding to the data used in the Phase 1B study) and the COE versus project scale curve shown in Text Box 4.

If policymakers establish two subcategories differentiated by project size, then Subcategory A (projects less than 40 MW nameplate capacity) receives one price, and Subcategory B (projects exceeding 40 MW) receives a reduced price. The COE data suggests that the Subcategory A price could fall in the range of $110/MWh to $150/MWh, and the Subcategory B price could fall in the range of $82/MWh to $110/MWh. The supply curve, although it captures more variables than just the sensitivity to project size, suggests that a FIT rate of $110 would support most of the available supply and overpay the majority of that supply by $10/MWh to $15/MWh. It also reveals that there is little to no wind likely to take advantage of a FIT rate of less than $95/MWh (because the resource analysis shows $95/MWh to be the lowest price on the supply curve).

One additional caution for policymakers is to consider how market participants are likely to react to a differentiated tariff. In the case that differentiates tariffs by nameplate capacity (provided above), for example, a significant difference in prices tends to encourage projects to be built up to (but not exceeding) 40 MW and thus forego the benefits of scale economies or encourage the division of larger projects into projects that are less than 40 MW each. It is critical to take into account the definition of a “project” to avoid such manipulations.

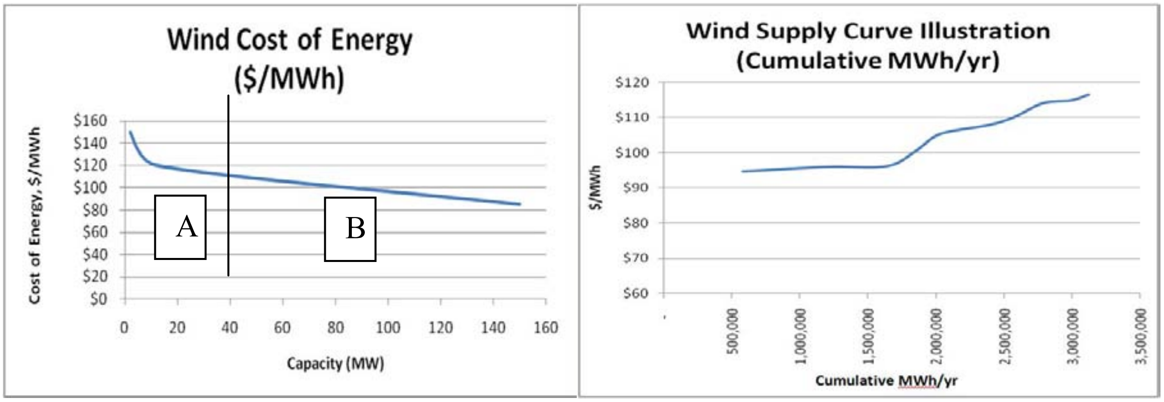

Figure 1. Adapted from a Competitive Renewable Energy Zone in a study of California's Renewable Energy Transmission Initiative (Black and Veatch 2009)

6.5 How Will Model Results be Used to Set FIT Rates?

An individual "run" of a model provides only a single perspective on COE, based on a unique set of inputs (unless the model is designed to generate sensitivity of COE to varying key input variables). As can be seen from the preceding examples, to inform regulators and stakeholders in the selection of a FIT rate, a model result can be used directly as the FIT rate or one or more model runs can be utilized in combination with a consideration of policy objective, resource potential, or other factors. If policy objectives include a conservative tariff rate and stakeholders can agree on cost inputs that are achievable for the most cost-effective projects, a single model run could suffice. A more robust and predictable outcome, however, will utilize multiple model runs to consider the range of possible COE figures and select the appropriate point within that range based on policy objectives and other factors. Such an exercise informs the process on expectations regarding what portion of the range of eligible resources meets investors' assumed threshold returns at that FIT rate schedule.

6.6 Modeling Rate Changes Over Time

Discussions of FIT rate setting often include discussion regarding how such rates could change over time. The FIT changes over time are neither an input nor an output of a COE model. Such models can be used to demonstrate the drivers of COE to all stakeholders, however, and to assess the appropriateness of changes to FIT rates over time to reflect current or anticipated changes in equipment or financing costs. Proposed changes to FIT rates over time also can stem from changes in policy objectives or could be a response to the market's experience with FITs. Degression, for example, is a schedule of automatic rate declines by which the FIT payment rate decreases over time. It typically is based on each technology's projected experience curve (Grace et al. 2009). Policymakers seeking to maintain downward cost pressure on FIT rates—particularly if experience (scale economies and technological process) is expected to reduce costs over time—might wish to periodically repeat or update a modeling exercise to adapt FIT rates for the assumed experience curve (in the case of degression) or to incorporate changes in cost of new installations over time (in the case of periodic review and tariff revision). Using a cost model to inform a degression rate or periodic rate reset involves changing cost and performance inputs over time, as well as monitoring and evaluating projected cost and production data trends.

7 Conclusion: The Cost-Based Model Methodology and Spreadsheet Tool Design Characteristics

This section summarizes the key features recommended for a FIT or other cost-based incentive cost-modeling methodology and the design of CREST spreadsheet cost models for use in establishing cost-based payment rates for three renewable energy generation technologies: solar, wind, and geothermal. The selection of these design features has been informed by the analyses and discussion provided in Section 2 through Section 6 of this report. Also provided is a flow chart (Figure 2) depicting the overall modeling methodology to be incorporated in the CREST models.

One of the key attributes of the CREST model is its flexibility to support a range of policymaking processes, as well as accommodate a range of data sources and levels of input granularity. This flexibility enables policymakers to consider tariff differentiation and aggressive versus conservative rate-setting, which is consistent with underlying policy objectives.

7.1 Lessons Learned from Survey of Existing Models

The survey of existing financial models described in Section 3 concluded that there is no single publicly available and recognized tool in widespread use that can be readily applied to the task of calculating cost-based FITs for a variety of generation technologies in the United States. The survey, however, revealed a number of useful models from which the best practices and features that influence the design of the CREST models can be drawn. These best practices reveal that the model must be:

- Straightforward enough to be used effectively by a diverse set of participants
- Flexible enough to accommodate a consensus-driven process for identifying inputs (which can vary in detail from state to state)
- Transparent enough to satisfy regulatory requirements.

The key features observed in other models that are recommended for inclusion into the CREST model include:

- “Introduction” tab that is embedded in the model and serves as a “quick-start guide”
- “Notes” providing a descriptive explanation of the appropriate use of many input cells, as well as the typical range of values for each input, where applicable
- “Check” cells used frequently to provide visual cues to ensure that the user populates all cells required to operate the model
- Option for user to provide inputs at one of three levels of detail
- Inputs for major federal and state tax incentives
- Sensitivity analyses of modeling results
- Graphic representation of results.

7.2 Lessons Learned from Industry Experience with FIT Calculation Methodology

The case study jurisdictions reviewed in Section 4, with a few exceptions, generally are characterized by:

- Comparative simplicity
- DCF, after-tax analysis
- Assumed private sector, commercial ownership
- Use of IRR as an evaluation metric
- Assumption that other available incentives are taken into account before the rate is calculated
- Aggregated cost inputs.

Additionally, the case studies identified interplay between stakeholder engagement and model structure and how different jurisdiction's legal and regulatory processes can shape modeling decisions or define how modeling outputs are used.

To be as useful as the other FIT models, it is recommended that the CREST models utilize the after-tax DCF approach and the IRR as an evaluation metric. Due to the desire to make the tool useful in a wide range of circumstances, however, the CREST model should have flexibility that supports a greater degree of cost detail, a wider range of ownership, and the ability to reflect all or a portion of various incentives in FIT rate determination.

7.3 Cost Modeling Methodology: Discounted Cash Flow

Based on the taxonomy of modeling methodologies described in Section 2, as well as lessons learned from industry experience with FIT calculation methodology described in Section 4, it is recommended that the CREST model utilize the DCF method of calculating the NPV and after-tax IRR on a renewable energy investment. This recommendation was based on several factors including the following:

- The DCF approach's ability to incorporate all broadly available tax incentives, including accelerated depreciation schedules. This feature is critical in the United States, where tax incentives historically have played an important role in renewable energy development and where the efficient monetization of all tax incentives can be important, even for smaller projects. The DCF models easily are made detailed and versatile enough to accommodate a range of tax incentives, cash incentives, or the migration from one to the other. At present, the American Reinvestment and Recovery Act has—at least temporarily—shifted the U.S. structure away from tax benefits to cash grants. The ability to handle both tax-based and other policy incentives, however, makes the DCF a durable tool that can adapt with U.S. renewable energy policy over time.
- The requirement for a substantial degree of transparency, necessitated by the likely use of stakeholder-driven FIT design processes. Transparency especially is important with respect to the assumptions that drive the rate-setting modeling process. The year-

by-year analysis in the DCF method provides for transparency regarding the impact of various key assumptions throughout the life of the project.

- The DCF method provides the flexibility necessary to support a wide range of circumstances and policy objectives. It allows a range of complexity in the level of input detail and modeling calculations. It also supports the analysis of project returns for different types of investors and accommodates a range of tax appetites. Lastly, it can aid the adaptation of FIT programs over time to account for changing federal incentives and overall conditions in the renewable energy market.
- Most FIT models that were investigated used the DCF approach as well, likely for the reasons listed here.

7.4 Output Metrics and Constraints

Consistent with the DCF methodology, the CREST model is recommended to use an after-tax IRR as its primary evaluation metric. An acceptable after-tax IRR is one that meets or exceeds the equity investor's required rate of return. The model, however, also must enable the user to ensure that any cash flow constraints, such as the debt service coverage ratio (if the project has taken on debt), are met. Lastly, the model should be designed to solve for the COE and meet the equity IRR and cash-flow constraints. The COE output of the model, therefore, is the desired result and can be used to either represent or inform the FIT payment rate.

The COE models sometimes provide results in real or constant dollars expressed in specific calendar years (e.g., constant 2012 dollars per megawatt-hour). This approach is attractive to economists as such a revenue requirement metric takes the general rate of inflation out of the equation. A result in real dollars, however, requires an ongoing adjustment for it to be useful in determining annual payments. As such, it is recommended that the CREST model specify outputs in nominal dollars. It is expected that policymakers and project financiers will be far more comfortable with rates specified in nominal dollars that correspond to actual payments under FIT rates. To address the range of potential FIT rate structures that can be considered by model users, the COE should be calculable as either:

- A nominal levelized rate in dollars per megawatt-hour (e.g., a fixed, flat rate for the life of the FIT contract)
- A year-one nominal rate in dollars per megawatt-hour (it is recommended that the user also be able to define an escalation rate, as well as the portion of the tariff to which it applies).

7.5 Data Inputs and Level of Data Granularity

The CREST model will be designed to include inputs at a level of detail sufficient to accurately capture each of the key economic drivers of renewable energy projects but not so complex as to render the model difficult to use in the generalized, state-by-state, regulatory decision-making context. The analysis involved with each design choice is discussed in detail in Section 5.

Table 11 summarizes the level of input detail recommended for this analysis. The CREST model provides for user-defined selection of data input granularity for the "Total Installed Cost" and "Operating Cost" categories. Using selections made from a drop-down menu, different sets of inputs are shown (and the input cells associated with alternative levels of granularity are disabled).

The simple option provides for a single input, and the intermediate option provides for a discrete set of five inputs. Users selecting the complex option are guided to utilize a larger free-form set of line-item inputs that are rolled into the subcategories corresponding with the intermediate option. For each installed cost input, eligibility for the ITC and various depreciation schedules can be specified. The resulting CREST model includes more detail than a simple economic feasibility study but less detail than would be necessary to satisfy a lender or (tax) equity investor for project-financing purposes or for analyses in which users attempt to understand the allocation of costs and benefits among a multi-member project-specific partnership.

Table 11. Summary of Modeling Complexity Recommended for FIT Rate-Setting Tool

Input Category	Recommended Input Complexity		
	Simple	**Intermediate**	**Complex**
Total Installed Cost	Select via drop-down menu	Select via drop-down menu	Select via drop-down menu
Operating Costs	Select via drop-down menu	Select via drop-down menu	
Ownership & Capital Structure			
Cost of Capital		√	
Term		√	
Incentives			
Federal PTC		√	
Federal ITC		√	
Utilization of Federal PTC/ITC		√	
State ITC		√	
Utilization of State ITC		√	
Grant, Rebate, or Capacity-Based Incentive	√		
Production-Based Incentives	√		
Property Tax Exemption		√	
Sales Tax Exemption		√	

7.6 Model Data Flow Chart

Figure 2 provides a schematic representation of the proposed flow of model data—from inputs to outputs and depicting the key internal calculation steps. It is recommended that the worksheets for the CREST model be ordered in the same sequence as the order in which they are to be used. As such, it is proposed that the user first be presented with a worksheet on which all inputs are aggregated and are arranged by category. Although the CREST model initially might be populated with illustrative values, the user must research and enter all inputs prior to reviewing or interpreting any model outputs. These inputs would flow into the recommended DCF analysis. The modeled cash flows then can be summarized on an annual basis. As described in Section 1, it is recommended that the CREST models solve for the COE. This enables the project to meet all expenses as well as the equity investor's required after-tax rate of return—and maintain minimum debt service coverage, if applicable. These steps are demonstrated graphically in Figure 2.

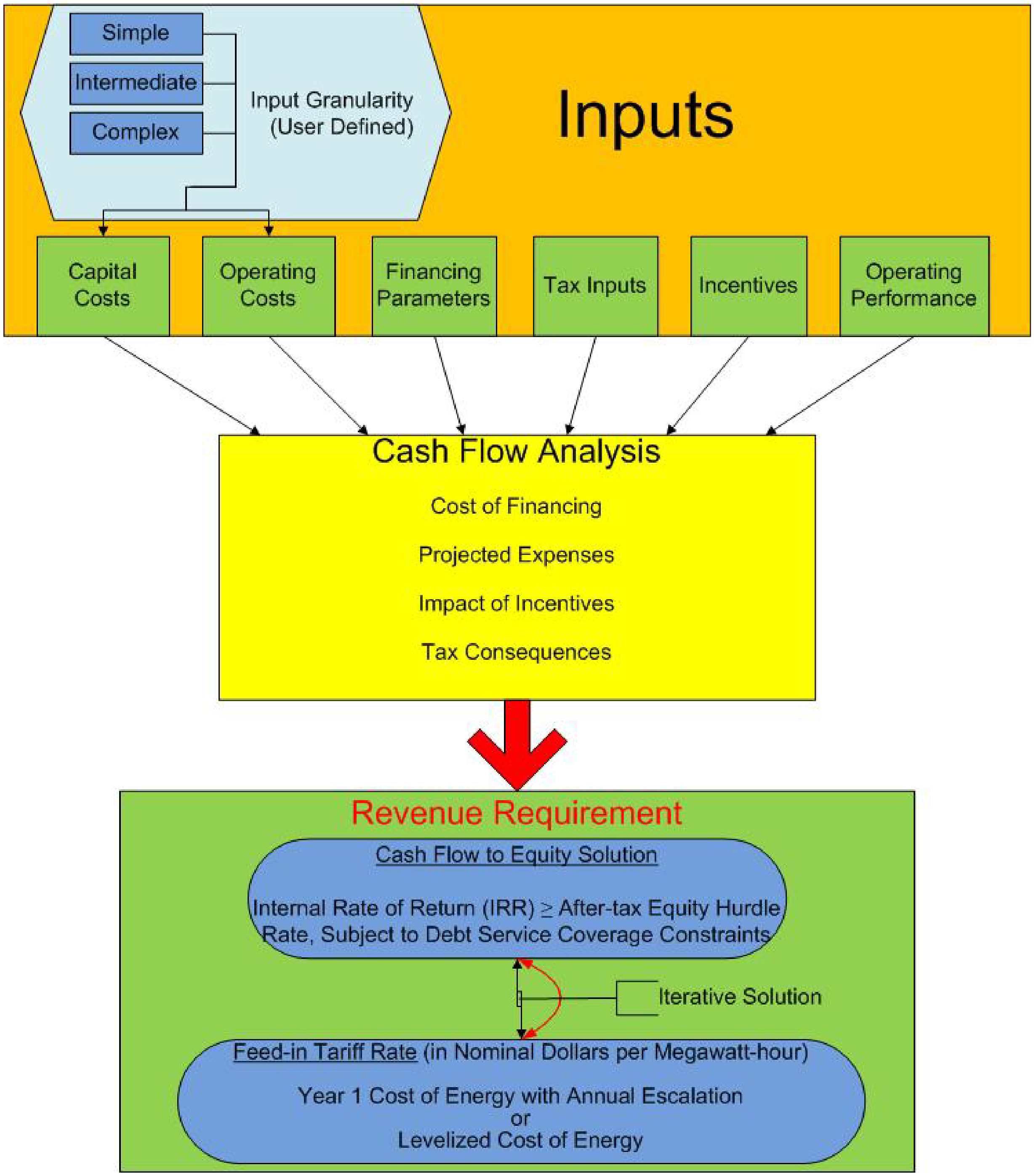

Figure 2. CREST model schematic data flow chart

7.7 CREST Models

Based on the decisions documented in this report, the next step in this project is to develop the CREST models for each of three illustrative technologies:

- Solar (model can be used for PV or solar thermal electric applications)
- Wind
- Geothermal.

The CREST models will have a user's manual, and each will be populated with illustrative data.

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Appendix A. Summary of Survey of Existing Models

A survey of publicly available financial models was conducted in an effort to identify either an existing tool for industry regulators and stakeholders to use in estimating the COE from various renewable energy technologies and help inform FIT rate-setting discussions or a series of useful model features that could be incorporated into a new model for this same purpose. Although a single tool was not identified, the slate of available models revealed a number of useful features. A summary of these useful features, as well as the model's applicability to FIT rate setting, is provided in Table A-1. The lessons learned from this review of existing models are applied to the development of the model accompanying this document.

Table A-1. Summary of Limitations and Useful Features of Existing Models

Model Name, Web URL, and Date of Access	Created By	Key Characteristics		Applicability to FIT Rate Setting	
		Purpose and Objectives	Taxonomy	Limitations	Useful Features
RETI Cost of Generation Spreadsheet; available at http://www.energy.ca.gov/reti/documents/index.html (accessed August 17, 2010)	Black & Veatch Corp. (as part of RETI Phase 1B)	Calculate the cost of generation for multiple technologies	DCF	Inputs might not be sufficiently detailed for some users	Minimizes year-one COE subject to equity return requirement, then calculates LCOE
Vermont Standard Offer Models; http://psb.vermont.gov/docketsandprojects/electric/7523/finalprice (accessed August 17, 2010)	Green Mountain Power Corp., adapted by stakeholders in regulatory process	Estimate and inform rate setting for Vermont Standard Offer Program	DCF	Some inputs embedded in formulas; cost inputs highly aggregated	Mini-perm[53] refinancing; reserve accounts; federal and state tax incentives
RETScreen; available at http://www.retscreen.net/ang/home.php (accessed August 17, 2010)	Canadian government	Evaluate economic feasibility of multiple technology types	Unknown	Does not adequately address U.S. tax incentives; insufficient transparency	Alternate levels of input detail
Gainesville FIT model; http://psb.vermont.gov/sites/psb/files/docket/7523/CostAnalysis/Attachment_-_Gainesville_FIT_model.xls (accessed August 17, 2010)	Gainesville Regional Utilities	Set solar FIT rates	DCF	Inputs might not be sufficiently detailed for some users	Shows summary of capacity factor degradation; calculates estimated impact on annual fuel cost adjustment to ratepayers
Solar Advisor Model (SAM); https://www.nrel.gov/analysis/sam/ (accessed August 17, 2010)	National Renewable Energy Laboratory; Sandia National Laboratory; Department of Energy	Consistent methodology for analysis across all solar technologies	DCF	Calculations are not available in Web-based version of model	Range of input options; sensitivity and optimization analyses; output graphics

[53] The term "mini-perm" refers to a type of debt with a shorter repayment schedule (e.g., 5 to 7 years) than a typical project loan but with a similar underlying amortization schedule (e.g., 15 to 18 years). The result is a project with standard debt service obligations for the first 5 to7 years but which must refinance the outstanding balance on the loan when it comes due in full at the end of the mini-perm because project cash flows alone could never support such repayment. The outstanding balance due at the end of the mini-perm often is called a "balloon payment."

Model Name, Web URL, and Date of Access	Created By	Key Characteristics		Applicability to FIT Rate Setting	
		Purpose and Objectives	Taxonomy	Limitations	Useful Features
EU PV Platform; http://www.eupvplatform.org/ (accessed August 17, 2010)	ADEME (French Environment & Energy Management Agency)	FIT calculator	Simplified DCF, using weighted average cost of capital	Depreciation schedule tied to life of project; will not accommodate U.S. tax incentives	Key metrics are defined; provides sample inputs to get started
Vote Solar Incentive Comparison Model; http://votesolar.org/resources/incentive-model/ (accessed August 17, 2010)	Crossborder Energy	Calculate incentives necessary to provide the same project economics under three different policy scenarios	DCF	Inputs might not be sufficiently detailed for some users	Tab dedicated to description of model; calculates not only project incentives but also total program incentives paid
Geothermal Electricity Technology Evaluation Model (GETEM); http://www1.eere.energy.gov/geothermal/getem.html (accessed August 17, 2010)	Princeton Energy Resources International; National Renewable Energy Laboratory; Sandia National Laboratory; Idaho National Lab	Evaluate the economic feasibility of Enhanced Geothermal Systems	FCR (GETEM is more a cost comparison model than a project finance model)	Substantial detail in system design and performance parameters makes model difficult for use by wide range of stakeholders	Detailed list of cost inputs; calculates LCOE for multiple technology types

Appendix B. Survey of Industry Experience with FIT Calculation Methodology

This appendix provides case studies of the different jurisdictions' FIT rate-setting models and processes described in Section 4. Table B-1 summarizes these case studies and compares the different jurisdictions according to the key design options and rate-setting approaches. The table is followed by detailed profiles of each jurisdiction.

Table B-1. Case Studies Highlighting FIT Rate-Setting Models and Processes in Five Jurisdictions

	Germany	Netherlands	Ontario	Vermont	Gainesville, FL
Degree of Tariff Differentiation	High (e.g., technology and size differentiation)	Medium (e.g., technology differentiation; limited size differentiation)	High (e.g., technology and size differentiation)	Medium (e.g., technology differentiation; limited size differentiation)	Low (e.g., PV)
Methodology	FCR	DCF	DCF	DCF	DCF
Payment Structure	Nominal fixed	Nominal fixed	20% of tariff price adjusted at 2.25% inflation for all technologies except PV; PV fixed nominal	30% of tariff price adjusted at 1.6% inflation for all technologies except PV; PV fixed nominal	Fixed; inflation not taken into account in the model
Tax Treatment	Pretax	After tax	After tax	After tax	After tax
Ownership Structure Assumed	Private	Private	Private	Private	Private

	Germany	Netherlands	Ontario	Vermont	Gainesville, FL
Data Granularity (Model Inputs)	A detailed listing of capital and operating costs is included in the model*	*Capital Costs* - One input for installed cost *Operating Costs* - Fixed maintenance - Variable maintenance - Other operating costs - Fuel costs	*Capital Costs* - One input for installed costs *Operating Costs* - Variable O&M - Fixed O&M - Other costs - Fuel costs - Property tax	*Capital Costs* - Debt reserve - Maintenance reserve - Working capital - Financing costs - Installation costs *Operating Costs* - Varies by technology -10 to 12 input cells available in the model (e.g., labor, insurance, and staffing) but most models used one input for maintenance with 1 to 2 other technology-specific inputs	*Capital Costs* - One input for installed costs *Operating Costs* - No inputs (installed cost input is multiplied auto-matically by a dollar-per-kilowatt-hour assumption to calculate operating costs, and this value is embedded in the pro forma)
Capital Structure	Debt/equity varies by tariff	80/20 debt/equity; 100% debt for small PV; 66/33 for waste-to-energy	70/30 debt/equity; non-recourse project financing	Varies by technology. Ranges from 75/25 debt/equity for farm methane to 30/70 for 100 kW wind	100% equity
Debt Term Relative to Economic Life	Same (20 years), except for large hydro	Same (15 years), except for hydro	Same (20 years)	Differs by technology; although all tariffs assume "loan tail" (i.e., loan is shorter than contract)	No debt

	Germany	Netherlands	Ontario	Vermont	Gainesville, FL
Other Incentives	None	Energy investment deduction tax credit (if applicable)	None	- 30% federal ITC for all but farm methane - Portion** of state tax credit assumed for all but farm methane	30% federal ITC
Interconnection/T&D Costs	- Interconnection built into rates - Transmission and distribution upgrades assumed socialized	-Interconnection built into FIT rate - Cost assumptions for lines and transformers built into FIT rate; - Connection charges recovered through transmission surcharge	- Built into capital cost assumptions -T&D upgrades assumed to be paid by the system operator and recovered from ratepayers (when justified)	- Interconnection costs built into rate as part of installed cost - No T&D upgrades assumed	- Interconnection costs built into rate as part of installed cost - No T&D upgrades assumed
Data Sources	- Market research - Data from feed-in tariff generators - Industry surveys	- Market research - Stakeholder process involving publicly available models	- Market research - Publicly available data - Industry polling - Workshops	- Regulatory process using expert testimony - Publicly available data and models - Data submitted by industry	- Publicly available data - Workshops
Granularity of Data Sources	Bottom-up		Top-down	Top-down	Top-down
Approval Process	Rates are recommended to policymakers. Research recommends rates to Ministry, Ministry recommends rates to Parliament, Parliament codifies in law	Rates are recommended to policymakers. Research recommends rates to Ministry, Ministry recommends rates to Parliament, Parliament codifies in law	Law set final rates, informed by a parallel Ontario Power Authority feed-in tariff design process	Rates are recommended to policymakers. Law requires regulator to set rates. PSB approves rates after regulatory proceeding	Rates are recommended to policymakers. Ordinance approved by the Gainesville City Commission following rate-setting process

	Germany	Netherlands	Ontario	Vermont	Gainesville, FL
Model Available to the Public?	No	Online	No	Online	Upon request
Process Transparency	- Some stakeholder engagement - Published description of methodology	- High degree of process transparency - Methodology subject to public comment	- Some stakeholder engagement - Published description of methodolog y	- High degree of process transparency - Methodology subject to public comment	- High degree of process transparency - Methodology subject to public comment
Evaluation Metric	IRR	After-tax return on equity (ROE)	After-tax ROE	After-tax ROE	After-tax IRR
Target Return on Equity	5% to 9%	12% for waste to energy 10% for PV 15% for all others	11%	12.13% (interim rates)*** 9.75% (final rates)****	4.99%

* Maike Schmidt, ZSW, personal communication, May 2010 (Germany's model is not publicly available).

**The rates were set assuming that 50% of the Vermont ITC could be utilized in the first year, with the remaining 50% providing no tax benefit to the project because it is assumed that generators would not have sufficient in-state tax appetite. For farm methane, the rates were assuming no tax credits because "the assumed tax appetite or taxable income of . . . projects is inadequate to apply either the Federal or State Investment Tax Credits" (Vermont Public Service Board 2010, p. 42).

***Established September 15, 2009, through Docket 7523.

**** Established January 15, 2010, through Docket 7533.

The Netherlands' Tariff Calculation Case Study

- **Tariff overview:** The FIT in the Netherlands is based on a spot market gap model, in which generators are paid an incentive equal to the difference between the market price for electricity and the generation cost-based FIT payment level (Cory et al. 2009; Couture and Gagnon 2010). If the FIT rate for landfill gas, for example, was 8.3 Euro cents, and the spot market price for electricity was 5.3 Euro cents, then the FIT payment would be equal to 3 Euro cents.
- **Degree of differentiation:** The FIT is differentiated into 10 different technology categories with limited additional differentiation by size. For PV and biomass, size is differentiated according to capacity, and for hydropower, size is differentiated by height.
- **Calculation methodology**: DCF model.
- **Payment structure**: The FIT payment is set as a nominal fixed value and is not adjusted for inflation. Instead, an assumed inflation of 2% is built into the model.
- **Ownership structure and tax treatment**: The FIT assumes that the generation is privately owned by commercial entities, and the rate is calculated on an after-tax basis, taking into account the corporate income tax rate and depreciation. For PV

systems of less than15 kW, the FIT is calculated assuming residential ownership, and no income tax on FIT revenues is assumed.

- **Granularity of cost inputs**: Both the capital and operating costs inputs are highly aggregated. Capital costs are aggregated into one cell, and operating costs are divided into fixed, variable and "other" operating costs, and fuel costs.
- **Evaluation metric**: The evaluation metric for the FIT rate is a 15% return on equity for most resources, except for a 12% return on equity for waste-to-energy plants.
- **Assumed capital structure**: The model assumes a leveraged structure of 80% debt and 20% equity for almost all of the technology categories. The two exceptions are waste-to-energy, for which a 67/33 debt-to-equity ratio is used to reflect the assumption that the plant is corporate financed, and PV of less than15 kW, which is assumed to be financed through a residential mortgage (i.e., 100% debt). In each case, the model assumes that the FIT term (which is either 12 or 15 years, depending on the technology) is the same as both the loan term and the depreciation period. The one exception to this is hydropower, which assumes a 30-year loan term and depreciation period but only a 15-year FIT term.
- **Interaction with other incentives**: The model assumes that some technologies—such as onshore wind and PV systems larger than 15 kW—are eligible for the energy investment deduction tax credit. The value of the energy investment allowance is taken into account when calculating the FIT rate
- **Interconnection and transmission costs**: Cost assumptions for additional wiring and transformers are built into the capital cost assumptions for the model.
- **Data-gathering and rate-setting processes**: The data-gathering and rate-setting processes are highly transparent. Initial assumptions for the model are collected through a joint research effort undertaken by a non-profit research institution and a for-profit energy consulting company. The results of the research effort then are entered into a public spreadsheet, which is made available for stakeholder comment online. Stakeholders can comment on the models' assumptions and lobby to have the cost figures changed, provided they can support their arguments with proof from real project-development efforts.
- **Approval process**: After the research and stakeholder processes, the Ministry of Economic Affairs recommends a set of final rates to the Parliament, which then establishes rates through legislation.

Gainesville Regional Utilities' Tariff Calculation Case Study

In March 2009, the GRU became the first municipal utility in the United States to offer a solar electricity FIT. The City of Gainesville previously offered utility customers a $1.50/kW rebate along with net metering. The FIT was designed as an alternative policy to this suite of incentives.

- **Tariff overview**: The Gainesville FIT provides a fixed, 20-year payment for solar electricity, renewable energy certificates, and any other environmental attributes that can accrue to the generation. The tariff is capped at 4 MW of PV capacity annually and is available each year through 2016. The available tariff declines each year starting in 2011.

- **Degree of differentiation**: The FIT is available only to PV generators and is differentiated into two rates. The higher rate is available to systems installed on buildings, on pavement, and to ground-mounted systems that are smaller than 25 kW. The lower rate is available to free-standing systems that are not pavement-mounted and are larger than 25 kW.
- **Calculation methodology**: DCF model.
- **Payment structure**: The FIT payment is set as a nominal fixed value and is not adjusted for inflation. The spreadsheet model also does not account for inflation.
- **Ownership structure and tax treatment**: The FIT assumes that the generation is privately owned by commercial entities, and the rate is calculated on an after-tax basis, taking into account the corporate income tax rate and depreciation.
- **Granularity of for cost inputs**: The capital cost input is aggregated into one cell. O&M cost assumptions are embedded in the cash flow model as $25/kW/year O&M and $1,000/kW for an inverter replacement in year 10.
- **Evaluation metric**: The evaluation metric for the FIT rate is 4.99% return on equity.
- **Assumed capital structure**: The model assumes that the PV project is 100% equity financed with no debt.
- **Interaction with other incentives**: The model assumes that PV generators claim the 30% federal tax incentive as well as the MACRS-accelerated depreciation schedule.
- **Interconnection and transmission costs**: Interconnection costs are not built into the model separately. They are assumed to be included in installed cost data that were gathered during the rate-setting process and in the installed cost assumptions that ultimately were included in the model.
- **Data-gathering and rate-setting processes**: The GRU rate-setting model required inputs for system costs, capacity factor, O&M costs, federal corporate tax rate, and system degradation rates. These values were collecting from existing sources and price surveys. Aggregated system costs (in dollars per watt) were determined using top-down data from the state rebate program and a survey of local installations. Capacity factor inputs were determined using NREL's PV Watts calculator.[54] A PV output degradation factor was drawn from analyses conducted by the California Public Utilities Commission and the Energy Information Administration. The policy-development process included a series of public meetings during which draft tariff designs and input assumptions were presented and discussed. The rate-setting model was designed to be less complex to make it an accessible tool for the stakeholders. The staff of the GRU managed the FIT rate analysis and rate-setting outcomes. The cost-setting model was refined during the course of the policy process based on stakeholder input.

[54] See: http://www.nrel.gov/rredc/pvwatts/. Accessed May 12, 2011.

- **Approval process**: The FIT policy was adopted through a city ordinance[55] passed by the Gainesville Regional Commission and signed by the mayor. The commission has the authority to set the rates at whatever levels it deems appropriate, and it included the rates recommended by the GRU when it adopted the ordinance.

Vermont's Tariff Calculation Case Study

The 2009 Vermont Energy Act (Act 45)[56] established the Standard Offer for Qualifying SPEED. The authorizing legislation included preliminary tariff rates as well as guidance that the PSB was to establish final tariff levels. An interim adjusted tariff rate went into effect in September 2009 (Docket 7523), and final tariff rates were established in January 2010 (Docket 7533).

- **Tariff overview**: The SPEED program is a long-term, fixed-price tariff for electricity, renewable energy certificates, and other associated environmental attributes.[57] The tariff is capped at 50 MW statewide, which is subdivided into 12.5 MW caps for each of the targeted technologies.
- **Degree of differentiation**: The FIT is differentiated to target six technologies (PV, hydro, farm methane, landfill gas, wind, and biomass). The wind rates are further differentiated into wind smaller than 100 kW and wind larger than 100 kW.
- **Calculation methodology**: DCF model.
- **Payment structure**: The FIT payment for PV is set as a nominal fixed value and is not adjusted for inflation. For the remaining resources, 30% of the payment level adjusts for inflation each year. Inflation is set at 1.6% rather than at the actual inflation level each year.
- **Ownership structure and tax treatment**: The FIT assumes that the generation is privately owned by commercial entities, and the rate is calculated on an after-tax basis, taking into account the corporate income tax rate and depreciation.
- **Granularity of cost inputs**: Hard capital costs are aggregated into one input cell, but financing (i.e., soft) costs are broken out by debt reserve, maintenance reserve, and working capital. With regard to annual costs, maintenance is aggregated into one input cell, but there are additional entry cells for property tax, insurance, and lease payments (where applicable).
- **Evaluation metric**: Act 45 requires the PSB to set the FIT such that project rate of return on equity is not less than the highest return on equity allowed for any of the state's investor-owned utilities. The PSB initially determined that all tariffs would be set to provide a 12.13% return on equity but subsequently lowered the return on equity of 9.75% when establishing the final rates in January 2010.
- **Assumed capital structure**: The models assumed all projects would use some level of debt financing, although the debt-to-equity ratio differed for each generation type.

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[55] See http://gainesville.legistar.com/View.ashx?M=F&ID=593626&GUID=B99E78E7-2DBD-42C5-921D-41D9B65F8C64. Accessed August 17, 2010.
[56] Available at http://www.leg.state.vt.us/docs/2010/Acts/ACT045.pdf. Accessed August 17, 2010.
[57] The exception is farm methane generators, which retain ownership of their renewable energy credits per the statute.

The PSB assumed that PV systems would use project financing and other technologies would use more traditional recourse financing. For modeling purposes, debt-to-equity ratios were set to assure that debt service coverage ratios averaged 1.5 throughout the life of the project. Debt levels for the PV model also were set to assure that debt service coverage ratios never were below 1.2.

- **Interaction with other incentives**: The authorizing legislation tasked the PSB with taking into account all "reasonably available" incentives in setting its tariff rates. For applicable technologies, this included both the federal ITC and five-year MACRS depreciation. The PSB did not assume that all project costs were eligible for the ITC and five-year MACRS. The models also partially account for state tax credits but do not assume the availability of funds from the state's Clean Energy Development Fund grant program.
- **Interconnection and transmission costs**: The PSB's final order noted that utility interconnection requirements generally are site-specific and can vary by the size of the generation project and location. Ultimately, "[p]arties agreed that the costs of [i]nterconnection were generally integrated into the cost modeling as part of the installed capital costs and no additional interconnection costs needed to be added to the project costs" (Vermont Public Service Board 2010, p.39).
- **Data-gathering and rate-setting processes**: The PSB established final tariff rates through a non-contested public docket that featured expert witness testimony from a range of market participants. Witness testimony informed the initial creation of the tariff-setting model and several iterations of the model were created over the course of the process to reflect new expert testimony. All tariff models were made public on the PSB website (http://psb.vermont.gov/docketsandprojects/electric/7523/finalprice, accessed August 22, 2010). Although initial cost surveys focused on some granular data points (Vermont Public Service Board 2009c), the data gathered for the final rates was primarily top-down, attained through surveys of different technology's total installed costs, rather than bottom-up data focusing on the prices of technology components (Vermont Public Service Board 2009b, p. 30).
- **Approval process**: Act 45 set interim rates and directed the PSB to determine whether the rates were a "reasonable approximation" of generation cost-based rates and then set those as interim rates. Act 45 also directed the PSB to develop final rates by January 2010. The PSB set interim rates in Docket 7523 and final rates in Docket 7533.

Ontario's Tariff Calculation Case Study

- **Tariff overview:** Ontario's FIT is paid as a fixed, long-term power purchase price. Different prices are offered for different technologies and for different project sizes. Tariffs are offered for 20 years for all technologies with the exception of hydro plants, which are offered 40-year contracts.
- **Degree of differentiation:** The FIT is differentiated into seven different technology categories with a high degree of project-size differentiation within each technology. Both biogas and solar PV systems have five different size categories.[58] Onshore wind

[58] For specific rates in Ontario, see: http://fit.powerauthority.on.ca/. Accessed May 12, 2011.

is distinguished from offshore wind, and two different size categories are offered for landfill gas, biomass, and hydro-power projects with different FIT prices awarded to each. Additionally, a sliding-scale bonus payment of up to $0.015/kWh is offered for community-owned and aboriginal-owned projects, based on the degree of local or aboriginal participation.

- **Calculation method:** DCF model.
- **Payment structure:** The FIT payment is a nominal fixed value. For all technologies other than solar PV, it indexes 20% of the initial tariff price to changes in the consumer price index, meaning that the price is adjusted upward annually. The assumed annual rate of inflation is 2.25%.
- **Ownership structure and tax treatment:** The assumed ownership structure in Ontario's FIT is private and commercial. Due to the different tax structures that apply to different types of private investors, three different corporate ownership structures were modeled. Calculations are made on an after-tax basis, taking into account the different corporate income tax rates and applicable depreciation.
- **Granularity for cost inputs:** There is one input for capital cost. Operating costs are broken out by fixed O&M, variable O&M, fuel costs, and property tax payments.
- **Evaluation metric:** The target rate of return is set at an 11% IRR. The cost of debt is assumed to be 7%.
- **Assumed capital structure**: The model used in Ontario assumes a 70% debt, 30% equity capital structure for all technologies and project sizes. It assumes a non-recourse project financing structure.
- **Interaction with other incentives:** The FIT payments are offered without an explicit reference to other supplementary incentives. Incentives offered under the federal Eco-Energy program are not assumed within the tariff calculation model, due in part to their unreliability and to the different abilities of market participants to capitalize upon them.
- **Interconnection and transmission costs:** Unspecified assumptions for interconnection costs implicitly were incorporated within the set of survey-based cost assumptions relating to a standard case. The costs of connection to the grid are assumed to be borne by the project developer, but the costs of necessary upgrades to the transmission and distribution infrastructure are passed on to the transmission authority and, ultimately, are passed on to ratepayers. Each upgrade is subjected to an economic connection test, which assesses the economic justification for the additional transmission investment in relation to similar investments in other areas of the grid, as well as their priority over others based on the date that the project proposals are submitted.
- **Data-gathering and rate-setting processes**: The data gathering was done privately by consultants, in conjunction with the Ontario Power Authority, which drew on previous bids submitted from the last round of competitive solicitations. The results of the analysis then were submitted in the context of an open public consultation process, and individual stakeholders could offer comments and suggest modifications

to the proposed tariff amounts. The final tariffs can be adjusted based on this open consultation to reflect legitimate arguments raised by stakeholders.

- **Approval process:** After a detailed stakeholder engagement process, and after receiving Royal Assent in the provincial legislature, the Ministry of Energy and Infrastructure announced the launch of the Green Energy and Green Economy Act, of which a central component is the FIT program.

Germany's Tariff Calculation Case Study

- **Tariff overview:** Germany's FIT is paid as a fixed, long-term power purchase price. Different prices are offered for different technologies, as well as for different project sizes, different fuels, and different technology applications. Tariffs are offered for 20 years for all technologies.
- **Degree of differentiation:** Germany's FIT is one of the world's most highly differentiated.
- **Calculation method:** FCR, which the German Environment Ministry refers to as the annuity method.
- **Payment structure:** The tariff prices are fixed nominal values and are offered within purchase guarantees that extend over 20 years (15 years for biomass). The tariff calculation assumes a 2% inflation rate per year. All costs for renewable electricity generation therefore are calculated on a real basis, adjusting them to inflation based on a specific reference year.
- **Ownership structure and tax treatment:** The FIT rate calculations are conducted on a pretax basis, although the FIT assumes that the systems are owned by private sector, commercial entities.[59]
- **Granularity for cost inputs:** Capital and operating cost inputs are aggregated in the spreadsheet model. The data gathered to support the aggregated cost inputs, however, are granular compared to some of the other jurisdictions. The German government collects and analyzes data on annual electricity production, hard costs (including machinery, electrical systems, construction, grid connection, and transformers), consultant and legal fees, interest incurred during the construction phase, and operating costs (fuel costs, labor, service, insurance, administrative, and land-lease costs).
- **Evaluation metric:** The German FIT assumes different returns on equity for different technologies, depending on their risk profile and assumed financing structure.
- **Assumed capital structure**: The assumed capital structure varies by generation type and project size.
- **Interaction with other incentives:** No other incentives are assumed in the setting of the FIT rate.

[59] In previous rounds of the rate-setting process, the ownership structure of small PV systems was assumed to be residential, and both taxes and tax credits were taken into account in the FIT calculation.

- **Interconnection and transmission costs:** Interconnection costs are borne by the generator and built into the FIT rate. The FITs are calculated based on typical "model" projects, and therefore, average values (i.e., based on average interconnection distances) are assumed as part of the cost model. Transmission and distribution system upgrades are socialized among national ratepayers.
- **Data-gathering and rate-setting processes**: Germany relies on a network of research institutes to carry out comprehensive surveys of plant developer/operator data, which are subsequently compared to published data and other relevant case studies. The data is derived both from market studies and from data reported by FIT generators. The data is used to define a "reference" generator for each tariff level that embodies system performance under standard operating conditions. This reference generator then is used as the basis for rate setting.
- **Approval process:** Similar to the Netherlands, the German FIT rates are adapted by the national legislature (the Bundestag), following recommendations from the Ministry of Environment.