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碩 士 論 文

美國太陽能產業獎助計畫之比較分析：可再生太陽能證書(SRECs)之於住戶光伏設備效用之研究

Comparative Analysis of Supporting Solar Policies in the USA: A Study of the Potential Effects of Solar Renewable Energy Certificates (SRECs) on Residential Photovoltaics

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Abstract

Numerous studies and market reports suggest that the Solar photovoltaic (SPV) markets rely heavily, if not entirely, upon governmental support policies at present. Throughout the majority of the world, these policies are enacted at a national level. However, within the United States there are 50 states, and among these fifty states there are different policies in place to foster the growth of renewable energy, and specifically solar photovoltaic markets.

This paper is an economic and financial analysis of the US federal & state level policies in states with Solar-targeted policies that have Solar Renewable Energy Credit (SREC) markets. Measuring a discounted cash flow, Net Present Value (NPV), and Internal Rate of Return (IRR), the author attempts to measure and compare the different policies' effect on Residential SPV markets. Then using the Present Value for each of the various policies each state has is compared to California's Feed-in-Tariff

The analysis could help:

- Assess the impact of SPV policies in different US States
- Identify ineffective SPV policies
- Add information and analysis to policy discussions
- Aid SPV residences in understanding the impact of policies on their systems

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Abbreviations

SPV	Solar Photovoltaics
Wh	Watt-hour
Wp	Watt of installed capacity
kWh	Kilowatt-hour
kWp	Kilowatt of installed capacity
MWp	Megawatt of installed capacity
FIT	Feed-in-Tariff
RPS	Renewable Portfolio Standard
REC	Renewable Energy Credit
ACP	Alternative Compliance Payment
SREC	Solar Renewable Energy Credit
SACP	Solar Alternative Compliance Payment
TGC	Tradable Green Certificate
PV	Present Value
PV/Wp	Present Value per Watt of installed capacity

I. Introduction

1.1 Overview

The past 10 years has seen a strong upward trend in renewable energy use in the USA, and around the world. In 2009, 8% of all US energy consumption was renewable, of which 9% was wind, and solar roughly 1% [1]. Meanwhile, in 2010, Germany had reached 17% of energy consumption from renewable sources.

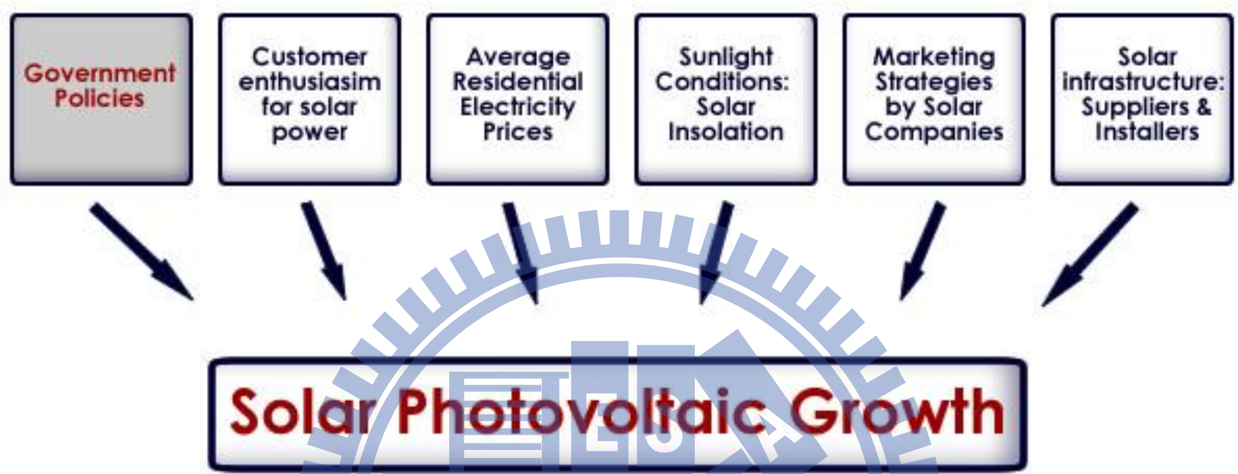
The SPV market is a rapidly increasing one, and the global market grew 139% in 2009 over 2008, creating a total of 18.23GW of solar capacity worldwide [2]. In Europe, where there is a long history of strong government support, and as such Germany ranks strongly ahead of all other nations with 7.74GW of SPV capacity installed in 2010. In 2010, Italy and the Czech Republic also each grew by over 1GW of installed SPV capacity.

Table 1: 2010 Worldwide Photovoltaic Capacity Growth [2]

Country	SPV Capacity Growth (in Gigawatts of Capacity)
Germany	7.74
Italy	3.74
Czech Republic	1.42
Japan	0.96
USA	0.95
France	0.72
China	0.53
Spain	0.38
Australia	0.27
Belgium	0.23

There are many reasons for the growth in capacity of renewable energy across the various nations and regions. Different places are better suited for different types of renewable energy generation; windy areas are particularly suited for wind, while sunny areas are better suited for solar power. Additionally, some nations embraced renewable sources sooner than others, and/or targeted different renewables more heavily (Wind, Solar, Nuclear, etc.).

Figure 1: Drivers for solar photovoltaic growth [3]



While there are certainly other factors driving global SPV demand, this is a good view of the forces behind the rapid growth in SPV installation. This study focuses on the government policy drivers, specifically focusing on financial incentive policies implemented in support of SPV. SPV is a high cost renewable resource, and therefore has lagged behind other sources of renewable energy, so subsidies and incentives are considered among the key drivers of global SPV demand [2].

The USA SPV market is ranked only 5th in the world despite being the largest economy. Even so, during the recession 2008 year, SPV capacity increased 36%, and began to boom in 2009 with 92% growth in installations [4]. Just like in Europe, government policies at both the federal and state level are the key drivers to the US SPV industry [4].

The problem within the USA for renewable energy is that unlike other nations, energy is not regulated at a national (federal) level, but at a state level and even lower. Likewise, electrical energy companies in the United States operate at a state or regional level, not typically on a national scale. Consequently, each state functions effectively as a separate energy market, and thus each state is effectively a separate SPV market. Currently, the largest SPV markets in the United States are California and New Jersey, and they have different types of policy initiatives and sun radiation levels.

Table 2: 2009 State Photovoltaic Capacity [5]

State	2009 Capacity in MW	2008 Capacity in MW	Percentage Change	Market Share
California	212.1	197.6	7%	49%
New Jersey	57.3	22.5	155%	13%
Florida	35.7	0.9	3867%	8%
Colorado	23.4	21.7	8%	5%
Arizona	21.1	6.2	240%	5%
Hawaii	12.7	8.6	48%	3%
New York	12.1	7	73%	3%
Massachusetts	9.5	3.5	171%	2%
Connecticut	8.7	7.5	16%	2%
North Carolina	7.8	4	95%	2%
Other States	34.2	24.6	39%	8%
Total	434.6	311.3		

1.2 Problem Statement

California and Hawaii have the oldest history of solar targeted support policies within the USA. Other states have been passing renewable energy support policies over the past decade, and have began creating solar "set-asides" or "carve-outs" specifically targeting a percentage of energy to be derived from SPV. Given the maze of different incentives each state provides, it is difficult to quantify how much each different policy affects the SPV industry. **This study attempts to**

compare and measure the potential of US policies with solar-specific policies as part of their Renewable Portfolio Standard policies.

1.3 Research Questions

1. Which US states with Solar Carve-outs that include SREC policies have the most robust package of incentives for SPV?
2. Which of the Solar Renewable Energy Certificate (SREC) policies have the highest potential to affect residential SPV installation?
3. Do any of the solar carve-outs have the potential to be as effective as California's Feed-in-Tariff, the federal tax credit, net metering, or state personal tax credits?
4. What are the shortcomings of the solar renewable energy certificate markets within the USA?

1.4 Study Significance

This study gives homeowners in each of the states discussed a clear view of the incentives. Other studies have attempted to quantify the incentives for some states [6], and for European nations [7][8]. Similarly, this study examines the potential economic impact of solar renewable energy certificate markets in the USA on residential SPV systems.

Additionally, the study can help aid policy makers in fine-tuning their solar credit markets. By providing an in-depth comparison of the different solar carve-outs, policy makers can isolate the shortcomings of the policies. Many policies are created in an effort to stimulate the SPV industry, and this can help add more information to further the debate.

1.5 Methodology

First, the different policy mechanisms are briefly explained. The positives and negatives of each policy are laid out. Then, those states with RPS solar carve-outs are analyzed in depth state-by-state.

Subsequently, an economic analysis using Net Present Value (NPV), Internal Rate of Return (IRR) and the present value (PV) for each policy is calculated. Data comes directly from the different government database of laws. Energy prices and residential SPV prices for the analysis are taken from the Energy Information Agency and National Berkeley Laboratories respectively.

1.6 Limitations

This study limits the incentives to direct incentives provided only at the federal and state levels of the United States. Also, while many of the policies have cost caps associated, for the private residential SPV analysis discussed, it is assumed that all cost caps will not be reached. Furthermore, the tradable credits (SRECs) investigated here are not fixed in price, and can range in price from $0 to the maximums that vary from state to state. In this analysis, the potential of these policies is investigated, so an effective maximum of 80% the penalty is taken as the price per credit.

Most of the states investigated have only recently enacted SPV-targeted incentive packages. Additionally, the size of the SPV markets, and current levels of installed capacity for these states is typically under 1 Gigawatt of installed capacity. As such, attempting to draw a correlation over the past couple of years to the low levels of capacity in place is beyond the scope of this study.

II. Supporting Policies

2.1 Overview

In the United States, there are many policy measures introduced at all levels of government to support renewable energy production. Federal incentives, state-level support strategies, and even municipalities all employ a plethora of tactics.

Renewable energy sources, especially SPV, have a fatal flaw in that they cost more than traditional energy sources. That is why governments intervene with a variety of measures that are all separately and collectively, aimed at covering the difference in cost between energy from traditional resources and energy generated from solar photovoltaics.

The policies examined thoroughly in this study are monetary incentives, however a multitude of other strategies are also in place. Most of these policies are designed to limit the bureaucratic impediments that can prevent residences from installing solar photovoltaic systems. In most all states solar easing laws and permitting laws have existed for decades whereby they allow solar panel installations on buildings to streamline through zoning red tape [9]. Additionally, many state organizations maintain communities and web portals that help put solar installers, manufacturers, and customers in contact.

2.2 Tax Credits

Perhaps the most effective method for promoting solar energy, tax credits are currently in place in the USA at a federal level in the "Residential Renewable Energy Tax Credit [10]." This law is a non-refundable personal tax credit and applies only to residential renewable energy systems. SPV falls under this category. As this is a federal incentive, there are no differences among different states.

It is important to understand that this is a personal tax credit that individuals can apply for when doing their tax returns. It is non-refundable, so if an SPV owner's tax liability is $10,000 in year 0, and their credit due from the SPV system is $15,000, said SPV owner's liability is reduced to $0 for year 0. The remaining $5,000 is available for carryover into the next year to decrease the liability in the following year.

The tax credit was established on January 1st, 2006, and is scheduled to expire on December 31, 2016 after recently being extended past 2011. The federal government allows SPV installations a **one-time credit equivalent to 30%** of the cost of installation. The price of the installation includes equipment, on-site preparation, assembly or original installation, labor costs, wiring & piping for connection with the grid. This price less other incentive offsets offered at state levels (rebates, etc.) can be claimed on an individual's tax form. It is not guaranteed, and must be approved when filing income taxes.

2.3 Net Metering

The simplest incentive for renewables is **Net Metering**. This allows customers to offset their electrical use by the amount of energy their integrated renewable systems generate. Integrated SPV systems are required to have a specified meter that records the flow of electricity in both directions.

Depending on the particulars of the different laws in place, the SPV owners are able to apply for rebates or simply pay less in their monthly energy bill. Effectively, **net metering is designed to allow customers to sell their generated electricity at the market price**.

Unfortunately, the cost of energy from SPV is above the current market price, thus net metering alone is not enough to put SPV in competition with traditional means of electric energy production.

2.4 Feed-in Tariff (FIT)

A **Feed-in-Tariff (FIT)** is usually a contractual obligation placed on a utilities company to purchase electric energy from integrated renewable systems at a fixed per kWh price. These contracts usually have a set time limit (20 years in Germany [11], 10-25 in California [12]) whereby the SPV installers are guaranteed a set amount of income per kWh of energy they produce.

This FIT price is paid in addition to net metering. FIT prices typically decrease over the course of their lifespan as the price of photovoltaic panels decrease in cost, unless energy costs are projected to increase faster (as they are in California). In essence, a FIT is designed to help offset the higher cost of generating electrical energy from SPV in the form of either a government payment, or a required payment from utilities.

These policies have been enacted with differing levels of effectiveness around the world. Germany's strong SPV position can be attributed to its successful FIT program [13]. Research on the various FIT programs around the world consistently shows that they are indeed successful at stimulating growth in SPV and other renewable resources.

However, FIT programs are not without their detractors. In the book *Renewable Energy Policy,* FITs are classified as "effective but not efficient [14]." FITs are also against the "growing role in the electricity industry of competitive markets and pricing – which are replacing regulation…rates paid to renewable generators are seen by many to be unsustainably high [14]."

Table 3: Feed-in-Tariff Law Pros & Cons [14]

Feed-in-Tariff Laws

Positives	Negatives
Effective at getting various new renewable installations	Reduced incentive for cost reduction
Not a direct general-revenue tax	No direct competition between suppliers
Can be very simple	Sets up a dependend and powerful constituency
Costs paid by ratepayers, not general public as a tax	Price paid reflects outcome of a political process, not costs
Low uncertainty	Not a market mechanism
Low direct cost to government	Can create excess profit for producers
Little Bureaucracy	

In California, they use a *Market Price Referent (MPR)* to determine the FIT price for each year. This *MPR* is "the predicted annual average cost of production for a combined-cycle natural gas fired base load proxy plant [12]" and in 2010 the incentive was a 15-yr contract at $0.09066 per kWh of energy produced.

2.5 Renewable Portfolio Standard (RPS)

In the United States, each state has strong, but not complete, authority to regulate utilities companies serving their markets. As such, many states have been setting goals and requirements for electrical energy production from renewable resources similar to those seen in Europe [8]. What qualifies as a renewable energy source may vary from state to state, as do the requirements. However, SPV falls under this definition in every state that has an RPS. 33 states and the District of Columbia have RPS programs in place [15]. 7 other states have goals, but no requirements to meet the targets.

These different RPS strategies cover the whole spectrum of renewable energy, and their implementation is different in each state. The RPS sets a requirement (or goal) for a certain percentage of retail electrical energy to be produced by renewable resources each year, scaling up to their final goals at some future date. The states usually enforce the RPS by acquiring a **Renewable Energy Certificate (REC)** which is equivalent to **1 MWh** of energy created by a renewable resource (similar to Tradable Green Certificates (TGC) often found in European nations [8][16]).

Should an insufficient amount of RECs be produced or purchased by energy producers, energy producers can pay an **Alternative Compliance Payment (ACP).** The ACP for each RPS is different, and subject to adjustment. Ohio's is \$45/MW, New Jersey's is \$50, and New Jersey's remains unchanged since 2004, whereas Ohio's ACP decreases \$5 bi-annually. The revenue from these ACPs is typically budgeted for Alternative Resources Projects being undertaken by each state's energy commission [9].

RPS policies solve many of the problems associated with FITs. FITs are seen as fighting against the market, whereas RPS policies do not pick which technologies will succeed in replacing traditional energy sources. Instead of setting a price irrespective of the market, RPS uses a market-based approach [14].

However, this is precisely why RPS policies alone cannot stimulate SPV markets. Due to the higher cost of SPV, the basic RPS goals have proven ineffective at stimulating SPV development [17]. As a result, states have been modifying their RPS systems by adding **credit multipliers**, **distributed generation provisions**, and/or technology-specific **"set-asides"** (also called "tiers," "bands," or "carve-outs").

2.6 Credit Multipliers

Credit multipliers weight different technologies heavier in RPS portfolios. A credit multiplier of 2 for SPV means that for every 1MWh of SPV created or installed, the producer gets credit for having created 2MWh of renewable energy towards their RPS obligation (or 2 RECS instead of 1). This mechanism has an obvious drawback in that it **decreases the actual effective percentage the RPS yields** [18]. Furthermore, without a specific set amount of energy per technology with set incentives and penalties for said technology, this form of policy has little bite.

Table 4: Credit Multipliers [17]

Positives	Negatives
Gives solar an added incentive over other renewable sources	Does not ensure any specified amount for solar
Allows policy makers an avenue to promote solar	Does not have a strong effect on smaller SPV installations
Does not disturb the market as much as a FIT	Reduces overall RPS percentage target
May be effective depending on details and other factors	Setting an effective level is difficult to determine or maintain

2.7 Distributed Generation

Many states have Distributed Generation provisions as part of their RPS policies. This requires a certain percentage of energy production to be produced across the grid and integrated to it. The most common method used for promoting DG is to make a multiplier for RECs from Distributed systems (integrated residential SPV is classified as DG).

2.8 Solar Set-asides

Within the different RPS laws, some states have specific requirements for different forms of energy. These are called either a "set-aside" or a "carve-out" for different energy sources, including solar photovoltaics. As of December 2010, the USA had 16 states with solar set-asides or distributed generation [9]. These set-asides are required percentages of state energy production from SPV. For example, Ohio's RPS has a 2025 goal of 12.5% renewable energy production, and a 0.5% solar set-aside. These set-asides have shown to be more effective than credit multipliers [18].

Just like all other RPS energy production, a REC is created for every 1 MWh of solar energy. However, these RECS are special **Solar Renewable Energy Certificates (SRECs)** and fall under different regulations. Specifically, the associated ACP is also a special **Solar Alternative Compliance Payment (SACP)**, and these SACPs are usually significantly higher than the standard ACP.

Table 5: Set-Asides [17]

Positives	Negatives
Greater certainty for the total amount of solar photovoltaics to be added	Higher risk of cost impact, and may force the RPS cost cap
Does not affect the overall RPS percentage target	More directly impacts the market for renewable
Easier to set effective levels and accompanying strength	Establishing level of support can be troublesome and often uncertain
Targets cost barriers	Once established can become difficult to modify

2.9 Solar Renewable Energy Certificates (SRECs)

Many nations have created green energy credit markets whereby utilities companies are required to purchase a set number of energy credits. Among the different states, this type of policy has picked up steam, and several states have enacted or planned these Solar Credit Markets (SREC). As these policies are less costly and less invasive on the market, political opposition is weaker [14].

Table 6: Tradable Green Certificates (SRECs) [14]

Positives	Negatives
Larger political support	Can be complicated to understand and implement
Generators like them, as they result in a new revenue stream	Newer policy with less history
Administrative cost control is low	Unclear relationship with carbon or pollutant tradable credits
A market mechanism	International trading can further complicate the programs

SREC markets are very new, and tradable SREC markets exist in 8states [19], with maturing markets existing in Maryland [20] and District of Columbia (DC), and New Jersey. Just like RECs, **1 SREC = 1 MWh** of solar energy produced within a given energy year. After SPV is installed, the owner is required to certify their program with their state utilities authority. This usually takes about 2 months to accomplish.

They are required to set up an approved tracking system. This is surprisingly simple for the grid management companies to arrange. The electric grid is not run directly by electric energy producers, but instead by private companies that operate across various regions, working with many utilities companies. The largest grid infrastructure company is PJM in the east where most of the SREC markets exist. PJM employs its GATS monitoring system [21], and stores each MWh produced by a system with a unique serial number.

To help speed up the process, these private equity markets allow you to use their service to manage GATS, and sell through their markets. SPV owners are able to use SRECTrade's EasyRec Program to get their systems certified and GATS installed. This costs the "greater of 3% - 5% or $5" [19].

These MW hours are then able to be verified RECs (or SRECs), and can be sold by the owner of the SPV system. Although depending on the specifics of an SREC market, or the contract signed by the household, they may not have rights to the SRECs from their systems.

The utilities companies within the states are required by law to purchase a set number of SRECs per year or pay a Solar Alternative Compliance Payment (SACP). Many SACPs have a set timetable whereby the price of SACP decreases annually, while others do not. At the same time, the quantity of SRECs mandated to be purchased increases annually as the solar carve-out percentage increases.

The way utilities companies acquire SRECs is up to them. They are allowed to build solar production plants, purchase SRECs from private SPV energy producers, or pay the SACP. Due to the ambitious scale of some SREC policies, the ever-evolving SPV technology, legal and bureaucratic obstacles to large-scale plants, the time it takes to create a SPV plant, and the conservative nature of utilities companies, companies tend to opt for either purchasing SRECs or paying the SACP. Even so, Concentrated Solar Plants (CSP) have increased recently in states whose carve-outs allow CSP megawatts to count as SRECs, and more utility-scale SPV plants are being produced [17].

Most Solar set-asides allow SRECs to be freely traded, so private equity markets have sprung up to capitalize upon the SREC policy trend: SRECTrade and Flettexchange. These exchanges are privately managed markets where people and companies can buy and sell SRECs throughout the course of a year. At Flett Exchange, and soon from PJM's tradable market, SRECs are traded based on bid & ask prices, and can be bought and sold by these spot prices. SRECTrade is an online auction house and works like an IPO with a monthly SREC price.

Due to the nature of SRECs, the SACP acts as a cap on the price of an SREC, because a utility company has no need to buy an SREC at the same price as it does to pay the SACP. No scenario exists where an SREC will exceed the SACP in price. Accordingly, SREC prices per state tend to stay very close to the SACP.

It is to be expected that should the ratio of SRECs demanded to SRECs supplied ever dip below 1:1, or approach it, the prices of SRECs should become more drop quickly as SREC holders attempt to ensure they get revenue of some sort for their solar production.

There is no guaranteed minimum for an SREC, and should the number of SRECs produced exceed the set-aside requirement, many could go worthless, so some states allow multi-year contracts to be signed. These contracts can help lower the Utilities' companies average cost for SRECs over the years of the contract. Similarly, SREC producers can decrease the market risk for their SRECs. By signing a long-term (and/or fixed payment) contract, SREC producers can be guaranteed of payment for the SRECs.

2.10 Drawbacks to RECS & SRECS

RPS requirements and their set-asides are not without their faults. Funding remains a major issue for all programs. The majority of the RPS Compliance Payments come with cost containment measures that cap the amount of money to be paid in the form of ACP or RECs. Already, in New Mexico & New Jersey, these caps are being approached. Due to the higher

SACPs, solar carve-outs may serve to complicate RPS cost containment [17], and potentially negatively affect the policy as a whole.

Given that residential SPV systems produce a small amount of SRECs annually, transaction costs for utilities companies to find each of these SRECs are prohibitively high. Therefore, SREC aggregators like US Photovoltaics [22], Sol Systems [23], and other private companies and individuals are emerging to purchase these residential SRECs and package them to utilities companies.

Essentially, the value of the SREC for the residential SPV owner is lessened by these transaction costs. PJM's GATS group reported in 2009 that SREC generators are in need of brokers so they can communicate with the SREC buyers (utilities companies) [24].

2.11 SREC Price Uncertainty

The uncertainty of the SREC price also makes it hard to determine exactly how effective they can be. Under most SREC legislation, SPV owners are not guaranteed any minimum price at which they will be able to sell their SRECs in the future. The elasticity of credits is very much inelastic [25], and should the supply of SRECs begin to outweigh the demand, the price of an SREC will very rapidly approach zero.

Price volatility and inelastic demand are the key problems with SREC policies. The only way around this problem is to establish some sort of floor in addition to the ceiling (SACP price) to put SPV owners at ease. When a minimum is put into place TGCs can be effective, as is the case of Belgium's TGC policy [8] [16]. However, to all intents and purposes, it becomes a sort of variable-priced FIT program. Then, the problems associated with FITs affect SREC policies, and make it hard to pass through as legislation due to funding questions [14].

This lack of a floor means that the best available strategy to SREC buyers and sellers is to make "long-term bilateral deals [25]. " This will lower the average price of an SREC to the seller and the buyer, reducing the maximum impact of the SREC policy, but also lowering the risk associated with the highly volatile SREC.

2.12 Measuring Policies

There have been many studies exploring the success of government policies on renewable energy sources. There is also no denying that government policies aimed at increasing SPV capacity growth are a major force driving the technology to date [4] [17]. Unfortunately, assigning value to each of the different policies is challenging [17].

Most studies have shown that RPS do indeed have an effect on renewable energy sources. Probability Distributions have been used to measure the effectiveness of each program (Net metering, Compliance Penalties (ACP), existing capacity, etc.), and show that, on a whole, RPS have been successful [26]. An in depth study of wind power policies also reveals that they have been helped to promote wind energy [27]. However, in 2010 a separate two-part model showed that RPS had a negative impact on increasing installed wind capacity, and for solar it had a negligible impact (0.01 correlation) [28].

Still further attempts to measure the effectiveness of solar policies have been attempted. A study of UK *banding* (similar to a carve-out) and carve-outs indicates banding has been more effective than carve-outs, but that carve-outs are still newer and need more data to get a stronger result [29].

Other studies attempt to compare different nations or states. Comparative financial and economic analysis of individual European countries using *Net Present Value* and *Internal Rate of*

Return for each of the different European nations' policies contrast different policies levels of effectiveness [7][8]. A similar study of solar thermal heating and residential SPV in Michigan and Hawaii suggest Hawaii's system is positive, while Michigan's remains negative or even [6]. These studies each measure the direct impact of policies on the SPV industry.

This study compares the SREC policy's portion of the whole incentive package by applying a *Present Value* (PV) for each of the SREC policies over 15 years. Then it measures this present value against the other policies that exist within the USA (California's FIT, net metering, and the federal tax credit, and net metering) as an attempt to measure and compare the potential effects of the emerging SREC policies within the USA.

III. State-by-State Policies

3.1 Overview

In this study, only those American states with Renewable Portfolio Standard solar carve-outs that contain Solar Renewable Energy Certificate (SREC) policies are evaluated. An in-depth overview of the state policies that apply and are calculated in the NPV analysis is provided for each of these eight states. Then, an overview for the successful Cailfornia Feed-in-Tariff is provided.

3.2 District of Columbia

DC passed its RPS in 2005, and in 2008 it amended it, increasing the requirements and ACPs. DC uses a similar method to Maryland. It has a Tier I, Tier II, and solar carve-out requirement. DC's solar target began at 0.005% in 2007, scaling up to 0.40% by 2020. The SACP is a fixed amount of $500 each year until 2018, after which it is undetermined. In order to convert a MWh produced by SPV into an SREC, the SPV owner must be certified by the DC Public Service Commission (PSC), and use the PJM GATS accounting system like most other SREC markets.

Like Ohio and Pennsylvania, DC allows solar credits produced outside of DC in states as far as Wisconsin to be purchased and retired by DC utilities companies in order to meet their RPS requirements. Out of state generated MWh can be used as SRECs in DC only if the resources within DC are "exhausted [9]."

Table 7: DC Overview [9] [30] [31][32]

2010 SACP	SREC Lifetime	Carve-out Goal	SPV Price per Watt	Avg. Solar Output (kW/kWp)	2009 Energy Price per kWh
$500.00	3 years	0.40% by 2020	$8.80*	1240	$0.1376
$500 until 2018, then undetermined					

3.3 Delaware

Delaware established its RPS originally in 2005 with a 10% goal by 2020, but was then modified to be 20% by 2026 with a 2.005% solar carve-out in 2007. Later it was scaled up again to 25% & 3.5% respectively. Delaware's RPS also has a 3x multiplier for SRECs, meaning an SREC counts as 3 RECs towards the utilities' ACP requirements, in addition to the 1 SREC towards the solar set-aside requirement.

Delaware's SACP system is particularly unique in that there is a punishment attached. Each time a company uses an SACP instead of submitting an SREC, the next year it must pay $50 should it use SACPs again. If a Delaware energy producer meets its compliance by acquiring 70% SRECs, and paying 30% SACPs of $400 each, the next year the number of SACPs purchased at $400 go up to $450, and any subsequent SACPs are paid at the lower $400 price. This scales up indefinitely at $50 each year with no maximum.

Undoubtedly, this strict and aggressive Solar Set-aside should jumpstart the SPV market within Delaware. However, the 2010 amendment adds provisions allowing for the compliance payments to be frozen should the payments (either in purchased RECs or paid ACPs) exceed 3% of total energy retail for that year. SREC requirements are ceased should SREC paid for or SACPs exceed 1% of total retail energy.

Table 8: Delaware Overview [9] [30] [31][32]

State	2010 SACP	SREC Lifetime	Carve-out Goal	SPV Price per Watt	Avg. Solar Output (kW/kWp)	2009 Energy Price per kWh
Delaware	$400.00 $400 indefinitely; increases $50 each time SACP is used	3 years	3.5% by 2026	$7.50*	1240	$0.1407

*National Average for SPV / Watt

3.4 Maryland

Maryland enacted its RPS in 2004, and subsequently revised it several times to include a solar carve-out, and tiers to target a wide range of renewable. The solar carve-out is aggressive, and scales up from 0.005% in 2008 to 2% in 2022. Maryland's SACP is set at $400, and was set to decline according to a set timetable, but in December 2010, Maryland approved extending the $400 SACP through 2016 to increase the strength of the program.

Maryland's solar set-aside requires the owner of a system that generates an SREC to first offer the SREC to an electricity producer for RPS compliance. It is not specified, but the law requires the SREC producer to post the SREC for sale on Maryland's Public Service Commission

(PSC)'s website for a minimum of 10 days before the SREC holder is allowed to sell their SREC to another person or entity [33].

Additionally, should the electricity suppliers decide to purchase their SREC directly from the SREC producer, the solar energy system owner must enter into a contract for at least 15 years. Specifically, for SPV systems under 10kW in capacity (residential), the purchaser must pay the value of the contract in a "single, up-front payment arrived at by calculating the net present value of SRECs over the life of the contract using a standard SREC value of 80% of the SACP and federal secondary credit interest rate in effect as of January 1 of that year as the discount rate [9]."

This is designed to help provide residential SPV owners some security in their SREC revenue, and to make SPV more attractive. Should the utilities choose not to deal directly with the SPV owners, it stimulates the private SREC market.

US Photovoltaics, Inc. is a unique company that has since been created specifically to purchase SRECs from producers, and resell the credits to the utilities at a per-SREC basis. US Photovoltaics make up the majority of SRECs for sale on Maryland's official PSC SREC website (along with SRECTrade) [33].

Table 9: Maryland Overview [9] [30] [31][32]

State	2010 SACP	SREC Lifetime	Carve-out Goal	SPV Price per Watt	Avg. Solar Output (kW/kWp)	2009 Energy Price per kWh
Maryland	$400.00	3 years	2.00% by 2022	$8.80	1228	$0.1498
	$400 until 2014, decreasing to $50 by 2023					

3.5 Massachusetts

The Department of Energy Resources (DOER) [34] has created a sufficiently complex RPS, with a total goal of 15% by December 31, 2020. It is tiered with 15% into Class I resources (of which SPV is included). In 2010, DOER created a unique Solar carve-out of 0.0679% the total energy produced each year until a capacity of 400 MW SPV is installed within MA. After 400MW capacity is reached, SPV falls back under the Class I status, and would have a lower ACP. A SPV system must be under 6MW in capacity to qualify for SREC production (effectively eliminating Concentrated Solar Plants).

In Massachusetts the SACP is $550, with no set increase or decrease. They guarantee no annual reduction in SACP greater than 10% in a given year to alleviate price uncertainty. Additionally, DOER has created a Solar Credit Clearinghouse Auction through which SREC holders can sell their SRECs. This auction has a minimum SREC cost of $300, effectively creating a floor of $300 and a ceiling of $550 for the price of any SREC.

Table 10: Massachusetts Overview [9] [30] [31][32]

State	2010 SACP	SREC Lifetime	Carve-out Goal	SPV Price per Watt	Avg. Solar Output (kW/kWp)	2009 Energy Price per kWh
Massachusetts	$600.00 $550 in 2011, but no set timetable;	1 year	400MWp by 2020	$8.40	1232.5	$0.1687

3.6 North Carolina

North Carolina's RPS does have a solar carve-out of 0.2% by 2020, but the SACP is currently only $30 per MWh, and set to increase to $42.39 by 2024, which is effectively a $0.042/kWh of SPV produced.

North Carolina does have a wide array of tax credits, grants, loans, and rebates. There is a strong personal tax credit at 35% of installation with a maximum of $10,500 for SPV (or wind) installations. Progress Energy (an NC energy provider) has a commercial SPV incentive whereby they pay $0.18/kW up to 50 MWh produced in a year. In exchange, they gain the rights to the SRECs generated from the SPV system.

Table 11: North Carolina Overview [9] [30] [31][32]

State	2010 SACP	SREC Lifetime	Carve-out Goal	SPV Price per Watt	Avg. Solar Output (kW/kWp)	2009 Energy Price per kWh
North Carolina	$30.00 Increasing to $42.39 by 2025 ($0.826 annually)	2 years (effective)	0.2% by 2020	$7.50*	1310	$0.999

3.7 New Jersey

New Jersey's solar market ranks second only to California. New Jersey originally passed their RPS system in 1999 under a different name, and subsequently added in separate requirements for "Class 1" and "Class 2" energies (SPV is a class 1). Then in 2006, NJ added a specific solar carve-out. NJ has a target of 22.5% renewable energy production by 2021, and a solar carve-out of 2.12%. This goal has since been revised to 5,316 GW of solar generation in 2026. The New Jersey Board of Public Utilities (BPU) is in charge of enforcing the RPS within the state [35]. The wide variety of mechanisms New Jersey enacts through its RPS and through successful solar loan, grant, and rebates have made New Jersey the USA's second largest SPV market despite not being situated in the sunniest of states.

There is a set timetable for SACP reduction, at $693 in 2009-2010 set to decrease by 2.5% annually until 2016, and the NJ BPU has provisionally said it will continue this strategy through 2019. NJ SRECs currently have a lifespan of 3 years after the MWh is produced, having been revised up from 1 year in 2009.

Solar facilities are allowed to accrue SRECs per kW hour produced over its "15 year qualification life [9]." This means a solar facility is only eligible to produce SRECs for 15 years after being connected to the grid, and can be sold any point within 3 years after their creation.

New Jersey allows long-term SREC contracts to be signed by utilities companies, and promotes it as an attempt to combat the uncertainty problems associated with SRECs. In April 2008, PSE&G (a major NJ utilities provider) created its **Solar Loan Program**, and was subsequently added upon in 2009 *as Solar Loan II* through the end of 2011 PSE&G signs agreements for 40-60% of the cost of installation for residential SPV systems in return for a 10 year 6.05% annual loan [9].

This loan repayment is to be financed with the SRECs generated throughout the lifetime of the SPV system until the loan is repaid. The 2011 basement price is $420 (which is 62% the SACP of the same year). This type of system is almost an ideal, and helps to alleviate many of the problems associated with SREC markets. There is a guaranteed return, paid up-front, and the uncertainty in the price of SRECs to the SPV buyer is completely eliminated. The BPU has since been pressuring the other three major utility providers to present long-term contract plans as well.

Table 12: New Jersey Overview [9] [30] [31][32]

State	2010 SACP	SREC Lifetime	Carve-out Goal	SPV Price per Watt	Avg. Solar Output (kW/kWp)	2009 Energy Price per kWh
New Jersey	$693.10 Declines 2.5% annually	2 years	2.21% by 2021	$8.10	1216.5	$0.1631

3.8 Ohio

Ohio targets 0.5% solar retail energy production by 2024 and beyond, and has tasked the Public Utilities Commission of Ohio (PUCO) [36] with enforcing Ohio's RPS. Ohio's SRECs have a 5-year lifespan, during which they can be used by utilities companies to count against their SACP requirements. The SACP in Ohio has a set time-table decreasing $50 bi-annually until 2024 where a $50 SACP is set to be permanent.

PUCO does allow long-term SREC commitment contracts by utilities with SREC producers. To date, only FirstEnergy, one of the four major utilities providers in Ohio, is offering these contracts. FirstEnergy agrees to purchase SRECs on or before 12/31 of each year at a payment amount equal to the weighted average price of an SREC within the applicable calendar year. The 2009 contract price was $390/SREC or $0.39/kWh [37]. Through its *Residential REC Purchasing Program* [38], First Energy offers 15 year contracts for residential SRECs. Unfortunately, the program enacted in 2009 is set to expire May 31, 2011.

Table 13: Ohio Overview [9] [30] [31][32]

State	2010 SACP	SREC Lifetime	Carve-out Goal	SPV Price per Watt	Avg. Solar Output (kW/kWp)	2009 Energy Price per kWh
Ohio	$400 Declines $50 bi-annually	5 years	0.5% by 2024	$7.50*	1176	$0.1067

*National Average

3.9 Pennsylvania

Pennsylvania titled its RPS "Alternative Energy Portfolio Standard (AEPS)," and its SREC is called a "Solar Alternative Energy Credit (SAEC)." However, they act the same as other SREC programs. Pennsylvania has a tiered system of requirements totaling 18% renewables by 2021 with a 0.5% solar set-aside.

The SACP is calculated every year by the Pennsylvania Utilities Commission (PUC) [39], and is based on the weighted average price for an SAEC within Pennsylvania during the previous year. In 2008, the SACP was $528.17, $550.15 in 2009, and in 2010 it was $654.37.

It is important to note that, this SACP is based on the SAEC price paid for Pennsylvania's energy credits, and these energy credits are also available for sale in other states (OH, NJ, DC, DE, MD, and NC), and the lower SACPs in those states could drag down the weighted average price for SAECs as the program progresses. Despite a 2009-2010 SACP of $654.37, the average SAEC for that year was $325.

If early 2011 is any indication, then Pennsylvania's SREC value is decreasing rapidly, reaching as low as $80 on SRECTrade's exchange. On the Flett Exchange, the 2011 prices dropped down to $120, and appear to be operating at an effective maximum of $199. In March 2011, a major Pennsylvania utilities company completed its request proposal for submitting SRECs to meet compliance with the RPS carve-out. Pennsylvania Power Company is offering a 9 year long-term contract for SRECs at $199.00 per SREC [40].

Pennsylvania's SPV market grew among the fastest in the nation since they established their **rebate program**. For residential SPV systems 1-10kW in capacity, a $0.75/W ($7.50/kW) rebate is provided to certified systems up to the lesser of $7,500 or 35% of installation costs. This rebate program is of note, because it is backed with $100 million in Pennsylvania state bonds, and is expected to last between 3 and 4 years after program was initiated on May 5, 2009 (through 2011 to 2012 or 2013).

Table 14: Pennsylvania Overview [9] [30] [31][32]

State	2010 SACP	SREC Lifetime	Carve-out Goal	SPV Price per Watt	Avg. Solar Output (kW/kWp)	2009 Energy Price per kWh
Pennsylvania	$654.37 Calculated annually; based on the previous year's weighted average SAEC	2 years (effective)	0.5% by 2021	$7.50*	1145	$0.1165

*National Average

3.10 California

California's FIT is the basis of California's overall solar-targeted policy. The policy is similar to the program implemented in Germany, and both have been very successful. As previous studies suggest, the California FIT is effective, and the targets have even been surpassed [14].

California offers SPV owners long-term, guaranteed money per kWh. They are offered contracts for 10, 15, 20, or 25 years. For purposes of this study, the 15-year contract starting in 2010 is used. California utilities providers are required to purchase all kWh produced by registered SPV the guaranteed price of $0.09066/kWh.

Table 15: California FIT Overview [12][30][32]

State	15-year FIT rate	Avg. Solar Output (kW/kWp)	2009 Energy Price per kWh
California	$0.09066/kWh	1414	$0.1474

IV. Comparative Economic Analysis Framework

4.1 Operational Hypotheses

1. The NPV and IRR of a residential SPV system in each state over 15 years is calculated and compared, and the highest of these is to have the most potent potential policy.
2. Cash flows from each SREC policy are computed and discounted, and then the highest **Present Value per Watt of installed capacity (PV/ W_p)** is used to measure which state's policy has the highest potential.

3. The same (PV/ W_p) for each SREC policy is then compared to California's Feed-in-Tariff (FIT) PV/ W_p, net metering, and state & federal tax credits to measure and compare SREC policies with other financial incentives.
4. After a thorough analysis of each state's policy, a comparison of the problems and positives of each policy is presented.

4.2 Theoretical Framework

In this study, of the 33 states with RPS, the 8 states with SREC markets are evaluated. The comparative economic analysis is performed by calculating the cash flows, NPV, and IRR for each state's package of policies. Then a present value for the cash flows from each separate individual policy is calculated to compare the potential for the SRECs against the other policies that make up the state incentive package.

Cash flows depend on many factors (average state energy price, solar radiation, SPV price, etc.), and various policies from the package of federal and state-level incentives (SREC income, net metering income, tax credits). The Cash Flows for each state is calculated the same as has been done in previous studies [7][8]. The cash flows are taken as the sum of all the costs and profits in any year *t* using the following:

$$C_t^* = F * E_t + c_{kWh,t} * E_t + C_0 * T_{fed} + C_0 * T_{state} - u * C_0 - C_{add} \qquad (1)$$

where:

F is the SREC value in year *t* (for California's FIT, this value is the series of payments under the terms of the FIT contract);

E_t is the energy produced in kWh in year t;

$c_{kWh,t}$ is the energy price per kWh in year t;

C_0 is the up-front cost of installation;

T_{fed} is the Federal tax credit (as a percentage of initial cost);

T_{state} is the state tax credit (as a percentage of initial cost);

u is the maintenance fee, estimated as a percentage of initial cost;

C_{add} is the insurance cost for the system over its lifespan

Then, these cash flows are discounted using the classical expression for discounted cash flows to get the present value of each year (to be summed later) as has been done in prior research [7][8]:

$$C_t = \frac{C_t^*}{(1+i)^t} \tag{2}$$

where i is the discount factor or cost of capital.

Then the classic methods for calculating NPV and IRR are applied as follows:

$$NPV = \sum_{t=1}^{N} \frac{C_t^*}{(1+i)^t} - C_0 \tag{3}$$

$$C_0 - \sum_{t=1}^{N} \frac{C_t}{(1+IRR)^t} = 0 \tag{4}$$

where N is the lifetime of the investment.

The **present value for each of the different portions** of cash flow (as calculated in Equation 1, and discounted in Equation 2) are calculated. This helps give a clearer view of exactly which of the various policies have the largest impact on the NPV analysis, and to compare each different policy separately. Finally, **each separate these present values is divided by the capacity of the system** to get an accurate view of just how much value a residential SPV owner receives per Wp installed from each separate financial incentive.

SREC or FIT PV/ W_p:

$$\left(\sum_t^{15} \frac{F*E_t}{(1+i)^t}\right)/W_p \tag{5}$$

Net Metering PV/ W_p:

$$\left(\sum_t^{15} \frac{c_{kWh,t}*E_t}{(1+i)^t}\right)/W_p \tag{6}$$

Federal Tax PV/ W_p:

$$\left(\frac{C_0*T_{fed}}{(1+i)^1}\right)/W_p \tag{7}$$

State Tax PV/ W_p:

$$\left(\frac{C_0*T_{state}}{(1+i)^1}\right)/W_p \tag{8}$$

4.3 Operational Assumptions

Residential SPV systems range between 2kWp and 10kWp, so in this comparative analysis is based on a 4kWp BIPV residential system. Some studies use a 10kWp system, but that is larger than the average residential SPV. The following assumptions are taken when performing this analysis, in accordance with what has been used in previous journal studies [6][7][8]:

- Different policies are enacted in different states, but this focuses on the effects of solar targeted set-asides.
    - Rebates are ignored, as they are paid on a first come, first serve basis, and tend to have lower caps, and are typically enacted at a municipal level or levied against specific utilities companies;

    - Grants, loans, and capital subsidies are also cast aside for the same reason.
- Net metering exists with a strong degree of similarity in all states, so it is included;
- State & Federal Tax credits are factored in, but discounted as the end of year 1;
- Solar Renewable Energy Certificate markets are factored in at a percentage of the SACP annually of 80%;
    - Due to the highly speculative nature of Pennsylvania's SREC market, any attempt at quantifying is not realistic, so it will not be evaluated;
- Discount factor is the average inflation rate for the USA, and is 3%;
- The mean operative efficiency of the SPV system is calculated based on the National Renewable Energy Laboratory program *PV Watts* [32], whereby solar insolation for each point in the USA is calculated and used to determine operative efficiency for any point on Earth;
    - The base stations in each state are averaged to form a state average level of annual solar output per 1kWp of SPV;
    - The default *PV Watts* rates for energy loss and positioning are used [32];
- The average residential electricity price is based on the 2009 state price [30];
- The electricity price in each state increases at 3% [8];
- The total costs of the SPV system vary by state, and are based on the 2009 price per Watt for SPV systems under 10kWp [31]. Except Ohio, Delaware, and North Carolina which use the national mean price from 2009 of $7.50/Wp;
- The annual maintenance price is between 0.5% and 2.4% of the price of the installed plant cost [41] – for this study, 0.5% is used;
- The annual insurance cost is the same for all states, and is set at $20 per kWp [42];

- The SPV system is assumed to lose 0.8% efficiency annually [42];

V. Results

5.1 Research Question 1: State Solar Renewable Incentives

Table 16: State NPV & IRR

State	NPV	IRR
New Jersey	$8,929.03	9.54%
Massachusetts	$5,644.97	7.75%
Delaware	-$671.62	2.54%
DC	-$3,238.13	0.14%
North Carolina	-$4,850.65	-6.17%
Maryland	-$5,318.19	-1.36%
Ohio	-$7,070.49	-3.90%

*As Calculated in this study

Table 16 shows the NPV and IRR for each of the states. The Carve-outs show that New Jersey and Massachusetts are clearly out in front with the strongest policies. Within only fifteen years, residential SPV systems are profitable, and the internal rates of return are significantly higher than the 3% annual inflation rate.

The other states all have negative NPVs within 15 years, though they come close to breaking even within that timeframe, and should the analysis continue out to 20 or 25 years as other studies have done [6][7][8], then they would also break even. North Carolina's solar-carve out incentives are the weakest, but the investment is nearly positive on the back of its personal tax credit which is not set to expire until 2015.

5.2 Research Question 2: State SREC Strengths

Table 17: Present Value (per Wp) of Each SREC Policy

State	SREC PV/Wp
New Jersey	$6.57
Massachusetts	$3.46
Delaware	$4.64
DC	$4.26
Maryland	$3.59
Ohio	$2.79
North Carolina	$0.43

*As Calculated in this study

The potential is evident simply in looking at the SACPs, and the present value analysis reflects them as the higher SACPs result in higher PV/Wp. Table 17 shows the PV/Wp of each state, and indicates that should the SREC market prices stay around 80% of each state's SACP going forward, then all of the states except North Carolina clearly have strong potential to affect the solar markets.

The different SREC states can be broken down into three different categories: aggressive, medium, and ineffective. New Jersey and Massachusetts have aggressive policies and high SACPs over $500. These states also have the highest Present Value for their SREC policy.

Ohio, Maryland, DC, and Delaware fall into a second tier, and do have very strong policies. In fact, the PV/Wp suggests that each of these policies have the potential to be stronger even than the federal tax credit.

North Carolina did pass an SREC market, but with a tiny SACP of only $30, the PV/Wp is below $0.50, and the North Carolina solar set-aside remains insignificant. Instead, North Carolina's photovoltaic market is dependent on its strong solar insolation and personal tax credit. In fact, with such an insignificant SACP payment, the resulting PV/Wp value of the SREC policy makes it so the North Carolina SREC market has little to no effect on residential SPV installations within the state.

5.3 Research Question 3: Comparative Analysis of Incentives

Table 18: Present Value (per Wp) for Each Policy

State	SREC	Federal Tax Credit	Net Metering	State Tax Credit		California FIT
New Jersey	$6.57	$2.36	$2.32	-		
Massachusetts	$3.46	$2.62	$2.50	$0.24		
Delaware	$4.64	$2.48	$2.09	-		
DC	$4.26	$2.56	$2.05	-	vs	$1.90
Maryland	$3.59	$2.56	$2.21	-		
Ohio	$2.79	$2.18	$1.51	-		
North Carolina	$0.43	$2.18	$1.57	$2.55		

*As Calculated in this study

Table 18 shows the PV/Wp of each of the different state SREC policy's against California's FIT, and the other policies that make up each state's portfolio of solar incentives. It shows that all the SREC policies except North Carolina have not just the potential, but significant ability to be as strong as California's FIT. In fact, the New Jersey's policy can be more than 3 times as powerful as California's FIT, and more than twice as strong as the federal tax credit.

The glaring limitation of this study is that SREC prices are highly uncertain, and a long-term, 15 year financial analysis does not take this problem into account. However, the financial options arising, and Massachusetts' clearing-house policy can give us a view of a sort of minimum value for SREC policies.

Massachusetts' minimum SREC strength with an effective SREC value of $300 has a **present value per watt capacity of $3.46**. This, when compared to the federal tax credit is 50% more powerful. Other SREC financing options that give 10%-60% of the initial upfront costs reveal that while the potential for SRECs at first seem to be incredible, the realistic value brings it down to somewhere around that of the federal tax credit.

Additionally, the PV/Wp of North Carolina's personal tax credit suggests that while its SREC policy is weak, within its package of solar incentives, the personal tax credit has great value, almost equaling that of the US federal tax credit.

5.4 Research Question 4: Conclusions & Policy Implications

5.4.1 DC

The DC SREC policy is designed well, and is simple enough to understand. DC is unique among the carve-outs in that it is not a state, but rather a special area the size of a large city. Therefore, by allowing the utilities companies within the state to purchase SRECs generated from neighboring states, the goals should be reached.

Unfortunately, DC's low 0.40% 2020 goal is not as aggressive as some other states, and due to its small size, the effect of DC's SREC policy on the national SPV market should be minimal. Additionally, the unclear SACP price after 2018 can dissuade potential SPV buyers, and cause issues.

5.4.2 Delaware

Delaware's SACP is not set to reduce below $400, and it has a very strong solar carve-out target of 3.5% by 2026, which make Delaware's policy quite strong. The $400 SACP is in the middle-range of current SACP prices, but while other states' SACPs decrease in time, Delaware's program helps bring some security that the price ceiling will not drop too low in the foreseeable future.

However, Delaware does have a glaring problem in cost control issues, and the way their SACP price increases are established makes it costly and more complicated. It puts energy producers in an interesting position. They have to choose to try to acquire SREC production capacity to avoid the ever-increasing penalties paid in SACPs, or simply accept that they will pay an additional 1% of total retail energy prices. Furthermore, the 3 year lifespan on SRECs and increasing SACP penalties may also invigorate the private SREC trading market for Delaware SRECs, and Delaware SRECs may behave very violently.

5.4.3 Maryland

Maryland's policy is one of the oldest SREC policies within the USA, and is already maturing [20]. Maryland has a high target of 2% solar energy by 2022, and has already altered their SREC policy to make it stronger once. Like Delaware, the Maryland SACP is medium-priced at $400, and is set to stay there until 2014, and decrease to $50 by 2023. This provides SPV providers with some measure of certainty that the policy will remain strong in the future.

Maryland's unique attempt at helping its SREC market by having an official post for all SRECs makes it easier to buy and sell. As such, SREC aggregators like US Photovoltaics are working in full force to accumulate the SRECs making it easier for residential SPV to maximize the value of their SRECs.

Maryland requires 10 days attempt at relieving the uncertainty attached with SRECs by giving utilities companies the ability to sign long-term contracts (at 80% SACP price). However, to date very few of the utilities companies purchase SRECs this way. Instead, they accept the risk of not having SRECs, and prefer purchasing from aggregators, or by paying the SACP. This lack of a floor and uncertainty still bog down the effectiveness of this SREC policy.

5.4.4 Massachusetts

On paper, Massachusetts has the best-designed SREC policy to date. Massachusetts has devised a clever SACP system that sets the SACP sufficiently high enough to make it attractive, and are the only state to have imposed a floor (at $300 is quite high) with their annual clearing-house system. The clearing-house system also solves another major problem for residences by helping bridge the gap between residences and utilities companies.

Massachusetts' SREC system does require more government monitoring and cost (associated with managing the clearing house). It also has a nominal requirement of 400MW capacity (about 100 times the 2010 Mass. capacity of 4MW). While this is aggressive, should the 400MW capacity be reached, the value of an SREC loses value dramatically.

Therefore, the potential for a SPV bubble in Massachusetts is high. As the state capacity creeps up on 400MW total capacity, SREC owners cannot expect their SRECs to be valuable projected into the future. Over the next few years, this should not be a problem, and one should expect the Mass. SREC policy to stimulate growth, in the medium to long term, this problem needs to be addressed.

5.4.5 North Carolina

There are very little strengths to North Carolina's SREC policy. The SACP is only $30, and the Present Value per Watt capacity is under $1. It is safe to say that North Carolina's solar credit market is insignificant. However, that is not the case for North Carolina's entire solar portfolio. While not researched in-depth in this study, North Carolina's rebates are similar to Florida's and provide great short-term value to the SPV industry within the state [9].

5.4.6 New Jersey

New Jersey's rebates have proven to be very strong over the past few years, and are largely why New Jersey (despite low solar radiation) is second in the US in installed solar capacity. However, New Jersey is attempting to make the step from short-term localized incentives through rebates to medium-term state-level policy through SRECs. New Jersey's 2.21% goal is among the highest, and with the size of the energy market within New Jersey, is also ambitious.

The New Jersey SREC has the highest present value, and has the strongest potential to continue its strong SPV industry. In fact, solar leasing companies like 1BOG [43] and others are capitalizing on the New Jersey market, and helping to aid in marketing the program.

These solar community/leasing companies along with aggregators are rising to lower the cash flows uncertainty for SPV installers, and allow the SREC policies to reach even the smallest residential homes. Additionally, New Jersey's pressure on the utilities companies to provide contracts and financing of 40-60% in exchange for SREC payments make it one of the most complete SREC policies in the US (and in the world).

The major problems associated with New Jersey's SREC is that with such a high SACP, they could have issues with cost control in the long-run, and the SACP decline rate may need to be adjusted should the average price for SPV installation decrease as predicted.

5.4.7 Ohio

Ohio's policy is also very new, and began in only 2010, and if history is any indication adjustments will be made. The 0.5% target by 2024 is comparatively low, and the SACP is moderately priced at $400.

Ohio SRECs have the longest lifespan of 5 years, making it more tradable, but with a set timetable for decrease; the value of the SREC should decline with each passing year. Ohio's set timetable all the way to 2024 and beyond does provide more certainty than the apparently volatile and difficult to predict Pennsylvania market.

The same timetable, however, does make the policy weaker than other SREC markets that have $400 SACPs The decreasing SACP lowers the cash flows noticeably, and makes Ohio's SREC policy the second weakest, and their whole solar portfolio of incentives the lowest overall.

While Ohio does allow long-term contracts to be signed, and there was initial pressure by the government on utilities companies to form them, the only contract policy in place is expires May 31, 2011, with no extension in sight. Therefore, Ohio's SREC policy relies on private financing companies to overcome the associated uncertainty without a floor.

On a whole, Ohio's policy is average, and does not provide a sufficiently strong enough ceiling to make SPV as competitive as other SREC policies do. However, the policy was designed to meet only 0.5% retail energy by 2024, so it seems properly made to meet its purpose.

Ohio is particularly ill-suited for solar power, because its lower energy price makes net metering less powerful (as evidenced by Ohio's low net metering present value). Additionally, the lower solar insolation is also working against solar power. However, Ohio need only add a personal tax credit to make the state's solar portfolio have a positive NPV.

5.4.8 Pennsylvania

The Pennsylvania SREC policy is potentially the strongest and weakest of all the USA solar credit markets. With its market-oriented SACP calculation, the SREC policy is set to maximize the value of the market-driven approach to solar supporting policies more than all other states. There is no set time-limit on the eligibility of a system to produce SRECs, so while New Jersey caps it at 15 years, Pennsylvania does not.

Pennsylvania's SREC market was created in 2009, and went into effect in the 2010-2011 year. There have been three SACP calculations to date, and each time the SACP has increased. However, as with all other tradable goods (that function as commodities), price volatility is a major problem with Pennsylvania.

Pennsylvania allows SRECs generated in neighboring states and Illinois to be bought and retired by Pennsylvania utilities companies to meet their compliance payments. As the other SREC market prices decrease, it is expected that Pennsylvania's SACP will come more into line with those states' prices.

Pennsylvania's strong overall solar incentive package has made it one of the faster growing SPV markets. While it is beyond the scope of this study, the growth of the SPV market's effect on SRECs is apparent in Pennsylvania. As a result of the growth in the PA SPV market on the back of its other policy (the rebate), and despite the high SACP, the going rate for SRECs is below $200 per credit, due to the oversupplied market [40].

As the rebate expires, and if it is not extended, a drop-off in SPV capacity growth within Pennsylvania should be expected, and the SREC policy will then become the most important factor driving the sector. Pennsylvania's SREC policy does have the potential to keep the SPV industry in Pennsylvania growing strong as its strong Sunshine Rebate Policy comes to a close in the upcoming years. However, the uncertainty associated with the SACP makes Pennsylvania's policy an enigma. Only time will tell how this SACP calculation affects the SPV industry, and it is very much experimental.

VI. Discussions

6.1 Overview

Like previous studies have found, each different policy portfolio has many different factors affecting it [6][7] [8]. In states with higher energy prices, net metering is more effective, whereas in Ohio, where the energy price is only $10.67/kW, net metering is much weaker. New Jersey and Massachusetts have higher energy prices, and thus stronger net metering programs. North Carolina and Maryland have higher solar insolation, and thus SPV requires less support.

6.2 SREC Floors

SREC policies undoubtedly have strong potential, and the present value of the SRECs investigated reflect that. However, this is merely potential at the moment. Only one of the SREC policies has a credible guarantee and price floor, and that is the newest policy enacted (MA). The real value a residential SPV owner can expect per SREC is most likely not 80% of the SACP, but somewhere lower, and possibly as low as $0.

There are two methods states are using to design floors into the SREC programs: private contracts leveraging the value of SRECs, and government mandated floors. Currently only one state has employed the required bottom price through an annual year-end auction clearing house. However, the private contract market is showing signs of growth.

Government mandated floors dampen the market-driven effects of credit markets, but as was found in Belgium, can be successful [8][16]. However, guaranteed floors make credit markets very much the same as FITs. That means that they will have the same problems as FITs: cost control issues and political difficulty.

Many of the states are pushing the utilities to offer long-term contracts in exchange for guaranteed SREC prices of about 60% the SACP of given years or 40-60% of the initial costs of investment. Should these policies be passed and enforced, it would represent a strong incentive for residences. For the residences it would be similar to a FIT in that it is a guaranteed.

Private aggregators are beginning to offer a slew of financing plans for SPV systems in exchange for SRECs. Companies act as brokers for SRECs, and many offer guaranteed annuities in exchange for SRECs. One company offers a guaranteed $250 annual annuity for 5 years of SRECs, or an up-front payment of 10-25% the initial cost (depending on the state) in exchange for 10 years of SRECs [23].

Also, as of March 2011, the Flett Exchange that negotiates long-term bilateral agreements for large amounts of SRECs is beginning to affect the overall SREC market price. Spot prices on Flett for SRECs give us a better understanding of the real value SRECs have at any moment in time.

6.3 Bureaucracy

Studies have shown that strong incentives alone are not enough to drive solar power. Long administrative procedures made policies ineffective despite strong incentives in France, Greece, and Cyprus [8]. The grid companies (namely PJM) handle most of the administrative procedures, and it acts the same across all the different state policies with surprising efficiency [21]. SREC generation and storage works seamlessly with net metering policies, as a sort of synergy between the two policies.

Unfortunately, residential SPV systems produce only about 3-6 SRECs annually, so the physical act of selling SRECs can be tricky for small residential SPV owners. They instead rely on the aggregators, and other private SREC financing methods to gain value from their SRECs. While this is not direct bureaucracy as in the case in other nations' policies, it acts as an added burden for residences.

6.4 Marketing

There is no denying that solar incentives of all varieties are very much capable of stimulating SPV capacity growth. However, if people are unaware of the benefits and financing methods available, they are not as effective.

This study shows that SREC policies are all very much able to match California's FIT in terms of financial incentives, but that is not all California did to create their thriving solar industry. California launched its *Go Solar* [44] marketing plan in addition to the actual incentives. Other states are relying on private industry to market for the industry.

There is a glut of websites that market SPV by using National Renewable Energy Laboratories' solar operative efficiency program and the various policies to calculate the costs and help with financing. This study does not attempt to measure the effects of marketing, but it may be equally as important as the incentives themselves.

6.5 Other Policies

These eight states are not the only states attempting support SPV directly, and there are many different plans in place to help SPV overcome its high-cost. SPV systems have high up-front costs, with each of the 4.0kWp systems discussed in this study costing $30,000 or more down. While grants and loans are not discussed here, the rise of PACE financing makes it easier and cheaper for SPV owners to acquire the money down, and is also credited as a key driver for SPV growth in America [4].

Rebates are often stronger than FITs and SRECs, but tend to have major cost control issues (as a result of their strength), and are incredibly short-term (regularly hitting cost caps within 6 months of the year they are created). Rebates are often enacted at a municipal (city) or by specific utilities companies. Many of the states with SREC policies also have rebates that are not quantified in this study, and make the state solar incentive portfolio even stronger than this study may suggest.

6.6 Evolution of SRECs

The political process in the United States is typically bottom-up whereby municipalities first test out policies around the country. Then states learn from these policies and various states begin passing legislation at the state level. As more states adopt policies, and experiment or alter them, the question is then asked whether to go federal with policy.

This is the process RPS, solar carve-out, and SREC markets are facing now. Many policies are being proposed, and there is a discussion about whether the USA should adopt a federal RPS, and associated tiers or carve-outs [45]. This study suggests that as far as SRECs are concerned, the policies within the USA are too new and untested to with far too little information to consider a national SREC policy. Additionally, each energy market in the USA has different characteristics, energy costs vary, wind, natural gas, solar radiation all vary widely. For these reasons, a federal SREC policy seems premature and difficult to implement.

6.7 SREC as a Long-Term solution

Solar carve-outs and associated SREC markets are mostly planned through 2020-2024, and thus have about a 10 or 15 year lifespan at the moment with any further extension difficult to predict or understand. For this reason, the incentives provided by SREC mechanisms weaken with each passing day and year.

As a result, SRECs at the moment are not a long-term solution as a solar policy. However, the commitment to funding over the next 15 years makes it a longer term plan than the rebates and tax credits with sunsets of usually a few years. Nevertheless, without longer term commitments to the SREC plans, one can expect them to be short-term to medium-term at best [17].

Appendix 1: State Information

State	2010 SACP	SREC Lifetime	Carve-out Goal	SPV Price per Watt	Avg. Solar Output (kW/kWp)	2009 Energy Price per kWh
District of Columbia	$500.00 $500 until 2018, then undetermined	3 years	0.40% by 2020	$8.80*	1240	$0.1376
Delaware	$400.00 $400 indefinitely; increases $50 each time SACP is used	3 years	3.5% by 2026	$7.50*	1240	$0.1407
Maryland	$400.00 $400 until 2014, decreasing to $50 by 2023	3 years	2.00% by 2022	$8.80	1228	$0.1498
Massachusetts	$600.00 $550 in 2011, but no set timetable;	1 year	400MWp by 2020	$8.40	1232.5	$0.1687
North Carolina	$30.00 Increasing to $42.39 by 2025 ($0.826 annually)	2 years (effective)	0.2% by 2020	$7.50*	1310	$0.0999
New Jersey	$693.10 Declines 2.5% annually	2 years	2.21% by 2021	$8.10	1216.5	$0.1631
Ohio	$400 Declines $50 bi-annually	5 years	0.5% by 2024	$7.50*	1176	$0.1067
Pennsylvania	$654.37 Calculated annually; based on the previous year's weighted average SAEC	2 years (effective)	0.5% by 2021	$7.50*	1145	$0.1165

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