Net Metering:
Costs, Customers, and a Smarter Way Forward

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Authored by
The Partnership for Affordable Clean Energy
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"We believe strongly that electricity customers deserve a strong voice in discussions of our shared energy future."

Laura Schepis
PACE Executive Director

The Partnership for Affordable Clean Energy (PACE) is a national not-for-profit organization that advocates for fair and sensible energy policies. Founded in January 2009, PACE brings together a wide variety of groups who have common concerns about the future of American electricity.

Through our public education efforts, the organization has helped to shape national and state energy conversations. This has included intervening in matters before public service commissions and other regulators, offering testimony to the Environmental Protection Agency in public hearings, submitting comments to state and federal policy makers on various energy proposals, and presenting at national and regional conferences about the importance of energy policy that works for customers.

Our vision is clear. PACE believes in an energy future that preserves access to reliable, low-cost electric power while continuing the significant environmental progress that has been made in past decades.

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All views expressed in this publication are Dr. Gattie's and not necessarily those of the University of Georgia.

FOREWORD

Solar power is a growing part of America's energy future. Nationwide, in sun-rich locations such as Arizona and somewhat surprising places like Massachusetts, an increasing number of homeowners are choosing to invest in rooftop solar. As they do, the need for sensible policy governing solar's integration with the power grid gains importance. Specifically, the need for net metering policies that work for all parties involved becomes critical.

PACE has been an outspoken voice on the topic of net metering, lending its perspective to policy makers from one coast to the other, from ongoing debates in one of the pioneer states for net metering, California, to discussions about how best to move forward with net metering policy in a still-developing solar state, Florida. We have written much on the topic through PACE's blog, offered perspective and written testimony to regulators and lawmakers, and appeared in front of policymaking bodies to offer a personal appeal for what we deem to be the right path forward for net metering.

Our core guidance for policymakers has been simple. In the effort to support the growth of residential solar power, make sure that net metering policies:

- Treat all customers fairly by avoiding cost-shifting;
- Accurately reflect both the benefits and costs to the grid of solar; and
- Don't distort the energy marketplace by paying excessive rates for rooftop generation.

Since we began our advocacy in this area, experiences nationwide, and even beyond our own borders, have informed the debate with real-life lessons about the consequences of net metering design. Academic studies, too, have enriched discussions with new information and new evidence that points policymakers in the right direction.

We hope that this paper serves as a useful tool for policymakers everywhere who continue to grapple with the intricacies of net metering policy. Our hope is that it summarizes PACE's position on this complex issue and distills the history and available research on the topic into a form that everyone can understand.

Customers nationwide, those who own solar rooftops and those who don't, are depending on their policymakers to choose a smart and sustainable path forward.

SECTION I: NET METERING OVERVIEW

Across the nation, an increasing number of homeowners are choosing to install photovoltaic (PV) solar energy systems on their property, most often in the form of familiar blue solar panels attached to rooftops. These PV systems harness available sunlight and convert raw solar energy into electricity, helping to supplement electricity available from the grid. When working properly, these solar energy systems can provide a substantial portion of a home's electricity needs. In some cases, a system can even generate more electricity than the homeowner requires, creating an opportunity to send excess electrons to the grid. When that happens, the homeowner becomes a supplier of electricity, as opposed to a recipient.

The situation described above raises a number of questions for the nation's utilities and for the people and institutions tasked with ensuring the stability of America's power grid. How do grid operators manage an energy system with an increasing number of small, intermittent producers of electricity? What technical problems might arise from additional electricity flowing independently into a carefully managed electricity distribution system? With the solar industry estimating the number of homes equipped with solar technology will reach a million in 2016, how does the grid grow and evolve to accommodate these new, decentralized power sources? What will that growth and evolution cost and who pays for it?

As utilities and grid operators labor to answer those technical questions, policymakers grapple with a more direct question: what is the best way to compensate solar rooftop owners for the electricity they send to the grid?

The answer to that question lies at the heart of the debate over net metering, which is the balancing of energy supplied to and taken from the grid by a solar rooftop owner.

A Brief History of Net Metering Policy

The practice of compensating solar owners for their power generation originated in U.S. law four decades ago, when the Public Utility Regulatory Policies Act of 1978 (PURPA) began requiring electric utilities to purchase power supplied to the grid by solar owners. The task of determining proper pricing was left to state regulators, leading to a variety of approaches. The source of variation was the law's requirement that utilities pay solar owners a capped rate for electricity equal to the "avoided cost" of power generation, meaning the cost had the electricity been supplied by the utility and not by the solar owner. Regulators nationwide interpreted this mandate on their own terms and calculated avoided cost in a way that made sense to them. In some service territories such as California, avoided cost payments to solar owners were relatively generous. In other regions, avoided cost was calculated differently and resulted in much lower payments.

Despite a clear legal requirement to pay the avoided cost for power generation supplied by solar home owners, some regulators established a policy of true net metering. In these cases, solar home owners are paid a rate for their excess electricity equal to the rate the utility charges for power supplied to the home. Each kilowatt-hour of electricity generated by the home solar PV system offsets, one-for-one, a kilowatt-hour of electricity consumed from the grid. In other words, those owning solar rooftop systems are paid at the full retail rate for electricity.

Recognizing that this arrangement is a perversion of the electricity marketplace, an important challenge to true net metering was lodged in 2002 by FirstEnergy, who argued to the Supreme Court of Ohio that net metering payments should be structured at a rate closer to true avoided cost. FirstEnergy proposed a net metering payment that distinguished between the generation portion of the retail rate and the portions such as transmission and distribution that are separate and unrelated to the cost of generating electrons. Since solar owners are only generating electricity, and not transmitting or distributing it, FirstEnergy argued that the avoided cost payment should only include that portion of cost that addresses generation. This line of argument was first rejected by the Ohio Public Utilities Commission, but later overruled by the Supreme Court of Ohio, which found that a net metering customer "does not provide transmission, distribution or ancillary services," and therefore the term "electricity" in the statute could be reduced to the power generation portion only.

This ambiguity was further resolved to some extent in 2005 by the addition of Section 111(d)(11) to PURPA, which set a more standard practice for calculating net metering on an avoided cost basis. The section added in 2005 reads -

> *"Net Metering – Each electric utility shall make available upon request net metering service to any electric consumer that the electric utility serves. For purposes of this paragraph, the term "net metering service" means service to an electric consumer under which electric energy generated by that electric consumer from an eligible on-site generating facility and delivered to the local distribution facilities may be used to offset energy provided by the electric utility to the electric consumer during the applicable billing period."*

While lawmakers in 2005 sought to clarify and standardize net metering practices, a key federal energy agency interpreted PURPA's avoided cost in a way that muddied the water for regulators. A decision by the Federal Energy Regulatory Commission (FERC) allowed net metering customers to receive payments higher than the avoided cost price cap. Because most solar home owners receive more electricity from the grid than they send to it, FERC reasoned that no "sale" is taking place as defined by PURPA or the Federal Power Act. Since there is no sale, PURPA's avoided cost mandate does not apply[1].

This line of reasoning has opened the door for some state regulators to require utilities to pay the full retail rate to solar home owners for electricity sent to the grid. Other states and service territories have chosen to pay an amount less than the retail rate. Whatever the model, today the vast majority of states (41) and the District of Columbia have codified their rules for net metering.

Net Metering Policy and Solar Deployment

While it is true that areas with richer solar resources have a longer history and more robust growth when it comes to rooftop solar, the deployment of home solar technology depends on more than just geography; it also depends heavily on net metering policy. States with higher net metering payments attract more solar rooftop investment. After all, the amount of credit for power supplied to the grid is a key factor in the decision by a homeowner to invest thousands of dollars in a home solar PV system.

Early evidence for the relationship between net metering policy and solar deployment came not from U.S. states, but from overseas as David Raskin discusses in his 2013 publication. Germany instituted a version of net metering in 1991, committing itself to widespread promotion of solar power. Denmark did the same in 1992, with Spain, Italy, and other European nations building on the model that Germany provided. By the beginning of this decade, 17 European Union member states had implemented aggressive payments to solar rooftop owners similar to true net metering.

Meanwhile, solar rooftop capacity in China nearly tripled in the early years of this decade while capacity in Japan more than doubled, due in large part to government policy that aggressively compensated solar rooftop owners.

Domestically, western states have been at the forefront of rooftop solar deployment, combining their rich solar resources with aggressive net metering policy to incentivize the installation of solar rooftops. California, in particular, has been a leader in supporting solar rooftop's growth. Today, the state is the clear leader in PV installations with more than one third of the nation's distributed capacity[2].

Hawaii, a state with exceptionally high retail electricity prices, has seen rapid growth in deployment of rooftop solar. Between 2011 and the end of 2013, for example, PV capacity in Hawaii increased by 283%, mainly in the form of rooftop solar. By the end of 2013, more than one in nine Hawaiian homes was meeting some of its power needs with solar[3]. Other states such as Nevada, Arizona, and New Mexico have also become hotbeds for solar deployment. Consequently, as this report will detail, those states have also become focal points in the debate over net metering policies, as they provide crucial real-life laboratories for what has worked and what hasn't when it comes to net metering design.

Adding to the incentive that true net metering provides for solar deployment, federal agencies have also implemented plans to increase the use of rooftop solar. For example, the U.S. Department of Energy's Million Solar Roofs initiative, which ended in 2006, estimates that it contributed to the installation of more than 377,000 solar water heating, photovoltaic (PV), and solar pool heating systems with 200 megawatts (MW) of grid-connected solar PV capacity.

The combination of these policies has led to a spike in solar installations in the U.S. In recent years, installed solar PV generation capacity in the U.S. has grown substantially. In fact, the period from 2008 though 2014 saw approximately 18 gigawatts of grid-connected solar PV added to the grid[4]. This is a staggering amount of generating capacity, equal to nearly five times the generating capacity of the nation's largest nuclear power plant. This magnitude of growth means that creating fair and sustainable metering policies is more important than ever.

Residential Solar in Market Context

There is a reason why the term net metering has become synonymous with a one-for-one exchange of kilowatt-hours added to the grid and taken from it. That is because in most states that have codified net metering policies, the net metering rate is equal to the utility retail rate. For context, today's average residential price of electricity in the U.S. is approximately 12.8 cents per kilowatt-hour[5].

When compared to grid-connected renewable energy sources that are larger in scale and not owned by individual residents, e.g. utility-scale solar farms, that are selling electricity at a rate near or below 3 cents per kilowatt-hour, it becomes clear that many utilities are grossly overpaying solar rooftop owners for the power those owners supply to the grid. In fact, true

net metering allows solar rooftop owners to sell their excess electricity back to utilities at prices between two and six times the market price. Other market-based evidence, too, reinforces the perspective that reimbursing homeowners at the retail rate for their solar generation amounts to a market distortion. A 2015 study by MIT found that PV rooftop generation is, on average, about 70% more expensive than generation from utility-scale projects using similar PV technology. The study found that even in California, which has created extremely attractive conditions for residential solar and benefitted from economies of scale, solar rooftops are not remotely competitive with utility-scale projects on a levelized cost of electricity (LCOE)[6] basis (MIT 2015).

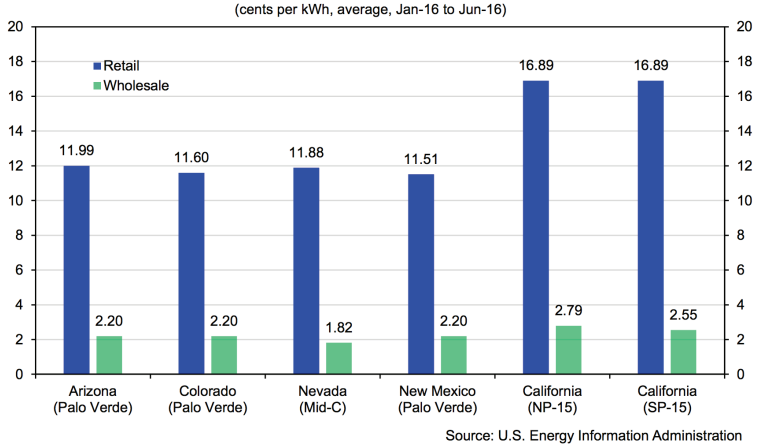
The Institute for Energy Research has also studied the disparity between net metering rates paid to solar rooftop owners and the rates available to utilities on the open energy market. As the chart below from the Institute's research illustrates, true net metering can often create a significant market distortion by requiring utilities to overpay for electricity.

California

As the nation's most prominent early adopter of net metering policy, California continues to support the payment of retail rates to solar rooftop owners. The California Public Utilities Commission voted in January 2016 to maintain true net metering through at least 2019.[7] With this action, regulators guaranteed for a minimum of three years that solar rooftop owners will be paid more for their generation than the marketplace would otherwise offer. To their credit, however, California regulators did add a time-of-use provision that compensates solar production at different rates depending on real-time demand for electricity. This helps to align California's net metering policy more closely with the market.

Figure 1: Wholesale vs. Retail Electricity Prices

(cents per kWh, average, Jan-16 to Jun-16)



Source: U.S. Energy Information Administration

Let us focus on three other states—Arizona, Nevada, and Mississippi—that have recently made important decisions about net metering. These states, each faced with unique situations, have begun—or at least attempted to begin—the process of recalibrating net metering policies to create a more fair and sustainable foundation for residential solar power's future.

Arizona

Arizona ranks among the top states in the the nation for solar resources, making it a strong location for solar rooftop deployment. In fact, Arizona today has more than 500 megawatts of installed residential solar power capacity, which is roughly the capacity of a small commercial nuclear power unit. The state also boasts four times that capacity in large-scale solar.[8] For net metering customers in Arizona, the size of an eligible PV system is capped at 125% of the customer's total connected electricity load to ensure that customers do not transmit an unreasonable amount of electricity to the grid (IER 2016).

As reported in the 2016 IER study, until recently, solar net metering customers received the retail rate for their excess generation, which is approximately 10 to 14 cents per kilowatt-hour

in Arizona depending on the customer's plan. After years of experience under this payment structure, regulators determined that net metering customers were not sufficiently paying for the upkeep of the electric grid. The state's largest utility, Arizona Public Service, found that net metering customers were paying only a little more than a third of the cost to provide electric service to them, avoiding around $1,000 each year in costs for operating the electric grid. This grid upkeep deficit was shifting an average of $16.80 annually to other customers' bills. In January of 2014, the state approved a 70 cents per kilowatt standing charge to be applied to customers who install new solar rooftops, providing a short-term fix for the rest of the customer base.

In October of 2016, a law judge in Arizona helped set into motion a longer-term solution for the state's net metering arrangement. The solution was the product of a three-year process that included testimony, discovery, and hearings about the proper way to integrate residential solar into the operation of the state's regulated utilities.[9] This process concluded that paying the retail rate for solar rooftop generation was no longer justifiable and that basing the net metering structure on avoided cost was a more sensible approach. In December of 2016, state regulators approved the judge's recommendations.

Moving forward, existing solar customers in Arizona will be "grandfathered in" to retail net metering payments for 20 years from the date of their connection. New solar customers, however, will eventually pay a rate of 4 cents per kilowatt-hour and will pay higher rates than other customers for the grid services they receive (Randazzo 2017).

Nevada

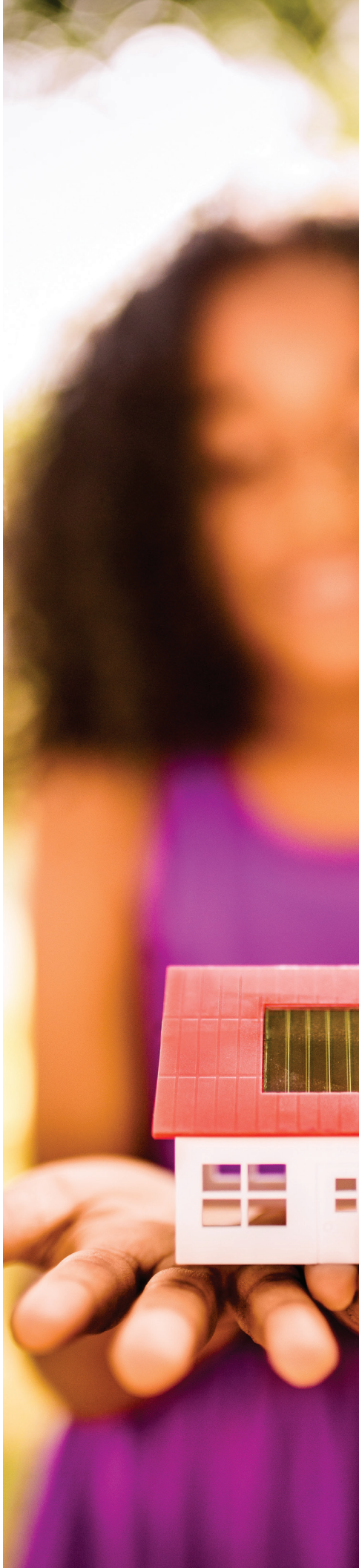
Nevada, another state rich with solar resources, continues to face a similar dilemma. Today, the state has more than 150 megawatts of residential solar capacity. For most of the past decade, approximately six thousand Nevadans participated in the state's net metering program. However, as the state continued to pay the retail rate to solar rooftop owners for their excess generation, many more customers chose to install solar rooftops. In just a few short months in 2015, 24,000 Nevadans signed up to take advantage of the state's net metering program (Fehrenbacher 2016). This was a shock to the Nevada program that raised red flags among the state's utility regulators.

Nevada regulators acted quickly to try to ameliorate the problem, tripling the monthly fixed rate for solar customers to nearly $40 and gradually reducing the retail rate paid to solar net metering customers to the wholesale rate—a reduction of about 75% (Rothberg 2017). The move reflected the action taken in Arizona to move from an attractive retail rate for net metering to rates more in line with the marketplace. Nevada's plan, however, affected all solar customers, including existing ones. There was no "grandfathering" clause. This drew the ire of solar industry heavyweights SolarCity, Sunrun, and Vivint, as well as solar activists.

A class action lawsuit filed in January 2016 against NV Energy, the state's largest utility, stalled the state's new net metering plan. More than 31,000 petitions were submitted in protest of the change and SolarCity, which employed more than 2,000 people in the state, laid off 550 employees in what some saw as a demonstration of contempt for the new net metering structure. Smaller companies such as Sunrun and Vivint, shut down their businesses in Nevada altogether (Trabish 2016, Jan 21).

In September 2016, despite information that showed that retail net metering was shifting $36 million per year to non-solar customers and that solar rooftop generation competed poorly with large-scale solar installations, the decision to end net metering was reversed. Moving forward, 32,000 solar rooftop owners in Nevada will be paid the full retail rate for the electricity they supply to the grid (Shallenberger and Bade 2016).

Following the 2016 reversal, Governor Brian Sandoval signed Assembly Bill 405 in June 2017 which fully restores net metering to near retail level rates for all net metering customers beyond those grandfathered in during the 2016 decision. While hailed as a victory by solar installers such as Tesla, Vivint, and Sunrun, this legislation essentially brings Nevada back to square one.[10]



Mississippi

A state with very little history with net metering, Mississippi has also taken important steps to provide a firm foundation for residential solar policy. In 2015, members of the Mississippi Public Service Commission began evaluating the best way to structure a new net metering program to accommodate a growing number of solar rooftop owners. In December of that year, after an extensive public comment and fact-finding process, the Commission required all investor-owned utilities in the state to allow customers to enroll in a net metering program.[11]

Mississippi's program compensates net metering customers at the wholesale avoided cost for electricity, plus an additional 2.5 cents per kilowatt-hour. Mississippi Power, the utility most affected by the new structure, has a wholesale avoided-cost that ranges from 2.29 to 3.62 cents per kilowatt-hour, depending on the time of day and season of the year.[12] That means Mississippi Power customers under the new net metering structure will receive in the neighborhood of 5 to 6 cents per kilowatt-hour for their contribution of electricity to the grid.

The Mississippi Public Service Commission also included provisions for net metered customers who qualify as low-income, falling at or below 200% of the federal poverty level. The customers will receive an additional 2 cents per kilowatt-hour for solar generation added to the grid. This premium will be available to the customer for 15 years from the date of enrollment in the net metering program and would bring the net metering payment for low-income customers to around 7 cents to 8 cents per kilowatt-hour.

As a way to control the amount of solar generation added to the grid from solar rooftops, Mississippi regulators also established a cap on net metered capacity at 3% of each utility's total retail peak at the time of the utility's total system peak, to be calculated on an annual basis. Because of this cap, solar PV systems are taken on a first-come, first-serve basis. The cap on net metering generation limits the exposure of utilities to unforeseen net metering payments, while Mississippi's use of avoided cost for net metering aligns payments more closely with the open market for electricity.

Other Examples

In addition to the other examples provided above, several other states also have taken action to recalibrate net metering policies that were deemed problematic.

In Louisiana, after seeing the state's direct tax incentive for residential solar grow from $500,000 to about $42 million, regulators in 2014 decided to reevaluate the state's net metering structure. Evidence showed that Louisiana's net metering structure was causing an $89 million negative net benefit to electric customers and that more than $2 million of utility costs per year were being subsidized by non-solar consumers (IER 2016).

Nationwide, in states with varying levels of solar resources, regulators are attempting to find solutions for net metering that are in the best interest of all electric customers. It is a complicated task, as it must balance popular arguments in favor of residential solar with market realities, ensuring along the way that **all customers - those who use solar and those who don't - are treated fairly by whatever structure is created.**

Since 2003, Louisiana has employed a policy of retail net metering, with the state enforcing a cap of 0.5% of a utility's peak load as the amount of net metering capacity that can enroll in the net metering program. In 2015, the state's major utilities met that cap, meaning that new solar PV installations would not be compensated at retail net metering.

Despite the findings pointing to the negative effects of the retail net metering structure, Louisiana regulators in December 2016 chose to lift the cap on net metering enrollment. Promising to review the state's net metering structure over the coming years, the Louisiana Public Service Commission has ensured that the retail rate remains the standard in the state for compensating solar rooftop owners. Data submitted to the Commission estimates that maintaining the retail rate for net metering could add as much as $809 million to ratepayer bills (Walton 2016).

In Indiana, a current piece of legislation, Senate Bill 309, would end retail net metering in that state, replacing the current structure with a lower wholesale rate. If passed, Indiana customers who own solar rooftops would be compensated at a rate of about 3 cents per kilowatt-hour.

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SECTION II: POLICY CHALLENGES AND COMMON ARGUMENTS

One of the most significant barriers to developing and implementing effective net metering policy is educating policymakers and the public about the mechanics of delivering electricity to customers.

Residential and commercial electricity customers see the physical grid— i.e. power poles, transmission lines, distribution centers—just as we do highways and bridges. They are ubiquitous and customers inherently know that these pieces of infrastructure exist to make the modern world possible. However, customers often know little about how infrastructure is funded. Public funding for roads and bridges is incorporated into the black-box of the federal, state, and local taxes we pay. And although members of the public don't write checks to the Department of Transportation, they know that somewhere in the taxes they pay is a contribution to the roads and highways that connect America.

Similar to our transportation system, the physical electric grid is such a staple of modern life that road-side power poles or towering high-voltage transmission lines blend into the backdrop of American life. Just like our roads and bridges, customers know the grid is paid for somehow, although for the vast majority of customers that funding mechanism remains mostly a mystery. Modern rate design for electricity ratepayers has further compounded public misconception about how the grid is funded, since most utility rate designs do not adequately account for the cost of the grid. Even if customers did investigate how much of their monthly bill is devoted to grid construction and upkeep, the percentage they would find would not accurately reflect reality.

The lack of visibility into the true cost of the grid creates a formidable barrier to customers and policymakers understanding the fair valuation for distributed energy generation such as rooftop solar. When customers and policymakers think of electricity rates only in terms of electricity generation, they fail to fully account for the larger, global cost of generating, transmitting, and distributing that electricity. The consequence of this oversight in the context of net metering discussions should be obvious: solar rooftops generate electricity, but that is all they do. In other words, residential solar rooftop systems can never be compared apples-to-apples with what full-service utilities provide.

When a solar rooftop owner becomes a net metering customer, that customer becomes a supplier of electricity. The electrons generated by the solar rooftop are indistinguishable from electrons generated by a large-scale power plant. The difference is that the net metering customer provides electricity only, while the utility provides much, much more. And while

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the solar rooftop owner provides electricity to the grid voluntarily, whenever it is available, the utility is under a federal mandate to ensure that electricity is available to customers all of the time, no matter the changes in demand due to weather or other factors. The electrons from each source might be indistinguishable; the circumstances surrounding generation and delivery are not.

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Not all observers agree with this position, particularly the solar industry itself, which desires net metering payments to be as high as possible. High net metering payments, of course, make the decision to purchase a residential solar PV system more financially sound and are a major tool for incentivizing the growth of rooftop solar. In furtherance of this cause, advocates for high net metering payments have used a variety of arguments to make their case. These arguments are often bundled together to produce a "value of solar" (VOS) calculation that takes into account the perceived benefits of solar's integration into the grid. While the VOS amount differs based on unique inputs, this amount typically exceeds the avoided cost of generation calculation used in many service territories and required by PURPA rules. In this way, VOS has become a useful tool for the solar industry to justify aggressive net metering payments to solar owners.

While VOS models can take into account any number of perceived benefits from solar, the most common include:

- Avoided Capacity
- Avoided Fuel
- Enhanced Reliability
- Hedge Against Price Volatility
- Transmission and Distribution Deferral
- Avoided Line Losses
- Environmental and Social Benefits

When taken together, advocates argue, these multiple benefits yield a VOS much richer than what many utilities and regulators would prefer to pay. Consider the case of Massachusetts, where a study by the Acadia Center in 2015 determined the VOS in that state to between 22 and 28 cents per kilowatt-hour, with an additional societal benefit of 7 cents per kilowatt-hour. When combined, these values produce a rate that is double—or sometimes more than double—the average residential retail rate for electricity in Massachusetts.

But are the benefits from solar power really all they are cracked up to be? A study produced by the National Renewable Energy Laboratory in March 2015 says perhaps not. In "Value of Solar: Program Design and Implementation Considerations," authors Joyce McLaren and Karlynn Cory, as well as contributors from the Solar Electric Power Association, calculate solar's value to be more moderate and probably less than what many in the solar industry would prefer.

The National Renewable Energy Laboratory study finds that the most sensible calculation for VOS to be around 7.5 cents per kilowatt-hour. Well more than half of this amount originated from avoided fuel costs. On the low side, the VOS calculation was found to be less than 5 cents; on the maximum, 11 cents. In general, the National Renewable Energy Laboratory study's findings point to a figure for VOS that is much more in line with avoided cost or avoided cost plus. Recall that Mississippi net metering customers, under that state's new "avoided cost plus" model, will receive around 6 cents per kilowatt-hour, with low-income customers receiving around 8 cents. The real-life figures from Mississippi mirror closely the research findings of the National Renewable Energy Laboratory.

Table 4. VOS Hypothetical Ranges (¢/kWh)

Category	Low	Middle	High
Avoided fuel	3.6	5.2	6.1
Avoided capacity	1.0	1.5	2.1
T&D deferral	0	0.14	0.19
Environmental	0	0.18	1.9
Losses	0.3	0.49	0.72
Total	**4.9**	**7.5**	**11.0**

Complementing the findings of the National Renewable Energy Laboratory are the conclusions of a paper published by Ashley Brown, Executive Director of the Harvard Electricity Policy Group, and Jillian Bunyan, a former attorney for the United States Environmental Protection Agency. The paper, entitled "Valuation of Distributed Solar: A Qualitative View," provides a detailed explanation of claims related to VOS, finding that many of the perceived benefits from solar simply don't add up. The following are summaries of Brown and Bunyan's investigations into various categories of VOS-related benefits.

Claim: Solar Helps Avoid Capacity

One of the benefits most commonly cited by VOS advocates is that the use of solar power helps offset the need for additional generating capacity. But as Brown and Bunyan explain, "The capacity value of a generating asset is derived from its availability to produce energy when called upon to do so. If a generator is not available when needed, it has little to no capacity value." The authors go on to explain that in many jurisdictions the most productive periods of the day for solar coincide poorly with overall peak demand for all customers. While rooftop solar normally produces best in the early afternoon, peak demand on most electrical systems occurs later in the afternoon or in the early evening. At other times, when conditions are not good for solar production, generation from rooftop solar could be virtually nothing at all. Brown and Bunyan argue that this misalignment between solar production and system needs must, by definition, greatly reduce the value of solar generation related to capacity.

Claim: Solar Enhances Reliability

Another common claim from VOS advocates is that solar rooftops, because they are widely distributed and physically closer to customers than central generation units like power plants, enhance the reliability of the grid. That added benefit, they reason, should be reflected in VOS and, by extension, net metering rates. However, Brown and Bunyan take exception to this argument, calling such claims "highly speculative" and "quite dubious" and concluding that "it would be a mistake to attribute added value to solar DG [distributed generation] because of reliability."

The authors explain that distributed solar provides more benefit to some systems than others, primarily based on the dominant sources of power generation that solar is used to complement. For example, solar intrinsically has more value in Brazil, which relies heavily on large hydropower plants that can store vast amounts of potential power generation. When solar power works well in Brazil, it offsets the need to operate hydropower facilities at their full capacity. In other words, solar power does what VOS advocates claim. On the other hand, the U.S. electrical system is dominated by thermal power plants that use nuclear, coal, and natural gas to generate electricity. There is little to no storage available in the U.S. system, meaning that electricity must be generated to meet customer demand on a real-time basis. Under these conditions, the authors explain that "solar power's intermittency makes it unable to assure its availability when called upon to deliver energy."

The real-life workings of the electrical grid mean that thermal power units, normally quicker-starting natural gas units, would be called on to back up solar power, not the other way around. A solar rooftop might provide greater peace-of-mind for the individual homeowner in cases where utility power is unavailable, but that solar rooftop does little to assist grid operators in making power more reliable for customers in general. As Brown and Bunyan state, "...absent storage, it is almost certainly the case that the system provides reliability for solar DG, rather than the other way around."

Claim: Solar Hedges Against Price Volatility

Some VOS advocates argue that solar power serves as an important hedge against price volatility. The rationale for this claim is that because the fuel used for solar power is free, the marginal cost of solar power is zero. In theory, Brown and Bunyan explain, this claim has some merit. In the real world of power production, however, it falls flat.

> *"In reality, however, solar is an intermittent resource that cannot serve as a meaningful hedge unless such zero-cost energy is both sufficiently and timely produced," the authors state. "Thus, solar DG is the equivalent of a risky counterparty whose financial position renders him incapable of assuring payment when required."*

Brown and Bunyan go on to conclude that any claim that solar hedges against price volatility has little validity in real-life applications.

"The argument that solar DG provides a valuable hedge function is reduced to virtual absurdity by the fact that the so-called hedge is not callable," the authors write. "In short, if the price rises to the level against which the hedge purchaser wants to be insured against, the solar provider of the hedge is not obliged to pay. That being the case, there is no hedge whatsoever."

Claim: Solar Defers Transmission and Distribution Costs

While there is likely some merit to the claim that solar power helps to defer some amount of transmission and distribution costs, that amount is likely very small. In fact, the National Renewable Energy Laboratory calculates the value of transmission and distribution deferral from solar power, under the maximum conditions, to be less than two-tenths of a cent per kilowatt-hour.

Brown and Bunyan largely agree with this assessment, but go even further, explaining, "It is nearly impossible to demonstrate that solar DG will obviate the need for transmission, much less quantify the cost savings associated with the purported benefit." They reason that while it is true that solar rooftops don't require any transmission costs to supply energy to the grid, that doesn't mean that customer-owned solar achieves any cost savings for the transmission system. Brown and Bunyan concede that in some cases a concentration of solar rooftops could reduce congestion or provide other ancillary benefits, but that any benefits must be examined on a case-by-case basis. In the end, they reason, "it is improbable that solar DG actually saves any investment in transmission capacity." The authors also explain that more solar rooftops could actually mean more distribution costs, not less.

Sifting through the claims about the perceived benefits of rooftop solar can be difficult and confusing for policymakers. Evaluating whether Value of Solar arguments have real merit, too, can be an exercise for regulators and public officials that requires a great deal of technical investigation and evidence. However, these common arguments lie at the core of the net metering debate and must be reckoned with if real consensus is to be established.

"It is more likely that solar DG will cause more distribution costs than it saves. That is because these generation sources could change voltage flows in ways that will require more controls, adjustments, and maintenance," Brown and Bunyan write. "Moving from a one-way to a two-way system will certainly increase the need for technical equipment to manage the reliability of the system."

Claim: Solar Avoids Line Loss

When electricity travels across transmission lines, some electrons are inevitably lost. Since solar rooftops are in theory located closer to customer demand than central generation power plants, VOS advocates claim that avoided line loss is yet another benefit of solar.

The National Renewable Energy Laboratory, in its study of VOS, gives credit to this idea. That study credits solar with causing the avoidance of 7% line loss for all power generated by customer-owned solar instead of central generation. Brown and Bunyan are less bullish about solar's contribution in this area. The basis of their disagreement is that any electricity exported to the system from solar rooftops would be subject to the same line losses as all other generation traveling the same lines.

"If there were locational prices on the distribution system, there might be line loss benefits that could be captured by DG but, since those price signals do not exist, the argument is purely academic," Brown and Bunyan conclude.

Claim: Solar Yields Environmental and Social Benefits

While the claim that increased deployment of solar power leads to quantifiable environmental benefit might seem self-evident, the case might not be as straight-forward as it seems. Even the National Renewable Energy Laboratory, which does support the idea that the use of solar power creates environmental benefits, places very little value on this category. In the most likely case, the benefit is valued at less than two-tenths of a cent per kilowatt-hour. Even on the high end, the environmental benefit of solar power, sometimes called the social benefit, is valued at less than two cents per kilowatt-hour. The National Renewable Energy Laboratory derived these calculations by examining reductions in sulfur dioxide, nitrous oxide, particulate matter, and greenhouse gases.

Brown and Bunyan take a different approach to examining these perceived benefits, arguing that "any analysis of the environmental impact of the generation mix should include an examination of the least-cost, most efficient ways to get the desired results." In other words, while replacing some portion of fossil-fuel power generation with solar power might produce fewer emissions, hence creating environmental benefit, there might have been more expedient, and less costly ways, of achieving the same result.

As evidence for their point of view, the authors point out that rooftop solar "is the least efficient of all renewable energy resources in common use in this country," a finding they argue is supported even by solar advocates such as Amory Lovins. Because of this, Brown

and Bunyan argue, it is likely that attempting to use solar rooftops to generate broad environmental benefits has the effect of squeezing more efficient forms of renewable energy out of the market and and actually making the goal of carbon reduction vastly more expensive than it has to be. Viewed through that lens, there might indeed be measurable environmental benefits to be derived from greater use of solar power. However, the choice to use customer-owned solar to achieve carbon reductions could be a poor one from a public policy point of view.

Brown and Bunyan offer the example of Germany, a nation that used high payments to solar owners as a way to achieve carbon reductions, only to experience spikes in carbon emissions and the use of lignite coal. In Germany, the attempt to derive broad environmental benefits from rooftop solar resulted in perverse outcomes.

"The German example clearly demonstrates that increased dependence on renewable energy resources, particularly intermittent resources, does not, as many solar DG proponents claim, ipso facto, mean fewer carbon emissions, and may, in fact, cause the opposite to occur," the authors write.

Sifting through the claims about the perceived benefits of rooftop solar can be difficult and confusing for policymakers. Evaluating whether Value of Solar arguments have real merit, too, can be an exercise for regulators and public officials that requires a great deal of technical investigation and evidence. However, these common arguments lie at the core of the net metering debate and must be reckoned with if real consensus is to be established.

We believe that critical analysis and available real-life evidence strongly points to a quantifiable value for solar that is less than what some solar advocates would desire. By carefully considering this analysis and evidence, policymakers can better equip themselves to cut through the clutter and determine which benefits from solar power are real and which are illusory.

SECTION III: A WAY FORWARD

There can be little doubt that utility regulators and other energy policymakers nationwide have a difficult task ahead of them when it comes to safeguarding the future of residential solar generation. Available evidence makes it clear in many states and service territories that something must be done, but net metering policy isn't just financially complicated. It is also politically charged.

As we've seen, discovering the problems inherent with a policy such as retail net metering doesn't always lead inexorably to action. In some cases, the work of solar activists and lobbyists creates a political climate that protects a flawed status quo. In other cases, regulators simply choose a wait-and-see approach that defers action.

The truth is that even the act of entering into discussions about proper net metering design is enough to trigger pushback from the solar industry and its customers, as any measure or plan that brings net metering payments more closely in line with the marketplace means lowering payments to solar customers. Often, such potential reductions in net metering payments are characterized by the solar industry as being intended to stifle solar deployment or protect utility profits, as opposed to efforts to create market-aligned payment structures. In the same vein, attempts to increase fixed charges for solar customers are often labeled as "taxes on the sun" or referred to as punitive policies, as opposed to their true intent, which is to more sufficiently collect from each customer the real cost of maintaining grid services.

Whatever the political pressures regulators might face, their responsibilities are multiple when it comes to net metering. At a minimum, those responsibilities include -

- Establishing a path forward for utility customers who wish to install residential solar and connect their generation to the grid.
- Laying a sensible groundwork for solar customers to be paid for the electrical generation they provide to the grid.
- Ensuring that all customers pay their fair share for operating and maintaining the grid.

A sensible payment structure for net metering customers will recognize that solar rooftop owners should not be compensated for anything more than the generation they provide.

- Protecting customers who choose not to install solar at their homes from bearing additional costs because of cost shifting from solar customers.
- Creating a net metering framework that allows for relatively accurate forecasting, both for solar customers who depend on net metering payments and for the utilities who must pay them.

Given these responsibilities, simply adhering to the status quo in most states and service territories does not seem like a prudent option for the vast majority of customers. With more homeowners choosing to install solar nationwide, acting quickly and appropriately to get net metering right should be a priority for policymakers. But what are their options?

Option 1: Preserve True Net Metering

As we have seen, California regulators have determined that their state's utilities will pay the retail rate for net metering until at least the end of 2019. Nevada, despite efforts by regulators to lower net metering payments in pursuit of a more equitable model, will also maintain the retail rate for the time being. Louisiana's regulators undertook a similar effort to lower net metering payments and arrived at a conclusion similar to Nevada's. But what does the decision to preserve the status quo of retail net metering mean for electricity customers and for the grid that serves them?

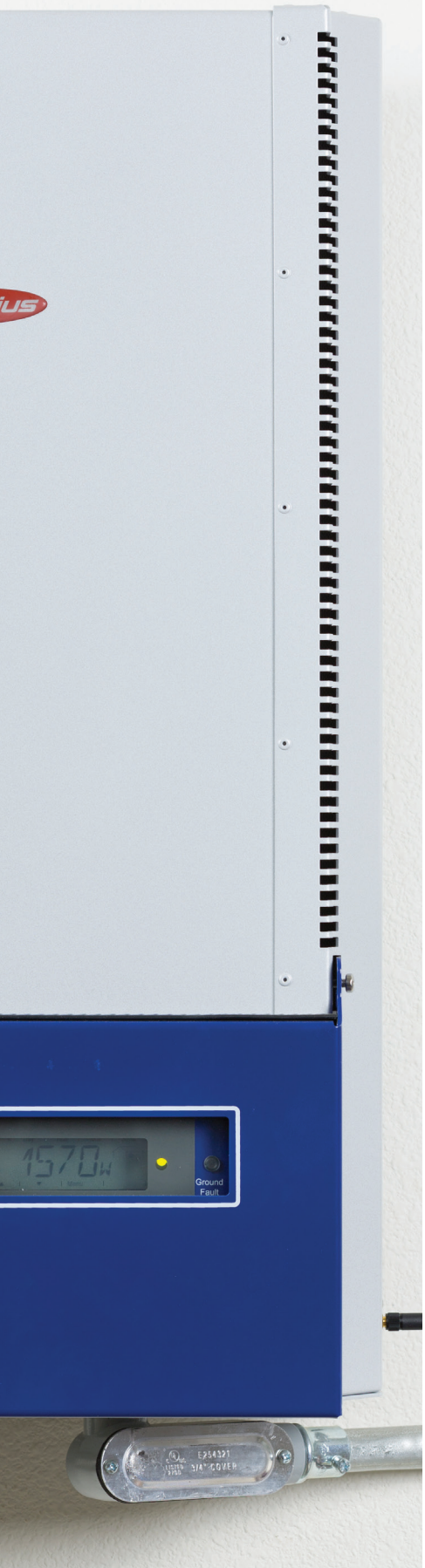
In California, the outlook is shocking. Estimates as far back as 2012 calculated that the total cost shift in the state from maintaining true net metering was $1.3 billion. San Diego Gas & Electric alone predicted costs shifting of around $20 million annually to non-solar customers to make up for collection shortfalls for fixed costs, eventually rising to $200 million per year. A more recent estimate from San Diego Gas & Electric calculates that the utility's customers by 2025 will pay an extra $300 each on their utility bills to accommodate paying the retail rate for net metering.[13]

The state's largest utility, Pacific Gas & Electric, eventually will up-charge its non-solar customers about $700 million annually (Baker 2013). Those are staggering figures that should alarm all ratepayers in the California system. California regulators themselves admit that the state's net metering payments are too generous, but were faced with 130,000 petitions from solar customers to maintain the existing model. In the end, the political pressure was too great to preserve a net metering scheme that subsidizes California's solar industry and the political will was too lacking to make a real change.

A similar set of circumstances occurred in Nevada. Despite clear evidence that paying the retail rate for net metering was causing significant cost shifting to other customers and distorting the energy market, Nevada regulators could not ultimately pass a lasting fix to the state's net metering rules. For the foreseeable future, Nevada will stick with true net metering.

A December 28, 2015, editorial from the Wall Street Journal harshly criticizes Nevada's decision to pay solar rooftop owners the retail rate for their generation.

> *"Sounds like a great deal - but there's no free green lunch, and non-solar utility customers must underwrite this hidden subsidy. Nevada's utility commission estimate that non-solar ratepayers - who tend to be lower income - subsidize each solar user in southern Nevada to the tune of $623 per year. Most of this flows to solar-leasing company investors such as J.P. Morgan Chase, Goldman Sachs, and Citigroup."*



Because of the inability of Nevada regulators to find a fix for net metering, millions of dollars per year will continue to be shifted from owners of rooftop solar in Nevada to non-solar customers. Louisiana, too, will press forward with net metering at the retail rate, despite a study commissioned by regulators that shows a total long-term price tag for customers of more than $800 million to preserve the true net metering model.

Speaking of the desire to hold on to a model that makes little sense for anyone except itself and its customers, the Wall Street Journal wrote in December of 2015, "Solar energy is no longer in its infancy, but the industry is refusing to grow up."

Option 2: A Smarter Way Forward

Not all regulators, though, have been unsuccessful in remediating flawed net metering practices. Experiences in Arizona and Mississippi represent cases of regulators recognizing distortions in the state's net metering structure and taking deliberate action to find solutions that work for the long term.

Part of the process in both Arizona and Mississippi was a recognition that the retail cost of electricity includes not just the generation of power, but also its transmission and distribution. These fixed costs are significant, for many utilities representing more than half of the cost of providing power to customers. A sensible payment structure for net metering customers will recognize that solar rooftop owners should not be compensated for anything more than the generation they provide.

A 2015 recent study from MIT explains -

> *"In an efficient and equitable distribution system, each customer would pay a share of distribution network costs that reflected his or her responsibility for causing those costs. Instead, 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 the electricity they generate, the result is a subsidy to residential and other distributed solar generators that is paid by other customers on the network. This cost shifting has already produced political conflicts in some cities and states - conflicts that can be expected to intensify as residential solar penetration increases."*

Arizona regulators in December of 2016, for example, recognized the importance of more closely tying net metering payments to the true value of electricity provided by solar rooftops.

Preserving the status quo of overly generous payments to solar rooftop owners only serves to deepen the shifting of grid costs to the overall customer base and extend a net metering model with fundamental flaws. On the other hand, recalibrating net metering policies to more accurately reflect the value of solar generation is in the interest of the vast majority of customers.

After a three-year investigation, regulators determined that moving away from paying the retail rate for net metering was essential to creating a clearer path forward for solar in that state (Randazzo 2016).

Among the findings in Arizona were that the state should -

- Move away from utilities paying the retail rate for net metering and toward a model reflects the actual value of rooftop solar.
- Use avoided cost methodology to determine the value of rooftop solar.
- Avoid using inappropriate and highly speculative factors such as societal or economic development benefits from solar, i.e. staples of the 'value of solar' argument, when attempting to quantify the value of rooftop solar.

These findings are critical to the pursuit of a net metering structure that both aligns with the market and protects the overall customer base from cost shifting. Using these principles, Arizona regulators implemented a substantial change for new solar rooftop owners that will decrease net metering payments from as much as 14 cents per kilowatt-hour to as little as 4 cents per kilowatt-hour.

Although existing net metering customers will have their existing payment arrangements kept in place for 20 years, regulators have at least set Arizona on a path toward a more sensible net metering regime. In the end, this model will help ensure that solar net metering customers eventually do not avoid as much as $1,000 per rooftop per year in grid maintenance and upkeep costs, avoided investments that today are being shifted to other customers in Arizona.

Like their counterparts in Arizona, Mississippi regulators also found a way forward that protected both solar rooftop owners and utility customers at large. In December of 2015, after a lengthy review of evidence, the Mississippi Public Service Commission instituted a new net metering program based on a model of avoided cost plus. This model will compensate solar rooftop owners at a rate of around 5 cents to 6 cents per kilowatt-hour for their generation. Solar rooftop owners qualified as low-income will receive an additional 2 cent premium for their generation.

Conclusion

The evidence speaks clearly. Most states with net metering policies, especially those that use the retail rate for net metering, need to soon consider significantly revising those policies. Those states need to make real changes in favor of fairness and market alignment, replacing ill-fitting net metering models with more mature and equitable ones.

Preserving the status quo of overly generous payments to solar rooftop owners only serves to deepen the shifting of grid costs to the overall customer base and extend a net metering model with fundamental flaws. On the other hand, recalibrating net metering policies to more accurately reflect the value of solar generation is in the interest of the vast majority of customers.

This report recommends that regulators and policymakers in states with net metering policies pursue the following course:

- Abandon any structure that pays the retail rate for net metering in favor of a model that uses avoided cost as its basis. Examples of states currently employing such models are Arizona, which uses a true avoided cost model, and Mississippi, which uses a model of 'avoided cost plus'.
- Adjust fixed charges for customers in a way that sufficiently accounts for the cost of maintaining the electric grid. Arizona, for example, assesses a 70 cents per kilowatt standing charge for newly installed solar rooftop systems. Another approach is to adjust the fixed cost of service for solar customers, or all customers, to more accurately reflect the true cost of providing grid services.

- Implement reasonable, but flexible, limits on net metering generation to provide greater visibility for policymakers and utilities. Mississippi's cap of 3% of retail peak is an example of a state monitoring and controlling enrollment in net metering programs. Accurately predicting the future is crucial to treating all customers fairly and providing a realistic platform for the growth of rooftop solar.

REFERENCES

Acadia Center (2015, April). "Value of Distributed Generation: Solar PV in Massachusetts". Retrieved from http://acadiacenter.org/document/value-of-solar-massachusetts/

Bade, Gavin (2014, October 7). "Study: Mississippi would benefit from net metering". Utility DIVE. http://www.utilitydive.com/news/study-mississippi-would-benefit-from-net-metering/316973/

Baker, David R., (2013, March 29). "Solar customers' 'net metering' challenged". San Francisco Chronicle. http://www.sfchronicle.com/business/article/Solar-customers-net-metering-challenged -4396058.php

Brown, Ashley & Bunyan, Jillian (2014). "Valuation of Distributed Solar: A Qualitative View". The Electricity Journal, Vol. 27(10).

California Public Utilities Commission (2016). Decision 16-01-044 January 28, 2016. ALJ/AES/jt2/ar9. Retrieved http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M158/K181/158181678.pdf

Fehrenbacher, Katie (2016). "The Other Side of the Solar Firestorm in Nevada". Fortune. Retrieved from http://fortune.com/2016/04/12/solar-firestorm-nevada/

Institute for Energy Research | Arduin, Laffer & Moore Econometrics, (2016, October). "The High Cost of Rooftop Solar Subsidies". IER. Retrieved from http://instituteforenergyresearch.org/wp-content /uploads/2016/10/The-High-Cost-of-Rooftop-Solar-Subsidies-Oct-16.pdf

McLaren, Joyce & Cory, Karlynn, et. al. (2015). "Value of Solar: Program Design and Implementation Considerations". National Renewable Energy Laboratory. NREL/TP-6A20-62361. Available at www.nrel.gov/publications.

Mississippi Public Service Commission (2015). Order Adopting Net Metering Rule, Docket No. 2011-AD-2. Retrieved here http://www.psc.state.ms.us/InsiteConnect/InSiteView.aspx?model=INSITE_CONNECT&queue=CTS_ARCHIVEQ&docid=362179

MIT Interdisciplinary Study, (2015). "The Future of Solar Energy. Massachusetts Institute of Technology". ISBN (978-0-928008-9-8). Retrieved from http://energy.mit.edu/research / future-solar-energy/

National Association of Regulatory Utility Commissioners, (2016). "NARUC Manual on Distributed Energy Resources Rate Design and Compensation". 1101 Vermont Avenue NW, Suite 200, Washington, D.C. 20005, U.S.A. Retrieved from http://pubs.naruc.org/pub/88954963-0F01-F4D9-FB A3-AC9346B18FB2

Public Recommendation to the Arizona Corporation Commission, (2016, October). Docket No. E-00000J-14-0023, Administrative Law Judge Teena Jibilian. Phoenix, AZ. Retrieved here http://images.edocket.azcc.gov/docketpdf/0000173840.pdf

Public Utility Regulatory Policies Act of 1978. Public Law 95-617: 92 STAT. 3117, 95th Congress of the United States. November 9, 1978.

Pub. Util. Reg. Policies Act of 1978, Pub. L. No. 95-617, § 111(d), 92 Stat. 3117, 3142-43 (codified as amended at 16 U.S.C. § 2621(d)(10)(E)(11) (2006)).

Randazzo, Ryan (2016, December 20). "Arizona regulators vote to stop net metering for solar". The Arizona Republic | USA Today Network. http://www.azcentral.com/story/money/business/energy /2016/12/20/arizona-regulators-vote-stop-net-metering-solar/95653350/

Randazzo, Ryan (2017, January 23). "Solar group asks Arizona utility regulators to reconsider net-metering decision". The Arizona Republic | USA Today Network. http://www.azcentral.com/ story/money/business/energy/2017/01/23/tasc-solar-group-asks-arizona-utility-regulators-reconsider-net-metering-decision/96959382/

Raskin, David B., (2013). "The Regulatory Challenge of Distributed Generation. Cambridge, MA: Harvard Business Law Review Online". Retrieved from http://www.hblr.org/wp-content/uploads/2013/12/Raskin_The-Regulatory-Challenge-Of-Distributed-Generation.pdf

Rothberg, Daniel (2017, January 9). "Regulators take 'a first step' toward restoring rooftop-solar rates". Las Vegas Sun. https://lasvegassun.com/news/2017/jan/09/regulators-take-a-first-step -toward-restoring-roof/

Shallenberger, Krysti (2016, January 22). "California utilities propose alternative to regulators' net metering policy". Utility DIVE. http://www.utilitydive.com/news/california-utilities-propose-alternative -to-regulators-net-metering-policy/412516/

Shallenberger, Krysti & Bade, Gavin (2016, September 16). "Updated: Nevada regulators approve NV Energy, SolarCity grandfathering proposal". Utility DIVE. http://www.utilitydive.com/news/updated -nevada-regulators-approve-nv-energy-solarcity-grandfathering-prop/426480/

Trabish, Herman K., (2016, August 4). "NARUC rate design manual reignites debate over cost shift, value of solar". Utility DIVE. http://www.utilitydive.com/news/naruc-rate-design-manual-reignites-debate -over-cost-shift-value-of-solar/423586/

Trabish, Herman K., (2016, October 24). "Why Arizona's long-awaited value of solar schemes please no one". Utility DIVE. http://www.utilitydive.com/news/why-arizonas-long-awaited-value-of-solar- schemes-please-no-one/428677/

Trabish, Herman K., (2016, January 21). "Solar Customers file lawsuit against NV energy over new net metering rates". Utility DIVE. http://www.utilitydive.com/news/solar-customers-file-lawsuit- against-nv-energy-over-new-net-metering-rates/412360/

The Wall Street Journal Editorial Board, (2015, December 29). "Nevada's Solar Flare: State regulators roll back the net-metering electricity scam". The Wall Street Journal: print edition. Retrieved digitally from https://www.wsj.com/articles/nevadas-solar-flare-1451346423

U.S. Department of Energy (2006). "Million Solar Roofs". Retrieved http://www.nrelgov/docs/fy04osti/ 34009.pdf

U.S. Energy Information Administration, (2017). https://www.eia.gov/

Walton, Robert (2016, December 2). "Louisiana regulators lift net metering caps, preserve retail rates until final review". Utility DIVE. http://www.utilitydive.com/news/louisiana-regulators-lift-net-metering -caps-preserve-retail-rates-until-fi/431547/

END NOTES

[1]For further discussion on the regulatory dynamics referenced in this section, see Raskin 2013.

[2]Source *Solar Energy Industries* Association state data, California Solar

[3]Source *Solar Energy Industries* Association state data, Hawaii Solar

[4]See MIT study *The Future of Solar Energy*

[5]Looking at the average between 2016 and February 2017 for the U.S. is approximately 12.5 cents. See *https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a*

[6]LCOE is a commonly used measure for comparing different sources power—it represents the net present value of the unit cost of electricity over the entire life of a generating asset.

[7]See *CPUC Decision 16-01-044 January 28, 2016.*

[8]Source *SEIA Top States, see http://www.seia.org/research-resources/top-10-solar-states*

[9]See October, 2016 Public Recommendation to the ACC by Judge Jibilian.

[10]See http://www.leg.state.nv.us/Session/79th2017/Reports/history.cfm?ID=894

[11]See MS PSC Net Metering Rule 2015

[12]See Mississippi Power's FAQ page on net metering, *http://www.mississippipower.com/my-home/solar-for-your-home/solar-faqs*

[13]SDG&E Media Statement on Net Energy Metering Decision, see https://www.sdge.com/newsroom/2016-01-28/sdge-media-statement-net-energy-metering-decision

pace energyfairness.org