Setting a Price for Solar Net-metering in California

by

Laura Knezevic

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Name: **Laura Knezevic**

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Examining Committee: **Chair:** Doug McArthur
Professor

Dominique M. Gross
Senior Supervisor
Professor

J. Rhys Kesselman
Supervisor
Professor

Nancy Olewiler
Internal Examiner
Director

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Abstract

Net-metering programs are an effective policy tool for promoting investment in solar energy generation, yet little attention has been paid to the rate at which excess energy generation is credited until recently. Like most States, California customers who participate in net-metering receive a credit for excess generation at the current retail rate for electricity. This buy-back rate does not take into account the value of solar energy to the utility or the costs to the customer of purchasing and installing a photovoltaics system. An alternative pricing policy is needed to better reflect the value of solar energy in a net-metering program while encouraging continued growth of solar investments. I analyze three case studies, Germany, Denmark, and Austin, TX, and evaluate their methods of pricing solar energy in buy-back programs. I recommend that California implement a pricing policy similar to that of Austin's new Value of Solar tariff, which provides a more accurate valuation and compensation rate excess solar energy generation.

Keywords: Solar energy; net-metering; California; buy-back rate; feed-in tariff

Dedication

To my husband Jim, for his love and support throughout this process

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List of Acronyms

CPUC	California Public Utilities Commission
FIT	Feed-in tariff
VOST	Value-of-solar tariff
PV	Photovoltaic
PURPA	Public Utilities Regulatory Policies Act
REC	Renewable energy credit

Executive Summary

California's current solar net-metering buy-back price does not provide a financial incentive to encourage investment in distributed solar generation. The standard net-metering arrangement, where excess energy causes the meter to roll backwards and the customer receives a credit for that energy at the retail rate, may be administratively easy to implement. However, it does not reflect the value of solar energy or provide a strong incentive to consumers to invest in solar energy. Net-metering has the potential to create significant growth in renewable energy, yet an effective pricing mechanism is needed in order to incentivize more robust growth of the program.

While California has experienced some growth in solar energy in the State, it still makes up a small percentage of the overall energy portfolio. Supporting solar energy through a production-based incentive, such as net-metering, is a desirable option compared to an investment-based incentive, such as a tax rebate. Production-based incentives are a more efficient inventive to encourage generation from renewable sources.

There are several key characteristics that are important for a robust net-metering program, and they include the relationship between the buy-back rate and the retail rate for energy, the billing cycle, compensation for residual energy credits, individual solar system size limits, additional fees levied on customer-generators, and potential overall net-metering program caps. Using these characteristics, three case studies are selected and evaluated to develop alternative pricing mechanisms for net-metering in California.

The first case study is the feed-in tariff of Germany, which has achieved a steadily growing solar market due to a tariff actively encouraging investment in solar energy. The second case study is Denmark, where high taxes on energy in general and a tax rebate for net-metering customers resulted in unprecedented growth in net-metering in 2012. The third case study is Austin, Texas, where a new Value-of Solar Tariff has been developed to reflect the value of solar energy to the grid and to satisfy the concerns of all stakeholders.

Based on the results of comparing the three case studies, I develop three policy options. The policy options are: (1) increased retail rate pricing through a time-of-use rate structure, (2) a feed-in tariff style buy-back rate for excess generation, and (3) a value-of-solar tariff that reflects the value of solar to the grid. The first option is administratively simple to implement, but is unlikely to garner the necessary support in California at this time. The second option would be successful in spurring greater investment in solar, but at too high a cost. The third option is the most popular option among stakeholders and increases the incentive to invest in solar without overheating the market with too high a tariff.

I therefore recommend implementing the third option, as it satisfies utility companies, utility customers, and the state utility commission while providing an improved incentive for investment in distributed solar generation. Improving the retail energy rate structure through time-of-use pricing should be examined as a complimentary policy as support for smart meters and alternative retail rates will evolve in future years.

1. Introduction

Net-metering has been available to utility customers in 43 states and the District of Columbia for over three decades. It is one of many different support mechanisms that can be used to encourage development of small-scale renewable generation from distributed sources. The most attractive feature of net-metering is simplicity. Customers who wish to offset part of their energy bill with renewable energy may install a generation system on their property and connect it to the grid. As the system produces energy, the customer's energy usage is offset and excess generation causes the electricity meter to run backwards, providing them with a credit for this production. These features make the program easy to implement, but also fall short of providing sufficient incentive for the degree of growth that is desired for renewable energy. As a result, net-metering programs have seen only modest growth, the majority of which took place during years when solar panel prices were falling.

The economic incentive inherent in the structure of the program is vital to encourage increased investment in distributed renewable generation. Without a sufficient economic incentive, net-metering programs will not reach their full potential. Given the importance of reducing greenhouse-gas emissions through increased renewable energy, it is vital that a more robust net-metering program be created in order to improve the incentive to participate. Net-metering has the potential to significantly increase renewable generation through private investment by individuals rather than relying on large-scale renewable generation to be developed.

I approach this issue by reviewing three case studies in which alternative pricing schemes are used for solar buy-back programs. I focus on the relationship between the retail price for energy and the buy-back rate as the driving force behind incentivizing investment in distributed solar generation. In addition, I examine other features that influence the economic incentive of net-metering, such as the billing cycle and use of additional fees for customer-generators.

The organization of the capstone is as follows. Chapter 2 provides an overview of net-metering, it's costs and benefits, and a discussion of feed-in tariffs. Chapter 3 describes how net-metering is implemented in California. Chapter 4 looks at the relevant literature on distributional effects of net-metering, evidence of willingness-to-pay for clean energy, and the types of support mechanisms currently in use for renewable energy. Chapter 5 outlines the policy problem and relevant stakeholders. Chapter 6 describes the methodology used to evaluate the problem. Chapter 7 describes and analyses three case studies of jurisdictions where alternative pricing mechanisms have been implemented. Chapter 8 describes the short and long-term policy goals as well as three policy options. Chapter 9 contains the analysis of each policy option and the conclusion drawn from the analysis.

2. Net Metering

Net-metering is a billing mechanism through which residential owners of renewable energy installations (such as wind, solar, and biomass) can receive a credit on their energy bill for excess energy that is exported to their utility company. The energy that is produced from the renewable installation is first used to meet the residential customer's individual demand. When net-metering customers' energy demand is greater than the amount of energy produced by the renewable system, they act as a typical utility customer and import additional energy from the utility to meet their needs. When the customer's energy demand is lower than the amount of energy produced by the renewable system, the excess is exported to the utility for a credit. In such an arrangement, a utility customer becomes a customer-generator, since they are both buying and producing energy. While net-metering is often open to a wide range of renewable energy, the majority of such projects in the United States consist of solar panels (Faden, 2001).

Net-metering in the United States was created through the enactment of the Public Utilities Regulatory Policies Act (PURPA) in 1978 with the intention of reducing America's dependence on foreign oil and encourage the development of renewable energy. The Act requires utilities to provide net-metering to its customers if requested. These customers must fall under the category of "small producers", meaning their renewable energy systems generate less than 80 megawatts of electricity.[1] The Act also requires utilities to purchase excess energy and pay a price no lower than their avoided cost rate, which is set by each states' utility commission (Faden, 2001).

Beyond these basic requirements, the Act does not stipulate additional regulations associated with net-metering. Instead, it gave states the freedom to interpret

[1] In comparison, an example of a large energy producer would be the Hoover Dam, which has a capacity of about 2,080 megawatts of electricity (Hoover Dam, 2009).

and implement the law. This has resulted in different rules and regulations for net-metering across the country. For example, while PURPA implies no limit to the size of an individual customer's renewable energy system to qualify for net-metering, most states have set their own limits ranging from as high as 80 megawatts (MW) to as low as 10 kilowatts (kW).[2] Some states, such as Arizona, New Jersey, and Ohio have no limits to individual system sizes. Net metering has been adopted to varying degrees of success by 43 states, the District of Columbia, and 4 territories. Some of the most successful states have increased the overall program caps to accommodate growth of the program while others have amended the policy to provide customers with full value for excess generation credits and ownership of renewable energy credits (Database of State Incentives, 2013).

To qualify to participate in net-metering, customers must use the energy generated by the renewable installation primarily for their own use and not for the purpose of generating or selling electricity even though a production cap is not imposed on household. This is an important characteristic of the program, because it sets net-metering apart from feed-in tariffs where renewable installations are established primarily for the purpose of selling electricity. The purpose of net-metering is to offer an easy and administratively simple method through which residential customers can install renewable energy on their property (Faden, 2001). The policy facilitates the proliferation of renewable energy outside of typical utility-scale projects, such as stand-alone wind farms or coal-powered generators, while offsetting energy costs for the participating customer.

Net-metering programs bill customers based on their "net" energy usage, so only one electricity meter is needed. When excess energy is generated, the meter runs backward, so the customer is automatically credited at the same price at which they would pay to buy energy. The simplicity of this billing arrangement makes net-metering an attractive option for customers wishing to install renewable energy on their property.

[2] A watt is a measure of power, or the rate at which energy is generated. In the case of solar power, it is the rate at which the sun's energy is converted into electricity. A kilowatt is 1000 watts, a megawatt is 1000 kilowatts, and so on. A kilowatt hour is a measure of energy, or how much fuel is used over the course of an hour.

However, the price paid, or buy-back rate, for excess energy does necessarily reflect the costs to the customer or utility of such an arrangement.

The buy-back rate for these credits varies from state to state, but is usually set to either the customer's retail rate for electricity or the utility's avoided cost rate. Credits are accrued over the course of each billing period, which is usually one month long, and are used to offset the purchase of energy from the utility. Should the customer-generator produce more energy than they use during any one billing period, the credits may be rolled over until the end of the year, at which point they expire. Some utility companies issue a refund for expired credits at the same buy-back rate, while others do not reimburse the customer for this energy.

Some states have adopted dual meter billing methods, where a second meter is installed so that purchased energy and exported energy can be assigned different prices for net-metering customers. This is often done so that credits for excess generation can be valued at the utility's avoided cost rate while energy purchased by the customer is done so at the retail rate. The resulting difference between the retail rate and avoided cost rate has a significant impact on the economic benefit of net-metering to participating customers. The avoided cost rate is almost always lower than the retail rate, making this arrangement favorable to utility companies. The larger the disparity between the retail rate and avoided cost rate, the less appealing net-metering becomes to potential participants (Faden, 2001). The rate structure of net-metering programs fundamentally alters the economic incentives to participate in the program.[3]

2.1. Feed-in Tariffs

Any discussion of net-metering requires a discussion of another type of buy-back scheme for renewable energy: feed-in tariffs. A feed-in tariff (FIT) is a system where renewable energy generators can receive a long-term contract from the utility to purchase energy at a specified price. These energy generators are usually

[3] In 2013, the payback period for an average California net-metering customer with a system size of 2.8 kilowatts was 9 years (Madsen, 2013).

homeowners, small businesses, or farmers. However, they typically do not use any of the energy generated by the installation, but instead sell all of it to the utility. The price that is paid for this energy is higher than the retail rate and often based on the cost associated with purchasing and installing the renewable energy system. For example, solar energy receives a higher price in a FIT scheme than wind power because it costs more to install a solar photovoltaic (PV) system. Participants in this program also receive a long-term contract, ranging from 5 to 20 years in length, for the purchase of their energy. In order to calculate the amount of energy that is exported to the utility versus the amount of energy the customer purchases, two meters are installed to FIT participants. This makes it easier to administer the program, but adds to up-front costs. FIT's are designed to ensure that participants will receive sufficient compensation to pay for the costs of installing the renewable energy system (Mendonca, 2009). Perhaps the most well-known country to implement an FIT is Germany, which will be discussed in more detail later.

I focus on net-metering in this study because the current buy-back rate system in California does not take into account the value of solar energy. Instead, it reflects the structure of an administratively easy program. The program's most appealing feature is its simplicity, but that is also its biggest weakness. By crediting excess generation at the retail or avoided cost rate, net-metering fails to address the economic incentive necessary to promote significant levels of investment in solar energy. Solar energy has traditionally been more expensive for utilities to purchase over conventional forms of energy due to its lack of subsidies and relative youth in the energy market. Support schemes such as net-metering are important methods for driving the costs of solar down and bringing them in competition with conventional energy (Faden, 2001). For the first time, solar energy became competitive with natural gas in Minnesota in 2013. A proposed natural gas plant with costs ranging from $0.28 to $0.65 per kWh was overlooked in favor of solar with a cost of just $0.18 per kWh during peak periods (Farrell, 2013). However, such cost competitiveness is still a goal to be achieved in much of the United States and the disparity between costs for renewable energy and conventional energy demonstrates a need for policy intervention to support solar energy. With an improved buy-back price, net-metering has the potential to encourage greater growth in the development of renewable energy and solar investment in particular.

I also focus on solar energy within net-metering programs because it makes up the lion's share of renewable energy technologies that are eligible to participate in the program both across the US and in California (Database of State Incentives, 2013). Amending the net-metering policy for solar customers will impact the vast majority of customer-generators. In addition, as far as I know, at this point there is little public information on the marginal costs of other forms of energy and thus, a comparison between types of energy is difficult. This is not to say that other forms of renewable energy are not important.

2.2. Benefits of Net Metering

Net-metering provides a number of benefits to both utility companies and customers. For customer-generators, they benefit from excess generation by receiving a credit towards future energy purchases. This makes it possible for customers to save money on their energy bill while offsetting the cost of a solar PV installation. The economic benefit provided to customer-generators through this billing mechanism is key to its success. The amount of money a customer anticipates saving or earning from their renewable energy system is a strong incentive to participate in the program (Faden, 2001). For example, a customer in San Francisco with a monthly energy utility bill of $180 who installs a 3 kW south-facing PV system on their home that costs $19,282 would realize a payback period of 12 years (Pricing PV Systems, 2013).

Over the long-term, net-metering has the potential to substantially contribute to regional energy independence for customer-generators. One residential solar installation can power two or three homes. Should enough homes in a neighborhood instal panels and participate in net-metering, the entire area could potentially go off the grid (Freeing the Grid, 2011).

Energy from solar net-metering can benefit utility companies by helping to reduce pressure on the grid during times of peak demand. Solar in particular is well suited for this task as it produces the most energy in the middle of the day when demand is at its highest. During hot summer months when energy demand strains the power grid, solar production is at its peak and net-metering can offset the need to buy power on the spot market to meet peak demand. This feature of net-metering can reduce the costs for a utility associated with purchasing energy at the most expensive time of day from the spot market. It also reduces the strain on the grid, postponing the need to make investments in transmission and distribution systems in order to meet peak demand (Mendonca, 2009).

Solar energy is considered an intermittent source of power, because it doesn't produce energy continually but rather only when the sun is shining. One way for utility's to manage the intermittent nature of solar power is to store excess energy in a battery until it is needed. However, while the price of battery back-up systems has been falling in Europe, they remain expensive in the United States and the current costs prohibit them as a realistic option. With net-metering, excess energy can be exported to the grid and used immediately, eliminating the need for expensive storage systems and offsetting the purchase of energy from conventional sources such as coal or nuclear (Mendonca, 2009)

Another benefit to utility companies is that the produced solar energy is distributed throughout the region. Unlike other energy generation, which is usually from large-scale stand-alone power plants, such as coal, natural gas, nuclear, and solar or wind farms), the PV systems are located within residential and commercial areas. This is beneficial because there are fewer transmission and distribution costs associated with such systems because they are located close to the points-of demand. As a result, utilities save money with net-metering because the energy is transported much smaller distances to reach customers (Faden, 2001).

Net-metering also benefits the utilities in that it allows them to avoid the costs associated with procuring energy from another source. In states such as California, where the utility commission requires that a certain percentage of energy be procured from renewable sources, net-metering can be a cheaper option to procuring energy from large-scale renewable systems. Utilities also avoid the cost of installing a second meter, which is usually required for a feed-in-tariff system.

2.3. Costs of Net Metering

Solar panels produce most of its energy during the middle of the day when the sun is in full force, but net-metering customers must still purchase power in the evening and on cloudy days. Incorporated into utility rates are costs for maintaining transmission and distribution systems. Since customer-generators purchase less energy than they would have otherwise, but are still using the grid, they pay a smaller share of the transmission and distribution costs than non-participating customers. In addition, the energy they export is distributed through the grid and the utilities must provide transmission services for this energy as well. While the impact to utility's is fairly small when the proportion of customer-generators is small, it may increase as net-metering adoption grows and the utility's collect less revenue from these customers (Weissman, 2012).

2.3.1. Resistance to Net-metering

Net-metering has faced considerable resistance by utility companies in recent years. One of their primary arguments for limiting net-metering buy-back rates is that it has a distributional effect on non-participating customers. They argue that customers-generators benefit at the expense of other customers. Those without net-metering pay more for their energy because net-metering raises the price of providing energy for the utilities and those costs are passed on to customers (Weissman, 2012).

Proponents of solar, however, argue that net-metering actually reduces energy costs for non-participants because distributed generation reduces energy costs because it is cheaper for the utilities to purchase. In addition, solar net-metering improves reliability of the energy grid for other customers because it is often producing energy at peak demand times (which is also when reliability becomes an issue because of the strains placed on the grid during peak demand) (Weissman, 2012).

While these arguments are frequently cited by each party, there is little reliable information available to back-up these claims. Studies conducted by utility companies tend to support their own positions and lack the transparency needed to verify the findings. In addition, much of the data about rate impacts to customers is insufficient or controlled by the utility because it is private or considered proprietary. This presents a challenge in determining the extent of distributional effects (Forsyth, 2002).

From the utilities perspective, distributed generation is essentially competition for their business model. As a result, they are often resistant to policies that would encourage further development of programs like solar net-metering. Much of their profit is derived from transmitting energy and distributed generation essentially circumvents the system, reducing the utility company's ability to charge for use of the grid (Faden, 2001).

While this policy may seem attractive to utilities, it runs the risk of encourage net-metering customers to go off-the grid. Recent improvements in battery storage technology are making it possible for owners of solar panels to store their excess energy on site for use when their energy needs exceed the panel's production. These storage systems are not yet cost-effective compared to buying energy from the grid (Lindley, 2010). However, measures that raise rates for net-metering customers will make these storage systems more attractive as costs decrease. A move away from the grid may compound the problem for the utilities as they lose more and more rate paying customers. Over the long-term, this will force utilities to spread out their costs to fewer customers, essentially raising the rates for individual customers.

3. Net Metering in California

California procures energy from a range of sources, including conventional sources of generation, such as natural gas and nuclear power in addition to utility-scale renewable energy projects. Approximately 20% of energy sold from each of the three investor-owned utility companies comes from renewable sources, yet two thirds of this is from hydropower. Net-metering makes up approximately 1.5% of energy produced by each utility company. Given California's legislated goal of reaching 33% renewable energy by 2020, further growth in renewable energy is needed in the state. This study focuses on net-metering policies in the State of California because of the opportunity it presents to incentivize investment in renewable energy. California's net-metering program is considered one of the most successful in the nation, with approximately 72% of U.S. net-metering customers living in the state. Yet net-metering customers make up just 0.77% of all customers serviced by the state's investor-owned utilities (Database of State Incentives, 2013). However, California has struggled in recent years to find a better method for pricing excess energy generated through their net-metering program.

3.1. History of Net Metering in California

California has historically been a leader in the US in terms of designing and implementing progressive energy policy. Net-metering was first enacted into law in California in 1996 and allowed for wind and solar systems up to 1 megawatt in size to be connected to the grid. 1 megawatt of solar energy powers 216 homes in California (What's in a Megawatt, 2013). The law has been amended a number of times over the years and now includes all eligible renewable energy as defined in the State's Renewable Energy Portfolio Standard grid (Database of State Incentives, 2013). The law limits the amount of energy capacity that can be installed in the state through net-metering to 5% of a utility's aggregate peak demand. For California's three largest investor-owned-utility companies, which serve the vast majority of California residents, the cap on net-metering capacity is as follows (Database of State Incentives, 2013):

- San Diego Gas and Electric: 607 MW of generating capacity
- Southern California Edison: 2,240 MW of generating capacity
- Pacific Gas and Electric: 2,409 MW of generating capacity

California originally mandated that all excess generation credits that remained at the end of the year expired without remuneration. In 2009, the law was amended to provide customers with two options for remaining energy credits. They could either roll over remaining credits indefinitely or receive a financial rebate for their remaining credits at electricity rate equal to the 12-month average spot market price for the year during which the power was generated. This improved the financial incentive for customer-generators by providing them with an option to receive a monetary return for their excess generation. However, if customers do not specify one option or the other, the credit expires without remuneration (Database of State Incentives, 2013).

California also issues Renewable Energy Credits (REC's) to those who generate energy from renewable sources. These REC's are not the same as the energy credits of net-metering, but rather credits that can be used towards fulfilling the requirements of the State's Renewable Portfolio Standard (RPS). California requires all utilities to purchase at least 33% of their energy from renewable resources by the year 2020 (Weissman, 2012). Since solar energy qualifies as a renewable resource under the State's RPS, all energy exported through net-metering contributes towards achieving this goal. Net-metering customers can keep those credits for any energy used on-site, but must relinquish them to the utility if they receive a financial rebate for their net-metering credits (California Net Energy Metering, 2013). Unfortunately, these credits are valued below $1 for 1 megawatt of energy and the costs to register these credits exceed their value. As a result, these renewable energy credits are not considered to be an important factor to those investing in renewable energy.

California does not currently allow any additional charges to a net-metering customer's bill that would not also be charged to other customers. This means that net-metering customers cannot be charged a monthly fee for access to the grid or to offset specific costs to the utility. They also cannot be charged interconnection fees, standby, or demand charges (Database of State Incentives, 2013).

3.2. Discussion of Net-metering in California

During the past several years, a debate has sprung up in California over the value of the exported energy in a net metering scheme. Utility companies argue they should pay less than the market rate for this energy as it costs them more to buy energy from these sources than it would from other sources such as a natural gas plant, for example. They must invest in transmission and distribution systems to transport the energy in addition to maintaining sufficient back-up supply since renewables are an intermittent source of power. They also argue that those without home solar installations are essentially subsidizing those with solar installations through higher utility bills that are necessary to pay for net-metering. Several utility companies recently proposed the addition of a monthly fee to the bills of net-metering customers to recover some of this lost revenue and mitigate the distribution effects on other customers (Beach, 2013). The law would have to be amended to allow such a fee as it is currently prohibited (Database of State Incentives, 2013).

Solar advocates argue that the utility should pay more than the market rate for this energy as they are providing energy for the utility at a lower cost than what they would have to pay for energy from another source. They emphasize the benefits of distributed generation as well as the avoided cost of having to procure and distribute energy from a carbon intensive source to meet demand (Heidell, 2013).

3.3. Energy Regulation

Regulation of the State's three investor-owned-utility companies is overseen by the California Public Utilities Commission (CPUC). They are responsible for setting the retail rate for energy that utility companies are allowed to charge customers. Changes to the retail rate are made annually based on requests filed by the utility companies in which they make their case for why a rate change should be granted. The CPUC uses a market price referent method for setting retail electricity rates, which relies on the long-term market price of electricity, rather than the marginal cost, to set energy rates. Utility companies include estimates regarding their average costs to provide energy in their rate change requests to the CPUC. California used to set retail rates based on the marginal cost of energy, but moved away from that method after deregulating their energy market in the 90's (Dargouth, 2011).

In 1998, the state began operating under a partially deregulated market where energy production operated within an open market while energy transmission and distribution continued to be regulated by the CPUC. This meant that wholesale energy prices could fluctuate as determined by the market, but retail rates are set by the CPUC. This system created a number of problems, because utility companies had to purchase energy at wholesale market rates that continued to fluctuate, while selling the energy to retail customers at a static rate. This system became particularly problematic when wholesale electricity prices rose drastically in the summer of 2000. Because utility customers paid a set rate for energy, they were shielded from the increase in wholesale prices and did not have an incentive to alter their energy usage in response to such changes (Borenstein, 2001).

The CPUC is also responsible for oversight of the net-metering program. The Commission has the ability to modify features of the program, including the overall program cap and individual system size limits. While evidence demonstrating the rationale for these caps is lacking, the CPUC has raised the cap twice in the past already. The first raise in 2006 wasfrom 0.5% to 2.5% of the utility's peak demand; the second raise in 2010 to 5% (Database of State Incentives, 2013). The Commission has not set goals for renewable energy generating capacity within the net-metering program.

3.4. Retail Energy Rate Structure

The underlying rate structure for retail energy rates is an important factor when considering net-metering. California uses a tiered energy rate structure where customers are billed higher rates per kilowatt-hour based on their monthly energy usage. Each utility company uses a slightly different rate for each tier and has either four or five rate tiers in total.[4] This type of rate structure encourages customers to implement energy efficiency measures in order to keep their energy rate in a lower tier. It benefits low-income customers because energy usage is tied to income so those who pay the lowest rates also tend to have the lowest income. Conversely, those who use the most energy and pay the highest rates tend to have the highest incomes (Polo, 2012).

However, this rate structure is not beneficial to net-metering customers. Since net-metering causes the meter to run backwards, excess generation causes energy usage to fall and customers may drop into a lower rate tier. This means that while they will pay a lower rate to purchase energy, they also receive a lower rate for excess energy generation, thus reducing the financial incentive of the program (Polo, 2012). The underlying rate structure in California creates a disincentive for net-metering customers, particularly when energy is credited at the retail rate.

California's energy rate structure does not incentivize customers to respond to market fluctuations in the price of wholesale energy and adjust their behavior accordingly because retail rates are flat within each tier. While the tiers provide an incentive to reduce their monthly energy usage, it does not encourage customers to use less energy during peak hours. Ideally, a pricing method that reflects the marginal cost of energy, such as time-of-use pricing, would provide such an incentive. However, recent research has found that customer responses to fluctuations in retail energy rates are very small at best and nonexistent at worst (Quantifying the Impacts, 2013). Electricity demand is fairly inelastic and customers may be either unwilling or unable to significantly alter their behavior to reduce energy usage. One study found that marginal pricing may be less effective at altering energy usage because consumers respond to average prices rather than marginal prices (Ito, 2014).

This has important implications for net-metering customers because the retail energy rate structure has a significant impact on investing in a PV system. Pricing retail energy based on its marginal cost may make the most economic sense, but it may not encourage the desired behavioral change in energy use.

[4] Pacific Gas and Electric and San Diego Gas and Electric have four energy tiers, while Southern California Edison has five tiers.

4. Literature Review

Central to the discussion on pricing excess energy in net-metering is the question of what it is worth to utilities as an energy source. To date, there have been over two dozen analyses of the costs and benefits of net-metering in the United States. The vast majority of these studies were conducted by utility companies or state utility commissions, yet a few were completed by independent groups. Each of these studies provides some insight into the value net-metering provides to utility companies and customers.

The methodology implemented for these studies varies widely, as the cost and benefits included in each analysis differs as well as the perspective of each study. Some completed the study from the perspective of the utility company, while others took a ratepayer perspective. None of the studies thus far have included a comprehensive societal perspective that examines all of the impacts of net-metering, such as impacts to the environment and local economy (Evaluation of Net-metering, 2013). For this reason, the results from these studies cannot be considered a fulsome accounting of all the costs and benefits associated with net-metering. Rather, they offer an initial glimpse at some of the effects of distributed solar generation on key features of the utility business.

4.1. Distributional Effects

Concern that net-metering shifts costs from customer-generators to non-participating customers is an often cited criticism of the program. The CPUC attempted to address the issue of distributional effects in their net-metering program on utility customers in a study they commissioned from E3, a private consulting firm. The study found that the current net-metering program resulted in a total cost to ratepayers of $20 million per year in 2008. They estimated that this cost would rise to $137 million in 2017 when the full capacity of the program, 2,550 megawatts, is reached (Beach, 2013).

A follow-up analysis of the California study was conducted by researchers at the University of California, Berkeley Center of Law, Energy, and the Environment. They found that the California study likely overstates the cost of net-metering because it did not take into account some of the benefits of the program, such as the benefit of reduced demand for energy from customer-generators. It also estimates avoided costs by assuming the next-best alternative energy source would be natural gas, which is very inexpensive. However, estimating avoided costs based on natural gas may skew the results since it may be more appropriate to compare net-metering to another source of renewable energy. Because of California's renewable portfolio standard, utilities will still have to purchase energy from utility-scale renewable sources if they are not to receive it from net-metering. A utility-scale renewable source is a more accurate estimation for the next-best alternative energy source (Weissman, 2012)

They also put the estimated cost from the California study into perspective by calculating the cost per kilowatt-hour to customers. The impact of net-metering in 2008, where the cost to customers was a total of $20 million, resulted in an increase of just $0.0001 per kWh to energy rates. The impact of the program in 2017 where the projected cost increases to $137 million, will result in an additional $0.00064 per kWH to energy rates (Weissman, 2012).

Their analysis also demonstrated that the cost of net-metering is relatively small compared to other demand-side management programs. The $20 million cost amounts to just 0.08% of the average utility customer's bill. The cost of all demand-side management programs is about 7% of a customer's bill. The study concluded that the total cost of net metering was very modest, especially when compared to costs from other demand-side programs. They also noted that these costs are borne not just by non-participating customers, but by customer-generators as well since they are built into the regular energy rates (Weissman, 2012).

The California Solar Energy Industry Association also did an analysis of the CPUC study. They found the benefits of net-metering to range from $0.05 to $0.12 per kWH, depending on the location of the customers. A national study of net metering estimated the benefits to be as high as $0.14 per kWh (Weissman, 2012).

The Vote Solar Initiative commissioned a study by Crossborder Energy also in response to the CPUC study (Beach, 2013). They found that net-metering does not impose a cost on customers, but instead will provide a small benefit of $2.1 million per year when the cap of 2,550 megawatts is reached in 2017. They found net-metering to present a net benefit to all commercial customers and most residential customers, with the exception of those in the utility territory of Pacific Gas and Electric.[5] The benefit for residential customers is small, ranging from $0.007 to $0.028 per kWh depending on the customer's utility territory. For commercial customers, net-metering presents a greater benefit, ranging from $0.063 to $0.112 kWh. This study found that commercial retail rates are a more accurate representation of the utility's actual cost of providing service than residential retail rates (Beach, 2013)

4.2. Willingness to Pay for Clean Energy

A number of polls conducted over the last several decades have revealed a willingness to pay among the public for renewable energy over conventional energy sources. One survey of more than 700 national polls revealed that about 40% to 70% of Americans would be willing to pay more in their energy bill for renewable energy. (Farhar,1996). A more recent national survey found that Americans are willing to pay as much as $162 more in their electricity bills per year.[6] This represents an increase of about 13% of the average utility bill. The premise for this survey was based on a plan by the Federal government in 2011 to implement a National Clean Energy Standard that would require 80% clean energy by 2035. This plan would actually only increase annual energy bills by $48 or $59 per year, depending on whether the House or Senate version of the legislation is adopted. This study demonstrated the degree to which Americans are willing to pay for clean energy even when the actual costs are not as great (Aldy, 2012).

[5] Pacific Gas and Electric, one of California's largest utility companies, charges higher rates for the upper tiers and has a lower avoided cost rate. This results in a cost of $0.013 per kWh for their residential customers (Beach, 2013).

[6] Based on a 95% confidence interval.

Some utilities have attempted to capitalize on this sentiment by implementing green pricing programs, where customers voluntarily pay more to purchase their energy from renewables instead of conventional energy sources. However, market research surveys revealed that while about 10% of respondents said they would be willing to participate in a green pricing scheme, only about 1% of customers actually signed up for such programs. This discrepancy may be due in part to limitations of the survey or errors from response bias. Nevertheless, it demonstrates that voluntary programs to encourage investment in renewable energy will be received with little success despite a demonstrated willingness by the public to pay more for renewable energy. (Farhar, 1996).

4.3. Types of Support Mechanisms

Support mechanisms for renewable energy production can be placed into one of two categories: investment-based mechanisms, such as tax credits and rebate programs, or production-based mechanisms, such as net-metering and feed-in tariffs. This is an important distinction because the manner in which support for renewable energy is administered can significantly affect the success of the program. (Talavera, 2005).

Rebates and tax incentives can provide significant support to an industry in the early stages of its development. However, they are also funded through public taxes and are typically temporary. They're temporary nature lacks the stability that is necessary to encourage investment in a young industry.

Production-based incentives such as net-metering provide investors with a constant stream of revenue. In addition, these incentives are supported through the utility rather than through public funds. These features make production-based incentives more appealing to lawmakers, customers, and potential participants in the program (Stoutenborough, 2008).

The optimal arrangement is one where support for renewable energy occurs during the production phase of the process. This type of support mechanism encourages efficiency and puts the focus on designing an optimal system for renewable generation. In addition, a well-designed buy-back scheme leaves no need for additional subsidies from the utility company or government (Nowak, 1998).

5. Policy Problem

My policy problem is that the current buy-back mechanism and rate do not provide a strong incentive to encourage investment in renewable energy. Net-metering has existed for many years as a simple and easy policy to promote small-scale renewable energy development. However it does not take into account the costs or benefits associated with such a program, resulting in a buy-back rate that undervalues solar energy and fails to incentivize participation in the program. The California Public Utilities Commission is struggling to determine how excess energy should be priced in their net-metering program while continuing to encourage growth of distributed solar energy generation. A modified policy for pricing excess energy is needed to maintain an effective net-metering program in California.

While efforts have been made in many areas of the US to decrease consumption through energy efficiency programs and increase the amount of renewable energy capacity, more action is needed in order to make a significant impact on emissions from the electricity sector. Net-metering is one of a handful of policies that can promote adoption of renewable energy to reduce greenhouse-gas emissions. Since the buy-back rate affects the degree to which net-metering programs expand, this policy will impact the amount of renewable energy penetration in the market, thus reducing greenhouse gas emissions.

The primary stakeholders associated with this issue are utility customers, both those participating in the net-metering program and those who are not participating in the program, utility companies, and the state utility commission. All utility customers, regardless of whether or not they participate in net-metering, will be impacted by any effect this policy may have on utility rates in both the short and long-term. Net-metering customers will be directly impacted by this policy as their ability to recoup their investment in a photovoltaic system is determined in part by the buy-back rate. Utility companies must consider a number of factors when planning for how they will meet expected demand and setting retail energy rates. Thus, their business plans and long-term energy purchase needs are affected. An increase in renewable energy sources offsets the need to purchase from other sources, which are most likely to be traditional greenhouse gas-intensive sources such as coal and natural gas. The State Utility Commission is responsible for regulating the energy industry in California and setting energy rates. They are also responsible for determining the buy-back rate for net-metering, so the implementation of this policy falls into their hands.

The secondary stakeholders associated with net-metering are society as a whole. The electricity sector accounted for a third of greenhouse-gas emissions in 2011 in the United States, contributing significantly to climate change. Electricity based emissions increased by 35% from 1990 to 2010 because of increased consumption of electricity in homes and businesses (Draft Inventory, 2014). Net-metering has the potential to create significant growth in the proportion of energy that is derived from renewable sources while reducing the proportion of energy that is derived from conventional and fossil fuel-based sources. Society will benefit from increases in solar energy capacity developed through net-metering as it replaces the need for further energy from fossil fuel based sources.

In the following chapters, I review alternative methods of pricing the energy exported from solar net-metering by analyzing similar policies in three other jurisdictions. These case studies offer examples of alternative pricing mechanisms that can further incentivize investment in PV systems through net-metering.

6. Methodology

The purpose of this study is to evaluate pricing policies of renewable energy buy-back programs to determine an appropriate pricing for energy exported in net-metering in California. My methodology consists of three case studies from jurisdictions where programs have been established to purchase renewable energy from distributed solar generation. These case studies provide a framework for analyzing the various features that contribute to a successful pricing policy for solar net-metering.

Case studies are the best available tool for evaluating the best alternative pricing policies for renewable energy buy-back programs. While valuable lessons can be drawn from the experiences of other jurisdictions, there are limitations to this analysis. Energy policy deals with numerous factors that vary based on location and time. The experiences of other jurisdictions may be influenced by factors that are different in California. In addition, information regarding customer energy usage and utility company costs are not available for third party research because it is considered private or proprietary information. This information would be valuable in evaluating the value of solar net-metering to society. Unfortunately, such analysis is not possible since this information is not shared beyond the CPUC.

6.1. Case Selection

While net-metering programs have been around since the enactment of PURPA in 1978, very few states have made significant changes to the policy. Those that have modified their programs have done so only in recent years in response to growing concerns about climate change and a desire to encourage growth of renewable energy sources. As a result, this leaves few States to which one can look for alternative policies within net-metering programs. In addition, most of the changes that have been made to net-metering policies have largely consisted of modifications to the structure of the program such as removing program caps and requiring rebates for remaining credits. Few states or regions have altered the rate at which excess generation is credited to customer-generators beyond the standard retail or avoided-cost rates (Database of State Incentives, 2013).

In selecting case studies, I examined jurisdictions that not only had successful solar buy-back programs, but also provided a buy-back price that encouraged investment in solar PV systems. There are other countries and states in which alternative prices have been implemented, but they were not selected because the rational upon which the price was set did not reflect the costs and/or benefits to stakeholders or the policy was not as successful as the cases selected for this study.

In the United States, the most innovative policy regarding pricing solar net-metering did not originate at the State level, but instead occurred in the city of Austin, Texas. Austin Energy, the city's municipally owned utility company, implemented a new pricing method in mid-2012 called the Value of Solar Tariff (VOST). Austin is presented as a case study because of this new approach. The VOST attempts to mitigate problems with the current pricing method and improve the pay-back period for customer-generations. Because of the recent enactment of this policy, there has not yet been enough evaluation to determine the effect it has had on investment in solar or retail energy prices over the long-term. However, the VOST is based on extensive research and models completed by Austin Energy and the consulting firm Clean Power Research (Rabago, 2013).

While net-metering programs are available in the vast majority of states in the U.S., there are relatively few in other developed nations. Of the half-dozen net-metering programs in Europe, Denmark's is by far the most successful (Energy Policies, 2011). Denmark's program contains many of the successful characteristics of net-metering programs, such as a lack of additional fees and program size cap. The country also has the highest retail energy rates in the developed world at $0.41 US per kWh and a relatively high buy-back rate for excess energy. The net-metering program was so successful after the tax rebate was implemented in January of 2012, the country reached its goal of installing 200 MW of solar capacity in just 8 months. Denmark was selected because of its great success in encouraging rapid growth of the program over a small period of time (International Energy Agency, 2013).

German's feed-in tariff was selected because, although it is not a net-metering program, it is considered one of the most successful renewable energy buy-back programs in the world and is largely credited with spurring the growth of the solar energy industry and causing PV prices to fall significantly in the last few years. There are several key differences between a feed-in tariff and net-metering that are important to note. Feed-in tariff programs provide a long-term contract to owners of renewable energy systems and the rate at which energy is purchased is guaranteed in the contract. Owners of these systems do not use the energy produced, but rather sell all of it to the utility company. While these are important distinctions between the two programs, there are also a number of lessons that can be learned from the success of feed-in tariffs. Feed-in tariffs have also historically been significantly more successful than net-metering in spurring investment in renewable energy. This is largely due to the fact that the tariff is much higher than the buy-back rate of net-metering because it is based on the cost of generating energy from renewables plus a return on the investment (Polo, 2012). The inclusion of Germany's feed-in tariff can shed light on the features of buy-back programs that will encourage continued growth of small-scale solar energy.

6.2. Analytical Criteria

The case studies examined in this study are net-metering programs in Denmark and Vermont, and the feed-in tariff in Germany. Each case study is selected and evaluated based on various criteria of the relevant renewable energy pricing policy. These characteristics are categorized based on the relevant stakeholders who are affected by these features of each policy. The table below outlines those criteria in each category and describes how they are measured in each case study.

Table 6.1. Analytical Criteria

	Characteristic	Measurement
Consumers	Ratio between the Retail Price for Energy and the Buy-back Rate for solar	What is the relationship between the price per kilowatt hour to purchase electricity from the utility and the price paid for solar generation that is exported to the utility?
	Billing Cycle	What is the period of time during which energy credits can be accrued?
	Residual Credits	What is done with credits that are left over at the end of the billing cycle?
	Individual PV System Size Cap	What is largest allowable size for an individual's PV system in the net-metering program?
Utility	Additional Fees	Are any additional fees charged to customers to support the renewable energy program?
	Program Cap	How many megawatts of net-metering capacity can be added within the program?

The criteria that are selected based on several studies that outline the most important characteristics necessary for a successful net-metering or feed-in tariff program. Faden (2001) outlines the importance of these characteristics for the optimal net-metering program. Mendonca (2009) and Lesser (2005) highlight each of these characteristics as necessary features for a successful and robust feed-in tariff program. These characteristics are featured in the literature because of their significance in contributing to a strong buy-back program that encourages investment in solar energy.

6.2.1. Consumers

The most important characteristics for net-metering customers are the various mechanisms of buy-back programs that affect the economic viability of their investment. Those include, the (1) ratio between the retail price to purchase energy and the price for which they are paid for excess energy generation, (2) the billing cycle over which credits are accumulated, (3) excess energy credits that remain at the end of the billing cycle, and (4) any additional fees levied by the utility company. All of these factors contribute to the economic incentive to install a PV system.

First, the retail price for energy and buy-back price are central to the structure of renewable energy buy-back programs. The financial return that customers will realize is based on the difference between the amount they owe on their energy bill and the value of the credits received for exported energy. The prices to buy and sell energy from the utility create certain incentives for customers when making decisions about how much energy to use and what size PV system to install. A relatively high price for energy encourages customers to install solar panels, but a low buy-back rate for excess energy can reverse that incentive. The relationship between these two prices is critical for understanding the success of renewable energy buy-back programs (Nowak, 1998).

It is also useful to note that the individual customer's energy use plays an important role in determining the economic pay-back of the PV system. Higher energy usage means that the customer will sell less energy from their system back to the utility and vice versa. Since individual energy usage cannot be addressed by this policy, it is not included as a criteria in selecting cases.

Second, the billing cycle, or the length of time during which energy credits can accrue, is an important component of the structure of net-metering programs for participating customers. An annual billing cycle is more beneficial to customers than monthly or hourly billing cycles because it provides more opportunity for them to use the credits that accrue. With shorter billing cycles, customers may end up paying for electricity in some cycles while receiving credits in others (Leepe, 2013). What is done with excess credits at the end of the billing cycle is also important to net-metering customers. Most net-metering programs allow customers to roll-over credits for a certain period of time, at the end of which they either expire without remuneration or can be redeemed for a cash rebate.

Third, the manner in which remaining credits are handled has a great impact on the economic benefit of the PV system to the customer. When credits can be accrued over each billing cycle, the customer-generator does not reap all of the immediate benefits produced by their PV system. If those credits expire without remuneration, then the customer-generator is not receiving the full value of the energy that they are providing to the grid (Faden, 2001). The issue of remaining credits is closely tied to that of the billing cycle, because the length of a billing cycle is less of a concern if remaining credits can be rolled-over indefinitely or credited with a cash rebate.

Fourth, individual system-size caps hinder the amount of solar capacity that is added within the program. They reduce the number of potential customers that can participate in net-metering because those who might be inclined to install systems larger than the cap allows are effectively shut out of the program. It unnecessarily limits the number and type of customer who can participate in the program and eventually reduces growth of the program (Leepe, 2013).

6.2.2. Utility

Regarding utilities, there are two criteria that should be taken into consideration: (1) additional fees applied to customer-generators and (2) caps on the total allowable capacity in the program.

First, additional fees levied by the utility, such as grid-connection fees, grid-maintenance fees, and standby charges present a hidden cost to customers that serve to reduce the financial benefit of buy-back programs. Renewable energy programs should ideally not contain any hidden additional costs such as special fees or taxes as they present a barrier to investing in renewable energy systems (Leepe, 2013).

Second, a feature of many renewable energy buy-back policies is a system-wide cap or cut-off of the total amount of energy capacity that can be to the program. These caps can be set as annual limits, total program limits, or a specific date at which additional capacity will not be allowed. The precise levels at which a cap may be placed may selected arbitrarily or based on a desired level of renewable energy capacity to be achieved. The motivation for such caps can be to limit the growth of a new program so that adjustments can be made before the program becomes much larger. As is often the case with renewable energy, the motivation can also be to prevent renewable energy from garnering a significant share of the energy market and thus replacing traditional forms of electricity generation (Mendonca, 2009).

The existence of program caps is not beneficial to buy-back programs in the long term. In the short-term, caps may encourage rapid investment in renewable energy systems just before the limit is reached (Leepe, 2013). This is a result of investors attempting to connect their system to the grid before the cap is met. In Spain, a cap on renewable energy in their feed-in tariff program caused rapid expansion of the system in a very short period of time. Once the cap has been met, the market will collapse. Such unreliability in a market is undesirable, especially for a market that is still relatively young and growing, such as renewable energy.

Caps also serve to impede the development and growth of mass markets for renewable energy. The purpose of buy-back schemes such as net-metering and feed-in tariffs is to encourage investment in renewable energy, reduce costs for renewable energy systems, and create economies of scale. Limiting the capacity of such programs hinders the creation of a healthy market when the goal should instead be to promote such systems (Mendonca, 2009).

6.3. Secondary Methodology

The most successful features of each case are the substantial rates at which energy is purchased from customer-generators. These rates make net-metering an attractive option, particularly when considered against the retail rate for energy. Attractive financing is one of the key factors in determining economic feasibility of solar investments (Faden, 2001). The buy-back rate is the most important feature of a generation-based incentive to support the growth of distributed solar. It must offer an attractive price for exported energy in order to encourage investment in distributed solar.

The billing cycle directly impacts how energy credits and purchases are settled. Longer billing periods provide more opportunity for solar generation to offset energy purchases, thus benefitting net-metering customers. Short billing periods, such as hourly billing, can significantly reduce the economic benefit of excess generation. Denmark's move to reduce its billing cycle from monthly to hourly demonstrated the effectiveness of this feature in reducing the financial gain for customer-generators. For FITs, the PV owner does not pay for energy in the same system in which it is paid for solar generation, so there is no billing cycle to consider (Mendonca, 2009).

Excess generation credits that remain at the end of the year is another feature of net-metering that contributes to the overall economic feasibility for customer-generators.

When excess credits expire, the customer-generator loses any means of compensation for the energy produced to earn those credits. While the impact on the final bill depends on the customer's overall energy use and production, it can chip away at the financial incentive provided in the program. In addition, the risk of losing credits for excess generation encourages customer-generators to install smaller systems than they might otherwise. They will size their system in order to avoid producing more energy than they use over the course of a year (Faden, 2001).

Retail electricity prices may affect the success of generation-based incentives based both on the price level and on their relationship to the buy-back rate. Low electricity rates don't encourage customers to seek methods to reduce or offset their energy bill through programs such as net-metering. High electricity prices have the opposite effect. The relationship between the retail price and buy-back price is also key. A buy-back price that is on par with the retail price of electricity does little to incentivize investment in distributed renewables. However, the greater the buy-back price in relation to the retail price, the great the incentive to reduce one's energy bill through net-metering (Faden, 2001). California's tiered energy rate system reduces the economic incentive for net-metering customers. As excess generation is sent to the grid and the meter runs backwards, it also reduces the customer's net energy usage. In a tiered rate system, this may put the customer-generator in a lower tier than they would otherwise be based on their energy usage. While it reduces the price they pay for energy purchased from the utility, it also reduces the price of the credit they receive for excess generation.

The lack of a limit to the amount of capacity that may be installed through these buy-back programs contributes to their success. Without a limit to the amount of capacity that can be generated through these programs, there is no incentive for investors in renewable energy to be cautious. Investors can move forward with planned installations without having to worry that the limit will be met before their system can be connected to the grid. (Mendonca, 2009).

Additional fees for grid access or participation in net-metering reduces the financial benefit to customer-generators. For net-metering customers, such fees can present a large reduction in the revenue provided from excess solar generation. In a feed-in tariff system, such flat fees make up a much smaller portion of revenue from the PV system and thus have a minimal effect on the economic incentive of the program (Mendonca, 2009). While California does not currently charge additional fees to net-metering customers, it is an option which is frequently proposed to the utility commission.

The US Interstate Renewable Energy Council, Inc. has established a list of best practices that should be applied to net-metering programs. These best practices confirm the importance of the above criteria for evaluating each case study (Database of State Incentives, 2013). IREC recommends the following:

- All excess energy generation should be credited without expiration
- No limit to individual system size
- No limit to program capacity
- Net-metering customers should not be charged any fees that would not also apply to non-participating customers

The retail electricity and buy-back rates are the most important features of a successful generation-based incentive program. They play a substantial role when potential customers investigate the cost-effectiveness of net-metering and are the most influential factors in spurring renewable energy development. They are the focus of the policy options considered here.

Billing cycle, remaining credits, and additional fees all also impact the economics of net-metering, but to a lesser degree. While they are important, they are considered within the scope of program features that may be implemented within all of the policy options. Program and individual system size caps are addressed in the same manner as they reduce long-term incentives to invest in distributed solar.

7. Case Studies

The following three case studies demonstrate the range of policy options that are available to modify buy-back rates for net-metering in order to encourage increased investment in distributed solar generation.

7.1. Germany

Germany has become famous for its feed-in tariff (FIT) program and the booming solar industry that resulted from the policy. Instituted in 1991, their FIT actively encourages residential solar installations by offering very attractive prices and long-term contracts for the energy they produce. It is based on the desired level of market penetration for solar panels and the costs that must be recouped by those who elect to install such systems (Mabee, 2011).

Feed-in tariffs differ from net-metering in that they are designed to actively encourage the proliferation of renewable energy (including wind, biothermal, and small hydropower). The price that can be offered in an FIT will be high when the desired level of market penetration has not been met. Conversely, the price is lowered when the desired level is close to being met. The target range for solar in Germany is 2.5 to 3.5 gigawatts of energy capacity each year (Trends, 2013).

While FITs may have a different payment structure from net-metering, it can offer useful insights when considering modifications to net-metering. Both programs are essentially different methods of purchasing energy from small-scale distributed generation by renewable sources. They are also both generation-based incentives intended to encourage investment in renewable energy. The pricing method for FITs offers an alternative method to the standard buy-back scheme of net-metering.

Germany sets far-reaching goals for renewable generation from FITs. By 2020, the Germany aims to procure at least 35% of the nation's energy from renewables and that rises to 80% renewables by 2050. Since the policy was first instituted in 1990, solar's portion of the overall energy portfolio has doubled about every 1.5 years. In 2012, solar made up 4.7% of the nation's energy consumption (Ullrich, 2013).

The policy has been credited with encouraging innovation in solar production and bringing down the cost of panels. The FIT forces renewables to compete with each other instead of conventional energy sources. This has produced an industry with many suppliers who must compete with each other for customers. As the market in Germany matured, prices for solar panels dropped considerably. From 2007 to 2012, the price of a PV system in German fell by more than half to just $3.42 per kilowat[7] (Maehlum, 2012). The proliferation of the solar market in German has been so pronounced that it is now home to about a third of the world's PV capacity.

The success of German's FIT is due to the structure of the policy that enables it, the Renewable Energy Act (EEG). This act required that renewable energy have priority on the grid. This forces utilities to purchase power from renewable sources before moving on to other conventional forms of generation. Like net-metering, these systems are guaranteed access to the grid, ensuring that owners will be able to sell the power they produce (Nowak, 1998).

In addition, contracts to purchase power from these installations are usually 20 years long, which is the expected lifetime of a PV installation. The contracts have also been designed to be easy to understand, so that the average person can negotiate the contract with the utilities without the need for a lawyer. These features of the FIT provide substantial security to investors, making it easier for them to pursue in such projects. In contrast, net-metering programs do not offer long-term contracts to purchase power at a set price, making the investment somewhat uncertain (Nowak, 1998).

[7] For comparison, the cost of installing a PV system in California was $6.56 per kilowatt (Maehlum, 2012).

7.1.1. Consumer

First, the tariff is set to ensure that compensation to owners of PV installations is enough to provide a return on their investment. It is calculated with a simple formula. The cost of the energy system is first divided by the number of kilowatt-hours that it is expected to generate over its service life (usually 20 years). Added to that is the return on investment (ROI) that is desired, which is five to seven percent in Germany. The resulting number is the tariff, or amount paid for energy exported by the independent power provider. This creates different tariffs for different sized systems and different types of energy generation (e.g.: solar, wind, hydro, or biomass). Small systems distributed throughout residential areas will produce power at a more expensive rate than large-scale solar fields (Mabee, 2011).

Retail price for electricity in Germany is equivalent to $0.35 US per kWh.[8] While the wholesale price of solar energy as dropped precipitously, the FIT has resulted in a higher retail rate for energy. This is in part due to the growth of renewable energy as a percentage of the nation's energy portfolio. However, it is also due to the exemption of energy intensive industries from paying the surcharge. This has forced consumers to bear the costs of the surcharge, making the rate higher for them than it otherwise would if all industries were forced to pay it. Consumers in Germany now pay more for their electricity than all other European Union members except Cyprus and Denmark (Wacket, 2013). Nevertheless, the ratio between the retail price for energy and the buy-back price is among the highest of any support schemes. The ratio ranges from 5 to 6, depending on tariff rate that year.

Second, in a FIT scheme, the billing cycle of the generator is irrelevant because the energy produced by their PV system is not tied to their energy use. FIT participants operate as small-scale energy producers, so they receive payments for the energy they produce rather than a credit (Lipp, 2007).

[8] The retail price of energy in Germany was 0.25 Euro in 2012. Using the conversion rate of 1.38 US dollars to the Euro on January 29, 2015, this translates into $0.35 US.

Third, because of the PV owners in a FIT scheme operate as power producers, they cannot accrue additional energy credits. All energy that is produced is exported to the grid and the owner receives a payment for that energy. Therefore, PV owners receive full payment for the energy produced by their system (Lipp, 2007).

Fourth, Germany limits the allowable size of individual PV systems that qualify for the FIT program to 10 megawatts in capacity (Trends, 2013).

7.1.2. Utility

The additional cost associated with FIT's is passed on to consumers in the form of a surcharge. In 2012, the surcharge was about 3.6 cents U.S. per kilowatt-hour (or ten euro's per month) for the average household in Germany. The surcharge rose to 5.3 cents per kilowatt hour in 2013 and is expected to continue rising. The surcharge is calculated by subtracting the market price for conventional energy sources from the guaranteed prices paid for renewable energy (Wirth, 2014).

Germany does not place annual limits to the program, but instead has an annual goal of 2.5 to 3.5 GW of solar capacity added each year. As additional capacity is added to the program each year and the goal is closer to being met, the tariff gradually falls (Ullrich, 2013). This has the effect of keeping the increase in solar capacity each year to the desired goal range.

7.2. Denmark

Denmark has a long history of consensus-based policy making, which has contributed to a relatively stable political environment. The government has committed to reducing the nation's use of fossil fuels and greenhouse gas emissions through several long-term plans. In 2011, the Energy Strategy 2050 was issued, outlining Denmark's goal to be 100% independent of the use of fossil fuels by 2050. This marked the start of an ambitious plan that involves extending existing policies to create a sustainable and affordable energy market (Sovacool, 2013).

Prior to issuing Energy Strategy 2050, an Independent Commission on Climate Change Policy was established to identify long-term policies that would be necessary to achieve the goals of the government. The Commission also conducted an analysis of the costs and benefits associated with the policies and determined that it would require more initial investment in order to lower energy costs in the future (Energy Policies, 2011).

Denmark sees itself as an influential leader regarding sustainable energy policy both within Europe and around the world. In designing policy and setting goals, they often take into consideration the influence it might have in driving similar change in other countries. It is one of the few nations that is on track to meet its Kyoto protocol obligations. The country benefits from such a strong drive to innovate, as it now exports many of the technological developments that have resulted from their efforts. For example, Denmark supplies approximately one third of the world market for wind turbines. About 10% of the goods exported from Denmark in 2010 were in energy technology and equipment (Energy Policies, 2011).

Net-metering or small-scale solar PV was first enacted in Denmark in 1998 as a four-year long pilot project. The program operated as most net-metering programs, offering a credit for exported energy at the same price as the retail rate. The program also did not offer any rebate for credits left over at the end of the one-year billing cycle. Net-metering was extended for another four years after the pilot program came to a close in 2002 (Trends, 2013).

Denmark's net-metering program experienced modest growth during the first ten years, adding several thousand kW's of installed capacity each year. In 2000, 1,255 kW of grid-connected solar power was installed under the program, growing steadily each year to reach 2,825 kW in 2008. Beginning in 2009, the amount of solar capacity installed each year grew more quickly, with 4,025 kW installed that year, 6.375 kW in 2010, and 15,875 kW in 2011. Much of this rapid growth was due to the falling prices for solar panels during that time period combined with increasing retail energy prices from higher taxes (Trends, 2013).

Denmark has not utilized feed-in-tariffs to encourage proliferation of solar energy. It wasn't until 2009 that the country established a feed-in-tariff option. The program was designed mainly to encourage growth in land-based and off-shore wind energy, so it has led to very little growth in the solar industry. Much of the growth in solar energy in recent years is instead due to the net-metering program (Energy Policies, 2011).

7.2.1. Customer

First, at $0.41 US for a kW of electricity, Denmark has the highest retail electricity rate in the world. Well over half of the price of residential electricity rates comes from taxes, duties, and a value-added tax. Electricity generation makes up 24% of the retail rate, grid tariffs are 13%, taxes and duties are 43%, and value-added tax is 20%. Only 27% of the price paid to purchase energy actually goes to the utilities. These taxes are levied to support policy programs to encourage clean energy research and development, particularly wind energy and distributed generation (Trends, 2013). Because energy prices are so high, the tax exemption for net-metering customers incentivizes energy exports from solar panels and encourages them to curb their energy usage. A high price for electricity, combined with the tax break for exported energy, makes net-metering a very attractive option.

In 2012, Denmark updated their net-metering law, leading to an unprecedented jump in installed grid-connected solar capacity. In less than a year, 315 MW was added to the grid as a result of a new pricing scheme for net-metering customers (Trends, 2013). The new law exempts net-metering customers from paying the tariffs, duties, and value-added tax, normally incorporated into the price of electricity, for the amount of energy that is exported to the utility. However, participating customers still pay the taxes and duties when purchasing energy from the utility company. This amounts to a financial incentive equal to the amount of tax, which is $0.24 US per kWh. The ratio between the retail rate and buy-back rate is 1.56.

Second, Denmark modified its billing period from one month to hourly in 2012. After the tax break was enacted at the start of 2012, the policy was so successful that it had to be modified in November of that year. To curb the rapid growth, they added a provision where the billing cycle for net-metering would change from 1 year to 1 hour. This had the effect of mitigated the financial benefits one could realize from solar net-metering (Trends, 2013).

Third, Denmark does not have credits that remain at the end of each billing cycle. All excess generation is credited fully in each bill. Fourth, Denmark limits the size of individual PV systems to 6 kW (Trends, 2013).

7.2.2. Utility

First, Dansk Energi, the national federation of utilities, announced in 2010 that they would not charge customer-generators a separate fee for interconnecting PV systems or use of the grid. There are also no additional incentives or support mechanisms, such as subsidies, for net-metered solar systems. (Trends, 2013)

Second, Denmark does not have an overall program limit for installed capacity from net-metering. However, Denmark did set a goal of reaching 200 MW of installed distributed solar generation by 2020, but quickly reached and surpassed that goal in less than a year as a result of the new policy.

7.3. Austin

The information for the case of Austin is coming from Rabago (2013). In October of 2012, the City of Austin implemented a new buy-back method called the Value of Solar Tariff (VOST) for residential customers.[9] The impetus for designing this new method was based on a conclusion by Austin Energy, the city-owned utility, that the standard net-metering buy-back scheme didn't provide sufficient incentive to address the capital costs of solar PV, nor did it accurately reflect the value of distributed solar generation to the utility. The Tariff is designed to reflect the real value of distributed solar generation while also ensuring that the utility company and non-participating customers are not negatively affected by the program. It represents a more accurate

[9] A program for commercial customers is currently in the works

method of calculating the avoided cost of solar net-metering than the standard arrangement. Austin has more than 420,000 utility customers, only 1,500 of which participate in solar net-metering representing just 0.4% of all customers.

The VOST is designed to meet a number of goals to satisfy customer-generators, utility companies, and non-participating customers. For customer-generators, the tariff is designed to reduce up-front costs of purchasing and installing a PV system as well as ensure that net-metering is cost-effective. While Austin energy currently offers a one-time rebate to help offset the cost of investing in solar, the rebate is temporary and falls as installed solar capacity increases. The VOST attempts to move away from temporary rebate programs to a production-based incentive. For utility customers, the tariff is intended to ensure that their transmission and distribution costs continue to be supported through the rate structure. For non-participating customers, the Tariff is designed to ensure that there are no distributional effects from the cost of net-metering.

The long-term goal of this method is to reach “value parity” between distributed solar energy and conventional energy generation. This is an important distinction because the traditional goal of grid parity is based instead on the levelized cost parity between distributed solar and conventional energy. Comparing solar energy against conventional energy on the basis of their value to society, rather than actual cost, results in a smaller disparity between each energy source.

The VOST was also intended to solve two unintended consequences of solar energy. The first is that customer-generators select the size of their PV system based on their base load energy consumption. When net-metering offers a credit at the avoided cost or retail rate for excess generation, there is little incentive for customer-generators to produce more energy than they expect to use. Therefore, they select the size of their system to closely match the amount of energy they will use to the amount of energy the system will produce. Should the customer-generator select a PV system that produces more energy than they use, the system is likely to export excess generation to the utility during mid-day when energy is the most valuable. However, the customer-generator will not receive compensation for that energy that reflects its value at the time it is produced.

The second unintended consequence occurs because the standard meter structure, where one meter is used and it rolls backwards when energy is exported to the grid, can effect consumption habits of customer-generators. Since the PV system offsets energy consumption, customers may view that energy they use as "free" and be less inclined to engage in efficiency measures.

7.3.1. Consumer

The methodology for valuing distributed solar generation and setting a buy-back rate was developed by Austin Energy and Clean Energy Research, an alternative energy consulting firm. Together, they created a "utility value calculator" that takes into account the value and benefits associated with solar net-metering.[10] The following components are included in the "utility value calculator":

- Loss savings; This component measures the benefit of reducing system losses because distributed solar generation produces energy close to the points where it is used.
- Transmission and Distribution Capacity savings; This measures the benefit of reducing peak load on the grid because solar energy is produced during peak times and reduces the need to invest in transmission and distribution infrastructure to meet peak demand.
- Energy Savings; This measure the benefit of wholesale energy purchases that are offset by energy from distributed solar.
- Generation Capacity Savings; This measures the benefit of the additional capacity added to the grid by distributed solar.
- Fuel Price Hedge Value; This measures the benefit of reducing uncertainty in fuel prices as solar energy has much less price uncertainty than natural gas.
- Environmental Benefits: This measures the "incremental cost of offsetting a unit of conventional generation". (Rabago, 2013).

Estimating values for each of these components can be quite complicated. Measurements for each component on the calculator were derived from previously published methodologies. The calculator is also updated annually to reflect the most recent data and methodologies. The calculator does not measure the marginal cost of

[10] To estimate the costs and benefits, a PV reference case was used, assuming a south facing panel with a 30-degree tilt and 95.5% inverter efficiency.

solar energy, but instead adds the value of the output of PV to the value of loss savings which is then multiplied by the marginal cost of energy.

There are a number of challenges associated with this calculation that made such studies too difficult and costly to complete in the past. They include; estimating solar generation where solar ground measurements are unavailable; estimating marginal line loss savings; fuel price forecasts; and estimating the effective capacity of PV systems. The model is based on a utility and ratepayer perspective rather than a societal perspective. Because of this, the model fails to include the value of solar net-metering's impact to the economy, environment, and market price for energy.[11]

First, the resulting Value of Solar for a typical customer was 12.8 cents per kWh in 2011 this rate was recently updated as of January 1st, 2014 to 10.7 cents per kWh. This method results in annual bill savings of $701 for the customer-generator and a simple payback period of approximately 9 years.[12] Because energy prices and solar generation are positively correlated (solar panels produce the most energy when energy prices are at their peak), a solar premium results in a value for solar that is considerably higher than the average energy rate. The ratio between retail energy rates and the buy-back rate ranges from 0.94 to 5.94, depending on the retail rate.

Austin Energy uses a tiered electricity rate structure with five separate tiers for residential customers and separate rates for the winter and summer months. The tiered prices range from 1.8 cents to 9.6 cents per kWh in the winter and 3.3 cents to 11.4 cents per kWh in the summer. Utility bills for Austin Energy customers are among the lowest in the State of Texas and fall below the average for the nation.

[11] Recent studies were conducted by Clean Energy Research in Pennsylvania and New Jersey where these impacts were included. The value of solar in those two studies ranged from 25 cents to 32 cents. The difference in value between these states and that of Austin, TX is due to considerably higher electricity prices in those states and the inclusion of all societal impacts into the analysis (Liffman, 2012).

[12] This model can also be used to modify rebates in order to reach a specified payback period. However, it should be noted that the VOST is not intended to be an incentive for solar net-metering.

Second, Austin Energy also changed the way in which customer-generators are billed. They receive a bill for the electricity that is purchased from the utility just as all other customers do at the end of every month. They are then sent a credit for all energy that is exported to the grid. Any credits that remain at the end of the year will expire without compensation. This new billing process allows customer-generators to receive a credit for excess generation that exceeds the avoided cost rate. It also achieves one of the program goals by forcing customer-generators to continue paying their normal energy bill, reducing the perception that this energy is "free" because it is offset by solar energy. However, two separate meters must be installed in order to complete the billing process in this manner. While this will bring additional costs to implementing the new billing method, it is necessary in order to implement the Value of Solar Tariff.

This billing method also allows the utility company to continue receiving payment for the full cost of providing energy to the customer because the regular energy bill continues to be paid while credits are provided separately. In theory, this prevents the loss of any revenue from solar net-metering to the utility company. In addition, there should be no distributional effects on other customers from the program because the utility is paying for solar energy at a rate that reflects its actual value.

Third, Austin Energy rolls over any credits remaining at the end of the month to the next billing cycle. However, all credits that remain at the end of the year expire without remuneration.

Fourth, Austin Energy limits the size of individual PV systems to 20 kW.

7.3.2. Utility

First, Austin Energy does not levy separate fees to customer-generators for the costs associated with transmission and distribution of excess generation. All transmission and distribution costs are incorporated into the retail price for energy that is charged to all customers. However, the utility does charge a $10 Customer Charge to cover the costs of administrative services such as billing, metering, and customer service. They also levy a Regulatory Charge of 0.794 cents per kWh to cover maintenance and investment in the transmission grid.

Second, the VOST pricing method is available to all net-metering customers with systems that have a capacity of 20 kW or less.[13] Austin Energy does not have an overall program cap, but plans to re-evaluate the program once a capacity level of 1% of the utility's load is met.

7.4. Case Study Analysis

Each of these case studies takes a different approach pricing energy that is exported from small-scale solar energy installations. While each policy achieves varying degrees of success, they all present alternative methods for valuing excess energy generation. The table below outlines the various characteristics of each case study.

Table 2: Case Study Characteristics

Table 7.1. Case Study Characteristics

		Case Studies		
	Characteristic	Germany	Denmark	Austin, TX
Consumer	Ratio between the Retail Price for Energy and the Buy-back Rate for solar	5 to 6	1.59	0.94 to 5.94
	Billing Cycle	NA	Hourly	Monthly
	Residual Credits	NA	NA	$0 after 12 months
	Individual PV system size cap	10 MW	6 kW	20 kW
Utility	Additional Fees	$3.42 per kWh charged to all customers	Not Allowed	Not Allowed
	Program Cap	Annual goal of 2.5 to 3.5 GW of solar added each year	No cap, but goal of 200 MW of solar capacity has been met	No Cap

[13] Systems larger than 20 kW must comply with the previous pricing method which credits energy at the avoided cost rate.

The most important and varied characteristic of the three cases is the ratio between the retail price for energy and the price paid for energy that is exported to the utility. While each case provides a ratio of approximately 1 or above, they each reach this ratio in different ways.

Germany's method of calculating the FIT ensures a standard return on investment, which provides sufficient incentive for the customer while keeping the program costs in check. Most importantly, the ratio between retail rates and the tariff is the highest of each case. The retail price for electricity is extremely high in both Germany and Denmark, where the prices per kWh are $0.35 and $0.41 US respectively. These are two of the highest energy prices in the world. Denmark's tax exemption proved to be very effective at spurring growth of the solar industry, but was almost too generous. The program surpassed its 8-year goal in less than one year because net-metering customers could make a significant return on their investment. The retail price to buy-back price ratio in Denmark was not exceptionally high, demonstrating the importance of high retail energy rates in addition to their relationship to the buy-back rate. Austin's energy prices are among the lowest in the United States. While high energy prices encourage customers to find a way to reduce their energy bill, the relationship between the retail price of energy and the buy-back rate also affects the incentive to adopt net-metering. In the case of Austin, the high retail rate to buy-back rate ratio is the most important characteristic for incentivizing solar investment.

These case studies demonstrate that it is essential to set a price that makes the program attractive enough to encourage adoption of solar PV systems, but not so vigorous as to make its growth untenable. With the average energy in the United States at $0.12 per kWh, it may be difficult to convince California residents to support such a high energy price. Much of the goal of the CPUC is to ensure that rates remain low and affordable for all residents, including the poorest. Tripling or quadrupling energy rates to encourage net-metering may not be palatable.

The billing period during which credits can be accrued is an important characteristic in the two net-metering cases. Denmark's move to meter hourly rather than monthly essentially eliminated any residual credit that one might accrue. This change was made in order to slow the expansion of their net-metering program, indicating that the rebate for remaining credits may have contributed to the rapid growth during the course of 2012. Austin Energy bills on a monthly cycle which provides customers with an ample period during which energy purchases and excess generation can be balanced. Unfortunately, credits that remain at the end of the year expire without remuneration, reducing the incentive to produce more energy than one uses. All of the energy generated under Germany's FIT is purchased by the utility, providing the maximum incentive to export as much energy as the system will allow. Germany's guarantee that all generation will be purchased provides the strongest incentive for customers to produce as much energy as possible and doesn't create an incentive to limit the size of their PV system.

All three cases set a limit to the size of individual PV systems. It should be noted, however, that the size limit for Germany is significantly larger than Denmark and Austin's caps. Considering how much more success Germany has had in accelerating the adoption of distributed solar, this characteristic is an important factor in contributing to the growth of net-metering. While individual system size limits may not be detrimental to the program, eliminating system size caps for will encourage more customers to participate in the program.

Germany is the only case presented here that levies a fee to pay for renewable energy generation programs. This fee is charged to all utility customers, making it a fairer method than charging only some customers additional fees to support the growth of renewable energy capacity. Neither Denmark nor Austin levies any additional fees, demonstrating that it may not be necessary to do so in order to finance renewables. While renewable energy is more expensive than conventional forms, an equal rise in electricity rates, either through a rate increase or separate fee, ensures that all customers shoulder the same burden.

None of the case studies set a limit to the amount of energy capacity that can be added to their respective programs, yet both Germany and Denmark set goals for additional capacity. Germany sets annual targets, and as those targets are reached, the incentives for FIT's are reduced. Denmark's goal was quickly surpassed because of the generous tax exemption measure, but it is important to note that the lack of a cap was beneficial in this situation. Had the country set a cap to net-metering capacity, the program would have had to stop as soon as 200 MW was reached and would not have grown to the 331 MW that exist today. This demonstrates the importance of setting goals for net-metering capacity, but not stifling it with a program cap.

These case studies demonstrate the variety of ways in which a program can incentivize the growth of distributed solar generation. The relationship between the retail rate for energy and buy-back rate is key to providing an incentive for customers to invest in a PV system. However, that relationship alone is not the only factor considered by customers. High energy rates, as demonstrated by Denmark and Germany, also encourage customers to seek an avenue to reduce their overall energy bill and net-metering provides a way in which to lower your bill.

Factors such as the billing cycle, residual credits, and additional fees all contribute to the economic incentives inherent in buy-back programs. Each one has the potential to reduce the economic benefit for customer-generators. They may not be deciding factors to potential investors, but they still play a role in determining the economic feasibility of a PV system.

System size and program caps serve as signals to the market to produce less energy than might otherwise be realized. These are important factors in determining the degree to which investment in solar energy will grow during the course of a year. It is essential that a net-metering program not limit the amount of solar capacity that can be added during the course of the year. Individual system size limits do not appear to be detrimental to the growth of solar investment as a whole, but they do prevent customers from maximizing production capacity. Such limits create inefficiencies in the market that only serve to hamper growth and do not provide a benefit.

**Table 7.2.	Comparison of California to Case Studies**

		Case Studies			
	Characteristic	Germany	Denmark	Austin, TX	California
Consumer	Ratio between the Retail Price for Energy and the Buy-back Rate for solar	5 to 6	1.59	0.94 to 5.94	1
	Billing Cycle	NA	Hourly	Monthly	Monthly
	Residual Credits	NA	NA	$0 after 12 months	Average spot market price
	Individual PV system size cap	10 MW	6 kW	20 kW	1 MW
Utility	Additional Fees	$3.42 per kWh charged to all customers	Not Allowed	Not Allowed	Not Allowed
	Program Cap	Annual goal of 2.5 to 3.5 GW of solar added each year	No cap, but goal of 200 MW of solar capacity has been met	No Cap	5% of utility's peak demand

Table 3 compares the characteristics of each case study to California. The ratio between the retail price for energy and the buy-back rate in California is the lowest out of all four jurisdictions. California does not offer a higher buy-back rate in comparison to the retail rate, nor does it have a retail rate structure that would incentivize a customer's move to net-metering. Given the importance of these characteristics to net-metering's success, it will be a focus of the policy options and analysis in the next chapter.

California currently bills on a monthly basis, allowing credits to roll over each month until the end of the year where a rebate is offered at the average spot market price. While both of these characteristics are positive and consistent with the most successful cases, it should be noted that the end-of-year rebate is not automatic. Customers must notify the utility as to whether or not they would like to receive a rebate or continue rolling credits over the next billing period. If they do not notify the utility of their choice, the credits expire without remuneration. This is also a fairly recent policy for the state, having been enacted in 2009. This is an important characteristic to monitor in California as it may still be subject to further review and changes in the future.

Like each of the other cases, California limits the size of individual PV systems. While such limits only serve to reduce investment in larger PV systems, they do not appear to be detrimental to the success of a buy-back program. Nevertheless, individual system size limits should be reconsidered for California.

Like Denmark and Austin, California does not charge any additional fees to net-metering customers to support the program. However, numerous proposals have been made to the CPUC to implement various additional fees to recover the costs associated with supporting renewable energy development through net-metering. It is important that this characteristic be maintained in California.

Unlike each of the three case studies, California does limit the amount of PV capacity that can be added to the program each year. Such a cap is unnecessary and only serves to limit consistent development of the program. This is an important characteristic that should be changed in California.

California currently includes several of the same positive characteristics as the three case studies. However, it falls short in many of the most important features of a successful buy-back program. These factors are the focus of the policy options that are considered in the next chapter.

8. Policy Options

Based on the results of the three case studies in this section, I define policy goals and develop three policy options to be considered for net-metering in California. Each of these options reflects the policies of the three case studies and incorporates the most successful elements of each case. In addition, I have included several general recommendations based on characteristics from the case studies and evidence from the literature review that should be implemented in all of the policy options. These are important features of a successful buy-back program and should be part of California's net-metering structure.

8.1. Policy Goals

The short-term policy goal is to create a net-metering program structure that encourages customers to invest in PV systems. Net-metering's simplicity makes it easy to implement, but doesn't allow for a buy-back rate that reflects the value of distributed solar to the utility company or its customers. In addition to the buy-back rate, other features of the program, such as additional fees and system-size caps, should be designed so that they do not limit the growth of distributed solar generation. These must be addressed and clearly laid out so that there is certainty in the program for potential customer-generators.

The long-term policy goal is to continue the growth of solar net-metering so that it reaches at least reached value parity or less compared conventional sources of energy. Net-metering has the potential to spur enough economic growth in the local solar industry to bring down costs to the point that it is no longer more expensive for utility companies to purchase. Germany's FIT is largely responsible for the country's rapidly growing solar industry, which created incentives that brought the price for PV panels down considerably. Net-metering has the potential to create the same effect in

California. Once solar energy is competitive with conventional forms of energy, the dynamics of the energy market will change, necessitating a re-evaluation of renewable energy support schemes such as net-metering.

8.2. Criteria and Measures

I consider three policy options to address the buy-back rate of net-metering. Each of these options reflects the success of the program in the three case studies. To evaluate these options within the context of California, I develop a list of criteria to evaluate these policies and make the comparable. Each criterion can score low, medium, or high with values 1, 2, and 3. The best performing policy is identified by the largest total score with all criteria having the same weight. Table 3 summarizes the criteria.

Table 8.1. Criteria Definition and Measurement

Criteria	Definition	Measurement	Score
Sustainability	Stability of price signals	Stable price signals Unstable price signals	High (2) Low (1)
Equity	Distribution of energy costs among utility customers	Costs of program paid by all Costs of program paid by non-participating customers	High (2) Low (1)
Effectiveness	Success of the program in incentivizing growth of distributed solar generation	Ratio of 5 to 6 Ratio of 1 to 4 Ratio below 1	High (3) Medium (2) Low (1)
Management and Implementation	Ease of implementing a new pricing scheme	No meter change needed New meter for net-metering customers New meter for all customers	High (3) Medium (2) Low (1)
Stakeholder Acceptability	Likelihood of support from utility companies	Stakeholder support for pricing mechanism	High (3) Medium (2) Low (1)
	Likelihood of support from the utility commission		
	Likelihood of support from utility customers		
	Likelihood of support from net-metering customers		

Sustainability: It is measured by whether or not the pricing mechanism sends a stable signal to the market to create a sustainable level of investment in distributed generation. This measure is drawn from evidence in the literature review that reveals that pricing mechanisms that offer a consistent incentive to investors results in the most sustainable program over the long-term. A mechanism that provides a stable price signal receives the highest score of 2, and a mechanism that provides an unstable price signal receives the lowest score of 1.

Equity: The horizontal equity impact of each option on utility customers is measured by whether or not the policy distributes the costs associated with net-metering to all customers or just non-participating customers. Assumptions about the manner in which program costs would be paid by customers are drawn from the relevant case studies. A policy that distributes costs equally among all customers receives a high score of 2, and a policy that distributes costs only to non-participating customers receives a low score of 1.

Effectiveness of the program is measured by the degree to which the buy-back rate encourages investment in PV systems. Since the economic incentive of the buy-back rate is inextricably linked to the retail rate for energy, the best way to measure its effectiveness is by using the ratio between the two prices. Nowak et. al., (1998), uses this method and develops a ranking system to distinguish the most successful buy-back schemes from the least successful based on the ratio between the buy-back and retail energy prices. Nowak defines the most successful programs as having a ratio of 5 or higher, moderately successful programs have a ratio of 1 to 4, and the least successful programs have a ratio below 1. I correlate her scale to a high, medium, low scale to evaluate the effectiveness of each policy option.

Management and Implementation: The relative ease of implementing and overseeing each option is based largely on the changes that would need to be made to the current billing system. A program that is administratively simple to implement does not require a second or special meter to measure energy usage. Some policies require the addition of a second meter for net-metering customers only. Such policies are moderately difficult to implement because while a second meter must be installed, it is done for just a small proportion of all utility customers. The most difficult programs to implement are those that require the addition of a new meter for all utility customers. A high score of 1 is given to options that require the installment of a new meter for all customers, a score of 2 is given to options that require a new meter for net-metering customers only, and a score of 3 is given to options that do not require a new meter.

Stakeholder Acceptability: The acceptability of each policy option to the state stakeholders is based on the expected level of support from each group for the relevant pricing mechanism. Utility companies are most concerned with recovering any costs associated with the program and receiving a fair value for the cost of providing service. The utility commission is interested in maintaining reasonable energy rates for utility customers. Utility customers are also interested in maintaining reasonable retail energy rates, but are also interested in supporting renewable energy programs. The literature review revealed that customers are willing to pay more in energy costs in order to support a shift towards renewable energy and away from fossil-fuel based energy generation. Net-metering customers are most concerned with receiving fair compensation for the energy they export back to the utility. The acceptability is based on the likelihood that each stakeholder group would accept the option given their stated interests. An un-weighted score of high, medium, or low is assigned to each stakeholder group based on the level of acceptability of the option to that group.

The budgetary impact of each option cannot be reasonably determined due to the lack of transparency in costs related to utility company processes. Utility companies maintain privacy over their precise administrative, transmission, and distribution costs associated with providing service. Details about these features of their business are considered proprietary and are not shared with the public let alone the utility commission.

8.3. Policy Options

This chapter describes three policy options to improve pricing of net-metering in California.

Policy Option 1: *Increase energy prices to encourage more customers to participate in the net-metering program*

This option draws from the experience of Denmark and would entail raising energy prices to encourage additional investment in distributed solar. For the best results, energy prices would be set to a time-of-use model rather than a tax increase so that the buy-back rate reflects the actual value of the energy as it is generation. This method maximizes value for solar energy because the PV system is producing the most energy at peak times, when rates are at their highest. It also avoids potential resistance that may be accompanied by a tax increase on energy retail rates.

The drawback to this option is that it relies only on the retail price of energy to encourage investment and doesn't necessarily provide a sufficient economic incentive for customer-generators by increase the retail rate to buy-back rate ratio. Low energy prices are also a highly valued aspect of California's energy system and such a proposal may be met with some opposition from the CPUC. Since the buy-back rate will still be tied to the retail rate, a separate meter is not needed. However, a smart meter that can measure energy usage based on time of day would be needed for all utility customers.

This option would also include several minor characteristics drawn from the case study analysis. Billing would be completed on a monthly basis with credits receiving a rebate at their full retail value based on the time in which they were generated. In addition, no extra fees would be levied because the policy does not increase buy-back prices relative to the retail rate. Individual system size caps and overall program caps would also be eliminated in this option.

Policy Option 2: *Set the price paid for excess energy to the minimum value necessary to receive a return on investment*

This option draws from the principles of Germany's feed-in tariff and guarantees a buy-back rate that provides a return on investment. The tariff would fall as technology improves and the price of solar falls. This option would be very effective at encouraging participation in net-metering while also preventing compensation to participating customers from being so high that the program becomes too expensive to run. It would allow participating customers to receive the financial assurance they to invest in a PV system. An additional meter would need to be installed for net-metering customers to allow for a separate buy-back rate to be implemented. This would allow for a separate fee to be levied to all utility customers to recover costs associated with the program, as is done in Germany. This option essentially modifies net-metering into sort of feed-in tariff and decouples energy purchases from energy generation.

All energy generation that is not consumed on site would be purchased by the utility at the tariff rate, so there would be no remaining credits that expire. In addition, there would be no individual system size caps or overall program caps so that customers are not limited in their investment choices.

Policy Option 3: *Set the buy-back rate to reflect the true value of distributed solar energy*

This option follows the Austin's model and would provide adequate economic incentive to customer-generators while appealing to utility companies and non-participating customers as well. The value-of-solar tariff (VOST) would be calculated using the methodology employed by Austin Energy to estimate the current value of solar to the energy market. This pricing mechanism provides a sufficiently high buy-back rate in relation to the retail price and should achieve sufficient incentive to encourage investment in distributed solar. The tariff would decline as the price of solar declines and the tariff is updated annually to reflect the most recent data. Any price increases as a result of net-metering would be incorporated into the utility's retail rate for energy and paid by all customers, including those participating in net-metering. A second meter would be installed for net-metering customers so that energy purchases could be billed separately from energy generation. This option would diverge from Austin's policy by providing full remuneration at the tariff rate for credits remaining at the end of the year.

Since the VOST incorporates the costs of the program into the tariff, no additional fees are needed. This option also eliminates individual system size caps and overall program caps.

9. Analysis of Policy Options

Each option is evaluated according to the criteria described in the previous section.

9.1. Option 1 Analysis

Sustainability: TOU pricing is a less stable form of pricing retail energy because it varies according to the utility's cost of providing energy during a particular time of day. These rates are subject to frequent adjustment in addition to the built-in variability throughout the day and year. As a result, net-metering buy-back rates will adjust along with the TOU rate. This benefits net-metering customers to the extent that solar energy produces most of its energy during peak times when energy prices are at their highest. However, it also means that customers do not have a consistent buy-back rate on which to rely, making it difficult to estimate the expected financial gain of the system. For this reason, TOU pricing is not considered a stable price signal for investment in solar net-metering.

Equity: TOU pricing alters the retail energy rates for all utility customers. In addition, there will be no additional costs associated with net-metering to be passed on to non-participating customers. This option results in an equitable distribution of costs among all customers, regardless of whether or not they participate in net-metering.

Effectiveness: Switching to TOU pricing maintains the standard net-metering arrangement of paying for excess energy at the same rate at which energy is purchased from the utility. Therefore, the ratio between the retail rate and buy-back rate will continue to be 1. As an incentive to invest in renewable energy based on expected revenue, this option will receive a low effectiveness score. TOU pricing offers an incentive only to the extent that net-metering offsets higher-cost energy purchases during peak times. This is not as robust an incentive as those with a higher retail rate to buy-back rate ratio and will therefore be less effective in encouraging investment in distributed solar generation.

Management and Implementation: Increasing energy rates through TOU pricing requires the addition of smart energy meters that measure customer's energy use hourly rather than a lump sum at the end of the month. Installing new smart meters is a substantial task that requires significant investment of time and manpower for utility companies to implement. Currently, only large commercial and industrial customers use smart meters in the service areas of California's three investor-owned utility companies. Utility companies have put forth proposals to the CPUC that smart meters be installed for residential and commercial customers, but they are still under consideration. Smart meters have also been met with considerable public resistance by customers who fear that they will cause negative health effects. It is unclear yet as to whether or not the CPUC will support a change to the use of smart meters.

Stakeholder Acceptability: Utility companies do not oppose raising retail energy prices, especially through a system such as TOU pricing. TOU pricing will provide revenue for the utility at a rate that more accurately reflects their costs of providing service. For this reason, it is a favorable system for utility's and will likely receive their support.

Maintaining low energy prices is considered an important goal of the CPUC, so raising them with the intention of supporting solar net-metering is likely to be met with resistance from the commission. The CPUC is committed to keeping retail energy rates as low as possible and is likely to consider TOU pricing to place a heavier burden on low-income customers that currently benefit under the current tiered pricing structure.

Utility customers are willing to pay more in energy costs if it is part of a support scheme to move to renewable energy from fossil-fuel based energy. California's residents are generally supportive of clean-energy initiatives and are likely to be willing to move to a TOU pricing structure as a means to incentivize better energy usage practices in the state, whether it is though net-metering or energy efficiency.

Net-metering customers will benefit more under TOU pricing than the current tiered rate structure. While TOU pricing will provide more value for excess generation because, it doesn't increase the ratio between the retail rate and buy-back rate for energy. This pricing scheme doesn't necessarily offer a fair value for the energy that is exported to the utility, so it will be met with moderate support from these stakeholders.

9.2. Option 2 Analysis

Sustainability: Feed-in tariffs are considered to be the most effective of any support scheme to promote sustainable investment distributed solar generation (Lesser, 2005). Implementing a feed-in tariff pricing method in California would result in very clear price signals for potential investors. While the tariff will decline along with PV prices, such a decrease is expected and encourages the development of a robust and sustainable market for solar panels. This option presents a stable and consistent price signal to customers and receives a high score for this criterion.

Equity: Implementing a feed-in tariff style pricing mechanism requires the implementation of a surcharge to support the program. A surcharge per kilowatt-hour distributes the costs of the program among customers based on their energy usage (Nowak, 1998). Customers who use less energy will pay for a smaller portion of the program costs than customers whose energy usage is relatively high. Implementing this surcharge in net-metering would mean that customer-generators also pay for the additional costs of the program through their purchase of energy. This is a more equitable method for distributing the costs associated with offering a high financial incentive for solar net-metering.

Effectiveness Feed-in tariffs have proven to be very effective in promoting investment in distributed solar generation due to the high ratio between the retail rate and buy-back rate for energy. A high ratio provides a strong incentive for investment in PV systems and will yield the most effectives program.

Management and Implementation: To implement this pricing system, two meters would be needed in order to measure energy purchases from the utility company and energy exported to the utility company at different prices. Such upgrades would be short-term and not require additional attention once the change is made. Nevertheless, this policy requires the addition of a second meter for customer-generators and is moderately difficult to implement as a result.

Stakeholder Acceptability: Support from utility companies is likely to be low given that the pricing system requires a buy-back rate that is considerably higher than the retail price for energy. They are also required to purchase this energy at a set rate, regardless of its value to the company. This option is likely to be received with resistance from utility companies.

The utility commission is likely to oppose the policy since it adds a surcharge to the price of energy to support the high tariff. Even though the costs are distributed evenly among all customers, the increase to utility bills is likely to be untenable for the commission.

Utility customers may also be hesitant to pay a higher rate per kilowatt hour to support the program, but are unlikely to strongly oppose the policy due to their support for clean energy generation. For this reason, their level of support is likely to be moderate.

A feed-in tariff style pricing system would be very popular with customer-generators as it provides a desirable return on their investment for the PV system. This is a highly advantageous mechanism for them as it provides a very high buy-back price for their excess energy. It is likely to be met with strong support from net-metering customers.

9.3. Option 3 Analysis

Sustainability: While the value of solar tariff has not been implemented for a long enough time period to determine its sustainability, the structure of the tariff follows that of other FIT's, which are very stable. The VOST provides a clear price signal that gradually declines as the price of PV systems falls. The VOST also provides a long-term commitment from the utility company to purchase energy at a set price. This provides more stability to the market and certainty for potential investors. The VOST is designed to be a sustainable incentive that will continue to encourage investment in solar PV systems over the long-term.

Equity: The VOST is designed to distribute any potential cost increase associated with the program evenly among all customers. Any impact that the growth of net-metering may have on energy prices is incorporated into the retail rate for energy. Because the policy decouples energy purchases from excess generation exports, customer-generators are treated as every other customer and pay for cost increases through their monthly energy bill. This is a relatively equitable method of shouldering program costs and receives a high score for this criterion.

Effectiveness: The effectiveness of the VOST in promoting growth of solar net-metering has yet to be determined. However, given that the tariff presents a significantly higher buy-back to retail price ratio than is currently offered in California, it increases the incentive to invest in solar. It follows that participation in the program will increase as well as a result of the higher rate ratio. The goal of a VOST is to reach grid parity with conventional energy sources, and it is likely to be reached given the structure of the declining tariff.

Management and Implementation: A second meter will need to be installed for customer-generators to measure energy purchases and energy exports separately. Installing a second meter requires additional oversight, but applies to only a small portion of utility customers. Therefore, it receives a score of 2 for this criterion.

Stakeholder Acceptability: The VOST is the most politically viable to all stakeholders due to its consideration of costs and impacts to each party. Utility companies will not be burdened with excessively high buy-back rates and can continue to recoup the costs of the program through retail energy rates. The VOST also reflects the value that solar energy provides to them, so it is considered a fair rate for the energy they receive from the customer-generator.

This option is likely to be met with strong support from the utility commission because it satisfies all parties and does not significantly raise retail energy rates. The commission can meet the requests of each stakeholder while maintaining an incentive for distributed solar generation.

Customers will support the program through retail rates, but the increase is expected to be very minimal. Moderate increases in energy costs from this policy are unlikely to be met with resistance from customers, especially when considering their willingness to pay for clean energy.

Net-metering customers will receive a higher buy-back rate to retail price ratio than the current system of 1 to 1. In addition, the tariff provides a rate that more accurately reflects the value of solar to society. However, this rate is not necessarily going to provide a return on their investment and is a more moderate incentive. Nevertheless, net-metering customers are likely to be supportive of this option.

The matrix below consists of a scaled ranking of each policy option against each criterion. Each option is given a score on a scale of high, medium, or low and are not weighted.

Table 8.1. Criteria and Measures Matrix

		Policy Options		
Criteria	Definition	Change Retail Price	ROI Rate	VOST
Sustainability	Stability of price signals	1	2	2
Equity	Distribution of energy costs among utility customers	2	2	2
Effectiveness	Success of the program in incentivizing growth of distributed solar generation	1	3	2
Management and Implementation	Ease of implement the pricing scheme	1	2	2
Political Viability	Likelihood of support from utility companies	3	1	3
	Likelihood of support from the utility commission	1	1	3
	Likelihood of support from utility customers	2	1	3
	Likelihood of support from net-metering customers	2	3	3
Total		14	15	20

9.4. Policy Recommendation

Based on the results of the case studies and analysis, I recommend the implementation of option three. This option provides a stable pricing mechanism for supporting net-metering that will create a sustainable program for the long-term. It distributes costs fairly among all customers, yet at a lower rate than option 2. The ratio between the retail rate and buy-back rate is not as high as that of option 2, but will still be effective in encouraging investment in solar energy. It is a considerable improvement on the current system of a ratio of only 1. It will require the utility commission to implement the VOST calculator, but once the calculator is created, it can simply be updated in future years to reflect the most recent value of solar net-metering to the grid. Additional meters will have to be installed for customer-generators, but such a move requires fewer resources than option 1 as only a small proportion of utility customers will need a second meter.

The greatest strength of this policy is that it is the most favorable option for each stakeholder group. This is due to the fact that it provides the fairest buy-back policy for all stakeholders, while improving the economic incentive for customer-generators over the current policy. Even though the VOST does not provide the highest buy-back rate compared to the retail rate, it meets the concerns of each stakeholder group.

Options 1 is likely not viable at this time in California. It would not be possible given the state's commitment to keeping energy rates low. The state is currently evaluating a number of different retail rates, one of which includes time-of-use pricing combined with tiered rates. However, a sole time-of-use pricing policy is considered less desirable because of the impact it would have on low-income customers during peak time such as mid-day hours in the summer. If political will changes in the coming years, it may be possible to incorporate this policy into the proposed VOST policy. Combining TOU pricing with the solar net-metering would further incentivize participation in the program as well as larger individual system sizes in order to offset energy purchases during peak hours.

Option 2 would offer a substantially higher buy-back rate, but may be so high that utility companies and customer object to the impact it would have on retail prices. This option would require the incorporation of a flat fee to all customers to support the program and would likely be met with resistance. While it does provide the highest retail rate to buy-back rate ratio, such a high incentive may be too generous to be palatable given the additional fee. The VOST provides the happiest medium at the moment since it incorporates features of a feed-in tariff while maintaining support from the necessary stakeholders.

9.5. Conclusion

California's challenges in determining an appropriate buy-back rate for excess generation in net-metering is one that many other states have and will continue to struggle with in the coming years. Net-metering has benefited from a simple structure, but modifications are needed if it is to incentivize the kind of growth in solar energy that is desired. The VOST policy achieves the goal of providing sufficient incentive for further development of distributed solar while appeasing the concerns of each stakeholder group. Further evaluation will be needed to determine the long-term effect of this policy on adoption of solar net-metering. However, it is the strongest option for California given the limitations voiced by utility companies and customers.

This study revealed several shortcomings that may prove useful for future research. Energy policy and net-metering in particular, are influenced by a number of factors that are constantly changing. Energy usage may rise and fall due to price signals and wholesale energy rates are in a constant rate of flux. The economic incentive for net-metering customers is influenced by their individual energy usage, which can be manipulated based on the degree to which they want to offset their energy purchases and maximize energy exports. While a pricing policy can be designed to maximize incentives for customers, the final financial outcome is a result of their energy purchases in relation to their energy exports.

It is also extremely difficult to determine the degree to which a specific net-metering policy contributes to investment in solar. There is considerable evidence demonstrating the success of some programs over others, which is why feed-in tariffs are often cited as success stories. However, falling PV prices also play a role and the degree to which they are responsible for investment in solar generation has not been thoroughly studied as of yet. Falling solar prices in recent years are often mentioned as factors to the growth of solar, but their precise contribution to increased investment rates has not been fully evaluated. Much of the research on the topic of energy incentives cites the difficulty in teasing one factor from the other as a limitation.

The greatest limitation to this type of research in the United States is the fact that utility companies do not share detailed information about their administrative and service costs to the public or the utility commission. Information about their business structure and transmission and distribution services is considered proprietary and they are not required to divulge such statistics. Utility companies present the commission with the avoided cost rate and aggregate administrative costs, but do not provide details of how those numbers are reached. In addition, information about individual energy usage is considered private and is not shared with the public. This makes it very difficult for third parties to conduct thorough cost-benefit studies to determine the exact impact of specific policies to their service and administrative costs. Such studies may be commissioned by the utility commission, in which case data is provided to consulting firm which conducts the study. However, the utility commission and consulting firm must rely on the utility company to provide accurate information. It is not possible for an outside party to review the findings and determine whether or not the information provided is accurate and the results are sound.

Improving information sharing and transparency between utility companies, the utility commission, and third party researchers is a useful area for further research. Given the importance of energy markets and renewable energy development for the future, better methods of providing information necessary to study these markets is needed. Transparency is necessary for sound public policy to be developed. Fair energy prices that reflect the true cost of service cannot be determined if the costs behind those numbers are not made available for evaluation.

Despite these shortcomings, my analysis demonstrates that there is a better method of pricing excess solar generation in net-metering. Distributed solar generation provides numerous benefits to utility customers and should continue to be encouraged through a pricing mechanism that incentivizes investment. The VOST offers a strong incentive for customer to participate in net-metering while satisfying the needs of all major stakeholders.

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