The Net Metering Debate: Replacing Rooftop Solar's Outdated Foundation

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Introduction

Accounting for a relatively small fraction of the United States' overall electricity generating capacity, solar energy has long been overshadowed by renewable energy sources such as wind, hydro, and biomass. Nevertheless, recent statistics suggest that solar energy is quickly gaining ground. According to the Solar Energy Industries Association, solar installations composed nearly 30 percent of all new installed generating capacity in 2015.[1] Analysts project that nearly 16 Gigawatts (GW) of solar generating capacity will be installed throughout the United States in 2016 alone.[2] These positive statistics, coupled with the decreasing cost of solar technology and extension of favorable tax credits, point to continued growth of the solar industry.

Utility-scale arrays still provide the largest share of solar generated electricity, but distributed solar for residential consumers – also known as rooftop solar – has grown increasingly popular in recent years. This growth is the result of renewable technology investment credits, tax rebates, and favorable policies that incentivize the installation of rooftop solar. While each policy plays a part in facilitating the use of small-scale solar generation, net metering has emerged as the most contentious issue dividing solar advocates from utility companies.

This essay identifies net metering as the key issue that will determine the future of small-scale, rooftop solar generation throughout the United States. This essay seeks to provide policymakers with a clear understanding of why net metering has become a contentious issue in the United States and the potential impact that changing regulations will have on the economic viability of distributed solar generation in the future. It begins by examining the background of net metering policies in the United States, focusing specifically on the development of policies in

[1] GTM Research, Solar Energy Industries Association, "Solar Market Insight 2015 Q4," *Solar Energy Industries Association*, March (2016): 4.
[2] Ibid.

California and Nevada. Second, this essay traces the diverging policies and arguments that are shaping net metering policies in both states. Finally, it provides four comprehensive policy recommendations outlining how policymakers could handle the growth of distributed solar energy and net metering policies. The authors recommend that states analyze the actual price of rooftop solar and implement net metering policies that accurately reflect the value of rooftop generated solar power. These accurate net metering policies would then allow utility companies to begin to transition to a new business model that focuses on providing a service rather than selling electricity.

Incentivizing Solar Growth

Policymakers have facilitated the growth of solar generation in the United States by implementing a variety of policies such as net metering, feed-in tariffs, investment tax credits, and renewable portfolio standards.[3] Net metering, feed-in tariffs, and investment tax credits offset the upfront purchase and installation costs associated with solar technologies for residential and utility-scale generators. These policies reduce investment risks and guarantee returns.[4] While not directly subsidizing solar generators or consumers, renewable portfolio standards set statewide minimum standards for renewable energy generation that encourage state governments and utilities to invest in renewable energy technology. Together, these four policies have contributed to the rapid growth of rooftop and utility-scale solar arrays throughout the country. Of these four policies, net metering has emerged as the most polemical issue.

Net Metering: Discovery and Definition

[3]Toby Couture and Karlynn Cory, State Clean Energy Policies Analysis Project: An Analysis of Renewable Energy Feed-in Tariffs in the United States," *National Renewable Energy Laboratory Technical Report*, June 2009, iv.
[4]Shahrouz Abolhosseini and Almas Heshmati,. "The Main Support Mechanisms to Finance Renewable Energy Development," *Institute for the Study of Labor,* No. 8182, May 2014, 2-5.

In 1979, work was completed on the Carlisle House – a 3,200 square foot home that combined an energy-efficient building design with rooftop solar generation to become the first "energy-independent" residence constructed in the United States.[5] The house was designed to generate the majority of its own electricity, but was also able to rely on the local electricity grid when needed.[6] When the Carlisle House was connected to the local electricity grid, the interconnection allowed the house to feed excess electricity to the grid. As a result, the Carlisle House's utility meter tracked both electricity generation and consumption. During billing periods, the number on the utility meter would be the net sum of both electricity outflows and inflows. As a result, the concept of net metering was born.

This "discovery" of net metering led to the realization that homeowners with distributed energy generating capacity could return their excess energy into the grid. Net metering was seen as a favorable arrangement for both rooftop solar users and utility companies. Rooftop solar users were able to reduce their amount of energy consumed from the grid, thus lowering their electricity bills. Utility companies enjoyed the positive media coverage that praised their support for renewable energy policies.[7]

Initially, the concept of net metering was straightforward: "A single meter ran forward when power flowed from the grid into the house, and backward when power flowed the other way. By default, the price of incoming power was the same as the price of outgoing power. This is called parity pricing."[8] This parity pricing arrangement proved to be an attractive incentive for residents looking to reduce electricity costs as well as their personal carbon emissions. Unlike feed-in tariffs or tax incentives, state governments did not have to authorize subsidies or alter

[5] "Carlisle Solar House," MIT Museum, accessed April 22, 2016, http://museum.mit.edu/150/138.
[6] Roberto Verzola, "Net Metering History & Logic — Part 1," *Clean Technica*, September 6, 2015, accessed April 22, 2016, http://cleantechnica.com/2015/09/06/net-metering-history-logic-part-1/.
[7] Ibid.
[8] Ibid.

existing utility regulations to promote the use of renewable energy. A stable parity pricing arrangement allowed residents interested in installing solar panels on their homes to plan out their eventual return on investment based on current costs of electricity and their projected usage.

Growth and Resistance

The success of the Carlisle House led to the spread of distributed solar generation and net metering programs throughout the United States.[9] By 1998, 22 states had implemented net metering programs that were designed to encourage the deployment of distributed solar generation. The number of states that have adopted net metering, regulatory policies, or some combination has continued to grow, in part thanks to the Renewable Energy Law of 2005 that mandated states provide net metering if requested by residents. As of April 2016, 41 states had implemented an official net metering policy.[10]

Net metering policies vary from state to state. In Colorado, for example, rooftop solar systems with less than 10 kilowatts of capacity are reimbursed at the full retail electricity rates.[11] Customers that have over 10 kilowatts of installed generating capacity receive renewable energy credits for the additional electricity that their system generates. In contrast, New Jersey regulators have removed any generating capacity limits on distributed solar generators. New Jersey's public utilities commission has instead opted for a system where utilities can cease offering net metering rates if "statewide enrolled capacity exceeds 2.5% of peak electricity demand."[12]

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[9] Verzola, "Net Metering History and Logic."
[10] Roberto Verzola, "Spread of Net Metering, & Utility Backlash — Net Metering History Part 2," *Clean Technica*, September 10, 2015, accessed April 22, 2016, http://cleantechnica.com/2015/09/10/spread-of-net-metering-utility-backlash-net-metering-history-logic-part-2/.
[11] "Net Metering: Colorado Overview," Database of State Incentives for Renewables and Efficiency, accessed April 25, 2016, http://programs.dsireusa.org/system/program/detail/271.
[12] "Net Metering: New Jersey Overview," Database of State Incentives for Renewables and Efficiency, accessed April 25, 2016, http://programs.dsireusa.org/system/program/detail/38.

High levels of insolation, supportive renewable energy policies, and adoption of net metering have transformed California and Nevada into two of the largest solar energy producers in the country. The rapid spread of rooftop solar has invited criticism from utilities concerned that net metering unfairly compensates residential users for the electricity they sell to the grid.[13] As leaders in the solar industry, the actions taken by residents, regulators, and legislations in California and Nevada can reverberate beyond state lines, affecting the future development and deployment of solar energy throughout the country. Understanding how net metering policies have developed in these two states provides policymakers with an insightful look into the divergent paths that net metering policies can take.

Solar Background - California

As of result of its high insolation rate, comprehensive renewable policies, and state-level support, California has emerged as the U.S. leader in both utility and rooftop solar generation.[14] After more than 40 years of growth, California's solar industry now accounts for more than 50% of national capacity, with over 500,000 rooftop installations across the state.[15] According to the California Energy Commission's "Go Solar!" campaign, the average cost of solar generation in the state is currently less than $5.00 per watt.[16]

Various policy decisions made by the State of California have led to the growth in solar in the last two decades. California first began to offer rebates for rooftop solar installations through the Emerging Renewables Buydown program in 1997. [17] The rebates failed to attract substantial

[13]"Net Metering Program Overview: Nevada," Database of State Incentives for Renewables and Efficiency, accessed April 22, 2016, http://programs.dsireusa.org/system/program/detail/372.
[14] U.S. Energy Information Administration. 2015. *California*. September 17. Accessed April 22, 2016. http://www.eia.gov/state/?sid=CA.
[15] "California Solar Statistics," California Solar Statistics, accessed April 22, 2016, https://www.californiasolarstatistics.ca.gov/faq.
[16] Ibid.
[17] "History of California Solar Power," California Solar, accessed April 22, 2016. http://www.california-solar.org/inform/history-of-california-solar-power.php.

interest in installing rooftop solar, however, due to the prohibitively high cost of solar panels. Looking to facilitate the spread of rooftop solar throughout the state, in 2001, the California Senate enacted a solar tax policy that allowed customers to earn a credit worth 15 percent of their solar installation costs.[18] Further renewable energy portfolio standards were enacted to encourage the spread of solar through the state, but a 2004 cut to the state's solar credit policies ensured that solar technology remained relatively expensive and inaccessible to many.[19]

Reacting to this slowdown, Governor Schwarzenegger sought to further expand the state's solar policies. In 2005, the governor began the "Million Solar Roofs" campaign – a set of policies implemented with the ultimate goal of installing 1,940 MW of new solar capacity by 2016.[20] Despite continued efforts to encourage the growth of rooftop solar throughout California, high prices and slow growth prevented the uptake that policymakers desired.

It wasn't until Governor Schwarzenegger enacted net metering into law in 2009 that growth began to accelerate.[21] Seeing the direct results of the program, in 2010 the net metering cap was raised from 2.5% to 5% of aggregate customer peak demand.[22] This increased limit ensured that more residential customers would be allowed to buy and install rooftop solar before utility providers reached an arbitrary net metering cap. By 2013 the average price of solar had decreased to $5.55 per watt, spurring even greater investment into rooftop solar.[23] Today, net metering rules in California continue to compensate solar generators for excess power at the full retail rate for electricity. As a result, the Golden State remains one of the top markets for rooftop solar technologies.

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[18] Ibid.
[19] Ibid.
[20] Go Solar California. *History of Go Solar! California.* Accessed April 22, 2016. http://www.gosolarcalifornia.ca.gov/about/gosolar/history.php
[21] John Byrne and Lado Kurdgelashvili, "The Role of Policy in PV Industry Growth: Past, Present and Future," *Handbook of Photovoltaic Science and Engineering* (New York: John Wiley and Sons, 2011), 41.
[22] Go Solar! California FAQ
[23] Go Solar! California FAQ.

Solar Background - Nevada

As another sunny state with ample space for solar arrays, Nevada ranks fifth nationally in installed solar generation capacity.[24] Nevada's original net-metering law was enacted in 1997 and amended several times throughout the early 2000s.[25] Since then, various amendments have gradually expanded the eligibility requirements and raised aggregate net metering caps. Due to these favorable policies, investments continued to pour into the state. In 2015, over $800 million was invested into solar installations throughout the state – a figure representing a 46 percent increase over the previous year.[26] With over 8,000 Nevadans employed in the solar industry, solar power was clearly benefitting from state-led support.[27]

As the industry grew, however, utilities began to push back, leading to a complete reexamination of electricity pricing and an inquiry into cost-shifting policies.[28] In June 2013, Assembly Bill 428 was enacted, requiring the Public Utilities Commission of Nevada (PUCN) to investigate the costs and benefits of net energy metering and to recommend a plan for appropriately allocating the costs and benefits it identified.[29] On September 26, 2014, the PUCN submitted its report to the legislature recommending that the legislature "modify the existing net metering statutes to provide the PUCN more flexibility to address net metering issues in general rate cases." Concerned that this legislation would make rooftop prohibitively expensive, customers rushed to install rooftop kits before the laws took effect. Between June and December

[24] "Nevada," U.S. Energy Information Agency, accessed April 22, 2016, http://www.eia.gov/state/?sid=NV.
[25] Ibid.
[26] "Nevada Solar Statistics," Solar Energy Industries Association, accessed April 25, 2016, http://www.seia.org/state-solar-policy/nevada.
[27] Ibid.
[28] NV State Legislature. 2015. "Legislative Research: NV SB374 | 2015 | 78th Legislature." *Legiscan.* June 5. Accessed April 22, 2016. https://legiscan.com/NV/bill/SB374/2015.
[29] "Assembly Bill 428," Nevada State Legislature, March 25, 2013.

of 2015, around 24,000 customers signed up to participate in the state's net metering program.[30] The dramatic influx of customers only deepened Nevada utility companies' concerns that net metering policies were unsustainable. In late 2015, PUCN concluded that the state's net metering policies were costing utilities nearly $16 million a year to compensate for losses due to the expansion of rooftop solar.[31] As 2015 drew to a close, solar advocates and utilities found themselves locked in a political battle to determine the fate of net metering in the state of Nevada.

Issues with Net Metering

The debate over net metering policies has evolved into a contentious issue that will play a decisive role in the continued success and spread of renewable energy policies throughout the United States. While favorable net metering policies provided solar owners with excellent retail rates and contributed to a remarkable spread of solar throughout the country, the overwhelming success of net metering may actually provoke an end to distributed solar's growth. At the core of the net metering debate lies utility companies' concerns that continued favorable policies benefitting solar customers will catalyze the beginning of the "utility death spiral" – a situation where customers utilizing cheap renewable energy pay less to the utility companies, thereby forcing utility companies to raise prices and making renewable energy even more appealing for the average residential consumer.

The Trouble with Transmission

Much of the debate over the feasibility of net metering policies revolves around the physical electricity grid that allows the transmission and distribution of electricity to areas distant from power plants. The U.S. electricity grid was originally created as a form of reliability

[30] Katie Fehrenbacher, "The Other Side of the Solar Firestorm in Nevada," *Fortune*, April 12, 2016, accessed April 22, 2016, http://fortune.com/2016/04/12/solar-firestorm-nevada/.
[31] Ibid.

insurance that ensured customers continued to receive electricity even if one plant went offline.[32] Nevertheless, as the U.S. energy market has evolved and distribution has been separated from transmission, the country's electricity grid has increasingly come under stress with power lines operating at high capacities and system congestion occurring more frequently.[33]

Adding to existing difficulties are uncertainty over future regulations, the emergence of disruptive technologies such as a smart grid and net metering, as well as consumers' appetite for higher prices.[34] While the fate of the United States' outdated yet critical electricity infrastructure remains in the balance, local utilities must continue to find a way to maintain their network of power lines and substations. To generate the funds to pay for this expensive upkeep, utility companies rely on a broad base of ratepayers paying retail rates for electricity. This scheme has been successful, but the widespread adoption of net metering – a disruptive technology that has the potential to substantially reduce the number of average rate-paying customers – threatens their current business model.

Utility Companies' Perspective

From the utility companies' perspective, net metering is yet another beneficial policy allotted to renewable energy producers that, along with generous subsidies and tax credits, has stacked the odds against them.[35] Net metering is particularly threatening to the current utility business model because it reduces the variable costs for residential consumers with solar generating capacity.[36] Utility companies rely on these various costs to pay for the maintenance of

[32] Peter Fox-Penner, "Rethinking the Grid: Avoiding more Blackouts and Modernizing the Power Grid will be Harder than You Think," *The Electricity Journal* March (2005): 30..
[33] Ibid, 32.
[34] Robert Hirsch, "Fifteen years later: Whither Restructuring in the American Electric Utility System," in *Power Loss* (Cambridge: MIT Press, 2013), 26.
[35] "United States Renewable Energy Policies," International Energy Agency, accessed April 17, 2016, http://www.iea.org/policiesandmeasures/renewableenergy/?country=United%20States.
[36] Scott Agnew and Paul Dargusch, "Effect of residential solar and storage on centralized electricity supply systems," *Nature Climate Change* 5 (2015): 316.

transmission and distribution capabilities – capabilities that rooftop solar owners continue to receive in the form of guaranteed, reliable electricity at all times of the day.

Utility companies have pointed to studies highlighting the destabilizing effects that widespread adoption of distributed solar is having on their ability to cover costs and maintain transmission lines. In February 2016, for example, the Louisiana Public Utilities Commission sponsored an investigation that found that solar net metering installations "are estimated to make a 64 percent contribution to overall utility costs across all LPSC-jurisdictional utilities."[37] They found that "any level below 100 percent indicates that solar net metering customers are estimated to pay less than 100 percent of their full cost of service."[38]

While this finding was controversial among supporters of distributed solar energy, researchers at MIT also came to a similar conclusion in their study on the future of solar energy:

> "Most U.S. utilities bundle distribution network costs, electricity costs, and other costs and then charge a uniform per-kWh rate that just covers all these costs. When this rate structure is combined with net metering, which compensates residential PV generators at the retail rate for electricity they generate, the result is a subsidy to residential and other distributed solar generators that is paid by other customers on the network."[39]

These arguments support the utility companies' claims that net metering is unfairly shifting the cost burden of transmission and distribution onto non-solar, rate-paying customers. Even researchers who would otherwise support the expansion of solar energy in the United States have argued that net metering is generating too much of a "pushback," thereby endangering the growth of solar.[40] By using the reports and sources cited above, the utilities have been able to craft a compelling argument against net metering policies. At the heart of their

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[37] David Dismukes, "Estimating the Value of Net Metering on LPSC Jurisdictional Ratepayers," (report prepared on behalf of the Louisiana Public Service Commission, February 27, 2015), vi.
[38] Ibid.
[39] Energy Initiative Massachusetts Institute of Technology, *The Future of Solar Energy* (Massachusetts: MIT Press, 2015), xviii.
[40] Julia Pyper, "Ditching Net Metering is in the 'Best Interest' of Solar, Say MIT Economists," *Greentech Media*, May 5, 2015, accessed April 17, 2016, https://www.greentechmedia.com/articles/read/whats-at-stake-in-californias-coming-net-metering-2.0-decision..

argument lies the fact that solar users are not paying their fair share for their use of transmission and distribution networks.

The Solar Industry's Perspective

Similar studies conducted in other states, however, have come to the opposite conclusion regarding the effect of distributed solar on grids and ratepayers. In Mississippi, for example, a study sponsored by the Mississippi Public Service Commission found that distributed solar "is expected to avoid costs associated with energy generation costs, line losses over the transmission and distribution system, future investments in the transmission and distribution system, and environmental compliance costs."[41] Based on these findings, the researchers recommended that the state implement a net metering policy because solar net metering projects "have the potential to provide a net benefit for Mississippi in nearly every scenario and sensitivity analyzed."[42]

Regulators in Vermont commissioned another study where researchers constructed a model anticipating future growth of net metering throughout the state. The final cost-benefit analysis found that utility revenue decreased while administrative costs associated with net metering increased.[43] Yet, the same model also found a series of substantial benefits due to reduced load, avoided transmission costs, and market price suppression. The study concluded that "Vermont's current net metering policy is a successful aspect of the State's overall energy strategy that is cost-effectively advancing the state's renewable energy goals."[44]

The diverging conclusions of these various studies illustrate why net metering has evolved into a contentious issue in various states throughout the country. It is evident that net

[41] Synapse Energy Economics, *Net Metering in Mississippi*, by Elizabeth Stanton, Joseph Daniel, Tommy Vitolo, Pat Knight, David White, Geoff Keith. (Massachusetts), September 19, 2014, 1.
[42] Ibid, 49.
[43] Vermont Public Service Department, *Evaluation of Net Metering in Vermont Conducted Pursuant to Act 125 of 2012* (Vermont, 2013), 11-21.
[44] Ibid, 30.

metering brings with it a host of potential benefits as well as drawbacks for both utilities and rooftop solar users, yet the two sides have become increasingly polarized. As the issue has evolved into a high stakes political battle, the momentum has depended on local influence and political clout. The outcome of political battles in Nevada and California offer important insight into the future viability of net metering policies and the potential alternatives.

Net Metering - California's Recent Experiences

As the leading solar market in the United States, California is home to more than 2,000 solar companies that employ over 70,000 people.[45] Due to the solar industry's important presence throughout the state, industry supporters have a powerful voice in the creation of laws that affect solar generation. The concerted efforts of California's solar industry played a crucial role in December 2015 when the California Public Utilities Commission proposed a new set of net metering laws that would maintain retail rates for the state's rooftop solar customers.[46]

On January 28, 2016, California's Public Utilities Commission narrowly passed the proposed revisions to the state's net metering laws with a 3-to-2 vote.[47] The new "Net Metering 2.0" maintained the state's retail rates paid to rooftop solar users who sold electricity to the grid. In addition, the bill preserved net metering rates for existing solar customers for up to 20 years. For solar advocates, this provision was a key element of California's new net metering laws. Rooftop solar can be expensive to buy, install, and maintain, and, if the retail rates had been

[45] "California State Solar Policy," Solar Energy Industries Association, accessed April 21, 2016, http://www.seia.org/state-solar-policy/california.
[46] Jeffrey St. John, "California Net Metering 2.0 Keeps Retail Rates for Rooftop Solar," *Greentech Media*, December 15, 2015, accessed April 21, 2015, http://www.greentechmedia.com/articles/read/breaking-california-net-metering-2.0-keeps-retail-rates-for-rooftop-solar.
[47] Jeffrey St. John, "Breaking: California's NEM 2.0 Decision Keeps Retail Rate for Rooftop Solar, Adds Time-of-Use," *Greentech Media*, January 28, 2016, accessed April 21, 2016, http://www.greentechmedia.com/articles/read/Californias-Net-Metering-2.0-Decision-Rooftop-Solar-to-Keep-Retail-Payme.

reduced or if the compensation timeframe had be decreased from 20 years, this would have severely affected the economic viability of rooftop solar throughout the state.

While the final decision was seen as largely in favor of the solar industry, a number of provisions were established to ensure that the state utility's concerns were also considered. Under "Net Metering 2.0" all net metering customers will be forced to pay a one-time interconnection fee as well as non-bypassable charges that add around 2 to 3 cents for each kWh consumed.[48] In addition, the laws included new stipulations that will be enacted in the coming years. In 2018, for example, the state will transition to a time-of-use model where new rooftop solar customers are compensated based on the current demand for electricity.[49] Commissioners also included a stipulation where they would review the laws again in 2019 – a decision underscoring their knowledge that increased adoption of rooftop solar throughout the state could impact transmission and distribution and the ability of utilities to manage electricity flows.

The close vote reflected the divided opinion of legislators who understood the value of the solar industry to California's economy and renewable energy plans, but also worried that net metering compensated solar at the expense of utilities and average rate-paying customers. Commissioner Mike Florio, for example, spoke out against last minute changes that were introduced to the bill and said, "...these last changes have taken a decision already hailed by the solar industry, and made it even richer. And I don't think these benefits are going to accrue to solar customers – they're going to accrue to solar vendors."[50]

While California's bill attempted to strike an equilibrium between utilities' and solar's concerns, the maintenance of net metering rates clearly benefitted the solar industry and

[48] Diane Cardwell, "California Votes to Retain System that Pays Solar Users Retail Rate for Excess Power," *The New York Times*, January 28, 2016, accessed April 21, 2016, http://www.nytimes.com/2016/01/29/business/energy-environment/california-narrowly-votes-to-retain-system-that-pays-solar-users-for-excess-power.html?_r=0.
[49] St. John, "Breaking: California's Net Metering Decision."
[50] Ibid.

residential users. Net Metering 2.0 will facilitate the further growth and spread of solar energy throughout a state that already has the most installed solar capacity of any state in the country. California is seen as a great success for the majority of solar advocates; nevertheless, recent experiences in Nevada highlight what happens if utility companies' interests determine legislation.

Net Metering - Nevada's Recent Experiences

In December 2015, Nevada's Public Utilities Commission found itself embroiled in a debate that was strikingly similar to the discussions taking place in California. On December 22, Nevada's electricity regulators voted in a series of new net metering laws that would substantially increase the costs for rooftop solar users. Key provisions included gradually increasing the fixed charge for Nevada residents with solar energy from $12.75 per month to $38.51 per month over a period of 12 years.[51] In addition, regulators reduced the net metering compensation rate from 11 cents per kWh to 2.6 cents per kWh.[52] Following the decision, Nevada utility NV Energy announced that "[the new law] is fair because it recognizes that the energy and suite of energy services provided by NV Energy to net metering customers differs from the intermittent excess energy delivered to NV Energy's system."[53] Notably, NV Energy's claims were identical to the claims of Californian utilities that questioned the value of distributed solar electricity to the grid.

While this rate reduction was unpalatable for many potential solar customers, the most controversial aspect of the bill revolved around the refusal to grandfather existing solar users into the original net metering rates of 11 cents per kWh. For residential users who had installed solar

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[51] Julia Pyper, "Nevada PUC to Reconsider Grandfathering Rooftop Solar Customers Into New Net-Metering Policy," *Greentech Media*, January 21, 2016, accessed April 21, 2016, http://www.greentechmedia.com/articles/read/nevada-puc-to-reconsider-grandfathering-rooftop-solar-customers-into-new-ne.

[52] Ibid.

[53] "Net Metering," *NV Energy Inc.*, accessed April 21, 2016, https://www.nvenergy.com/renewablesenvironment/renewablegenerations/NetMetering.cfm.

panels with the understanding they would receive a predetermined rate for the next 20 years, the decision suddenly transformed their investment into a losing proposition. Solar companies and advocates quickly responded to the Nevada decision.

The new net metering provisions were set to go into effect on January 1, 2016, and SolarCity – a large California-based solar company – announced its decision to move operations out of the state only days later.[54] SolarCity reported that its decision would remove 550 jobs from the state while CEO Lyndon Rive said, "...I am convinced that [Nevada Governor Sandoval] and the Public Utilities Commission didn't understand the consequences of this decision, not only on the thousands of local jobs distributed solar has created, but on the 17,000 Nevadans that installed solar with the state's encouragement."[55] Other solar companies such as Sunrun and Vivint made similar decisions regarding future operations within the state of Nevada.

For solar advocates throughout the country, the Nevada regulators' decision to retroactively lower reimbursement rates for thousands of existing solar customers served as a reminder that public utilities will continue to campaign against net metering laws. In response, solar customers filed a class action lawsuit against the Nevada Utilities Commission. They claimed that regulators "conspired to unlawfully reduce incentives."[56] The resulting controversy surrounding the commission's decision was surprising even to Nevada's commissioners. Shortly after the decision was made, Commissioner David Noble said, "In 19 years with the commission, I've never seen anything like that. As the decision time got closer, the rhetoric continued to

[54] Alex Nussbaum and Chris Martin, "Sunrun Joins Nevada Solar Exodus in Response to Utility Fees," *Bloomberg News*, January 7, 2016, accessed April 21, 2016, http://www.bloomberg.com/news/articles/2016-01-07/sunrun-joins-nevada-solar-exodus-in-response-to-utility-fees.
[55] "Following Nevada PUC's decision to Punish Rooftop Solar Customers, SolarCity Forced to Eliminate More than 500 Jobs in Nevada," Solar City Press Release, January 6, 2016, http://investors.solarcity.com/releasedetail.cfm?releaseid=949101.
[56] Pyper, "Ditching Net Metering is in the 'Best Interest' of Solar, Say MIT Economists."

increase."[57] The swift response from the solar industry has caused Nevada's Commission to reexamine the grandfathering clause, but authorities have yet to make a decision.

Policy Options and Recommendations

Governments have a variety of policy options to choose from in determining how to compensate rooftop solar. Some will encourage its further expansion while others may have an uncertain or even negative impact on its future. In this section we four discuss potential options.

1. Retail Net Metering

The simplest option, and the one for which most solar companies advocate, is to continue net metering at the retail rate. Net metering policies are straightforward, encourage growth of renewable energy through guaranteed returns, and give individuals some degree of independence from utilities. These attributes make net metering attractive to certain interest groups, often from both sides of the political spectrum. In addition, net metering does not require extra technology, hardware, or studies to implement. Finally, rooftop solar has not seriously affected the balance sheets of utilities in most markets. Utility companies' claims regarding the death spiral and grid defection have been overstated.

Nevertheless, continuing net metering would result in a protracted battle between rooftop advocates and utilities for the support of citizens, public utility commissions, and state governments across the country. It is uncertain whether supporters of net metering would win these battles as rooftop penetration increases and begins to generate substantial costs to the grid. This uncompromising approach would set up net metering for either big wins or losses in fights like those in California and Nevada and carries substantial risk since it does not attempt to find a middle ground with utilities nor determine the true value of rooftop solar electricity.

[57] Robert Walton, "Nevada regulator stands by net metering decision," *Utility Dive*, March 18, 2016, accessed April 21, 2016, http://www.utilitydive.com/news/nevada-regulator-stands-by-net-metering-decision/415902/.

2. Modified Net Metering

A second approach is to modify net metering by including additional charges for rooftop customers. These charges could take the form of a fixed fee, an increased electricity rate for rooftop customers similar to California's Net Metering 2.0, or some combination of the two.

Unfortunately, this option also increases the complexity of net metering. Instead of adjusting parity pricing to less than the retail rate directly, it would make utilities effectively overpay rooftop customers for their power, and then require those customers to pay back the excess value to the utilities. Abandoning parity pricing would be more efficient from a billing perspective given this redundancy, but doing so would require an additional meter to track the electricity fed back to the grid.

Despite increased transaction costs associated with this approach, it does separate the issue of transmission and distribution (T&D) cost sharing from the benefits rooftop solar provides. If utilities judge that rooftop customers are adequately contributing to fixed T&D costs, they may feel less threatened by net metering. Rooftop solar advocates might view this approach as conciliatory to utilities, but it would mitigate the risk of extreme political losses in states less supportive of renewables and set a precedent for iterative value adjustments between retail and wholesale rates.

3. Utility-Owned Rooftop Solar

A third option is for utilities to own rooftop systems themselves, thereby reducing the incentive mismatch they have with solar companies in determining the true value of rooftop electrons. Indeed, a minority of proactive utilities currently compete with solar companies, most

notably in Georgia.[58] The state's largest utility, Georgia Power, sees rooftop solar not as a "threat," but as an "evolution of something [they've] always done."[59] Nevertheless, a combination of regulatory constraints and conservative corporate culture prevents most utilities from voluntarily following Georgia Power's lead.[60]

Extraordinary political and regulatory action could mandate that utilities own rooftop solar systems, forcing the rooftop industry to merge with utilities and reconciling their interests. Neither solar companies nor utilities support this action, however, and it is unlikely to gain political support in the foreseeable future.

4. Self-Consumption

The final policy option for rooftop solar is self-consumption. Self-consumption is similar to net metering, but was designed for the European market and thus differs in important ways.[61] Germany and its neighbors do not support rooftop solar through net metering. Instead, they use a feed-in tariff (FiT) that differs from the retail rate of electricity and guarantees a fixed compensation per kWh for twenty years.[62] A brief background of this policy is integral to understanding how self-consumption would function in the United States.

At the outset of Germany's FiT in the early 2000s, the government guaranteed rooftop solar producers rates well above retail to catalyze its Energiewende, or "energy transformation;" as late as 2009, homeowners were still being promised 43 euro cents/kWh for the energy they

[58] Lauren Sommer and Molly Samuel, "Like Night And Day: How Two States' Utilities Approach Solar", *National Public Radio,* January 1, 2016, accessed April 26, 2016, http://www.npr.org/2016/01/01/460960961/like-night-and-day-how-two-states-utilities-approach-solar
[59] Ibid.
[60] Herman K. Trabish, "Why can't utilities innovate like startups?" *Utility Dive*, August 21, 2015, accessed April 26, 2016, http://www.utilitydive.com/news/why-cant-utilities-innovate-like-startups/404045/.
[61] Jesse Morris. "Germany eyes new kind of net-metering: 'self-consumption'". *Christian Science Monitor,* October 12, 2013, accessed April 21, 2016. http://www.csmonitor.com/Environment/Energy-Voices/2013/1012/Germany-eyes-new-kind-of-net-metering-self-consumption.
[62] Bentham Paulos, "Are the Legacy Costs of Germany's Solar Feed-In Tariff Fixable?", *Greentech Media*, June 04, 2014, Accessessed April 21, 2016, http://www.greentechmedia.com/articles/read/germany-moves-to-reform-its-renewable-energy-law.

generated.[63] Rooftop customers still pay their regular electricity bill, but they also get credited separately for the power they generated that month at their FiT rate. The FiT is financed by a surcharge levied on all ratepayers and results in a marginally higher cost of electricity that the Germans nevertheless supported.[64] Since their rooftop electrons were worth more than those they bought from the grid, neither solar firms nor rooftop generators had any incentive to lobby for net metering.

As rooftop solar penetration increased in Germany, FiT rates for new adopters were decreased, falling below the retail rate. Indeed, only four years later in 2014, the FiT was below 14 euro cents/kWh, partially because of a realization that the legacy costs of existing locked-in FiTs coupled with enormous rooftop uptake were driving up electricity prices faster than expected.[65] An FiT lower than the retail rate does not necessarily make rooftop solar uneconomic, but it does increase the payback period of new systems and, in turn, reduces their attractiveness to homeowners. The relatively stagnant rooftop market in Germany today is a direct result of unattractive FiTs.

Regardless, FiTs below retail in Germany, Italy, Spain and other countries have prompted a rise in self-consumption as a byproduct. Rooftop solar customers engaging in self-consumption try to consume as much of their own electricity as possible because it is worth less to the grid than the power they buy from it. This can be accomplished through not just reducing overall electricity consumption, but also through demand-side management (DSM) at the household level. Innovative household DSM includes putting timers on appliances to coincide with solar production, installing smart thermostats such as a Nest, or even investing in energy storage.

[63] Ibid.
[64] Ibid.
[65] Ibid.

For a hypothetical solar home with an FiT rate that is half the retail rate, every kWh of consumption that the homeowner shifts from the grid to her roof is worth twice as much by virtue of avoided cost. To utilities, homeowners pursuing self-consumption appear the same as homeowners adopting energy efficiency measures from a billing perspective, with the exception that the utility has to pay a discounted rate for that customer's excess power. However, even this cost is minimized since rooftop customers try to maximize self-consumption.

Recommendations

If policymakers are interested in compensating rooftop solar in an economically efficient manner as well as minimizing carbon emissions, a self-consumption model is the best option. However, instead of compensating rooftop with an arbitrary FiT, we recommend using the true value of rooftop electrons. Unfortunately, as highlighted earlier, this value is not known.

If it were straightforward to determine the economic worth of rooftop solar electricity, the net metering debate would be far less complex. However, the United States' electricity grid is a complex system that does not, in most places, have the ability to send data back to system operators. Moreover, rooftop's true value, like the power from other generation sources, varies by location and changes every second with supply and demand fluctuations, going beyond the relatively simple concept of paying a "fair share" for fixed T&D costs as discussed in our second option.

For other power resources like coal and natural gas, the day ahead and real-time power markets try to address the issue of temporal value, while Locational Marginal Pricing (LMP) attempts to address the problem of geographic value. The day-ahead market accepts bids from generators by the hour and the real-time market makes up for the residual need between forecasted demand and real demand; both markets purchase electricity on the basis of variable

cost with the goal of minimizing overall costs by accepting the lowest bids.[66] Utility-scale solar, wind, hydro, and other renewables are naturally used first in this system, termed economic dispatch, because their variable costs are near zero. Rooftop solar is not included, however, as the grid simply takes whatever power is produced automatically.

One could argue that it does not matter whether rooftop participates in economic dispatch bidding since it would always be selected along with utility-scale solar, but this would ignore two issues:

1. PV devaluation: the increasingly apparent phenomenon in places with high solar penetration where the marginal economic value of each additional solar PV kWh is worth less than its predecessors due to PV's fixed supply profile, intermittency, and nondispatchable nature.[67]

2. Electricity generated by rooftop systems simply costs more –roughly twice as much as utility-scale systems per kWh- and requires the extra funds guaranteed through net metering to be competitive.[68]

Given these two facts, net metering results in a favoring of rooftop over utility-scale solar at a higher cost to everyone. This is because utility-scale systems have to be competitive on the market to be worth the investment, while rooftop under net metering gets a much higher rate of return. Rooftop solar might cost twice as much to build but is given perhaps three times the return as large systems. Moreover, as more rooftop systems are installed and penetration increases, the marginal value of solar electrons decreases -utility-scale projects have to be even leaner to find finance. It would be poor policy to create an environment in which cheaper, more

[66] Eric Schubert,"A Primer on Wholesale Market Design," *Public Utility Commission of Texas* (2002): 22.
[67] Andrew Mills and Ryan Wiser, "Changes in the Economic Value of Variable Generation at High Penetration Levels: A Pilot Case Study of California," Ernest Orlando Lawrence Berkeley National Laboratory, (2012): 7.
[68] Verzola, Roberto. "Net Metering History & Logic — Part 1." Clean Technica, September 6, 2015. Accessed April 22, 2016. http://cleantechnica.com/2015/09/06/net-metering-history-logic-part-1/.

efficient systems are not built because of the taxpayer-guaranteed success of small, more expensive systems, especially if fighting climate change is the overall goal.

It is clear that from a day-ahead or real-time market perspective that rooftop has no advantage over utility-scale solar, but electrons are also priced by location (LMP), and this is where rooftop can add extra value. We argue that this is the only variable that has the potential to make up the discrepancy between utility-scale and rooftop systems since the other benefits, such as avoided fuel costs, investment in fossil fuel generation units, and carbon emission externalities are the same for either size system.

To shed light on the locational value of distributed solar, the University of California at Berkeley conducted a study to analyze the value of rooftop installations in its own state and found that rooftop's value to the grid varies greatly by where it is located.[69] Its value came from the avoided cost of not having to change circuits that would otherwise need upgrading due to higher future peak demands in certain places.[70] These benefits to the 10% of circuits that would require upgrading were substantial, and the authors argued that the benefit would be roughly equal to the fixed charge utilities wanted to impose on rooftop customers for not paying their "fair share" to maintain the grid.[71] Nevertheless, the benefits in most places were not significant enough to justify rooftop's higher price tag.

What is needed then, is a comprehensive modeling of the country's electricity grid so that it is clear where rooftop electrons are worth enough to justify higher compensation. A "smart" computer program that can be paired with a meter and can automatically calculate rooftop's

[69] Jeffrey St. John, "Solar's Value for Grid Circuits: Not Much on Average, but Huge for a Handful," Greentech Media, June 25, 2015, accessed April 26, 2016, http://www.greentechmedia.com/articles/read/solars-value-for-grid-circuits-not-much-on-average-but-huge-for-a-handful.
[70] Ibid.
[71] Ibid.

worth based on location and time of day would properly compensate customer-generated solar and incentivize economically efficient investment.

Secondly, since the primary goal of all of these policies is carbon emissions mitigation, we recommend that this meter be designed to optimize household energy use in accordance with actual electricity market conditions since all customers should be moved first to time-of-use pricing, then RTP to properly incentivize greener energy consumption patterns. These pricing policies would see demand shift away from traditional peak times to align more closely with the cheapest electricity – that from renewables.

Finally, we recommend mandating a radical shift in the utility business model. Currently, utilities are incentivized by profit to sell as many electrons to the grid as possible. In a world attempting to minimize its carbon emissions, this creates an obvious conflict of interest not just around rooftop solar, but around energy efficiency as well. New York realized this conflict of interest could make it more difficult for the state to reduce energy consumption, maximize efficiency, and incorporate third-party renewables and in response launched its Reforming the Energy Vision (REV) that introduced the idea of the regulated utility as a "Distribution System Platform (DSP) Provider" in 2014.[72] A DSP is much like an air traffic controller in that its job is to optimize the system; its incentives would no longer be at odds with those of third-party providers, including rooftop solar customers.[73] In turn, this would result in an unbiased assessment of all generation sources. Reforming the utility business model, moving customers to market-based rates, and smart self consumption policy may or may not lead to a proliferation of

[72] Gavin Bade, "REV in 2016: The year that could transform utility business models in New York," Utility Dive, January 20, 2016, accessed April 26, 2016, http://www.utilitydive.com/news/rev-in-2016-the-year-that-could-transform-utility-business-models-in-new-y/412410/.
[73] Ibid.

rooftop solar, but it would give states a framework for pursuing decarbonization in the most efficient, equitable manner.

Bibliography

Abolhosseini, Shahrouz and Almas Heshmati. “The Main Support Mechanisms to Finance Renewable Energy Development.” *Institute for the Study of Labor.* No. 8182. May 2014.

Agnew, Scott and Paul Dargusch. "Effect of residential solar and storage on centralized electricity supply systems." *Nature Climate Change* 5 (2015): 315-318.

Bade, Gavin. “REV in 2016: The year that could transform utility business models in New York," *Utility Dive*, January 20, 2016, accessed April 26, 2016, http://www.utilitydive.com/news/rev-in-2016-the-year-that-could-transform-utility-business-models-in-new-y/412410/.

Byrne, John and Lado Kurdgelashvili. “The Role of Policy in PV Industry Growth: Past, Present and Future." *Handbook of Photovoltaic Science and Engineering*. New York: John Wiley and Sons, 2011.

California Solar. "History of California Solar Power." Accessed April 22, 2016. http://www.california-solar.org/inform/history-of-california-solar-power.php.

California Solar Statistics. "California Solar Statistics." Accessed April 22, 2016. https://www.californiasolarstatistics.ca.gov/faq.

Cardwell, Diane. "California Votes to Retain System that Pays Solar Users Retail Rate for Excess Power." *The New York Times*. January 28, 2016. Accessed April 21, 2016. http://www.nytimes.com/2016/01/29/business/energy-environment/california-narrowly-votes-to-retain-system-that-pays-solar-users-for-excess-power.html?_r=0.

Couture, Toby and Karlynn Cory. State Clean Energy Policies Analysis Project: An Analysis of Renewable Energy Feed-in Tariffs in the United States." *National Renewable Energy Laboratory Technical Report*. June 2009.

Database of State Incentives for Renewables and Efficiency. "Net Metering: Colorado Overview." Accessed April 25, 2016. http://programs.dsireusa.org/system/program/detail/271.

Database of State Incentives for Renewables and Efficiency. "Net Metering Program Overview: Nevada." Accessed April 22, 2016, http://programs.dsireusa.org/system/program/detail/372.

Database of State Incentives for Renewables and Efficiency. "Net Metering: New Jersey Overview." Accessed April 25, 2016. http://programs.dsireusa.org/system/program/detail/38.

Dismukes, David. "Estimating the Value of Net Metering on LPSC Jurisdictional Ratepayers." (report prepared on behalf of the Louisiana Public Service Commission, February 27, 2015).

Energy Initiative Massachusetts Institute of Technology. *The Future of Solar Energy.* Massachusetts: MIT Press, 2015.

Fehrenbacher, Katie. "The Other Side of the Solar Firestorm in Nevada." *Fortune.* April 12, 2016. Accessed April 22, 2016. http://fortune.com/2016/04/12/solar-firestorm-nevada/.

Fox-Penner, Peter. "Rethinking the Grid: Avoiding more Blackouts and Modernizing the Power Grid will be Harder than You Think." *The Electricity Journal* March (2005): 28-42.

GTM Research, Solar Energy Industries Association. "Solar Market Insight 2015 Q4," *Solar Energy Industries Association.* March (2016).

Hill, Joshua S. "First Solar–Funded Study: Utility-Scale Solar Much More Cost Competitive Than Rooftop Solar". *Cleantech Media*. July 19, 2015. Accessed April 26, 2016. http://cleantechnica.com/2015/07/19/first-solar-funded-study-utility-scale-solar-much-more-cost-competitive-than-rooftop-solar/.

Hirsch, Robert. "Fifteen years later: Whither Restructuring in the American Electric Utility System." in *Power Loss.* Cambridge: MIT Press, 2013.

International Energy Agency. "United States Renewable Energy Policies." Accessed April 17, 2016. http://www.iea.org/policiesandmeasures/renewableenergy /?country=United%20States.

Mills, Andrew and Ryan Wiser, "Changes in the Economic Value of Variable Generation at High Penetration Levels: A Pilot Case Study of California", *Ernest Orlando Lawrence Berkeley National Laboratory*, 2012.

MIT Museum. "Carlisle Solar House." Accessed April 22, 2016. http://museum.mit.edu/150/138.

Nussbaum, Alex and Chris Martin, "Sunrun Joins Nevada Solar Exodus in Response to Utility Fees." *Bloomberg News*. January 7, 2016. Accessed April 21, 2016. http://www.bloomberg.com/news/articles/2016-01-07/sunrun-joins-nevada-solar-exodus-in-response-to-utility-fees.

NV Energy Inc. "Net Metering." Accessed April 21, 2016. https://www.nvenergy.com/renewablesenvironment/renewablegenerations/NetMetering.cfm.

Paulos, Bentham. "Are the Legacy Costs of Germany's Solar Feed-In Tariff Fixable?". *Greentech Media*. June 04, 2014. Accessed April 21, 2016.

http://www.greentechmedia.com/articles/read/germany-moves-to-reform-its-renewable-energy-law.

Pyper, Julia. "Ditching Net Metering is in the 'Best Interest' of Solar, Say MIT Economists." *Greentech Media*. May 5, 2015. Accessed April 17, 2016. https://www.greentechmedia.com/articles/read/whats-at-stake-in-californias-coming-net-metering-2.0-decision.

Pyper, Julia. "Nevada PUC to Reconsider Grandfathering Rooftop Solar Customers Into New Net-Metering Policy." *Greentech Media*. January 21, 2016. Accessed April 21, 2016. http://www.greentechmedia.com/articles/read/nevada-puc-to-reconsider-grandfathering-rooftop-solar-customers-into-new-ne.

Schubert, Eric. "A Primer on Wholesale Market Design." *Public Utility Commission of Texas* (2002).

SolarCity Press Release, "Following Nevada PUC's decision to Punish Rooftop Solar Customers, SolarCity Forced to Eliminate More than 500 Jobs in Nevada." January 6, 2016. http://investors.solarcity.com/releasedetail.cfm?releaseid=949101.

Solar Energy Industries Association. "California State Solar Policy." Accessed April 21, 2016. http://www.seia.org/state-solar-policy/california.

Solar Energy Industries Association, "Nevada Solar Statistics." Accessed April 25, 2016. http://www.seia.org/state-solar-policy/nevada.

Sommer, Lauren and Molly Samuel. "Like Night And Day: How Two States' Utilities Approach Solar ." *National Public Radio.* January 1, 2016. Accessed April 26, 2016. http://www.npr.org/2016/01/01/460960961/like-night-and-day-how-two-states-utilities-approach-solar.

Stanton, Elizabeth, Joseph Daniel, Tommy Vitolo, Pat Knight, David White, and Geoff Keith. Synapse Energy Economics. *Net Metering in Mississippi*. (Prepared for the Public Service Commission of Mississippi). September 19, 2014.

St. John, Jeffrey. "Breaking: California's NEM 2.0 Decision Keeps Retail Rate for Rooftop Solar, Adds Time-of-Use." *Greentech Media*. January 28, 2016. Accessed April 21, 2016. http://www.greentechmedia.com/articles/read/Californias-Net-Metering-2.0-Decision-Rooftop-Solar-to-Keep-Retail-Payme.

St. John, Jeffrey. "California Net Metering 2.0 Keeps Retail Rates for Rooftop Solar." *Greentech Media*. December 15, 2015. Accessed April 21, 2015. http://www.greentechmedia.com/articles/read/breaking-california-net-metering-2.0-keeps-retail-rates-for-rooftop-solar.

St. John, Jeffrey. “Solar’s Value for Grid Circuits: Not Much on Average, but Huge for a Handful.” *Greentech Media*. June 25, 2015. Accessed April 26, 2016. http://www.greentechmedia.com/articles/read/solars-value-for-grid-circuits-not-much-on-average-but-huge-for-a-handful.

Trabish, Herman K. “Why can't utilities innovate like startups?” *Utility Dive*. August 21, 2015. Accessed April 26, 2016. http://www.utilitydive.com/news/why-cant-utilities-innovate-like-startups/404045/.

Vermont Public Service Department. *Evaluation of Net Metering in Vermont Conducted Pursuant to Act 125 of 2012.* (2013).

Verzola, Roberto. "Net Metering History & Logic — Part 1." *Clean Technica*, September 6, 2015. Accessed April 22, 2016. http://cleantechnica.com/2015/09/06/net-metering-history-logic-part-1/.

Verzola, Roberto. "Spread of Net Metering, & Utility Backlash — Net Metering History Part 2." *Clean Technica.* September 10, 2015. Accessed April 22, 2016. http://cleantechnica.com/2015/09/10/spread-of-net-metering-utility-backlash-net-metering-history-logic-part-2/.

Walton, Robert. "Nevada regulator stands by net metering decision." *Utility Dive*. March 18, 2016. Accessed April 21, 2016. http://www.utilitydive.com/news/nevada-regulator-stands-by-net-metering-decision/415902/.