STATE POLICY STAGING TO OPTIMIZE PRIVATE INVESTMENT IN SOLAR TECHNOLOGIES

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ABSTRACT
Understanding how policies encourage private investment in the development of solar markets is critical to optimizing implementation of cost-effective state-level policies. This report summarizes a statistical analysis of state policy effectiveness, and while acknowledging the complexities of the relationships, includes the following major findings: 1) market preparation policies that have low costs for state and local governments, interconnection and net metering for example, are correlated with private investment in markets; 2) low-cost policies that align with established best practices for distributed generation support are statistically linked to states with higher PV penetration; and 3) well designed market preparation policies seem to bolster the effectiveness of more expensive policies. In addition, the paper provides an overview of current efforts to further explore the effect of low-cost-enabling policies. The study normalizes for resource and demographic factors that affect solar installations regardless of which policies are implemented. Results to date suggest that specific policy pathways can be effective for streamlined market development in various state economic and demographic environments.

1. INTRODUCTION

State and local policymakers are responding to increased public interest in renewable energy, in particular customer-sited distributed solar photovoltaics (PV), through a variety of policy initiatives that are intended to support private investment and a robust PV industry. Policymakers face a number of challenges in crafting policies that will effectively stimulate and support PV installations in their jurisdictions. Among these are limited budgets and a lack of guidance regarding the effectiveness of the various policy options and different policy strategies.

Recent work (Krasko and Doris 2012) evaluated the hypothesis that the order in which policies are implemented (referred to as “policy stacking”), and the presence of low-cost enabling policies such as interconnection standards and net metering, can have a significant impact on the success of states in both stimulating private investment and minimizing the public investment needed to develop PV markets. Krasko’s and Doris’s analysis methodology employed a nuanced approach in which scores from the Network for New Energy Choices (NNEC) Freeing the Grid (FTG) report were used to incorporate an assessment of the *effectiveness* of interconnection and net metering standards, rather than simply whether they exist. The researchers found that reducing institutional barriers, for example, through implementation of interconnection standards and valuation of excess electricity (e.g., net metering), along with indicators of public support for a solar PV market (e.g., Renewable Portfolio Standards (RPS)), and a non-policy determinant (population) explain about 70% of the variation between new PV capacity in the United States.

Implementing low-cost policies (interconnection and net metering) prior to more expensive policies (RPS, incentives) may bolster the effectiveness of the latter policies. The quality of the components of the interconnection and net metering policies also was found to impact the overall effectiveness of PV market development.

The National Renewable Energy Laboratory (NREL) team expanded existing policy stacking work to investigate how effective policy stacking is related to the demographic and macro-economic context in which the policy is being implemented. The general methodology used to achieve this goal is to identify states that have similar non-solar policy-related characteristics; those, in the absence of policy, should have similar solar market characteristics. After grouping the states according to these non-policy characteristics, the solar markets and policies are compared for states within each group. When these non-policy factors are taken into account, the general relationship between market preparation policies and increased solar PV market penetration generally continues to hold true. However, non-policy contextual differences between states also affect the market penetration of solar PV, as illustrated by the broad differences between the solar market penetration among the different groups of states. The team will develop case studies for states that appear to be anomalies within their categories, either because they have higher than expected solar PV market penetration for their group (e.g., Hawaii), or lower than expected market penetration (e.g., Iowa). The case studies will be used to identify whether and how policy may play a role in explaining differences in solar markets between states.

2. IDENTIFICATION OF STATE TYPOLOGIES

The team investigated a variety of state characteristics that might influence the effectiveness of PV policy to develop state "typologies" that can be used to guide policy strategies in each state. The characteristics were selected with the goal of capturing the physical, economic, and demographic environment within each state relevant to the success of various policy options and policy implementation strategies. Grouping similar states into typologies also serves to normalize for the factors used in the selection of states for each group. Differences in solar installations among states in the same grouping were expected to be due to differences in policy, rather than other factors such as household income.

The team grouped the states into four "types" based on the characteristics evaluated. A wide variety of state characteristics were compiled and evaluated for the potential relevance to the development of PV markets in the state. Table 1 lists the state characteristics and the source for each set of data. The analysis intentionally focused on state economic and demographic characteristics that are not directly related to solar PV installations, but that may impact whether the state has a favorable or unfavorable climate for investment in residential PV, regardless of whether state policy programs are in place.

TABLE 1: STATE CHARACTERISTICS EVALUATED FOR POTENTIAL RELEVANCE TO PV MARKET DEVELOPMENT

State Characteristic	**Data Source**
Population	2009–2011 American Community Survey 3-Year Estimates
Population density (people/square mile)	2010 Census Redistricting Data (P.L. 94-171) Summary File
Housing units – total	2010 Census Summary File 1
Housing units – % inside urban areas	2010 Census Summary File 1
Housing units – % inside urban clusters	2010 Census Summary File 1
Housing units – % rural	2010 Census Summary File 1
% Renter-occupied housing	2010 Census Summary File 1
% Housing units that are one detached structure	2010 Census Summary File 1
Residential electricity price (cents/kwh)	EIA – Electric Power Monthly (Sep. 2012)
Replacement cost of a typical house	Lincoln Institute of Land Policy. Housing cost defined as The replacement cost, after accounting for depreciation, of a typical owner-occupied housing structure for each state.
Number of retail trade establishments	2010 Census
Number of transportation and warehousing establishments	2010 Census
Number of wholesale establishments	2010 Census

Paid employees – agriculture, forestry, fishing, and hunting	2010 Census
Paid employees – mining, quarrying, oil/gas	2010 Census
Percent of income spent on energy	Electricity price and yearly consumption by state (EIA, 2010), Median Household Income by State (in 2010 Dollars, Census)
Estimated Technical Potential for Rooftop PV (gigawatt hours (GWh))	Lopez, 2012
State Energy Efficiency Scorecard Score	ACEEE 2012 State Scorecard
Median Household Income by State	2010 Census

The team grouped the states based on a combination of four physical and demographic characteristics. Characteristics include estimated technical potential for rooftop PV, which is a combination of roof area and solar resource (Denholm 2008; Lopez, Roberts et al. 2012), median household income, average electricity price, and the American Council for an Energy Efficient Economy (ACEEE) 2012 State Energy Efficiency Scorecard score (Foster, Chittum et al. 2012). The State Energy Efficiency Scorecard score was selected as a proxy measurement of the state's interest in, and progress toward, addressing energy-related issues within the state without consideration of specific policies regarding solar PV. As this work progresses, additional characteristics may be added or substituted. The following four initial groupings of states were developed:

- High Potential – States in the High Potential category were selected first, thereby eliminating them from further consideration for other groups. These states have excellent solar resource and good opportunity for residential solar installations. States in the High Potential category also have a wide variety of complimentary policies in place, as well as programs supporting energy efficiency that demonstrate a general policy interest in energy-related issues. In general, it is expected that these states, based on non-PV related characteristics, should have high installed capacity of PV.

- High Resource – States in the High Resource category were selected from the states remaining after eliminating states in the High Potential category. These states also have higher than median technical potential for rooftop PV, but have lower than average median income, electricity price, and ACEEE Energy Efficiency Scorecard score.

- High Motivation –These are states with poorer than median technical potential for rooftop solar PV, but may be expected to have high interest in PV due to higher than average electricity prices and a general interest in energy-related issues.

- Opportunity – These states have lower than average ACEEE Energy Efficiency Scorecard score, but show a broad range of income, electricity price, and technical potential. Because states that are expected to have high PV penetration have already been grouped in previous categories, these states would be expected to have lower PV penetration.

Table 2 lists the states in each category and the criteria used to select them. Summary statistics for the criteria used to develop the state contexts are presented in Table 3.

TABLE 2: STATE CONTEXT GROUPINGS

State Contexts

High Potential	**High Resource**	**High Motivation**	**Opportunity**
Criteria			
1. ACEEE Energy Efficiency Scorecard score > average 2. Estimated Technical Potential for Rooftop PV > median	1. ACEEE Energy Efficiency Scorecard score < average 2. Cost of electricity < average 3. Income < average 4. Estimated Technical Potential for Rooftop PV > median	1. ACEEE Energy Efficiency Scorecard score > average – OR Cost of electricity > average Income > average	States not identified in the previous three groups. These states have a variety of values for the characteristics evaluated.
Arizona California Colorado Hawaii Illinois Maryland Michigan Minnesota New Jersey New York Pennsylvania Washington Wisconsin	Alabama Florida Georgia Indiana Louisiana Missouri North Carolina Ohio South Carolina Tennessee Texas	Connecticut Iowa Massachusetts New Hampshire Oregon Rhode Island Utah Vermont Delaware Alaska	Idaho Maine Montana New Mexico District of Columbia Nevada Kentucky Virginia Arkansas Oklahoma Nebraska Kansas South Dakota Wyoming West Virginia North Dakota Mississippi

TABLE 3: STATISTICS FOR CRITERIA USED IN STATE CONTEXT GROUPINGS

	State Contexts				
	All States (51 values)	**High Potential (13 values)**	**High Resource (11 values)**	**High Motivation (10 values)****	**Opportunity (17 values)**
Estimated Technical Potential for Rooftop PV (GWh/year)		**> median**	**> median**		
Median*	12,443	19,189	19,685	6,616	5,337
Average	16,709	26,866	29,960	5,570	6,862
STDev	19,428	24,620	20,656	3,600	5,296
2012 Energy Efficiency Scorecard Score		**> average**	**< average**	**> average**	
Average	19.6	27.9	13.9	27.9	12.1
STDev	10.0	5.9	3.7	10.2	5.5
Median Household Income by State (in 2010 Dollars, Census)			**< average**	**> average**	
Average	$50,115	$54,082	$43,544	$57,231	$47,148
STDev	$7,408	$5,775	$2,825	$5,800	$5,970
Residential electricity price (cents/kilowatt hour (kwh))			**< average**	**> average**	
Average	12.4	14.9	10.7	14.2	10.5
STDev	4.3	6.9	0.9	2.9	1.5

*The median value was used as the criteria cutoff for the Estimated Technical Potential for Rooftop PV.
**The High Motivation category includes states with ACEEE Energy Efficiency Scorecard values greater than the average of all the states, or both higher than average income and higher than average electricity prices.

3. SUMMARY COMPARISON OF SOLAR PV MARKETS AND SUGGESTED CASE STUDIES

As stated earlier, the High Potential category was selected first, the High Resource category second, and so on, eliminating states in each category from consideration in subsequent categories. Each of the state groups was then compared to a variety of measurements of the PV market. A summary of statistics for solar installations and policy is presented in Table 4. Outliers (states within a group with significantly more or less installed solar capacity than the rest of the group) will be selected for case studies with the goal of identifying the source or sources of differences. Identification of attributes that make solar policies more or less effective may provide insight into tailoring policy strategies to be more effective in certain types of states. The case studies will provide detail that clarifies attributes of policies that influence the effectiveness of the policies in different environments.

TABLE 4: SUMMARY STATISTICS FOR SOLAR INSTALLATIONS AND POLICY

	State Contexts				
	All States	**High Potential**	**High Resource**	**High Motivation**	**Opportunity**
Current installed solar PV (W/person)[1]					
Median	0.6	2.9	0.2	2.5	0.3
Average	3.3	9.2	0.3	2.5	1.1
STDev	7.4	12.6	0.3	2.0	2.1
Number of solar 1603 projects (12/5/2012) per 100,000 people[2]					
Median	1.1	2.4	1.0	1.6	0.4
Average	2.2	4.4	1.0	3.0	0.7
STDev	3.0	4.4	0.9	2.7	0.8
FTG – net metering score (A = 4, B= 3, C = 2, D = 1, F = 0)[3]					
Median	3	4	1	4	3
Average	2.6	3.4	1.4	3.5	2.2
STDev	1.4	0.7	1.4	0.7	1.4
FTG – interconnection score (A = 4, B= 3, C = 2, D = 1, F = 0)[3]					
Median	2	3	0	3	0
Average	1.8	2.5	1.0	2.5	1.5
STDev	1.6	1.3	1.2	1.4	1.7
PPA Allowed (yes = 1, unspecified = 0, no = -1)[4]					
Median	1.0	0	1.0	0	0
Average	0.8	(0.1)	0.6	0.1	0.3
STDev	0.4	0.7	0.5	0.4	0.6
RPS (RPS w/set-aside +1, RPS w/o set-aside 0, no RPS -1)[4]					
Median	0	1	(1)	0	(1)
Average	(0.1)	0.5	(0.4)	0.1	(0.5)
STDev	0.9	0.5	0.9	0.8	0.8

[1] State population data from the U.S. 2010 census (http://www.census.gov/2010census/). Total installed MW PV are from Greentech Media Inc. U.S.SOLAR MARKET INSIGHT REPORT | Q3 2012 | FULL REPORT and IREC U.S. Solar Market Trends 2010, http://irecusa.org/wp-content/uploads/2011/06/IREC-Solar-Market-Trends-Report-June-2011-web.pdf).

[2] Summarized from "Section 1603 – Payments for Specified Renewable Energy Property in Lieu of Tax Credits" spreadsheet downloaded from (http://www.treasury.gov/initiatives/recovery/Pages/1603.aspx).

[3] Scores from Freeing the Grid 2012 report downloaded from (www.freeingthegrid.org).

[4] dsireusa Jan 2012.

As expected, the High Potential category has higher values for the current installed PV and more recipients of Treasury 1603 grants than the national average. These states also have higher than average Freeing the Grid scores for net metering and interconnection; this supports the previous conclusion that solar market penetration is correlated with these policies (Network for New Energy Choices, Freeing the Grid 2012). Inclusion of Hawaii (at 46 watts (W)/person) to a lesser extent Arizona and California, skew the average upward for this group. Hawaii has achieved its success despite receiving an "F" interconnection score from Freeing the Grid until very recently (2012, when Hawaii received a "B"). There are also two states in this group, Illinois and Michigan, with solar installations less than the national median of 0.6 W/person. Both states have reasonably good interconnection and net-metering standards and a statewide renewable portfolio standard. Case studies will be used to assess the reasons for the success or lack of progress for these states.

The High Resource typology also presents an interesting trend. This group of states was selected after the High Potential states, and captures the remaining states with high solar resource, with the exception of Virginia (22,267 gigawatt hours (GWh) estimated potential) and Oklahoma (the median value state at 12,443 GWh estimated potential)(Lopez, Roberts et al. 2012). The states in the High Resource typology also have lower than average median income, electricity price, and ACEEE Energy Efficiency Score. Despite the high solar potential in these states, as a group, they have lower than the national average for installed solar and number of 1603 grants. There is not as much variability among the states in this group as there is in the High Potential group. For example, the installed solar ranges from 0.04 W/person to 0.76 W/person in the High Resource Group. However, several states in this group, such as Indiana and North Carolina stand out because they seem to counter the trend of higher interconnection and net metering scores correlating with higher solar market penetration. Indiana has less than 0.1 W/person installed solar capacity, but net metering and interconnection scores of "B," while North Carolina has close to 0.8 W/person installed solar capacity despite a net metering score of "D" and an interconnection score of "B."

The High Motivation group of states looks most similar to the High Potential states in level of solar PV market penetration and number of 1603 grants, but the average PV market penetration for the High Motivation group is lower than in the High Potential group, possibly because the states in the High Motivation group have lower solar potential than those in the High Potential group. Alaska is included in this group because of its very high electricity prices; however, it has virtually no installed solar. Iowa also has very little installed solar (0.03 W/person) despite its relatively good Freeing the Grid scores for net metering and interconnection (B) and better than average solar potential (8,646 GWh), as compared to other states in this group. The possible reasons behind Iowa's low solar market penetration will be explored in a case study.

Earlier work indicated a relationship between low-cost market preparation policies, such as net metering and interconnection standards, and solar PV market penetration. By normalizing for state contexts, this analysis tests to determine whether these relationships continue to hold true. Grouping the states into typologies to normalize for characteristics not related to solar policy allows for policy to be studied, at least partially, in isolation from external non-policy related factors. When these non-policy factors are taken into account, the general relationship between market preparation policies and increased solar PV market penetration continues to hold true, with a few exceptions. However, non-policy contextual differences between states also have a marked effect on the market penetration of solar PV, as illustrated by the broad differences between the solar penetration among the different typology groups. The team will develop case studies for states that appear to be anomalies within their categories, either, because they have higher than expected solar PV market penetration for their group (e.g., Hawaii), or lower than expected market penetration (e.g., Iowa).

4. REFERENCES

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(3) Krasko, V. A. and E. Doris. Strategic Sequencing for State Distributed PV Policies: A Quantitative Analysis of Policy Impacts and Interactions. Golden, National Renewable Energy Laboratory, 2012

(4) Lopez, A., B. Roberts, et al. U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis, 2012