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A Policymaker's Guide to Feed-In Tariffs: Encouraging a Responsible Transition to Renewable Electricity in California

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Introduction

The renewable electricity sector is one of the most promising markets in terms of long-term sustainability, energy security, and environmental responsibility. Renewable energy technologies, such as photovoltaic solar panels and wind turbines, have opened the door to an almost inexhaustible source of natural energy. As fossil fuels become scarcer, it is imperative that countries begin to develop new ways to harness these sources of energy and improve efficiency of their everyday processes. In addition to its inexhaustibility, harvesting energy from renewable sources has far fewer negative impacts on the environment than conventional energy production. The health and productivity costs associated with global climate change are significant, causing many countries around the world to enact stricter environmental regulations and set dramatic emissions reduction goals for the near future. Renewable energy offers a solution for all these challenges and production must be encouraged in significant, but responsible ways.

Unfortunately, renewable energy production currently represents a very small fraction of our total energy production. According to the International Energy Agency, the world relies on renewable energy sources for just 13.1% of its energy supply. Although this number is a result of significant increases over the past decade or so, it is still a far cry from the production necessary to reverse global climate change and ensure future energy security. To make matters worse, forecasts for future energy demand allude to increases across all consumption types, from residential to commercial and industrial. Although new sources of fuel have been found using methods such as hydraulic fracturing, the extraction of these fuels is extremely damaging to the environment and is, of course, still finite.

The greatest barrier associated with the proliferation of renewable energy is its cost. Like most new technologies, the technology associated with renewable electricity faces very high research and development costs. This results in much higher initial construction costs for renewable energy installations, causing consumers to shy away despite the production cost per kilowatt hour being relatively low over the course of longer time horizons. In comparison, conventional energy technology has long benefited from economies of scale, leading to very low initial costs and well-established infrastructure. With customers intimidated by high costs, renewable energy technology is not receiving the capital necessary to speed up development and proliferation rates. This is a major issue that some countries have begun to address through intervention in the market.

The challenge of high technological costs is compounded by a variety of market failures within the energy industry, as well as by stubborn social norms that downplay the gravity of environmental issues. The most significant market failure is the unaccounted cost of negative externalities caused by conventional energy production. A recent study conducted by the National Research Council concluded that the production of electricity using fossil fuels causes upwards of $63 billion dollars in environmental and health damages per year (NRC, 2010). This figure represents approximately $.036 in damages per kilowatt hour, a figure that, if internalized, would increase current electricity rates by 40-50%. Other market failures include unaccounted for national security expenditures, asymmetric information, and unregulated market power of leading firms, each of which involve a negative externality that, if internalized, would increase the price of conventional electricity by even more.

Although more and more people are starting to believe in global climate change and its various causes and effects, many are still skeptical about the effectiveness of available technology. This skepticism is reflected in consumer preferences, which take the form of low adoption rates in the renewable energy sector. Despite some consumers expressing a willingness to pay a premium for environmentally-friendly products, including renewable electricity, other factors such as perceived inconvenience and unreliability severely hinder actual implementation. The most significant cause of these psychological biases is the lack of appropriate information, both on climate change and its possible solutions. To be fair, climate change is an extremely complex process that has yet to be fully understood, even by the experts. Therefore, it is even more important that information is consumer-friendly and relevant to the major concerns of those that remain unconvinced.

There is no doubt that renewable electricity will need to play a major role in our future energy production, therefore it is imperative to encourage its growth and development now. Many countries around the world, and a few states here in the US, have already enacted policies to encourage the proliferation of renewable electricity. The most popular policies have been based on traditional subsidy mechanisms, in which the developing technological sector is protected from the competitive nature of existing substitute products. This protection incentivizes entry into the sector, accelerating development and increasing competition.

A subsidy can be financed several different ways, each having a different effect on the greater market. One subsidy in particular, called a feed-in tariff, has been implemented with some success in Europe and the United States, as evidenced by increases in renewable electricity capacity without major market implications. A feed-in tariff is a subsidy that is financed by the existing firms in a sector, in this case conventional energy utilities. These utilities are mandated to increase their renewable generation capacities by entering into contracts with independent, renewable electricity generators. These contracts stipulate the long-term purchase of renewable electricity at a price determined by a variety of different market factors.

Instead of targeting the initial construction costs of renewable electricity systems like some energy programs do, feed-in tariffs target the long run costs of producing renewable electricity. This improves stability in the renewable electricity market as well as increases the chance of turning a profit in the long run, which subsequently encourages investment in the sector. The feed-in tariff is decreased over the length of the contract to parallel the decreasing costs in technology, and to encourage honest development towards cheaper and more efficient products. Ideally, feed-in tariffs will phase out as the once-new technology can compete on its own with traditional technology.

This paper will examine the theoretical framework of a feed-in tariff before analyzing the political and economic characteristics of existing feed-in tariff systems adopted here in California and in Germany. Along with a set of policy criteria, proper analysis of existing market failures, barriers, and behavioral factors will be provided with concern to the proliferation of renewable resources. The goal of this paper is to provide policymakers with the information necessary in devising new incentive programs and to improve existing policies, specifically the feed-in tariff system. I will finally provide my own policy recommendations based on the criteria and analyses described above.

The structure of this paper will be as follows. Chapter 1 will describe, in detail, the past and current energy production and consumption landscapes in the state of California. This chapter will also address forecasts for future consumption before outlining the major efficiency and environmental goals outlined in California policy. Chapter 2 will delve into the current status of renewable energy technology with respect to its environmental advantages and economic challenges. This section will also examine some of the existing social norms and psychological biases surrounding environmentalism and the adoption of green technology. Chapter 3 will set up the necessary, theoretical framework for a renewable energy incentive program, specifically addressing the policy challenges and market effects of subsidies and feed-in tariffs. Chapter 4 will then analyze existing feed-in tariff policies in California and Germany, comparing the effectiveness of each from a cost and capacity perspective using a set of established criteria. Lastly, Chapter 5 will consist of my analysis and policy recommendations for improving the feed-in tariff system here in California. These recommendations will hopefully have applicability outside of California for states looking to adopt or improve their own renewable energy policies.

Chapter 1: California's Electricity Landscape

California's electricity production over the last half century has experienced a variety of trends in both supply and demand. These trends, including changes in state population, consumer preferences, technology, and natural resource markets, have affected pricing and consumption in dynamic ways. Consequently, these changes have had dramatic effects on the local and regional climate and environmental quality, spurring the need for comprehensive policy changes. It is important to analyze energy production and the environment together, as their relationship is strongly intertwined and will become even more so in the coming decades as the United States transitions to renewable energy.

I. Electricity Production and Consumption: Past and Present

California, like the rest of the nation and world, has produced the majority of its electricity using conventional technology and fossil fuels. Currently, natural gas fired plants account for 57.1% of all energy produced, followed by hydroelectric[1] and nuclear at 17.5% and 9.2%, respectively. Electricity produced from coal-fired plants is relatively low, accounting for a mere .8%. By comparison, coal-based power plants account for over 44% of the United States' electricity production, while natural gas accounts for just 23% (Long, 2011). Although California has done well to limit the use of coal by using somewhat cleaner burning natural gas, both will have to be reduced and eventually replaced by renewable sources in order to achieve portfolio goals.

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[1] The environmental impacts of hydroelectric facilities have yet to be fully understood. However, early studies show that land displacement caused by dams and reservoirs may cause significant greenhouse gas emissions due to the decay of submerged trees and other plants (Castaldi *et al*, 2003). Regardless, the focus of this paper is on prevailing renewable technologies surrounding wind and sunlight.

California's electricity production ranks high within the United States in several categories. California ranks first in both net generation from renewable sources and geothermal generation. California also ranks high in the nation for conventional hydroelectric, placing third. Lastly, the state ranks tenth in the nation for electricity generation from nuclear plants (Smutny-Jones, 2007). This diverse portfolio of production sources has served its consumers well, providing reliable power even during peak demand. However, emissions from the electricity sector account for nearly 25% of California's greenhouse gas emissions, amounting to over three metric tons of greenhouse gas per person per year in California. Although steps are being taken to account for these emissions, power plants and utility companies have yet to truly internalize all of the costs.

From a growth standpoint, California's energy production has been on the upswing for many decades. According to the California Energy Commission, electricity production is up 67% since 1980, when production was approximately 170,000 GWh. Over the same period, California's population has increased by only 59%, revealing a slight increase in per capita electricity production. Electricity generated from wind has experienced a growth rate of 178% over the last 15 years, leading all categories. Solar has seen similar success, growing by 30% over the same period. That being said, electricity generated from coal and natural gas has also experienced relatively large growth at 37% and 22%, respectively (CEC Online Database, 2012). Although growth in the renewable energy sectors looks impressive, electricity from these sources still represents a drop in the ocean compared to fossil fuel based generation.

California is able to produce enough energy to meet approximately 70% of total demand; the remaining 30% must be imported from neighboring states to the North and East. This represents a fairly large production gap and will require serious attention in order to meet statewide demand. Arizona and Oregon, both large electricity exporters to California, have experienced significant population growths over the past decade, limiting electricity surpluses and therefore their ability to provide California with extra power (Alvardo and Griffin, 2007). California's population is still growing, albeit by a decreasing rate, so growth in electricity production will have to at least match this increasing demand. Efficiency regulations will certainly help in closing this production/consumption gap, but will by no means account for the full 30%. Therefore, California must expand use of renewable sources.

Consumption

Understanding the consumption landscape for electricity is also important for policymakers. Unlike production statistics, looking at electricity consumption reveals significant demographic characteristics that can be used to form demand-side programs and regulations. Consumption can be broken down in several different ways, particularly by sector, which may allow for more pointed renewable policies and efficiency standards. Also, remembering the 30% supply gap and subsequent importation of electricity, the type of energy that ends up being consumed in California does not necessarily parallel the source percentages of in-state production. This is an important distinction and one that must be considered when creating effective climate policy.

California energy consumption was last reported in 2011 at 284,953 GWh, according to the California Energy Commission. This consumption has been on a steady incline since detailed reporting began in 1990, when total energy consumption amounted to 229,868 GWh. This represents a 23.9% increase in just two decades. California gross energy consumption falls behind only Texas, where electricity plays a major role in oil and gas extraction. Similar to yearly consumption, peak demand[2] has also increased, from 35,000MWh in 1980 to over 65,000MWh today (Marshall and Gorin, 2007). Peak demand represents the highest point of demand during any given day and, as revealed by the statistics, is much more sensitive to population increases. This is a result of consumption trends along various sectors.

When breaking consumption down by sector, we see that commercial and residential users far outweigh the industrial and agricultural sectors. Together, the commercial and residential sectors account for approximately 218,000 GWh, or 76% of total consumption. Not only do these sectors already enjoy the largest pieces of the consumption pie, they are also experiencing steady increases in consumption. On the other hand, consumption in the remaining two sectors has remained fairly constant over the last few decades and is not forecasted to increase. With respect to the industrial sector, the static consumption rate can be attributed to a decrease in manufacturing as a percentage of California GDP. Similarly, agriculture only amounts to approximately 2% of California's GDP, hardly making it a considerable electricity consumer.

It is important to identify which sectors are energy intensive for a couple reasons. First, remembering California's 30% supply gap, the introduction of new energy sources, i.e. renewable electricity, should be located near intensive users to minimize transaction costs. This makes a strong case for distributed electricity generation, an argument that will be made in more depth later in this paper. Another reason to identify top electricity consumers is to better target product efficiency standards. For example, commercial and residential buildings rely heavily on electricity for heating, cooling, and lighting, whereas the industrial and agricultural sectors rely on electricity for mostly mechanical processes. Consequently, efficiency standards should be

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2 Peak demand is a particularly difficult challenge for renewable energy, as peak supply must be consistent every day of the year. Conventional electricity can easily provide the load balancing necessary to meet demand at all hours of the day, including peak demand. This is a major challenge for the renewable energy sector and one that will hopefully be solved through technological advancement.

targeted at home and commercial appliances such as air conditioners, light bulbs, and other large appliances. Both of these reasons for consumer identification have significant environmental implications that will help achieve California's future emission goals.

From a per capita perspective, California again finds itself atop the national rankings for the right reasons. Per capita consumption in California over the last ten years has remained between 7,000-7,500 KWh/person/year. This is compared to a national average of nearly 12,000 KWh, a number that has increase by nearly 40% over the last 30 years. California's low per capita consumption is the result of strict building and home appliance efficiency standards (CEC Online Database). For example, California regulations demand that a standard home refrigerator cannot consume more than .1(refrigerator volume in feet)+2.04 KWh per day. The list of appliance regulations is exhaustive and incredibly precise, accounting for every possible variation in the type of appliance (CEC, 2010). Many states do not have as strict standards, or any standards at all, leading to higher per capita electricity consumption.

Despite California's progressive looking electricity production portfolio and per capita electricity consumption, their involvement in the national electricity market reveals some serious problems. Of the 30% of imported electricity, nearly 80% of was produced using coal-burning power plants, specifically from the Navajo Station in Arizona and the Four Corners installation on the Arizona-New Mexico border. This amounts to nearly 70,000 GW of electricity per year that is far from clean and would severely hamper California's progressive reputation if produced in state. The remaining 20% of imported electricity is produced from nuclear plants in Arizona and hydroelectric plants in the Upper Northwest, leaving a remainder of 0% for truly renewable sources. This analysis of import consumption alone is enough to reveal that electricity consumption in California is not as green as its production, a trend that should be combatted by environmental and renewable energy policy.

Electricity consumption in California paints a very different picture than production when evaluating the state's progressive reputation. Unfortunately, consumption seems to be less environmentally friendly than California production, utilizing a larger percentage of fossil fuels, specifically coal. This is a result of demand outweighing supply, making it necessary to import a large percentage of its annual electricity consumption. If electricity demand continues to grow in states bordering California like it has over the past decade, importing electricity will become more expensive and less feasible. This may, however, be a blessing in disguise, as it will further encourage the proliferation of renewable electricity and its positive environmental externalities. Environmental policy must take into account demand-side trends, especially trends across sectors, in order to effectively reduce emissions.

II. Electricity Demand: Forecast of the Future

Forecasting future electricity demand is a challenging but necessary task when planning to improve a state's electricity portfolio. The sheer number of variables that affect demand is exhausting, ranging from yearly temperature trends to changes in technology over time. Due to this high degree of uncertainty, it is necessary to calculate a bracket of future demand, including a low and high estimate depending on different factor outcomes. The high electricity demand case accounts for high economic and demographic growth along with relatively low electricity prices and low self-generation rates. Vice versa, the low demand case assumes low growth rates and strong participation in efficiency programs and self-generation.

The California Energy Commission predicts that electricity consumption will increase to over 320,000 GWH by 2016. However, the annual rate of consumption growth is forecasted to fall to 1.29% between 2008 and 2016, down from 1.98% between 2000 and 2008 (Marks, 2007). This decrease in growth rate is due to several factors. First, the recession in 2008 severely impacted California's economic growth, dropping state GDP growth from 3.1% in 2006 to .4% by the end of 2008. This significant decrease will take years if not decades to reverse, causing California's electricity consumption to also lag. Secondly, relatively mild weather between 2008 and 2010 reduced electricity consumption associated with air conditioning and heating. Weather in recent years however, has proven more extreme and should be absorbed into the next round of forecasts, most likely pushing consumption upward. Lastly, California's population growth has slowed to less than 1 percent a year, down from nearly 1.5% during the 1990s (Goodridge, 2007).

The overall future trends in consumption are paralleled at the sector level, with net growth bolstered by significant increases in the residential and commercial areas over the coming decades (See *Figure 1*). Energy consumption in the industrial and agricultural sectors is forecasted to remain unchanged, staying at 42,500 and 20,000 GWh/year, respectively. On the other hand, commercial and residential energy consumption is expected to continue its increase through 2018. Here in 2012, the commercial and residential sectors consume 118,000 and 100,000 GWh/year, respectively. These numbers are expected to increase to 122,000 and 116,000 by 2018 (Marshall and Gorin, 2007).

Along with estimates for a substantial increase in yearly net consumption, the California Energy Commission predicts that peak demand will also increase, although relatively modestly. The middle case of their forecast model predicts an increase of 8-9%, from approximately 65,000MWh to over 70,000MWh by 2016. But again, the rate of growth is less than in previous periods. Unlike yearly consumption, peak demand is affected by other mechanisms. This time, the CEC specifically cites household generation, specifically photovoltaic, as a key factor in the decline in peak demand growth. An increase in self-generation using PV is predicted to be the result of decreasing technology costs and increases in government programs. Programs that encourage household PV that are currently in place include the California Solar Initiative, New Solar Homes Partnership, and the Self-Generation Incentive Program.

From a per capita perspective, the CEC predicts that energy consumption will plateau around 7600 KWh/year and begin to fall slightly over the next half decade. Self-generation will again play a large role in this trend, along with the continuing decline of California's population growth (Metz *et al*, 2012). Another major factor that has yet to be discussed is the changing behavior of consumers. Individual preferences will most likely shift as environmental initiatives become more popular, consequently increasing demand for green products, including renewable electricity. This is an important demand-side factor and one that will be discussed later in this paper.

Demand forecasts can be somewhat unreliable as they are strongly tied to trends that are difficult to predict. That being said, forecasts do provide valuable insight into demand growth under a variety of economic, demographic, and environmental circumstances. Forecasts also allude to the direction of emissions, which closely follow the trends in consumption. The environmental effects implied in these demand forecasts are certainly dire and must be addressed. Legislators should make a strong effort to understand both the methods and results of such forecasts when prescribing policies to encourage renewable electricity production and emissions reduction.

III. California Climate and Energy Policy: Goals of AB32 and Energy Implications

The United States ranks second in the world in carbon dioxide emissions, releasing a total of 6.5 billion metric tons of CO_2 per year. As the most prevalent greenhouse gas, CO_2 is directly responsible for the increased levels of thermal radiation occurring in Earth's atmosphere. California currently ranks 12th in the world among carbon emitters, above entire *countries* such as Brazil, Spain, France, and Australia (EPA, 2012). California's annual emission of 450 $MMTCO_2$ accounts for approximately 6% of United States total emissions, again falling behind only Texas. Transportation and the industrial sector are by far the worst offenders, accounting for 37.9% and 19.5%, respectively. Although in-state electricity generation only accounts for approximately 12.3% of carbon emissions, the electricity sector's share of emissions jumps to 23% with the addition of electricity imports (ARB, 2007) (See *Figure 2*). Legislators need to devise policies that effectively target both in-state and out-of-state generation.

Although the use of fossil fuels in electricity generation is relatively cheap, pricing does not take into account the environmental externalities associated with their combustion. For instance, the coal industry is responsible for a variety of different environmental hazards, from the initial mining stage to the transportation and combustion stages. Along with a host of other toxic heavy metals, coal releases a large amount of carbon dioxide, sulfur dioxide, and nitrous oxide upon combustion (Epstein *et al*, 2011). Natural gas combustion, although much cleaner than coal combustion, emits methane gas. Methane emissions amount to less than .5% of United States carbon dioxide emissions, but account for approximately 10% of the greenhouse effect (US Department of Energy, 2009). Natural gas also requires substantial infrastructure in the form of piping that poses a significant land use challenge. It is these methods that new energy legislature aims to curtail in favor of environmental responsible energy production.

California's environmental policy is complex and exhaustive, however most pieces of legislature are aimed at achieving one key goal—lowering greenhouse gas emissions to 1990 levels by 2020 and 80% below 1990 levels by 2050 (See *Figure 3*). In order to curb emissions, California legislators passed the Global Warming Solutions Act of 2006 (Assembly Bill 32). AB32 set a variety of emissions goals and supporting mechanisms across many offending sectors, including the electricity sector. First, the California Air Resources Board (CARB) mandated GHG emissions reporting for all large industrial plants, suppliers of transportations fuels, electricity providers, etc. In addition to this reporting, CARB also established a cap and trade system[3] for GHG emissions, effectively incentivizing the reduction of emissions for offenders across all industries. AB32 also targets fuel consumption in the transportation and construction sectors by mandating efficiency standards for automobiles, passenger vehicles, households, and commercial spaces. Lastly, AB32 targets the electricity sector specifically by setting a portfolio goal of 33% renewable energy production by 2020 and approximately 67% by 2050 (CEC 2011). Plans to achieve this goal involve a variety of market-based solutions, particularly programs that improve the competitiveness of electricity produced by renewable sources through incentivizing adoption of green generation technology. Along with stricter renewable portfolio standards[4], AB32 also aims to encourage "green" consumerism in the electricity sector by appealing to a variety of individual behaviors and community social norms.

AB32 relies on four, overarching measures in order to reach the 2020 and 2050 emissions goals for the electricity sector. The first is aggressive efficiency regulation with regards to energy

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3 The cap and trade system serves as the backbone for reducing GHG emissions in California. Certificates for emissions are issued and traded among offending firms depending on their offsetting needs. The number of certificates is reduced over time to incentivize cleaner technology. While experts struggle to determine the actual cost of damages associated with GHG emissions, the cap and trade system is quickly forcing the largest offenders to internalize the costs using an auction-based system. Any policy encouraging renewable energy should cooperate with cap and trade mechanisms.

4 Renewable portfolio standard simply refers to the overall percentage increase in renewable energy provided by utility companies. The goal of 33% renewable electricity in California by 2020 represents an increase in the renewable portfolio standard.

consumption. Although this is a major staple for the reduction of emissions in the transportation sector with concern to liquid fuel, this also targets end-use electricity products such as home appliances, air conditioning, and light bulbs. The second measure is the overall electrification of California's energy production. The more machines and automobiles that can run on electricity the better, as the use of electricity is far less emissions-heavy than conventional fuel, especially when produced using renewable sources. Next, AB32 aims to decarbonized electricity production while doubling supply. Sustainable technology is already available in the form of renewable source generation, but development must continue in order for these sources to become competitive. And lastly, when electrification is not a possibility, AB32 calls for other decarbonization methods for conventional energy production, specifically the use of nuclear technology as a substitute and carbon capture and storage (CCS) when the burning of fossil fuels is absolutely unavoidable.

Although electrification and decarbonization already come hand in hand for some production methods, specifically nuclear and fossil fuel with CCS, there are other drawbacks that hinder their feasibility. First, nuclear production has been and continues to be unpopular in the public eye, especially after the Fukushima disaster following the Japanese tsunami in 2011. Nuclear production not only draws questions on safety, but also poses a particular challenge in nuclear waste disposal. Both of these externalities would have to be examined thoroughly before proposing new legislation. Energy production via fossil fuels with carbon capture and storage has been shown to be fairly carbon-neutral, with some technology able to sequester approximately 80% of emissions. However, cost-effective technology is still not widely available. Not to mention, CCS requires a vast amount of underground carbon sinks and at the end of the day still relies on fossil fuels. These technologies may be sufficient options to offset some externalities associated with traditional generation methods, but neither represents a long-term solution in their current forms. Therefore, we must look to improve renewable electricity technologies and methods.

Chapter 2: Renewable Energy Technology and Market Challenges

With nuclear generation and carbon capture and storage still caught in technological and social approval limbo, renewable sources represent the most feasible choice in long-term, environmentally responsible electricity production. Renewable electricity not only represents a low-emissions alternative to conventional sources, but also brings a host of other environmental benefits. These benefits include the reduction of water consumption, noise, waste, adverse land-use, and thermal pollution. However, these benefits currently come at a premium. Technology associated with renewable electricity is fairly new and the research and development costs have proven significant. This presents the renewable electricity sector with some serious challenges within the greater electricity sector, where conventional technology enjoys a variety of economic advantages.

Renewable energy production in California currently sits at 15.2% of total production, well above the national average of less than 5%. However, this percentage must be more than doubled to meet the energy portfolio mix demanded by AB32. Currently, geothermal[5] energy accounts for 46.8% of all renewable energy produced, followed by wind (28%) and biomass (21.3%). Solar energy currently accounts for just 3.9% of all renewable energy production (Long, 2011). This chapter will outline the environmental advantages offered by renewable electricity sources before going into the market challenges faced by these budding technologies.

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[5] Geothermal energy, although clean by conventional standards, is marred by other economic and environmental issues that put its long-term feasibility in question. First, geothermal water contains dissolved solids and gases that can be very toxic. Geothermal sites have also proven to be finite, with some of the older sites in California already experiencing a significant decrease in output. Therefore, geothermal energy does not offer the same long-term potential as other sources, particularly sunlight and wind.

I. Environmental Advantages

As described in Chapter 1, conventional energy sources pose a variety of very serious environmental threats including air and water pollution, waste production, and adverse land use. These environmental impacts subsequently cause a wide range of health concerns including the increased risk of respiratory disease, heart disease, and lung cancer (World Health Organization, 1999). Renewable energy sources effectively minimize all these negative effects, while also assisting in the reduction of existing pollution.

The reduction of air pollution and greenhouse gas emissions is undeniably the greatest triumph for renewable energy. Excluding biomass, which does result in some GHG emissions, renewable energy sources eliminate the emissions of several key gases including sulfur oxides, the main cause of acid rain; nitrogen oxides, which are responsible for the creation of ground-level ozone; and carbon dioxide, the kingpin of global warming. Solar and wind are almost completely carbon neutral, only emitting harmful gases during the transportation and construction of their necessary infrastructure (Smutny, 2007).

Renewable electricity sources also result in almost no waste production. Conventional sources, especially coal, result in millions of tons of waste associated with extraction of the necessary natural resource. For example, only a small percentage of a mined area is usable coal, the rest consists of unusable ore and shale that is left behind in giant piles referred to as "spoil tips" (Epstein *et al*, 2011). Not only does wind and solar energy production avoid the extraction externalities caused by fossil fuel sources, the materials used to construct solar panels and wind turbines can be successfully recycled.

Lastly, the amount of land necessary for renewable electricity generation can be much less than conventional sources. Reducing land use is an important goal from an ecological standpoint. Mining and the construction of pipelines for oil and natural gas have displaced many species and destroyed thousands of acres of natural habitats. On the other hand, wind turbines have been found to cause almost no issues for wildlife, including bird species, and their plot size is very small in comparison to conventional plants (The National Academy of Sciences, 2007). The land-use advantages are less clear-cut for solar panel installations, which undeniably increase in cost-effectiveness as their size increases. That being said, distributed, rooftop solar panel installations *may* be the future, in which land displacement would be almost negligible. Technological advancement of photovoltaic solar panels should see this as a priority moving forward.

The environmental drawbacks for renewable electricity production are few and far between. Most negative environmental impacts are incurred during the initial stages of construction, as construction machines and vehicles are still powered almost exclusively by fossil fuels. As technology improves, even these small environmental detractors will cease to exist, leaving a process that is carbon neutral from day one. In terms of land use, although large-scale renewable installations *do* require fairly large plots of land, the acreage pales in comparison to land that is irreversibly damaged by mining. If the value of these positive environmental externalities was monetized, renewable energy would quickly become much more competitive in the energy sector. Although the California cap and trade system is starting to account for environmental hazards, the playing field is still tipped in favor of conventional energy.

II. Market Failures and Barriers to Entry

Proper examination of market failures and barriers for renewable energy is the most important aspect of effective policymaking. Market failures exist on both the supply and demand side of the electricity sector. Failures arise due to less-than-rational decision-making on the part of the firm and on the part of the consumer. Poor decision-making exhibited by the firm leads to *market failures*, while irrationality on the behalf of the consumer is identified as a *behavioral failure*. On the other hand, market *barriers* are defined as any disincentive to adopt the technology. Policies will have to design mechanisms that properly mitigate all three of these issues in order to truly encourage renewable energy proliferation.

Despite their value in terms of sustainability and emissions, renewable sources remain uncompetitive in the greater electricity market without the assistance of government programs and subsidies. For example, the cost of 1KWh of electricity produced by solar is approximately $.22, compared to approximately $.04/KWh for coal (See *Figure 4*). If the price of electricity generated from conventional sources appropriately internalized the cost of the negative externalities associated with production this price disparity would be much less (Allcott, Mullainathan, Taubinsky, 2012). However, these environmental externalities are not accounted for, causing the largest market failure in the electricity sector. This externalities market failure is then accompanied by failures associated with national security and asymmetric information.

The environmental externality market failure might seem like a rather obvious issue, but the challenge lies in quantifying the environmental impacts. Actions that affect ecological and biological processes are difficult to assess because the impacts are difficult to attribute to the source. For example, should the increase in healthcare costs associated with asthma caused by poor air quality be attributed to harmful emissions from automobiles, power plants, or heavy industry? In addition to this confusion, researchers have a difficult time quantifying the monetary cost of damage caused by emissions. The Environmental Protection Agency and the Council on Economic Advisors have examined the cost of damages caused by carbon dioxide emissions and concluded with results ranging from $5.50-72 per ton of CO_2. Other studies conducted by independent analysis groups have resulted in much higher damage costs, some totaling over $800 per ton of CO_2. Although the emissions cap and trade system has begun to account for these externalities, they still represent a major market failure in the electricity sector.

National security also creates major inefficiency in the energy market that is often overlooked. Oil and natural gas reserves are very geographical concentrated, falling in a relatively small number of countries, of which the majority are politically unstable. The United States spends a significant amount of money to ensure the security of these reserves and the steady stream of supply back to the US. This expenditure is again an unaccounted for externality of the conventional energy market. Renewable energy does not require any such security, yet its price does not reflect this convenience (Owen, 2004). Or rather, the price of conventional energy does not reflect this security *inconvenience*. Consequently, renewable energy is again under-used.

Lastly, the general lack of information concerning all the aforementioned externalities and market failures keeps the public uninformed of the advantages of renewable sources. Because renewable electricity is a relatively new industry, there have been relatively few comprehensive studies conducted. It is difficult to assess the success of the industry or its comparative advantages over conventional energy when data collection has been limited to a handful of years. Information will increase over time, but the current lack of information is affecting behavioral factors that will be difficult to reverse, a challenge that will be analyzed shortly.

In addition to market failures are inherent disadvantages associated with renewable technologies and their associated resources. The most significant intrinsic disadvantage faced by renewable electricity is its high variability (Poortinga, Steg, Vlek, 2002). That is to say, renewable technology is, and will always be, at the mercy of Mother Nature. There are hopes to mitigate variability in the future by improving energy storage technology for renewable electricity, but it remains a major flaw until then. As long as this disadvantage persists, investors will be faced with some added risk, a serious detractor when encouraging capital flows into the industry.

Increased variability leads to a second intrinsic disadvantage in an unreliable load-balancing schedule. Using conventional sources, utility firms can produce power exactly when it is most needed, specifically during peak demand hours in the late afternoon when air conditioning and appliances are being utilized. Renewable sources don't necessarily follow the load trends during a given day and the technology necessary to store such electricity for later deployment has yet to be perfected. This poses a serious challenge for utility companies, who *must* be able to supply enough electricity at all hours of the day. California residents may recall the electricity crisis of 2001 that resulted in massive rolling blackouts and lead to the bankruptcy of Pacific Gas and Electric and the near-bankruptcy of Southern California Edison (Goyette, 2011). Although this shortage in supply was the result of external factors, this crisis exemplifies the pressure under which utility companies are to meet demand. These issues of uncertainty posed by renewable electricity represent long-term and even permanent challenges.

Lastly, the most significant *barrier* to entry in the renewable energy market is simply the high technological cost (See *Figure 4*). The technology associated with each renewable source is relatively new and therefore expensive. Learning-by-doing and economies of scale will help reduce the cost, but at the expense of time (See *Figure 5*). Learning-by-doing refers to the increase in productivity that comes naturally after repeating a process over and over again, i.e. the more solar panels a construction worker installs, the better he gets at it. On the other hand, economies of scale refer to the increase of productivity that comes with expansion, i.e. larger solar installations are more cost-effective than smaller installations because the fixed costs are divided by a larger amount of panels. As technology develops and installation methods are perfected, renewable sources will certainly become more economically viable (Beck, Martinot, 2004). However, this growth must be actively incentivized now in order to ensure its cost-effectiveness in the future when resources for conventional energy run scarce.

The market failures, inherent disadvantages, and entry barriers that currently exist in the renewable electricity market pose significant challenges for the growth of the industry. Some of these issues are being addressed by current policies; others will slowly fade as conventional resources become more scarce and unsustainable. However, the speed at which these issues are addressed is a problem in and of itself and must be expedited by further policy and more stringent regulation. To make matters worse, many of these failures and disadvantages are compounded by behavioral factors. Consumers, like firms, often do not behave in the rational manner that theory suggests. It is important to analyze these behavioral factors and their effect on the growth and implementation of renewable technologies.

III. Behavioral and Social Challenges

Another significant challenge associated with moving California towards a greener future is encouraging the necessary shift in public opinion. Any given program may in fact introduce the appropriate mechanism to drive the production of renewable electricity, but it must be framed in a way that captures the positive behaviors of the average consumer and attracts their participation. "Green" consumerism has certainly improved over the last decade as people continue to demand cars with better gas mileage and water bottles with thinner plastic. However, the reasons for this increase in demand are sometimes misguided. For many consumers, better gas mileage is simply a way to alleviate pain at the pump, rather than a means to reduce emissions and curb global climate change (Litvine, Wustenhagen, 2011). The effects of many incentive programs, particularly subsidies such as the feed-in tariff, and the adoption of renewable electricity are much less cut-and-dry, making it even more difficult to encourage adoption. A successful policy concerning renewable energy should not only appeal to consumers' wallet, but also to their conscience.

The adoption of innovative products, including green electricity, can be framed in five steps. These steps concern cognitive and behavioral factors and how they affect an individual's decision to participate in a pro-environmental behavior or not (Diaz-Rainey, Ashton, 2010). Step one is the gathering of knowledge on an environmental issue and the innovative technology that is supposed to address it, or rather the general improvement of environmental awareness. Step two is the formation of an attitude towards the technology. Step three is the resulting decision to either accept or reject the technology. And lastly, step four and five concern the actual implementation of the technology and the confirmation of its effectiveness. Successful policy should guide the consumer through these steps to ensure the greatest chance of actual implementation and the subsequent establishment of strong social norms in favor of environmentalism.

Encouraging Awareness Before Action

Green consumerism is only possible when consumers adopt a greater sense of environmental awareness. This awareness does not only stem from knowing an issue exists, but also from understanding the causes and effects behind its existence and the possible actions that might be taken to curtail its consequences. There are many factors that affect an individual's environmental awareness, some more influential than others. Researchers have explored the effects that knowledge and information have on improving this awareness. Studies have also proposed links to human rationality and moral obligations, both of which seem to be strong influencing factors.

Environmental knowledge can be broken down into several different types, each with its own effect on an individual's actions. The first and simplest form of environmental knowledge is factual knowledge, or the understanding of relevant definitions, mechanisms, and causes of environmental problems. After this comes procedural knowledge, which refers to the awareness of possible actions and behavioral factors associated with environmentalism (Tobler, 2011). Although both these forms of knowledge seem like significant factors in pro-environmental behavior, studies have shown that even this level of knowledge has moderate effects on actual participation. The pinnacle of these two types of knowledge is effectiveness knowledge, which refers to the understanding of the relative effectiveness of different actions seeking a certain outcome. This type of knowledge requires both factual and procedural knowledge, yet also is found to have a relatively weak relationship with pro-environmental behavior. Researchers surmise that this relationship is hindered by the difficulty to match knowledge across all three types. That is to say, an individual might be aware of the facts and solutions concerning a given issue, but not necessarily the effectiveness of the solutions. Feed-in tariffs will have to take into consideration all levels of knowledge, or lack thereof.

In terms of climate change, studies show that the majority of the population knows relatively little about its causes and consequences. First and foremost, there seems to be general confusion surrounding the difference between weather and climate, with individuals often using the terms synonymously or even in the reverse. The confusion increases as the idea becomes more specific, such as the facts surrounding ozone depletion or the role of greenhouse gases in climate change. Although consumers can be motivated without completely understanding the mechanisms behind global climate change, this does pose a significant challenge.

Two other models have been developed in accordance to environmental awareness, one associated with rationality and the other morality. The first model concerns ecological behavior, or human's inherent use of logic in decision-making. This model states that an individual will act pro-environmentally if the action is framed by incentives, such as monetary savings, and consequences, such as health costs associated with pollution (Osbaldiston, Schott, 2011). The only drawback to this model is that it is perhaps too optimistic of our ability to be rational. We often make decisions that go against the supporting evidence. The second model, called the value-belief-norm, comes from an ethical approach, examining morality and its effect on pro-environmental behavior. Researchers point to our awareness of our effects on a fragile biosphere and the sense of responsibility that accompanies it. Intergenerational equity also plays a role, as humans tend to want to leave a better world for the next generation, namely their children. This model also falls a bit short in explaining environmentalism, as recent economic worries have eclipsed moral obligations under certain circumstances.

It is clear that environmental awareness is achieved through a variety of different factors involving both knowledge and intrinsic cognitive functions, and that each individual will be differently affected by these factors. Consequently, pro-environmental behavior is the result of acting on any combination of information or emotional and social thought processes. Because there is such a wide variety of motivating factors across individuals, it is difficult to design a campaign that appeals to a majority of the population. Policymakers should make a point to determine which factors have the most effect on the local population, especially for policies as specific as a feed-in tariff for renewable electricity.

Attitude: Reversing Negative Perceptions and Framing Benefits

Two of the most popular, and therefore most difficult to reverse, consumer perceptions towards renewable technology are that it is too expensive and that it is less functional than existing technology. The first perception is caused by the consumer's failure to properly consider all the costs and benefits associated with renewable energy technology, specifically the social benefits. The second perception is due to a general lack of understanding stemming from the environmental awareness factors described above. In terms of framing a green product, such as photovoltaics, it is important to frame their value not only in terms of functionality, costs, and expected outcomes but also in terms of the consumer's identity, image, and social norms within the greater community.

The consumer's failure to fully analyze the costs and benefits presented by renewable electricity, and the resulting perception that the technology is too expensive, is a result of his or her bounded rationality (Ozaki, 2009). Bounded rationality is a psychological theory that states that human's decision-making abilities are hindered by limited information, limited cognitive abilities, and the finite amount of time they have to make any given decision. It is undeniable that the costs and benefits surrounding green energy are complex and sometimes difficult to discern altogether. Economic costs are difficult to determine due to the industry's dynamic nature and the speed at which the market responds to fluctuations in demand for and supply of conventional electricity. On the other hand, the social costs and benefits of green electricity are even harder to quantify. The monetary costs of avoiding greenhouse gas emissions are a contentious subject, as are the health costs associated with poor air quality. The average consumer does not have the ability to crunch all these numbers, often leading to inaction when faced with the decision to adopt green electricity.

The second perception, belief that green technology is not as functional or reliable as conventional technology, is the result of our limited attention. Similar to bounded rationality, limited attention is our psychological tendency to lose interest in a subject over time and as the complexity of the subject increases. In addition to our inability to fully consider the costs and benefits of renewable technology, we tend to be intimidated by the sheer size of environmental issues and the complexity of the solutions that have been proposed (Masini, Menichetti, 2010). The Earth as a biosphere is as dynamic as it gets, involving ecological systems that take experts decades, if not centuries, to fully understand. It is no surprise that the average consumer often chooses to maintain his or her blissful ignorance.

In terms of solutions and technological advancement, consumers perhaps find solace in the relative simplicity of existing methods and technology. The processes necessary in creating energy from fossil fuels are fairly straightforward—coal is burned, water is heated, steam turns turbine, television turns on. We tend to lose our attention when faced by the more technical explanation of photovoltaic solar systems for example, which rely on processes that are much less "physical" than those associated with fossil fuels. This xenophobia could be combatted if the benefits of renewable technology were better (i.e. more simply) framed.

The perceived benefits of adopting green energy can be broken down into two categories: utilitarian and psychological. Utilitarian benefits are most closely associated with traditional decision-making; or rather the perception that a green product has additional benefits, and that if these benefits outweigh the cost premium of the product the consumer will adopt the technology. In the case of renewable energy technologies, many consumers rightly believe that green energy decelerates climate change and reduces pollution and energy dependency (although they don't necessarily understand the science behind it). However, despite this positive outlook on renewable electricity, the negative perceptions described above outweigh the willingness to pay this premium. Another significant drawback is that utilitarian benefits of renewable energy are difficult to see on the individual level, as noticeable environmental results are really only achieved once there is collective participation. This factor is particularly difficult to overcome at the individual level no matter how a policy is framed, as it simply relies on the participation of a larger group.

The psychological benefits are more tailored to the individual and include the "warm glow effect" and self-expression benefits. Unlike utilitarian benefits that are only realized after significant, community adoption of a green technology is achieved; warm glow effect is simply the individual's psychological response to positively contributing to a common good. Some of this response can be attributed to altruism. However, the warm glow effect also suggests that some consumers are willing to buy a premium product not because of its environmentally positive impacts, but because it makes them feel better about themselves (Hartmann, Apaolaza-Ibanez, 2012). This positive psychological response is seen in other pro-social behaviors, such as donating to charity and volunteering. Although it may be argued that pure altruism is more ethical, the results are the same, therefore good policy should target both.

Self-expression benefits refer to an individual's status projection within a group or community. Here, the satisfaction comes from signaling to community members by making decisions and taking actions that are deemed as positive by established social norms. Consumers make signaling purchases all the time, from sports cars to designer clothes. Renewable electricity generation is symbolic of the individual's environmental awareness and sense of responsibility, two desirable social norms. However, consumers make signaling purchases because they perceive the benefits to outweigh the costs. Although being responsible and environmentally aware might both be desirable, for many the costs are simply greater than the expected utility. Policies should aim at increasing this perception of utility in order to tip the scales in favor of adoption.

Evoking these benefits is the key challenge for a successful campaign for green electricity proliferation. Establishing a positive attitude by reversing current perceptions will of course be difficult, due to behavioral factors such as limited attention and bounded rationality, but certainly not impossible. Policies should be able to address cost through technological advancement on the supply side while also improving consumer perception and willingness to pay. Policies should first target behavioral factors at the individual level, before pursuing the psychological benefits of being part of a larger participation group. However, increasing the perceived utility of renewable electricity is not enough, the adoption process itself must also be framed as a positive, or at least manageable, experience.

Adoption and Implementation: Acting on Attitude

Studies have found that consumers, even those that identify themselves as "green thinking," often do not adopt new technology despite claiming a willingness to pay a premium for green products (Jacobsen, LaRiviere, 2012). This discrepancy is caused by the belief that the adoption process is too inconvenient. Although this is partly true, a fact that will be addressed later in this paper, this perception must be reversed to ensure participation when the adoption process *is* eventually streamlined. Even if the perception of inconvenience did not exist, many consumers admit that they are hesitant to be the first to adopt, and that they would be much more willing to take the plunge if the norm was already established. Renewable energy policy will have to devise a scheme to induce the proverbial “snowball effect” in order to increase adoption of the technology.

The current processes necessary in adopting renewable electricity technology *are* less than convenient. The application process, especially in the state of California, is time consuming, both to fill out the initial paperwork and for the paperwork to be correctly processed. Information is not readily available on either the specific eligibility requirements or the transition process itself. All of these issues are compounded by limited time, causing even the greenest consumer to abandon the adoption process. These inconveniences all chip away at the perceived benefit of adopting the technology. So even though a great deal of consumers say they would be willing to pay a premium for environmentally-friendly products, when actually faced with transition costs the adoption rate falls dramatically.

The lack of strong, specific social norms also tends to hinder adoption rates for renewable technology. A qualitative study conducted by Ozaki found that, despite believing in the positive effects of renewable energy, consumers were often hesitant to be the first of their respective communities to adopt. Other studies examining social norms have found that fluid adoption does not take place until 10-25% of the local population has adopted the technology or product. For example, only .6% of California households have been equipped with photovoltaic systems, perhaps a reason for, and not just a result of, the stagnant adoption rate. When coupled with a perception of inconvenience, this hesitation can easily tip the scales against adopting the technology. Some programs, including those part of the California Solar Initiative, have been implemented to entice adopters in the short-term by offering upfront financing assistance on renewable installations. However, programs that target adoption through long-term assistance, such as a feed-in tariff, should be just as convincing if framed correctly.

Nowhere has technology adoption through social norms been so dramatic than the proliferation of online social media over the last decade. The adoption rate for media outlets such as Facebook, Twitter, and Google+ are significantly exponential, clearly exhibiting a quintessential snowball effect[6]. In fact, the effect is so strong that Google+ reached 10 million users in just 16 days, as it was strongly framed as superior to the industry leader, Facebook. Social media outlets become more valuable and productive the more users they receive. The same is true for renewable energy, as evidenced by the growing presence of utilitarian benefits as adoption increases. There is now a social stigma associated with those who do not participate in social media; successful energy policy should try to create a similar perception in regards to conventional electricity.

Barriers to adoption create a very specific group of actual adopters, whose demographics might actually be a discouraging force for other consumers considering adoption. There are two large groups that remain after all the current barriers have been experienced: consumers with significant, expendable income and consumers who value pro-environmental behavior extremely high (Roper, 2003). The first group sees the economic cost of adoption as very small in comparison to their wealth and is, regrettably, fairly homogenous in terms of ethnicity. The second group, arguably an even smaller segment of the population than the first, views the benefits of pro-environmental behavior so highly that the premium is almost negligible. Both of these groups represent distinctive minorities, causing other segments of the population to feel alienated from the cause, and therefore made even less likely to adopt the technology. An effective policy should strive to encourage a diverse group of adopters to ensure that segments of

[6] The snowball effect is closely related to Metcalfe's law, especially in regards to networks. Metcalfe's law states that the value of a network is proportional to the square of the number of connected users. For example, two Facebook users can only make one connection, but 5 users can make 10 connections and 10 users can make 66 connections. Adopting renewable energy is not explicitly part of a network, but the adoption rates would parallel this idea with the establishment of strong social norms.

the population are not disenfranchised by the formation of strong environmental norms in minority groups.

Solidifying Social Norms

Not only does solidifying a specific environmental social norm improve the adoption of that specific technology or habit, it improves the likelihood of other environmental practices becoming norms as well. Studies show that individuals who already have habits within an overarching ideology, such as environmentalism, are more likely to continue picking up habits that fall under that category than those who do not already exhibit any of those habits (Egmond, Jonkers, Kok, 2004). For example, consumers that purchase high efficiency light bulbs are probably more likely to adopt renewable electricity than consumers who don't buy efficient light bulbs.

Reaching the 10-25% threshold at which a social norm begins to take hold also has positive effects on technological advancement and, of course, the associated utilitarian benefits. In terms of renewable energy, a significant increase in adopters leads to a significant increase in demand and capital flowing into the market. As described in the economic section above, this influx increases competition within the renewables market and, subsequently, increases competition in the greater electricity sector. As discussed, utilitarian benefits can be a strong influence, but only if the benefits are relatively easy to discern. Reaching the social norm threshold would create a positive feedback loop, in which the utilitarian benefits would become more distinct, leading to an even greater number of adopters and further strengthening the norm.

Chapter 3: Criteria and Theoretical Framework for Successful Policy

I. Distribution Type

The first thing that must be considered in creating policy is the desired type of renewable energy infrastructure, distributed or utility-scale. Until recently, wind and solar installations have taken the form of very large, concentrated systems. These systems require large amounts of surface area, leading to their construction out in the deserts away from the more populated areas of California. These systems, despite taking advantage of the economies of scale associated with large installations, do pose economic challenges that reduce their feasibility. On the other hand, distributed rooftop systems tend to represent a more flexible installation option. And although the cost per KW is higher, distributed installations benefit from a variety of other economic and environmental aspects.

First, large installations require a considerable amount of land. A newly proposed solar installation in the Mojave Desert is expected to cover nearly 4,000 acres. This will be the largest installation in California history and will have a capacity of approximately 550MW. That being said, several other large installations are currently being completed or have been proposed for the future, which will undoubtedly cause the displacement of thousands of more acres. Although these installations pose few threats in terms of pollution[7], they do run the risk of disrupting ecology systems, including the destruction of habitat for species living in the area. Many desirable areas for renewable electricity installations also coincide with valuable agricultural land, which will more often than not take precedence.

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[7] Large solar installations do require a fair amount of water in order to properly clean the panels. This cleaning process may introduce some contaminants into the water supply. However, very few studies have addressed this question so the effects are generally unknown. One can surmise that the amount of water pollution certainly depends on what cleaning chemicals are used in addition to water. Water requirements can also introduce maintenance costs to the project that vary depending on the location of the installation.

Large installations also decrease feasibility due to the added transportation costs. The Mojave Desert may be abundant in sunshine, wind, and land but it is geographically distant from demand. This added distance increases cost in two categories. First, the added distance significantly increases transportation costs for the necessary construction equipment. Apart from being costly, the transportation of the renewable technology is by far the most environmentally destructive aspect of the installation from an emissions standpoint. Secondly, increasing the distance between supply and demand poses several energy transfer challenges (Evans, 2011). Good connection to the grid is imperative to maximize efficiency and reliability, two key aspects that are already a challenge for renewable electricity. The physical infrastructure necessary to connect to the grid, including advanced transformers, additional power lines, and specialty meters, is expensive and often incurred by the utility company, further decreasing the incentives for investing in the renewable technology.

Lastly, large renewable energy installations tend to run into more permitting and regulation issues than small, distributed systems. The lands on which these installations are generally built are often designated agricultural or protected wildlife lands. Changing the necessary zoning regulations can be time consuming and costly. In addition to zoning and general plan provisions, plans for large installations must also be wary of agricultural groundwater rights as well as cultural and visual regulations that might be in effect. Not only does abiding by these various regulations make planning more tedious, the necessary permits and associated paperwork can be costly and very time consuming.

For example, several projects in the Mojave Desert where delayed for months due to legal battles activated by environmental groups and Native American tribes. The environmental groups asserted that the installations would irreversibly damage the ecology of the desert while the Native American tribes sought to protect ancient cave paintings and other spiritual sites located in the area (Helmore, 2012). Installation developers fought back, claiming that losing even 1/10th of the necessary land would leave the project economical unviable, revealing how thin the profit margins are for even the largest of projects. Regulatory issues such as these run the risk of discouraging investors, especially if they persist over the course of months.

In comparison, distributed renewable energy systems effectively combat all the aforementioned issues, while only facing a few challenges of their own. Distributed systems do not require nearly as much land, in fact, distributed systems usual occupy land that has already been developed, such as the case of rooftop solar panels. Small systems rarely displace land that would otherwise be used for a different purpose. Secondly, distributed systems are often located where demand is highest. Rooftop solar panels can provide energy for the house or commercial structure that it is built upon. If the energy is to be sold to a utility, small installations are more often than not located within the existing grid, reducing the cost of the energy transfer and the necessary infrastructure. Lastly, distributed systems have to jump through far fewer regulatory hoops than utility-scale operations. This is mostly the result of the land use advantage, but is also due to the fact that residential zoning already gives homeowners the right to take advantage of incident sunlight on their property.

The only significant disadvantages to distributed renewable energy systems concern cost and ownership. As mentioned before, the cost per kilowatt of capacity is significantly higher for small-scaled installations, as they fail to take advantage of economies of scale. The actual installation of the panels represents a large portion of the initial cost, which fails to be displaced because of the project's small size. In the long run however, as the construction costs are absorbed, per KWh cost begins to align with large-scale production costs. Utilities are also less likely to invest in distributed production because ownership remains in the hands of the household or commercial business. Large-scale installations are owned and controlled by utilities, ensuring that any decisions made are made to benefit the utility firm. Although both of these issues fall in the favor of utility-scaled installations, the overall benefits of distributed systems seems to take the upper hand.

Distributed renewable energy systems effectively avoid the economic and political issues faced by utility-scale installations. Although distributed systems have a few drawbacks of their own, they certainly represent the future of renewable energy production as land becomes scarcer and technological costs decrease. This is not to say that doing away with plans for large-scale systems is also the correct response, as diversity of generation is a valuable characteristic of a stable and reliable electricity grid. However, the time and space necessary for constructing large-scale projects simply do not coincide with the goals set forth by AB32. Existing utility-scaled projects contribute a significant amount of renewable energy, but the remaining supply gap must be filled primarily by distributed sources.

II. Policy Criteria for Encouraging Distributed Renewable Energy

When addressing existing policies or devising new policies, it is important to approach the problem using a consistent lens. Using explicit criteria is especially useful when dealing with complex issues, a category that renewable electricity growth certainly falls under. Criteria allow decision makers to discern key differences between policies, particularly by highlighting each policy’s respective benefits and disadvantages. There are an infinite number of ways to devise policy that encourages the production of renewable energy; therefore the appropriate set of criteria must also be extensive.

- First, the policy must be effective. Effectiveness can be measured by simply examining the increase in gross capacity of the renewable electricity technology. This measurement only concerns capacity and is blind to cost. Not only should a policy be effective, but it should also be effective in a responsible way. In other words, policies that are *over* effective can lead to unforeseen negative effects that may compromise the entire program.

- Next, a policy should be *cost*-effective. This measurement concerns the overall cost of the policy divided by the capacity of the resulting technology. This criteria point is particularly good when comparing two policies side-by-side. Policymakers should be savvy to consider both monetary and social costs in this analysis. Although some social costs (or benefits) are difficult to quantify, as is often the case for environmental products, they can often be the most significant aspect of a project.

- Successful policy should consider both short-term and long-term assistance. Depending on the size of the project and the type of producer, policies should cater to their most pressing financial needs, whether they be the upfront costs of installation or the cost of production over time.

- Renewable energy policy should mitigate uncertainty in the market. Incentive programs should create a stable investment atmosphere that fosters significant, financial involvement. Just as in any other market, prospective investors are deterred by risk. The more certainty a program can promote, the better. In addition, policy should ensure that existing firms in the sector, specifically investor-owned utilities, are not unfairly burdened by any remaining risk.

- Another important market characteristic that policies should strive for is efficiency. Policies should aim to minimize transaction and other processing costs in order to streamline adoption. Transaction costs may include administration fees, permit fees, or the actual infrastructural costs of adopting renewable energy. Minimizing these costs also ensures that a greater percentage of investment funds go directly to development and technological research. Efficiency can also refer to the proper accounting of any externalities associated with the electricity sector, both from conventional and renewable sources.

- Next, policy goals and mechanisms should be transparent. Although mechanisms might be fairly complex, information must be available for those who demand it. All costs must be accounted for and available to the public. Transparency is also important in terms of behavioral factors. Improving access to reliable information will hopefully convince those who may be on the fence in their adoption decision.

- A long-term criteria goal for renewable energy involves market conformity. Market conformity is the creation of a mature, stable, and competitive market. Policies assisting the proliferation of renewable energy, even long-term policies, must have a well-thought-out exit strategy that leaves renewable electricity producers able to compete on their own with conventional sources.

- Another persistent criteria point is the continual incentivizing of technological development. Policies should not only encourage pure capacity growth, but also continuous development toward more efficient and lower-cost technology. Technological advancement will greatly increase the chances for market conformity as programs expire.

- Lastly, policies must be cognizant of behavioral factors and social norms. Understanding these factors will assist in creating a policy that has significant consumer appeal. Consumer behavior can be targeted in two ways: information availability and framing. For many consumers, simply being educated on the problem and the proposed solution is enough to win them over. For those that need further convincing, framing information in a way that appeals to certain behavioral factors can be very effective.

This set of criteria encompasses the most important characteristics of a successful renewable energy policy. It is with this lens that I will evaluate the qualities of a feed-in tariff system. However, before delving into policies in the real world, it is important to understand their theoretical properties.

III. Theoretical Framework

In order to create successful policy, decision-makers must consider the market failures and behavioral factors outlined in the previous chapter, as well as the costs and benefits of a distributed system. Although the ideal, theoretical policy will not be perfectly applicable in the real world, it is an appropriate place to start in order to understand some of the underlying economic mechanisms that exist in the market. As a fledgling industry, the renewable electricity sector must be protected from the competitive nature of the greater energy sector. The two most popular policy options are a subsidy and a tariff. A subsidy is assistance paid to a business or industry by the government or other supporting body in order to prevent the decline or closure of the business due to persisting unprofitable operations. A tariff on the other hand, is a tax or duty employed on a certain industry or product, effectively lowering its competitiveness. Successful policy might include aspects of both a subsidy and a tariff to achieve the desired outcome.

The key goal of a subsidy is to lower the price of the product for consumers while raising the price received by producers. Traditional subsidies are typically financed by the government through taxes. The subsidy effectively shifts the supply curve to the right, increasing supply and lowering the price experienced by consumers. The producer then receives the price paid by consumers plus the subsidy, resulting in a price that is higher than the previous free-market equilibrium (Batlle, 2011). The gains by the consumer and the producer depend on the slope of the supply and demand curves. Producers will tend to experience larger gains than consumers due to relatively inelastic demand (seen as a steep demand curve). Energy is a necessity good, meaning that changes in price will have little impact on demand in the short-term, the definition of inelasticity. However, demand in the long-term may be more sensitive to price.

Several studies have been conducted to elicit the price elasticity of demand for electricity, most concluding that it depends on the responsiveness of the utility company. A survey of residential demand found price elasticities ranging from -1.25 to -2.57 (Lafferty, 2001). This fairly wide range is the result of time-of-day considerations, with elasticity at its lowest during peak demand hours. On the other hand, price elasticities found for commercial customers were much tighter and more inelastic, ranging from 0 to -.47. This is intuitive, considering the fairly consistent electrical needs of commercial buildings. Price elasticity depends strongly on the responsiveness of utility companies. Utilities that use a fixed price tend to see more inelastic demand curves, while utilities that use dynamic pricing, such as hourly adjusting, experience more elastic demand curves. Here in California, most utilities provide dynamic pricing options. Although elasticity is still quite low, price changes should be kept within reason so as to avoid significant changes in demand and to ensure renewable electricity producers are well supported. This is especially important in the long run, as time allows consumers to substitute away from a good if they experience significant price increases.

Although a subsidy undoubtedly benefits the receiving industry, it comes at a cost. The gains by both producers and consumers come at the cost of government expenditures. This number can be quite substantial depending on the size of the industry and how high the subsidy must be to effectively protect it. The renewable energy sector is a relatively large sector and only becoming more so. The subsidy necessary to protect renewable electricity, especially for solar technology, will also be significant. In addition to the high gross cost of a subsidy, the cost-benefit ratio is not 1:1. That is to say, the costs are not perfectly offset by the benefits. A subsidy introduces a fair amount of deadweight loss, which refers to the difference between the total cost and the combined market gains of producers and consumers (Eichner, Runkel, 2010). Deadweight loss is almost unavoidable when market regulations are adopted, however they can be a deciding factor in the adoption of a subsidy and must be properly considered.

In contrast to a subsidy, a tariff is aimed at reducing the competitiveness of a specific industry, in this case the conventional electricity sector. Opposite of a subsidy, a successful tariff increases the price paid by consumers while decreasing the price received by producers. The difference of these two prices is equal to the size of the tax. These prices are the result of a leftward shift of the supply curve, moving it upwards along the demand curve (Lesser, Su, 2007). This time, again due to the elasticity of demand, the brunt of the tax burden will fall on consumers. Although demand is relatively inelastic, large price changes due to the tariff burden *will* affect demand.

Instead of costing the government, a tariff increases revenue equal to the number of products sold multiplied by the size of the tax. This would be a significant amount of money considering the size of the conventional energy market. This added revenue could be used to invest in renewable energy programs or in other government obligations. However, as with a subsidy, a tariff still creates deadweight loss in the market. Politically, a tariff is difficult to gain support, as it is more or less a tax. On the other hand, a traditional subsidy, although not a tax itself, requires taxes for funding. Therefore, the issue lies in creating a policy that is as close to budget-neutral as possible.

IV. The Feed-in Tariff: A Budget-Neutral Subsidy

A feed-in tariff is best viewed as a combination of a subsidy and a tariff, in the sense that the subsidy is financed by the competitive industry instead of the government. In a feed-in tariff system, utilities are required by law to enter purchase agreements with renewable electricity generators. A feed-in tariff causes the supply of renewable electricity to shift right, just as a subsidy would, while at the same time causing a leftward shift in supply of conventional electricity, like a tariff (Rio, 2011). In theory, a feed-in tariff not only fosters technological development but also mitigates the risks associated with investing in the renewable sector. An ideal feed-in tariff also has a natural exit strategy, phasing out as the new technology becomes more competitive with conventional technology. Lastly, the utility companies bear the extra cost associated with renewable electricity production, effectively internalizing their negative externalities and financing the tariff without government funding.

Mitigating Risk

In theory, a feed-in tariff effectively addresses the risks inherent in the renewable energy market described in Chapter 2, those being price, volume, and load balancing. Price is perhaps the most important risk factor to mitigate, as it has the most significant market implications. Feed-in tariffs employ long-term contracts, typically 20 years, which promise minimum per KWh payments to renewable electricity generators. These payments adjust annually according to predetermined degression rates. Price degression works within contracts as well as across contracts over time. Within a specific contract, the renewable energy producer agrees to a fixed, annual degression rate[8] over the life of the contract. This rate is usually designed to maintain a 4-5% return of investment each year. Across contracts, the starting tariff price is lower for newer contracts, as they presumably have access to technology that is better and more efficient than technology employed by earlier contracts. (Shrimali, Baker, 2012). Both the longevity of the contract and the fixed degression rates provide stability for prospective investors, allowing them to calculate precisely how much energy a project must produce in order to experience a profit.

Secondly, feed-in tariffs do away with most all the risk concerning volume. Along with guaranteed pricing, feed-in tariff contracts also ensure that generators are compensated for any amount of electricity they wish to sell. Renewable electricity generators can enter contracts that stipulate the complete purchase of all energy produced by the installation. On the other hand, generators can also choose to sell only the surplus in electricity after their own power needs have been met. In the event of underperformance by a renewable electricity generator, a feed-in tariff can impose a penalty, allowing utilities to purchase renewable electricity elsewhere in order to

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8 Fixed digression rates are typically based on technological development forecasts and demand forecasts based on conventional electricity. Although fixed rates do mitigate risk for those entering contracts, they do run the risk of being incorrect due to poor forecasting or unforeseen circumstances in the market. If the degression rate turns out to be too low, the renewable energy producer reaps the benefit and vice versa.

meet their renewable portfolio standards (California Energy Commission, 2010). These contracts provide certainty for both the renewable electricity producer and the utility company.

Lastly, feed-in tariffs can eliminate the risk of load imbalances for investors altogether by placing the load-shaping burden on the utility. Although this presents a challenge for the utility company, conventional wisdom asserts that the more capable of the two parties should bear the responsibility. In this case, the utility has the physical and analytical wherewithal to address load-balancing issues, whereas the individual renewable electricity producer does not. That being said, a tariff may employ a price schedule that reflects trends in daily demand, i.e. paying higher tariff prices for electricity generated during hours of peak demand (Couture, Cory, Kreycik, Williams, 2010). This somewhat protects the utility companies by incentivizing generators to development technology that will increase the load-following ability of renewable electricity.

Technology Development and Exit Strategy

Feed-in tariffs offer the flexibility necessary to assist all types of technological development. Contracts can be tailored to any type of renewable energy, ensuring the long-term development of technologies across the board. This is particularly effective in states and countries that have a wide variety of renewable sources available. The pricing mechanism necessary to foster growth across technologies can be complex, as the construction and productions costs differ greatly among sources. However, source diversity is a valuable portfolio characteristic and will only become more so in the future. Therefore, it would be irresponsible to allow technological growth to stagnate for any particular source.

Feed-in tariffs naturally encourage technological development before phasing out completely as competitiveness is achieved. This is another outcome of the fixed degression rates included in the contracts. As the feed-in tariff degresses, generators have the incentive to increase efficiency (Lesser, Su, 2007). As described in Chapter 2, renewable energy technology will begin to benefit from productivity gains stemming from learning-by-doing and economies of scale. Degression rates promote these productivity gains while also protecting utilities from overpaying for tariffs. The idea is that, in the long run, tariff prices will regress to zero just as renewable energy technology becomes competitive with conventional technology.

Financing and Other Political Advantages

Ideally, the price of purchasing a cap and trade certificate to offset emissions is equal to or greater than the price of the feed-in tariff, causing the utility companies to finance the full cost of the tariff. For example, if the price for an emissions certificate is $100 and the cost of offsetting the same amount of emissions by employing renewable energy is a certain fraction of that, the choice is an easy one. If the costs for these two abatement strategies are equal, the utility company may certainly choose to simply purchase certificates out of convenience. Therefore, it is imperative that the feed-in tariff is promoted in other ways, such as limiting the use of certificates or decreasing the supply of certificates overall, effectively raising the cost of that abatement strategy.

Aside from the economics, which seem advantageous in theory, a feed-in tariff system has several key characteristics that make it feasible from a policy perspective. First, a feed-in tariff establishes a uniform system across all utilities within a country or state. The tariff is mandated by law, demanding that utilities use the same criteria when considering contract proposals from independent generators (Butler, Neuhoff, 2008). At the same time, a feed-in tariff can be designed with certain flexibilities that protect utilities. For instance, utilities may not be obligated to honor *all* contract proposals. Instead, utilities can work towards their renewable capacity goals by selecting the most competitive independent systems. This not only maintains some level of competitiveness for conventional utilities but also encourages renewable electricity generators to be as cost-effective as possible. Also, in an ideal world, a feed-in tariff represents a budget neutral approach to renewable energy promotion. This is an extremely beneficial characteristic from a political standpoint, considering about half of the United States' population prefers that the government stays out of the free market and reduces spending overall.

Unfortunately, economic and behavioral theory does not necessarily parallel real world causes and effects. Ideally, successful feed-in policy would address *all* of the issues outlined above, however the sheer scale and variety of some challenges will make this nearly impossible. Therefore, it is important to examine the various characteristics of feed-in tariffs as they exist in the real world and compare them to those of other policy options. Many countries around the world have deployed feed-in tariffs and we can look at the characteristics of California's own policy, which is in its early stages.

Chapter 4: The Feed-In Tariff and Other Policies in the Real World

I. Alternative Renewable Electricity Policies

AB32 provides the necessary framework and goals necessary for reducing California emissions over the coming decades, including the valuation of greenhouse gas emissions and the internalization of their associated costs using the cap and trade system. AB32 does not however, provide any programs specifically aimed at encouraging renewable energy production. Current programs that are designed to encourage greater energy efficiency and the development of renewable sources, in addition to the feed-in tariff, include the New Solar Homes Partnership (NSHP), the California Solar Initiative (CSI), property tax exclusions, and Property Assessed Clean Energy (PACE) financing. Each of these programs is designed to target different projects based on size, cost, technology, efficiency, and output. Most programs target the initial cost of installing renewable electricity systems, while others target the production of electricity over time. Most of these programs are relatively new and still require a great deal of analysis, however they certainly represent a step in the right direction for renewable electricity generation and lower emissions in the future.

Most renewable electricity policies target the cost of the initial construction. This is due to a large disparity between construction costs and production costs between conventional and renewable electricity producers. Traditional electricity sources are characterized by low construction costs and relatively high production costs. That is to say, it is fairly cheap to build a coal power plant relative to the actual production of electricity. On the other hand, renewable sources are characterized by high construction costs and very low generation costs (EWEA, 2005). If government programs could incentivize small businesses and households to invest in renewable energy systems by assisting with construction costs, the cost-efficiency and general deployment of renewable source electricity could increase considerably.

Programs underneath the California Solar Initiative, including the New Solar Homes Partnership and some property tax exclusions, aim to reduce the initial construction cost burden experienced by solar self-generation systems. Current PV systems cost approximately $6.75 per watt, with the majority of that figure being labor and installation costs. The New Solar Homes Partnership provides rebates of $2-2.90/watt depending on the type of project and technology. The higher rebates are reserved for projects involving affordable and government housing projects, while the lower rebates assist general residential and commercial projects. The NSHP also takes into consideration the efficiency of each building type, requiring compliance of 15% better and 30% better than current Building Energy Efficiency Standards depending on the rebate value (Nasim, Nguyen, 2012).

One major limitation of the California Solar Initiative is that consumers must be customers of one of three investor-owned utilities (IOUs), those being Pacific Gas and Electric, Southern California Edison, and San Diego Gas and Electric. Although these three IOUs service the majority of Californians, accounting for approximately 70%, there is still a very large population of Californians that are serviced by municipal utilities, leaving them unable to apply for CSI rebates. Many municipal utilities offer similar assistance programs, however this lack of universal policy may present challenges in the future as utilities change their electricity portfolio mixes.

Similar to the NSHP, California property tax exclusions and PACE financing are in place for commercial, industrial, and residential solar systems. Initial owners and owners installing new systems can exclude 100% of the system value from their property value, substantially lowering property taxes depending on the size of the system. Also, unlike CSI programs, tax exclusions can be claimed by any electricity consumers, not just those serviced by IOUs. For those who are looking to build a new PV system, PACE financing provides flexible loan options with low interest rates. Local governments offer bonds to investors and then use the capital to loan to consumers. Consumers pay back the loan via a slight increase in property taxes over an assigned term, with initial investors collecting the interest rate. This loan financing allows consumers to diffuse the initial cost of a PV project over many years (typically 15-20), greatly improving the economic viability of such projects.

As construction and installation costs for renewable self-generation systems decline, the impact of construction-based subsidy programs such as the California Solar Initiative will also become less significant. It is inevitable that PV technology, as well as renewable technology in general, will become more affordable in the coming decades. Thus, California must look to create policies that aim to encourage the long-term generation of renewably sourced electricity. Feed-in tariffs, when designed correctly, provide valuable long-term assistance to generators, fostering a responsible transition to renewable electricity.

II. The Feed-In Tariff: Real World Design and Application

Feed-in tariffs have been employed in the renewable energy sector in countries around the world for decades. In the European Union alone, over 15,000MW of photovoltaic electricity have been generated between 2000 and 2009 as a result of feed-in tariffs. On a global scale, over 75% of electricity generated from photovoltaic systems can be attributed to the encouragement of feed-in tariffs (Frondel, Ritter, 2010). A feed-in tariff's most significant advantage is its flexibility. Tariffs can be used to target a variety of technologies and can utilize many different pricing strategies, all of which come at little cost to federal or state governments. Feed-in tariffs also create several positive externalities in addition to the proliferation of renewable energy production including job growth, load balancing, increased exports, and reduced GHG emissions.

The first feed-in tariff was implemented in Germany in December of 1990. As part of the Electricity Feed-in Law, utilities were required to buy electricity from non-utility, renewable energy generators. Price per KWh represented a certain premium above the retail electricity price. This premium was determined by the cost-of-generation associated with each technology and included distinct degression rates based on technological development forecasts for each source (Fulton and Capalino, 2012). Germany's feed-in law also employs an acceptable capacity "corridor" to protect against renewable electricity flooding the market and causing significant market failures (Fulton, Mellquist, Rickerson, Jacobs, 2011). Denmark and Spain soon followed suit and enacted their own feed-in tariff policies, closely modeled after Germany's. Since then, countries around the world, including China and the United States, have enacted their own versions of feed-in tariffs, tailoring the policy to fit their renewable energy goals.

Feed-in tariffs can be tailored to fit almost any scenario by adjusting the eligibility standards and pricing methods. First, tariffs can target any type of generation technology, from photovoltaic to small hydro and wind systems. This is an important advantage, as it allows developers to focus on a wide range of technologies while receiving the same chance to experience returns on their investment. This also plays an important role in tariff pricing strategies, which will be discussed in detail shortly. Secondly, tariffs may utilize different caps. Tariff caps can be based on individual installation capacities, program-wide capacity, total program cost, or a combination of all three. Lastly, eligibility can be limited to certain investor or owner types depending on the market demographics of the utility area.

Pricing is the most flexible aspect of feed-in tariffs and represent the most important decision when creating policy. Current feed-in tariffs utilize four distinct pricing strategies: fixed price, cost of generation, value to the system, and auction-based. Fixed price tariffs guarantee the generator a certain premium above the retail price of electricity. The fixed price strategy is constant across technology types. Vice versa, pricing based on the cost of generation is determined by the actual cost of the renewable technology (Mendonca, Corre, 2008). This pricing scheme results in premiums very similar to fixed prices but allows for more flexibility in choosing the type of technology. This is particularly effective in locations that might have two or more renewable energy sources.

Pricing based on value to the system represents the most progressive pricing method. Unlike fixed pricing and cost of generation pricing, which concern the paper costs of conventional and renewable generation, value to the system takes into account the positive externalities associated with renewable electricity production as well as time-of-delivery consideration. Prices would reflect the lower emissions of the renewable source as well as account for the avoidance of fossil fuels depending on the utility's portfolio mix. Electricity would also be priced according to the time of delivery, providing higher payments for electricity generated during times of peak demand. Along with being the most progressive pricing strategy, value to the system presents a difficult price degression challenge. On one hand, the tariff should be responsive to changing values in the market over the length of the contract. On the other, the tariff still needs to provide price and volume certainty to investors entering contracts. This dilemma must be addressed.

Lastly, some feed-in tariffs have adopted an auction-based pricing mechanism. Auctions allow utilities to choose tariff applicants based on their estimated cost per KWh generated. After meeting the initial eligibility requirements, generators compete with each other by offering to accept the lowest tariff amounts. This allows generators to still realize a profit while minimizing cost to the utility company. Auction-based pricing allows for swift reactions to changes in input costs faced by renewable electricity generators. For example, if the price of photovoltaic panels decreases due to advances in silicon technologies, generators would become more competitive and drive down the price of the tariff during the auction. Under a fixed price system, this reaction could not occur and utilities would be forced to pay for higher profit margins.

In addition to the initial pricing strategy, there are also several ancillary design features that consider the cost of generation over the length of the contract and adjust the tariff price accordingly. Price degression strategies encourage generators to continue to pursue cost saving measures over the life of the contract, such as improving technology and efficiency. Tariffs can utilize pre-established price degression rates or rates that adjust every year or two depending on market characteristics and technological advancement.

Under the first strategy, considerations may include adjustments for inflation, front-end loading, and time of delivery considerations. The first protects the real value of renewable energy projects by following the Consumer Price Index. The second offers higher initial tariffs to assist in construction financing, followed by lower long-term rates. And lastly, time of delivery pricing provides different tariff rates depending on daily and seasonal electricity demand trends. Under the second strategy, degression rates may also hinge on changes in the electricity sector over time. This degression method introduces some added risk to tariff contracts, as changes in the market may diverge from forecasts or investor expectation. Deciding on a pricing strategy is the most important part of establishing a feed-in tariff system.

III. A Case Study: Feed-in Tariffs in Germany

Having bought heavily into the Kyoto Protocol, Germany and the rest of the European Union have prioritized responsible environmental policy much higher than the United States in recent years. Similar to California, Germany has set a renewable energy generation goal of 35% of production by 2020. German policymakers have certainly embraced the challenge of reducing emissions and improving energy security through a variety of different strategies. Most importantly, Germans have taken an environmental approach that works closely with leading industries instead of against them, taking care to allow proper time for adaptation before tightening standards and increasing regulation. Among other policies, the German feed-in tariff system is often lauded as the most progressive in the world. However, economists disagree as to whether or not the system, in its current form, truly represents the most cost-effect path to renewable energy growth.

Germany's initial feed-in tariff was based on a fixed percentage of the retail electricity price, later transitioning to a cost-of-generation pricing method. At first, the tariff was based on a given premium above the retail rate and was blind to technological differences for renewable sources (Ragwitz and Huber, 2005). The policy protected utilities by enacting a cap for fed-in renewable electricity at 5% of total generation. However, geographical and technological differences soon created pricing and volume issues. Utilities in northern Germany became inundated by feed-in tariffs coming from wind turbines located in the area, making them less competitive than utilities in the south that experienced fewer tariff applicants. To combat this trend, the tariff system was amended to utilize a cost-of-generation pricing strategy with 20-year contracts and fixed degression rates. In this system, tariff prices are based on the cost of generation of using a specific type of technology. The rate of degression is then calculated based on the empirically derived progress ratios of each technology, subsequently encouraging manufacturers to continue to pursue increased efficiency measures and other cost-saving developments (Mitchella, Bauknecht, 2006).

Current tariff prices for photovoltaic generation in Germany range from 21.11 Euro cents to 28.74 cents/KWh depending on the size of the system (See *Figure 6*). The larger the system, the smaller the tariff due to the benefits associated with economies of scale. In comparison, tariff prices for hydro, onshore wind, and biomass average approximately 6.6 cents/KWh, 7.4 cents/KWh, and 10.9 cents/KWh, respectively (Fulton and Capalino, 2012). This large price difference across technologies exemplifies the cost-of-generation pricing employed by the current feed-in system. Degression rates for PV are based on capacity in order to prevent any major market failures. If the cost of PV falls and capacity increases dramatically, the tariff declines, protecting utilities from having to overpay for fed-in renewable electricity. This in turn, protects electricity consumers from experiencing a spike in electricity prices.

Market Effects

In theory, Germany's feed-in policy seems sound, but experts argue whether or not the results are significant and therefore cost-effective. Supporters of the feed-in system point to its stability, job creation, low transaction costs, and cost-of-generation benefits. From an investment perspective, the German feed-in tariff creates a stable environment that minimizes risk and volatility. The cost-of-generation strategy nature allows investors to see exactly where the price of the tariff is going for each technology over the next 20 years. Future prices are usually a significant unknown in investment markets and a large factor in risk. Experts calculate that the German feed-in system has led to the creation of 180,000 jobs between 2004 and 2009, bringing the renewable energy sector to a total of 340,000. Of these, an estimated 65,000 jobs were created in the PV industry alone (Frondel *et al,* 2010). Supporters claim that these trends are bound to continue, but even the job creation statistics presented here should be taken with a grain of salt, as explained below.

The German feed-in tariff system enjoys other cost-of-generation benefits, including very low transaction costs. Transaction costs are inherently low, as the system does not require expensive selection methods, preparation procedures, or infrastructural requirements outside of the already established power grid. Eligibility requirements are fairly straightforward and the contracting process is relatively painless. Some German's who have successfully entered feed-in tariff contracts claim that the entire process, from the first phone call to the actual grid connection, took a matter of days. Not only do low transaction costs make the initial transition more convenient, they also give investors the opportunity to be in complete control of the profitability of the project. Since transaction costs are low and completely transparent, investors can focus their efforts on analyzing variable costs on their side. Other benefits from this price scheme come in the form of stability on the consumer side. Consumers, like investors, benefit from the foresight provided by 20-year contracts.

Critics of the German feed-in tariff do not deny that the system encourages growth in the renewable energy sector; their argument is based on cost efficiency. Opponents point specifically to the tariff's affect on retail prices and job loss in other industries. In late 2011, actual capacity of new PV systems taking advantage of the tariff was more than double the projected amount—approximately 7,400MW versus the predicted 3,500 (Frondel *et al*, 2010). Although the tariff is based on capacity, it does not react quickly enough to significant spikes such as this. This lag leads to upward pressure on electricity prices in the short-term as utilities are forced to raise prices to cover the cost of paying the tariff. This price increase has been named the EEG surcharge, and represents the difference between the feed-in tariff price and the price of energy on the energy exchange.

With the addition of the EEG surcharge for electricity consumers, retail prices in Germany *have* increased by approximately 20% over the last half decade (See *Figure 7*). However, the increase cannot be solely attributed to the EEG and the feed-in tariff. Economists point to two other factors that could be just as, if not more, responsible for the increase in prices. First, as part of their environmental campaign, Germany took nearly half (8 of 17) of their nuclear power plants offline over the past several years. As recent as 2005, Germany relied on nuclear power for over 25% of their electricity needs. Shutting down half of their nuclear plants would certainly cause a shift in supply and an upward swing in prices, although no formal studies have been conducted. Germany plans to take the remainder of their nuclear plants offline by 2022, a transition that could have noticeable price implications. Secondly, over the same five-year period, German utilities have increased their profit margin from 1.1% to 8.2% (Gille and Morris, 2012). This is a massive increase and most certainly had a positive effect on retail prices. All things considered, more analysis must be done to conclude the exact source of electricity price increases.

Job creation is also a contested issue between supporters and opponents. Although there is no doubt that a boost in renewable energy demand will spark job growth within supporting sectors, the question remains as to whether or not job loss in other industries eclipses the positive growth. The rising cost of electricity due to the proliferation of renewable energy, whether directly impacted by the feed-in tariff or not, significantly raises costs for energy intensive industries. In the European Union, where labor and capital are relatively mobile, firms that are hit hardest by increasing electricity prices can move to countries with lower energy costs. The alternative to migration is reducing wages to offset the rising costs, another tactic that results in lower economic output. Again however, these effects are hard to blame distinctly on the feed-in tariff and require further study. In reality, it is probably impossible to identify for certain which jobs are created and which jobs are destroyed as a result of a policy as specific as a feed-in tariff.

Lastly, the effectiveness of renewable energy at reducing emissions is undeniable, yet critics of the feed-in approach again cite its costs. The European Union currently utilizes an Emissions Trading System, in which Germany participates. This cap and trade system demands firms to purchase credits to cover their emissions, creating the incentive for firms to reduce their emissions in order to reduce their credit payments. However, efficient technology has outpaced the reduction of certificate supply, causing certificate prices to plummeted in Germany and the rest of the EU (Faber *et al*, 2012). Credits bought under the ETS are currently priced at 8 Euros/ton of greenhouse gases and are expected to continue to decrease if the available credit pool is not reduced substantially. In comparison, the abatement cost for a ton of carbon under the current feed-in scheme is considerably higher. If one simply took the total cost of the feed-in program and divided it by the emissions reductions, the result could be as high as 716 €/ton (Frondel *et al*, 2009). However, this number is somewhat misleading considering that the costs of the feed-in tariff cover a variety of positive externalities, particularly the long-term development of renewable technology.

IV. California's Current Feed-in Tariff Policy

California is one of only four states in the U.S. that has enacted statewide feed-in tariffs in one form or another, joining Hawaii, Vermont, and Maine. Of these four states, California is the only one whose tariff is based on time-of-delivery considerations rather than cost-of-generation. That is to say, tariff prices for all technology types are based on *when* the electricity enters the grid, providing higher tariff prices for electricity produced during peak hours. California's feed-in tariff utilizes a variety of implementation and pricing strategies, setting it apart from the German system analyzed above.

The California feed-in tariff, like the German system, represents a budget neutral option for increasing renewable energy growth. Utility companies are on the hook to pick up the tab for two reasons. First, AB32 has enacted strict renewable portfolio standards over the coming years, with the first major goal of 33% production by 2020. If utilities companies fail to meet the RPS, they may be subject to fines and other penalties. These penalties are typically higher than the costs associated with paying a feed-in tariff, so it is in the utilities' best interest to utilize the feed-in tariff system. Similarly, utility companies are also responsible for reducing their emissions. By law, utilities may only use emissions certificates to offset 25% of their emissions. Therefore, the remainder of emissions reductions must come from producing renewable energy. Although the added cost of employing renewable energy will affect prices, the feed-in tariff system will not require significant government spending.

Eligibility for California's feed-in tariff relies on system capacity and location. The three major investor-owned utilities have designated two capacity levels, systems under and over 3MW[9]. System owners can choose to enter full-buy or excess contracts (DeShazo, Matulka, 2010). The first concerns the sale of all energy produced by the system over the course of the contract, while the second concerns the sale of surplus energy after then electricity needs of the site have been met. Because larger generation systems benefit from economies of scale, the tariff

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[9] For comparison, a single-family home can be fully sustained by a 4KW system producing 5,400KWh/year.

allotment is generally less. Utilities also value a system based on its location, offering a premium for systems located in high demand areas.

California's feed-in tariff is also unique, in that it works hand-in-hand with the state's Renewables Portfolio Standards (RPS) program. The state RPS system mandates that investor-owned utilities must procure 33% of their energy from renewable sources by 2020. The current capacity goal is 750 MW of renewable energy capacity and is divided up between the three largest IOUs according to the size of their costumer base. Pacific Gas & Electric is responsible for 218.8MW, Southern California Edison 226MW, and San Diego Gas & Electric 48.8MW. These three utility companies currently average 20.1% production from renewables, up from just 13.8% in 2003. However, this rate of growth will have to increase in order to meet the 33% goal in the next 7 years (Long, 2011).

California feed-in prices are based on time-of-delivery considerations and are frequently amended based on a Renewable Market Adjusting Tariff (RE-MAT) or a Renewable Auction Mechanism (RAM) depending on the size of the project. Current feed-in tariff prices range from 8.1¢/KWh to 9.7¢/KWh depending on the length of the contract (10-20 years). These rates are considerably less than the tariff prices experienced in Germany. Initially, the California feed-in system utilized a Market Price Referent (MPR). The MPR took into account the general operating costs associated with a baseload natural gas plant as well as time-of-delivery for fed-in renewable electricity. However, California has since moved to the RE-MAT pricing system. The RE-MAT makes the same considerations as the MPR, including the time-of-delivery factors, but is based on a bidding system.

The baseline of the RE-MAT is determined by weighting the highest executed contract price achieved using the Renewable Auction Mechanism (RAM), which is used to determine tariff pricing for projects over 3MW. These larger renewable energy projects came together in late 2011 to bid for financing from the IOUs in the first RAM. In this auction, 13 renewable electricity generation projects won contracts totaling 140 MW. The highest accepted proposal was $89.23/MWh, or 8.9¢/KWh. Consequently, projects under 3MW start at this price level and are then compensated with regard to the electricity's time-of-delivery, resulting in the price range mentioned above. Intuitively, electricity produced during off-peak hours receives a smaller tariff than electricity produced during peak hours. If too few generators sign contracts at the initial price, the RE-MAT slowly increases the tariff price until prospective renewable projects are able to see profitable returns and consequently sign up.

Degression rates for the California feed-in tariff are based on market forecasts and technological growth expectations. Just as any other feed-in tariff, the California degression rates are designed to encourage technological advancement and improvement in efficiency. The degression rates are fixed for any given contract and are independent of rates used in previous contracts. Unlike the German degression rate, which adjusts annually according to activity within the renewable energy sector (namely capacity), the California degression rate is predetermined, adjusting annually based on forecasts calculated at the time of the initial contract signing. This rather inflexible approach provides certainty for both utilities and renewable electricity generators, but also may run into problems if initial forecasts are incorrect. If the degression rate proves too steep, renewable energy projects could become economically unviable towards the end of their contracts. Vice versa, if the degression rate is too flat, the utilities will end up paying tariffs that are too high, hurting their competition.

Market Effects

California's feed-in tariff is in its early stages so market effects will only start to become apparent in the coming years. However, comparing the California tariff to its German cousin, we can make some assumption for it's future effects. First, the smaller size of the California tariff will likely keep capacity growth modest over the coming years. This more gradual adoption of renewable electricity will have less affect on electricity price, barring other effects such as economic growth or changes in utility profit margins. One downside is that the slower adoption rate will have less immediate effect on the environment. This might pose a challenge with concern to the California emissions goals over the coming decades, especially the 2050 goal of 80% below 1990 standards.

Secondly, the uniform pricing method used for the California tariff will favor one type of technology in the long run. This is not necessarily a bad thing for a couple different reasons. First, renewable sources in California are dominated by the potential of solar power. The current development rates for solar technology are significantly steeper than development rates associated with wind and other technologies. Therefore, it makes sense to invest in programs that encourage solar energy, as each dollar spent results in a larger marginal gain in technological advancement. Secondly, other renewable technologies are nearing competitiveness. For example, tariff prices for large, onshore wind installations in Germany are only a few percentage points higher than wholesale electricity prices. It seems that wind, and other technologies that are nearing competitiveness, will reach maturity with little assistance.

Lastly, the California degression rates, although promoting certainty over the life of a contract, may spell disaster in the event of a significant shock in the electricity sector. For example, if yet another extraction method for fossil fuels is discovered, the subsequent reduction in electricity prices will leave the tariff much too high. Utilities would have to pay a much higher percentage to continue to support renewable electricity production, making the feed-in tariff even costlier in relative terms. Similarly, if the price of photovoltaic technology drops significantly and unexpectedly, the utilities will be stuck paying for high profit margins for renewable electricity generators, a far from efficient outcome.

These predictions should be taken with a grain of salt, as we won't know the true market effects of the tariff until they occur. However, uncertainty should not discourage policymakers from determining which characteristics of the feed-in tariff are most valuable and applicable to California. The following chapter will delve back into the policy criteria established in Chapter 3. Both the German and the Californian feed-in tariff will be evaluated with respect to the criteria before recommendations for effective improvements are made.

Chapter 5: Discussion and Policy Recommendations

I. Criteria Analysis

Examining existing policies using consistent criteria is an effective technique in eliciting the most significant differences between them. Because criteria are based on theoretical framework and revolve around ideal policy characteristics and mechanisms, their application on real world policies can reveal the major shortcomings of economic and political theory. This section will evaluate the California feed-in tariff with respect to each criterion, while also commenting on the benefits or disadvantages of the German tariff.

Effectiveness

The California feed-in system, at its root, *is* effective. Even in it's early stages, California has experienced a growth in renewable energy capacity that can be directly tied to the feed-in tariff. That being said, growth has been fairly slow due to relatively low tariff rates and the fairly complicated contract process. On one hand, the slow adoption rate can be viewed as responsible. Utilities need time to adjust to a changing portfolio mix, especially changes that require such vastly different technology. On the other hand, the slow adoption rate is burning valuable time in the race against emissions. Germany's adoption rate under the feed-in tariff was *too* effective, flooding the market and wreaking havoc on retail prices. The appropriate level of effectiveness is clearly in between the slower rate of California adoption and the faster German rate.

Cost Effective

Cost-effectiveness is difficult to evaluate, as feed-in tariffs result in many positive externalities that are difficult to quantify. The largest unknown is the cost of damages associated with greenhouse gas emissions. Assuming higher cost figures, renewable energy promoted through the feed-in system can be somewhat cost-effective. One key difference between the two tariff policies is that a large portion of Germany's budget is being spent on encouraging solar power, which is not necessarily the county's most abundant natural resource. In California, solar power is clearly the abundant resource and is rightfully receiving the most attention. In the long run, this may result in a renewable energy portfolio that is more cost-effective than Germany's. All things considered, it seems that emissions certificates through cap and trade systems represent a more cost-effective way to reduce greenhouse gas emissions. However, we know that increasing efficiency alone will not be enough to meet future emissions goals, and that renewable technology must be promoted. Therefore, the lower cost-effectiveness of the feed-in tariff might be a necessary evil.

Upfront vs. Long-Term Financial Assistance

This criterion is more a comparison between the feed-in tariff and current policies that target construction costs, such as those underneath the California Solar Initiative. The feed-in tariff is a good strategy for promoting medium to large-scale renewable installations. Because the feed-in tariff does not provide upfront assistance, aside from a steeper tariff schedule option that starts high and decreases quickly, the prospective renewable generator must have the funds necessary to cover the initial construction costs. Having the level of liquidity necessary to finance construction costs becomes less likely as the size of the installation decreases. Therefore, programs such as the New Solar Homes Partnership and Property Assessed Clean Energy financing cater much more effectively to small-scale installations that need assistance in the short-term, rather than in the long-term. That being said, the feed-in tariff represents a valuable opportunity for larger projects that have the upfront funds but seek long-term returns on their investment.

Mitigation of Risk and Uncertainty

Mitigating risk is yet another extremely important criterion for a prospective policy. Investors consider risk more than anything else when making a decision to enter a market or not. If the risk overshadows the possible rate of return on investment, investors will shy away and the renewable energy sector will not acquire the capital necessary to boost capacity and develop technology. The rate of return under the feed-in tariff system is typically small, ranging from 0-5% over 20 years, therefore the risk must also be relatively small. 20-year contracts and locked-in tariff rates *do* improve certainty in the long run, giving investors the foresight necessary to conduct accurate cost-benefit analysis. However, it is the various degression mechanisms that add risk over the life of the contract.

First, the German degression rates are based on capacity, yet do not respond quickly enough to significant changes. This adds a significant amount of risk for utility companies. Germany has already experienced one spike in renewable capacity that had serious implications for the utility companies and the electricity market, raising prices by a significant amount. The Californian degression rate is even more inflexible over the course of a given contract. Although this provides certainty in the short-term, its inability to respond to market changes in the long-term could be an issue. The Germans have recently implemented a capacity "corridor," making sure that tariff and degression rates promote increases in capacity within a given band. This could represent an effective solution, as long as changes in capacity can be identified quickly and the tariff prices adjusted accordingly.

Market Efficiency

The feed-in tariff, like any other government regulation imposed on a market, does create some deadweight loss. To put it simply, the natural equilibrium at which the utility companies would supply electricity would occur using a generation portfolio of mostly conventional sources, as they have provided for decades. Thus, the forced introduction of higher-cost renewable electricity by the feed-in tariff inherently decreases both consumer and producer surpluses, at least in the short run. In the long run, the feed-in tariff ideally results in the full competitiveness of renewable energy, signifying a return to equilibrium in the electricity sector. The main issue is that the free market will *not* adopt renewable electricity fast enough to reach the emissions goals set forth by AB32. So from an environmental perspective, particularly one that is savvy to the economic and social costs of greenhouse gas emissions, the feed-in tariff is efficient.

In terms of transaction costs, which decrease efficiency of a program, the German and Californian tariffs could not be more different. In Germany, information regarding eligibility and contract processes is readily available and easy to understand. There are very few overhead costs in the form of administrative or regulatory fees that inherently make the adoption process easy and effective. In California however, information regarding the feed-in tariff and its various eligibility requirements are very difficult to come by, and even harder to understand once procured. This is a major detractor for possible investors who value time and convenience in their decision-making. The transaction costs also get worse as the size of the renewable installation increases, as permitting issues increase and legal council becomes almost a necessity.

By comparison, the efficiency of rebate programs such as the NSHP seems to be much better than the feed-in tariff. However, this is perhaps an unfair comparison due to the relatively small-scale of installations that take advantage of these upfront programs. Installations of this sort are usually built on rooftops and other existing structures where construction is already permitted and access to necessary electrical infrastructure is good. Larger installations will *always* have to jump through more regulatory hoops than smaller projects, but the California system has a thing to learn from its streamlined German cousin.

Transparency

This criterion sees yet another significant difference between the German and Californian feed-in tariffs. The German system, having far fewer administrative and regulatory issues, is simpler, naturally causing it to be more transparent. The Californian feed-in tariff feels much more bureaucratic, leaving prospective investors to sift through information on both government websites and investor-owned utility websites. Transparency does not increase the monetary cost-effectiveness, but it certainly caters to the individual's preference of convenience, which has serious implications for actual adoption. This phenomenon will be addressed in more detail in the behavioral section below.

Market Conformity

We can see from the German system that the feed-in tariff *does* lead to market conformity in the long run. Although PV technology is still highly subsidized through the tariff, wind, hydro, and biomass are all approaching competitiveness in the greater electricity market. Wind in particular has experienced great increases in competitiveness due to the feed-in tariff, this is even more important considering its abundance throughout Germany. That being said, the German tariff has been active for nearly two decades, alluding to a conformity process that is slow and not without its challenges. Judging from the German experience, California is at *least* two, if not three, decades away from making renewable electricity a fully competitive and mature market. In the scheme of things, this transition is not all that slow, especially when being compared to the length of transition that would occur without government regulation.

Technological Advancement

Both the German and Californian feed-in tariff designs effectively promote the advancement of renewable electricity technology. However, there are some key differences. The German pricing scheme is based on cost-of-generation, providing equal support to all types of technology with respect to their unique construction and operating costs. This across-the-board assistance promotes advancement in all technologies rather than focusing on the source that might have the most potential. This is where the Californian feed-in tariff might be at an advantage. The Californian system promotes more *efficient* technological advancement through specialization. Since solar energy has the most potential, California's value-to-the-system pricing strongly encourages the advancement of solar technology. Also, remembering the advantages of distributed versus utility-scale renewable installations, the advancement of flexible, rooftop solar technology bodes well for its competitiveness in the future. Specializing on advancing technologies that concern California's most abundant renewable source, while other states and countries perfect the technologies associated with *their* abundant renewable sources, seems like the most efficient way to get to worldwide renewable electricity competitiveness.

Technological advancement underneath the feed-in tariff, regardless of what source it targets, is far superior to technological advancement under upfront rebate programs. Rebate programs that assist small-scale installations hardly promote advancement at all, mostly because household systems are generally a one-time investment and are primarily used to offset onsite electricity needs. The incentive to increase efficiency or improve technology is simply not there, as profit margins for small installations are slim to none. Small-scale generators also lack the financial and physical capabilities necessary to improve technology. In this regard, the feed-in tariff is highly advantageous.

II. Behavioral Factors and Social Norms

Behavioral factors are by far the most overlooked issue in terms of environmental policy design. Current environmental programs here in California, whether targeting emissions reductions or promoting renewable electricity, do not properly address green consumer preferences or environmental social norms. Over the past decade or so, the environmental movement *has* gained significant ground, yet access to good information and marketing of green products still remains weak. The principles of the feed-in tariff are economically sound, but they fail to capture even the greenest of consumers due to the prevalence of negative and incorrect perceptions concerning reliability, convenience, and price. The feed-in tariff, as well as all the other renewable electricity programs, should be accompanied by aggressive marketing campaigns that target all consumer demographics and stress the importance and relatively easy process of adopting renewable electricity.

The two most widely held negative stereotypes concerning renewable electricity are that it is more expensive and less reliable than conventional technology and that it is inconvenient to adopt. Current policies, especially the feed-in tariff, do very little to combat these perceptions and even bolster certain aspects of them. First, the average consumer does not understand the economics behind subsidies and tariffs; they simply know that renewable technologies are more expensive than conventional technology. Marketing campaigns do not necessarily have to convey the inner-workings of a subsidy, but they should stress the bottom line, which is what the majority of consumers use to make a purchasing decision. Using the feed-in tariff, generators receive ample compensation for producing renewable electricity, and in most cases even experience a positive return on their investment. Therefore, the positive bottom line should be enough for a good percentage of prospective adopters. For those consumers who do want to do their own research, access to good information needs to be available. Although the feed-in tariff is in its early stages, more studies need to be conducted and the causes and effects must be explicitly presented. There are plenty of academic studies that concern feed-in tariffs around the world, as evidenced by this paper, but interested consumers will be much more persuaded by literature that focuses on possible causes and effects in their own backyard[10].

Similarly, framing of the policy does not have to include why renewable electricity is just as reliable as conventional energy, only that it is. After all, those who adopt renewable energy using the feed-in tariff are still connected to the same grid and continue to receive the same energy they did in the past. It is facts like these that need to be highlighted for consumers in order to build appeal and encourage adoption. In terms of convenience, the current California feed-in tariff shoots itself in the foot. Consumers perceive the transition as inconvenient because the transition using the feed-in tariff *is* inconvenient. However, this is more an issue of the actual mechanics of the policy, rather than an issue of behavioral factors.

Although many consumers hold the same negative perceptions towards renewable electricity, the ways in which these perceptions can be altered differ greatly between various consumer groups. Therefore, it is imperative that policies concerning renewable electricity properly target different demographics in order to gain the mass appeal necessary to truly encourage adoption. Targeting demographics is particularly important in a state like California, where the consumer base is extremely diverse. Electricity consumers represent every race, socio-

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[10] This is a result of familiarity bias, or rather the tendency for individuals to have higher confidence levels in decisions that involve issues they are familiar with. This familiarity can be a result of locational proximity to the issue as well as similarities in occupational knowledge or interests.

economic class, cultural background, and occupational sector. One of the most damaging stereotypes of the environmental movement is that it is for wealthy, Caucasian males. Marketing for renewable electricity adoption must break down this stereotype by highlighting the accessibility of programs to everyone.

The feed-in tariff certainly faces a unique set of challenges in terms of breaking down perceptions and increasing appeal, mostly due to the type of generators that it targets. This paper concluded that the feed-in tariff is most effective for medium and large-scale operations, i.e. businesses and larger cooperatives rather than individual households. Although many of the behavioral factors are framed in terms of individual consumers, a lot of them apply to businesses as well. Like individuals, businesses are part of a much larger business community that establishes and practices its own set of social norms. A policy will be successful if it can instill a sense of environmental responsibility at this larger scale.

Environmental policies can positively frame renewable electricity and instill a sense of environmental responsibility within business communities in two ways. First, the feed-in tariff can be framed directly to the business community as the fiscally responsible thing to do. Unlike the average individual, businesses are more likely to employ quantitative methods during the decision-making process. Therefore, stressing the higher future cost of conventional electricity can encourage a switch to renewable electricity now. Also, businesses generally consider longer investment timelines than individuals do. So framing the feed-in tariff as a steady form of long-term revenue will certainly be appealing to most businesses that are concerned with fiscal stability over the long run.

Second, marketing of the policy can influence businesses indirectly by encouraging the customers of businesses to demand greener business practices. This strategy has the chance to be extremely effective. As addressed earlier, many consumers state that they are willing to pay a premium for green products. However, when actually presented with the opportunity to go green, they fail to adopt the product, often citing inconvenience as the deciding factor. In this case however, the consumer does not bear the inconvenience of adopting renewable electricity. Even if a business must raise its prices to cover the cost of going green, consumers that previously stated they were willing to pay a green premium but didn't will now be much more likely to make the switch, simply because the inconvenience factor is no longer there.

While marketing for the feed-in tariff focuses on various business communities and their customer bases, marketing for smaller-installation programs needs to focus on demographics of the individual consumer. Programs such as the NSHP *need* to be framed as convenient, as the participants will always be the ones that bear the transaction and opportunity costs associated with the adoption process. Highlighting positive characteristics such as transparency and low overhead costs certainly improve the perception of convenience. These programs also need to be framed as accessible to all consumers, regardless of socio-economic status. The major point of these programs is to assist consumers with the initial construction costs regardless of their financial status. This should be at the forefront of any marketing campaign.

Policies concerning renewable electricity can be framed in ways that appeal to a wide variety of possible adopters. These frames can be actual differences in the policy's mechanisms or simply rhetorical frames that appeal to different consumer behaviors. Just like marketing campaigns for any competitive consumer product, renewable energy policy can seek to capture the interest of people of different economic classes, ethnic groups, and cultural backgrounds. This is not to insinuate any bending of facts, but rather the selection of different policy aspects to sell to different audiences. The population of California is diverse; therefore the methods to attract renewable energy adopters must be as such.

Current advertisement for the feed-in tariff and other renewable electricity programs is weak to nonexistent. Policies must consider the above behavioral factors and associated marketing strategies and pursue them aggressively. At the same time, the claims made in framing the programs must be true. This means improvements must be made to the adoption processes of programs, especially for the feed-in tariff. Improvements should be aimed specifically at reducing transaction costs and inconvenience in order to create a more streamlined process for the adopter.

III. Recommendations for California

In addition to improving consumer awareness of renewable electricity programs, California should make some minor changes to the actual mechanisms of the feed-in tariff. First, renewable energy capacity underneath the feed-in tariff should be increased, while at the same time ensuring that over-adoption does not occur. Secondly, the feed-in tariff should cooperate more closely with the California emissions cap and trade system, so as to improve market efficiency and ensure the internalization of negative environmental externalities. Lastly, California must streamline the adoption process by increasing transparency and reducing transaction costs.

The current adoption rate in California under the feed-in tariff is too slow, leading to a renewable energy capacity increase that will struggle to meet the 2020 RPS goal. In order to increase capacity, tariff rates should be slightly increased. The current tariff price in California is less than 1/3rd the PV tariff price offered in Germany. Raising the tariff by just a few cents should have a positive effect on capacity that is larger than the negative effect on consumers in the form of higher retail prices. This should of course be the focus of intense economic analysis, but judging by Germany's success using much higher rates, a slight increase in California tariff rates should not cause significant market effects. In conjunction with raising rates, California should also adopt a capacity "corridor" similar to Germany's in order to prevent over-adoption.

As mentioned throughout this paper, the lack of distinct pricing of greenhouse gas emissions causes internalization of the associated environmental and social costs to be incomplete. As in Europe, certificate prices in the cap and trade system have proven to be unexpectedly low. This does not point to the failure of the system, but rather to the fact that reducing greenhouse gas emissions has been cheaper than expected. Therefore, reduction expectations under the cap and trade system should be drastically increased to better mirror the true damages caused by emissions. Firms will continue to pay for certificates until it is cheaper to employ other emissions reduction strategies, i.e. switching to renewable electricity. These larger firms represent ideal candidates for installing renewable electricity technology using the feed-in tariff.

One of the largest issues associated with the current feed-in tariff system is that it is confusing. Finding information on eligibility standards and contract procedures is nearly impossible and extremely time consuming. On top of that, the actual contract process requires a great deal of paperwork and does not result in a grid connection or tariff payments until months later. Making the process more user-friendly would reduce administrative costs and get contracts on the grid more quickly, while also making the feed-in more appealing to other prospective adopters. In addition, better communication between the government and the investor-owned utilities would improve the responsiveness of tariff prices for new contracts, once again ensuring that the renewable energy capacity does not increase too quickly.

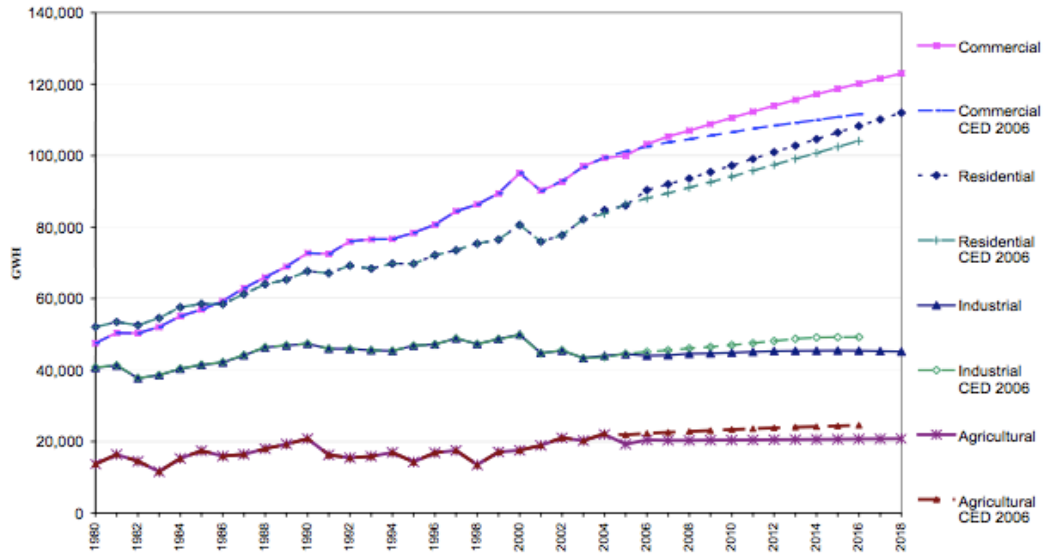
It should be noted that these recommendations are mostly based on comparisons to the German feed-in tariff experience. Although the two feed-in tariffs are somewhat similar, the market responses could be vastly different due to differences in renewable source availability, electricity market infrastructure, consumer preferences, etc. It should also be noted that the California feed-in tariff is still in its early stages. All these considerations point to the fact that further studies need to be conducted, and that in the meantime, the policy should be given a chance as it stands. However, if renewable electricity *does* begin to fall behind its expected capacity goals, these policy recommendations may very well be the correct responses.

IV. Conclusion

The feed-in tariff is a flexible, yet effective mechanism in promoting the proliferation of renewable electricity in California. The tariff creates a stable investment environment that protects both the utilities and the renewable electricity generators. Not only does the system foster capacity growth, but also technological advancement to the point where renewable electricity can compete in the market without assistance. From an environmental standpoint, the feed-in tariff contributes significantly towards achieving the emissions reduction goals set forth by AB32 without causing harmful increases to electricity prices.

The feed-in tariff model has been used in countries all over the world and in countless variations. The California model is certainly unique, using a dynamic combination of eligibility requirements, pricing mechanisms, and degression rates. Flaws can already be spotted in the system, but it is too early to tell what type of market effects will truly prevail. The key will be to analyze the market effects as they happen and adjust the tariff accordingly. In the meantime, it would be advantageous to pursue more aggressive green marketing campaigns in order to establish meaningful social norms in favor of environmentally responsible goods and practices. These strong social norms will help to ensure quicker and more effective transitions to green products in the future, including the complete transition to renewable electricity over the coming generations.

Appendix



Source: California Energy Commission, 2007.

Figure 1: State Consumption Trends by Source

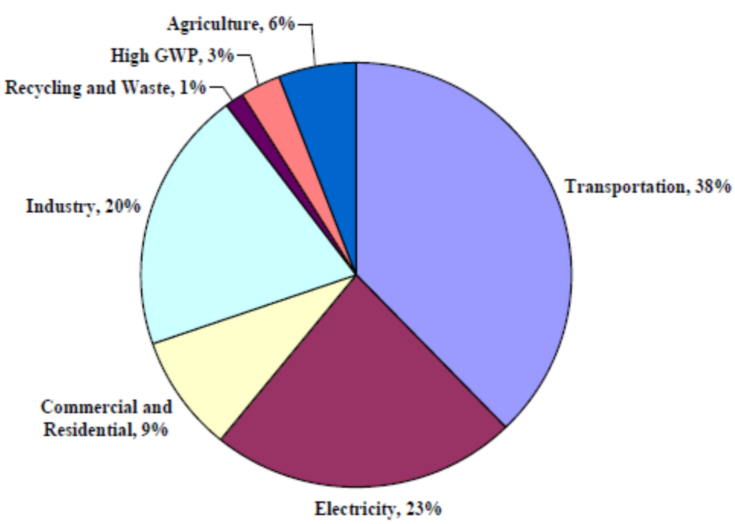


Figure 1. California's Greenhouse Gas Emissions (2002-2004 Average)

Source: California Air Resources Board

Figure 2: Greenhouse Gas Emissions by Source

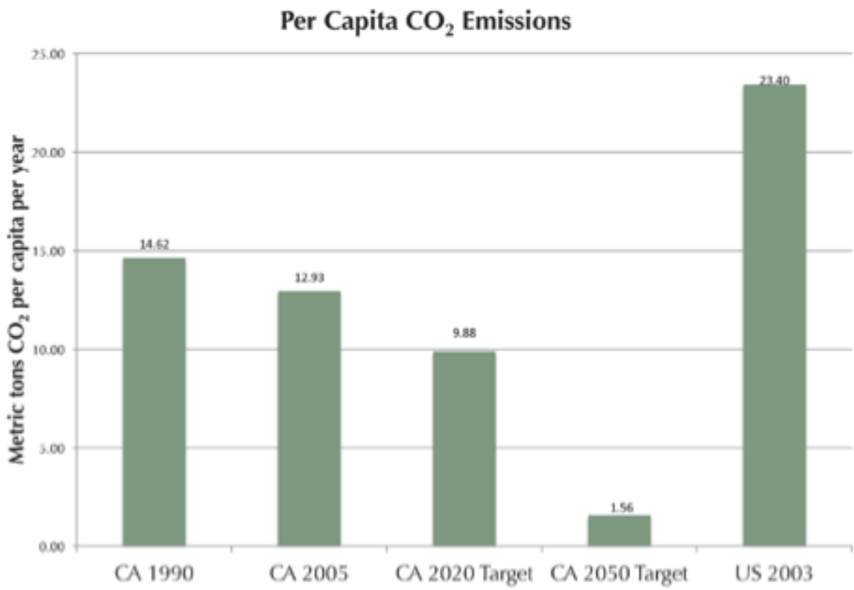


Figure 3: Emissions Reduction Goals (Long, 2011)

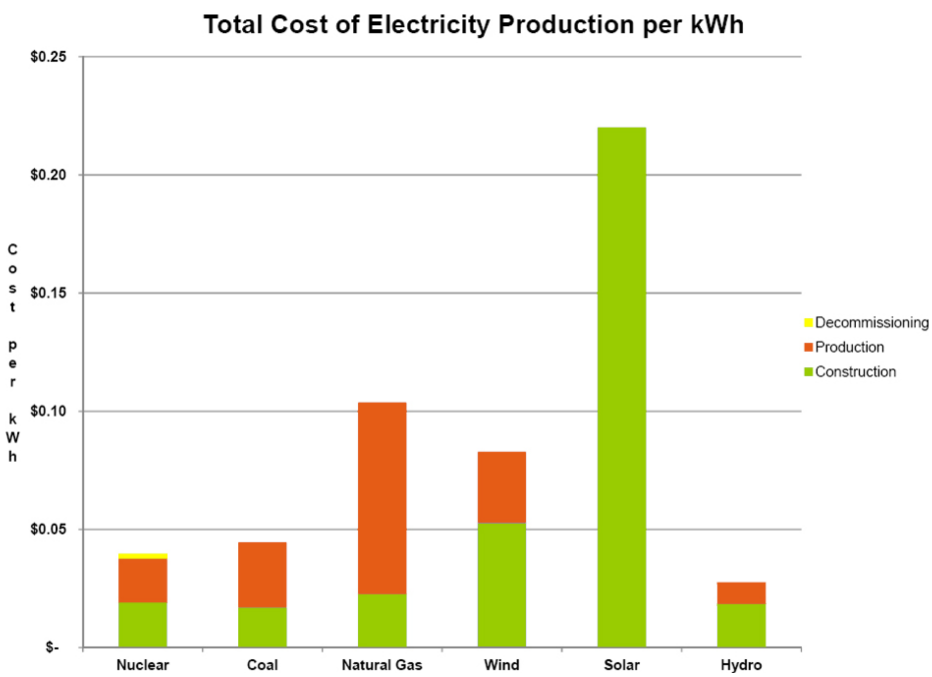


Figure 4: Total Cost of Electricity Production per KWh (Frondel *et al*, 2012)

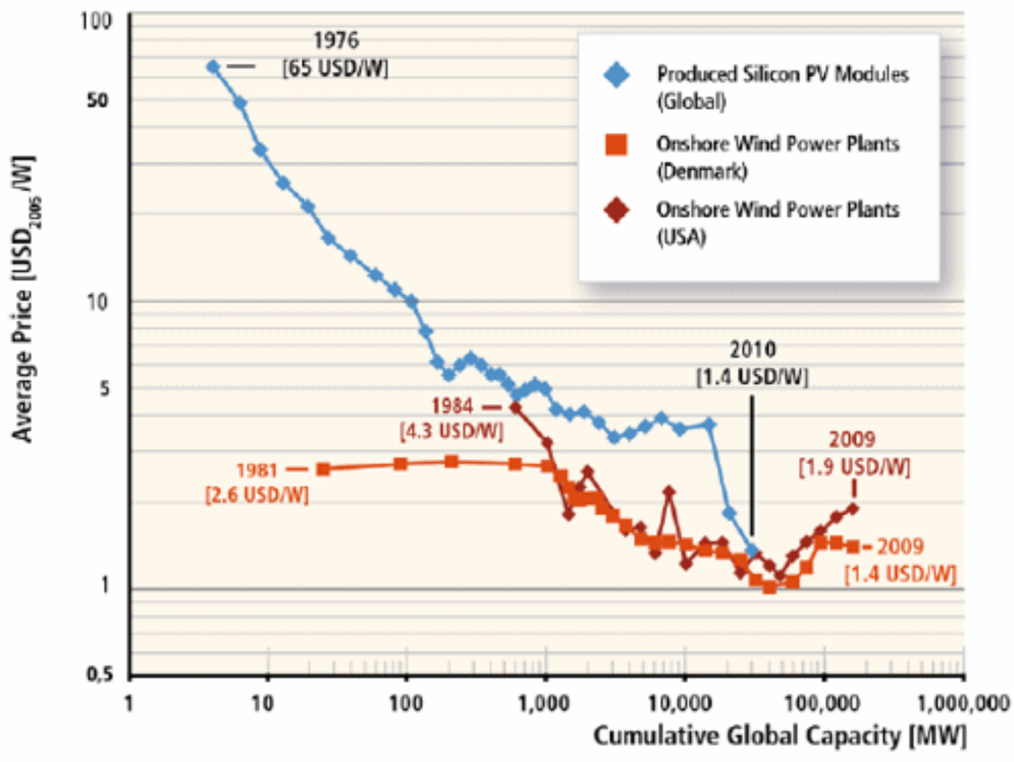


Figure 5: Cost Curves by Renewable Technology (Think Progress, 2011)
http://thinkprogress.org/climate/2011/05/26/208184/ge-solar-cheaper-than-fossil-fuels-in-5-years/

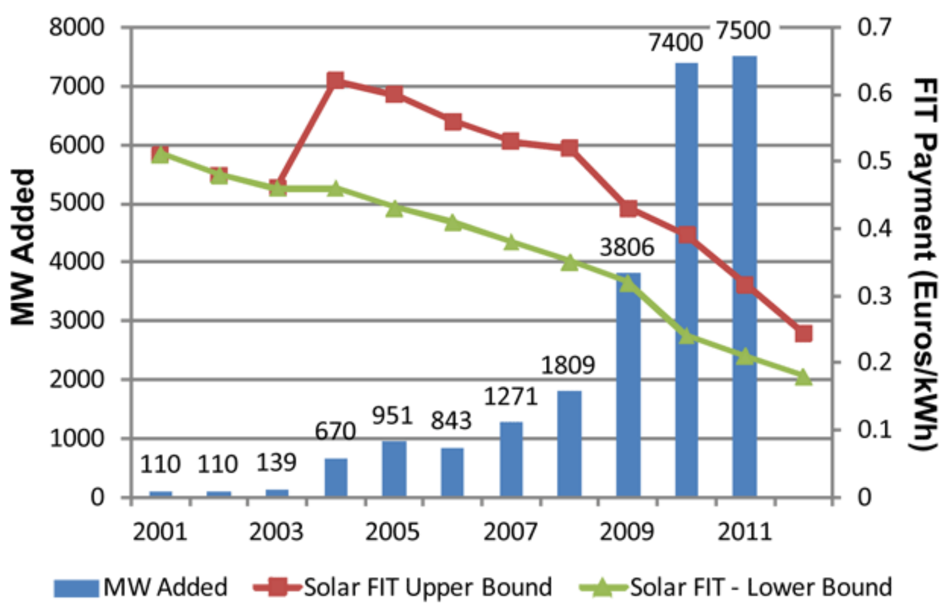


Figure 6: German Feed-In Tariff Prices and Capacity Gains (Fulton and Capalino, 2012)

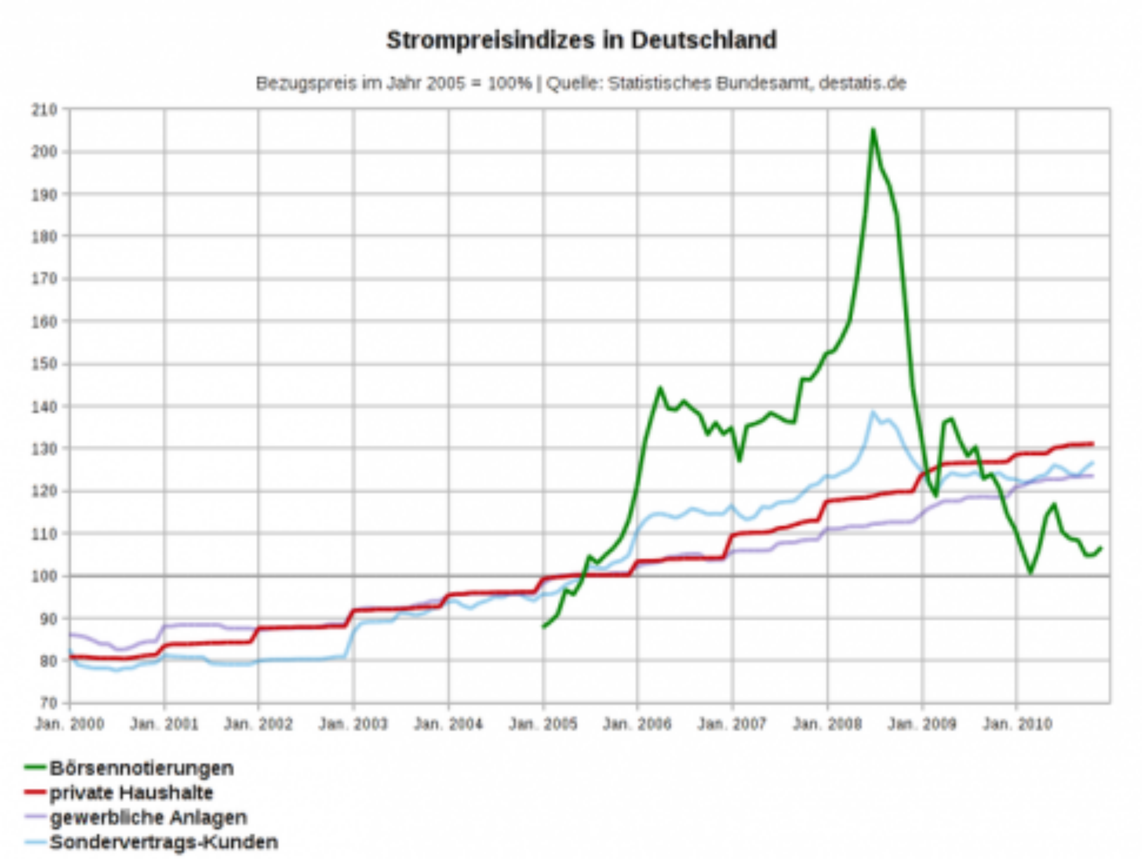


Figure 7: German Electricity Prices as a % of 2005 Prices (Clean Technica, 2012). http://cleantechnica.com/2012/09/03/german-electricity-prices-rise-as-utilities-increase-their-profit-margin-from-1-1-to-8-2/

*Note: The three gradual lines represent the retail prices in the Residential, Commercial, and Industrial sectors. The more volatile line is the wholesale price of electricity as paid on the Electricity Exchange.

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