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► **To cite this version:**

Chelsea Schelly, Edward P Louie, Joshua Pearce. Examining interconnection and net metering policy for distributed generation in the United States. *Renewable Energy Focus*, 2017, 22-23, pp.10-19. 10.1016/j.ref.2017.09.002 . hal-02111393

HAL Id: hal-02111393

<https://hal.science/hal-02111393>

Submitted on 26 Apr 2019

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Examining Interconnection and Net Metering Policy for Distributed Generation in the United States

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ABSTRACT: Following requirements of the Energy Policy Act of 2005, most U.S. states require utility companies to adopt interconnection and net metering policies, allowing customers to become prosumers who both consume and produce electricity, generating electricity using distributed renewable energy technologies, connecting to the existing electric utility grid, and receiving compensation for excess electricity generation. This paper reviews existing interconnection and net metering policies instituted by investor owned utilities (IOUs) across the U.S., specifically focused on policies regulating small scale, residential or Tier 1 (a term used to indicate policies applicable to smaller scale rather than larger scale, although the size at which DG systems are classified as either Tier 1 or higher tiers varies by utility) installations. Publicly available data from each IOU reveal inconsistencies in interconnection and net metering policies, within states and even within individual companies. In addition, accurate information is often unavailable to consumers. Perhaps most importantly, results suggest that compensation for excess distributed generation is often obscured in utility policy. The results of this study provide important insight into interconnection and net metering policies for distributed renewable energy generation, as states and utilities continue to modify interconnection and net metering policies in response to increased adoption of distributed renewable energy systems.

Keywords: net metering policy; renewable portfolio standard; distributed energy generation

List of acronyms:

DG	Distributed generation
IOU	Investor owned utility
LCOE	Levelized cost of electricity
PV	Photovoltaic
RE	Renewable energy
RPS	Renewable Portfolio Standard

1. Introduction

For more than half a century, scholars have recognized solar energy technologies as a viable source of sustainable electricity generation (Heywood, 1956). There is currently widespread popular support for renewable energy technologies (Gallop, 2015; Greenberg, 2009). In comparison to the existing reliance on fossil fuel resources as an energy source, renewable energy (RE) technologies offer a diverse suite of benefits, including climate mitigation and health benefits via reduced emissions (Buonocore et al., 2016; Wiser et al., 2016) as well as economic benefits (NREL, 1997) and achievement of sustainable development (Dincer, 2000).

The cost of RE technologies continues to decline (Barbose et al., 2014). The levelized cost of electricity (LCOE) from photovoltaic (PV) technology has dropped below the retail rate of electricity throughout much of the U.S. (Branker, Pathak, and Pearce, 2011). Further, new methods of financing PV are increasingly becoming more widespread in availability (Alafita and Pearce, 2014; Branker, Shackles and Pearce, 2011; Coughlin and Cory, 2009; Drury et al., 2012; Hede, Nunes and Ferreira, 2014; Overholm, 2015).

One of the benefits of renewable energy technologies is the possibility for distributed generation (DG, abbreviated here as DG for brevity, but with specific reference to DG from renewable energy sources), where electricity is produced in a decentralized fashion, distributed across diverse sites near the point of consumption. DG can help address the negative environmental externalities associated with conventional fossil fuel-based electricity generation and provide economic benefits (Pearce, 2002; Stern, 2006). Further, accounting for the full cost of energy production through the LCOE, DG is cost competitive when compared to centrally generated electricity (Barbose et al., 2014; Branker, Pathak, and Pearce, 2011).

DG is also arguably a major benefit to existing electric utilities. While calculating the full costs and benefits of distributed renewable energy generation for customers, utilities, and the environment is incredibly complex and highly debated, several studies suggest that DG provides a net benefit to utility companies (Hallock and Sargent, 2015; Hansen, Lacy, and Glick, 2013; Keyes and Rábago, 2013). By relying on electricity produced by grid tied prosumers, utilities are less singularly reliant on their own centralized electricity generation to meet customer demand. Thus, both DG prosumers and utility companies can benefit from net metered interconnections. While there are clear environmental benefits to DG (Qian, et al., 2008) and specifically to transitioning to renewable forms of electricity generation as a means of mitigating carbon emissions (Tsikalakis & Hatzigiorgiou, 2007), there are also potential co-benefits for the security and resiliency of the electrical grid system (Prehoda et al., 2017).

Using DG, existing utility customers can become “prosumers” - both consuming and producing electricity by connecting installed DG connected to the utility grid and feeding excess electricity generation into it. In order to do so, electric utility companies must enable and regulate the process of electrical interconnection between DG and the existing electrical grid. Interconnection and the associated rights and responsibilities of utility companies and prosumers are typically managed through net metering agreements.

In the United States, there are a complex set of policies at multiple scales that shape the economic and practical feasibility of renewable energy technology development, DG, and net metering. The Residential Renewable Energy Tax Credit is a federal tax credit available to help offset the cost of renewable energy system installation. The federal Energy Policy Act of 2005 included a requirement for states to work with electric utilities to establish net metering policies. Yet the United States continues to lack clear and comprehensive federal energy policy for promoting renewable energy technology development, continuing to rely primarily on electricity generated from centralized sources such as fossil fuels and nuclear to meet energy demand (EIA, 2015; Lutzenhiser, 2001) as well as relying on state level policy (Bush et al., 2014) as well as local policy (Li and Yi, 2014) to regulate and promote renewable energy technology development.

Many states offer up-front rebate and incentive programs. For example, 38 states have property tax exemptions and 29 states have sales tax exemptions for solar energy technology. However, these policies vary widely by state and have changed, evolved, and dissipated over time. One state level energy policy mechanism is the renewable portfolio standard (RPS), which stipulates that utility companies generate a mandated percentage of their electricity portfolio from RE sources (Berry and Jaccard, 2001; Hass et al., 2004; Kydes, 2007; Rabe, 2006). More than half of U.S. states now have established RPS policies. Of these, 22 state RPS policies include specific provisions for DG technology, meaning that states either require a specific portion of the RE come from DG or will count DG toward the RPS requirement. These “set asides” for DG have a measurable impact on adoption (Steward and Doris 2014).

An RPS with these provisions can help promote DG by allowing utilities to include customer-generated RE from small scale solar photovoltaic (PV), microhydro or wind energy technologies as part of their portfolio. One specific aspect of policy guiding DG-utility grid interconnection is net metering, which provides a means of accounting for and compensating DG generation. Utilizing interconnection and net metering, customers can produce electricity and offset part or all of their own electricity demand while staying connected to the utility grid and relying on grid power when necessary. Net metering certainly can take place without a state level RPS established, but RPS is one policy that can promote the need for effective net metering so that DG installing prosumers produce electricity that counts toward utility compliance with RPS goals.

Net metering is a simple accounting system for compensating prosumers for electricity contributed to the grid. Net metering is a system by which prosumers are credited for electricity they produce in excess of what they use; this is what distinguishes net metering from a feed-in tariff system, where DG adopters are given credit for all electricity generation. Net metering can provide prosumers with long-term savings in overall utility expenditures while also contributing to reduced fossil fuel reliance and carbon emissions from a utility’s total energy portfolio (Dargouth, Barbose, and Wiser, 2011; 2014). Although there is no federal RPS in the United States, federal regulation does require states to establish a net metering policy. However, there are currently seven U.S. states with no specific net metering policy, and utility compensation for electricity generated by customers varies widely (Yamamoto, 2012; Poullikkas, 2013).

Net metering is one means of shifting the utility business model to support sustainable energy sources, arguably a necessary step for a sustainable energy future (Chu and Majumdar, 2012; Mai et al., 2014a; 2014b). Some argue that the value of DG outweighs the costs of net metering even without considering environmental externalities and other indirect benefits of renewable energy generation technologies (Carbajales-Dale et al., 2014; Czarnowska and Frangopoulos, 2012; Epstein et al., 2011; Haines et al., 2010; Kenny, Law, and Pearce, 2010). Yet net metering is currently governed by a host of complexities and complications. These include how much credit is given by utilities for excess generation from prosumers (either retail rates – what the prosumer pays the utility for electricity – or some lesser rate), how the

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prosumer is reimbursed for excess generation (through credits or payment), and how and how often net metered accounts are settled (some options include annual settling of accounts, annual expiration of excess credits, or indefinite rollover of credits).

Further, net metered DG changes the profitability and ratepayer revenue generation of electric utilities, which have been structured based on centralized generation and guaranteed rates of return. Recent work has examined how variation in local regulatory and permitting processes changes the installed price of DG PV (Burkhardt et al. 2015). However, this work is most often conducted at the state level of analysis. For example, one state level analysis found that utilities are the bottleneck for permitting and approval of DG systems, with utility review and approval of applications for DG taking longer than any other step in the installation process (Ardani et al., 2015).

Some electric utilities are currently seeking to shift electricity charges from consumption rates (\$/kWh) rates to fixed charges (\$/bill) (Biello, 2014; Cardwell, 2015; Farrell, 2014; Munson, 2015; Stanton, 2015). Previous work demonstrates that such rate structures financially punished both distributed generators and energy-efficient consumers (Pearce and Harris, 2007; Sterzinger, 1981). Utilities in some U.S. states are attempting to institute additional impediments for DG adopters, such as standby rates (demand charges added to the price per unit energy when prosumers are using power from the grid, which penalize DG customers) and fixed charges, adding an additional amount per bill for DG prosumers regardless of energy generated or used (Goldenberg and Pilkington, 2013; Jaffee, 2013; Rule, 2015).

Some consumer protection and policy study experts claim that net metering policies are changing as utility companies seek to avoid paying prosumers fair compensation for the energy they produce (Biello, 2014; Cardwell, 2015; Farrell, 2014; Munson, 2015). Some say the proposed net metering policy changes ignore the economic benefits that DG provides for utilities (Carbajales-Dale et al., 2014; Kenny, Law, and Pearce, 2010; Pearce and Harris, 2007; Price et al., 2014). Others argue that DG increases costs for utilities (Beach and McGuire, 2015; Cai et al., 2013; Eid et al., 2014; Martin and Chediak, 2015).

Instead of entering that debate, this study examines net metering policies for each IOU, as they currently exist across the U.S. and as they apply to residential, small-scale, Tier 1 interconnected DG systems, to examine how prosumers are compensated for DG generation through existing net metering policy. The current study is unique in that it examines each IOU and its operation in each state independently, which is important in order to consider the extent to which actual utility policy implementation varies even within each state. Furthermore, this study involved analysis of the detailed content of net metering reimbursement schemes for each utility and across each state among IOUs in the United States. There are studies in industry and government literature (Sigrin et al., 2016) and several publicly available sources of information about interconnection and net metering policies by state (such as DSIRE, dsireusa.org, and the “Freeing the Grid” project, freeingthegrid.org). All states are required to specify their policies for DG interconnection, but policy implementation for regulating grid interconnection and net metering accounting varies widely by utility. Thus, examining interconnection and net metering policies for each IOU allows for a comprehensive examination of energy policy across the entire U.S. Further, previous research suggests that while financial incentives may not be the primary or exclusive motivator for DG adopters, adopters are aware of utility net metering policies and that behaviors do change in response to the incentives or disincentives that are structured by the specific net metering policy (Schelly, 2014a; 2014b). This qualitative work with DG adopters indicates that variation in net metering compensation may matter to potential adopters, who talk to their friends and neighbors and recognize variations in net metering compensation as either a motivation or a barrier for their own DG adoption.

This study involved review of publicly available information on interconnection and net metering policies for residential, small-scale, Tier 1 systems provided by utilities to examine technical requirements and compensation schemes. Given the messy and multi-scalar nature of energy policy in the United States, this paper examines the world of policy implementation, specifically the requirement at the federal level for states to implement a net metering policy, the various ways states are aiming to promote RE technology, and the way these issues get operationalized in net metering policy across utilities and across states.

These results suggest that net metering policies tend not to offer retail reimbursement rates for DG consumers, challenging the conception of net metering as a 1:1 reimbursement scheme. True retail reimbursement is rare; even among utilities that advertise their policies as providing retail reimbursement, stipulations about credits expiring or differences in reimbursement for payback versus credit mean that most utilities do not provide compensation as advertised by state level analyses. These results and conclusions can assist policy makers in understanding implementation of interconnection and net metering policies across large U.S. utilities.

2. Methods and Data Analysis

This project involved collecting data on 166 IOUs operating in the U.S., representing 86% of the

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total 192 IOUs that serve 68% of the total electric utility customers in the nation. Utility companies not included in this analysis (14% of the IOUs operating in the U.S.) did not have adequate net metering policy data publicly available. Publicly owned utility companies and rural electric cooperatives were not included in the analysis; there are over 2,000 publicly owned utility companies operating in the U.S., but they serve only 14% of all electric utility customers, while rural electric cooperatives serve only 12% of all electric utility customers (APPA, 2016). Furthermore, net metering policies that result from attempts to promote DG for the purposes of meeting RPS standards are most likely to be implemented by IOUs, as RPS requirements are often placed on IOUs but are often not required of or are less stringent for public, municipal and rural utilities.

Individual utility company websites and websites for each state’s public utilities regulatory commission (sometimes referred to as the Public Utilities Commission or PUC) were used as data sources. Where data were not available publicly online, phone calls were placed to the relevant employee at each utility to gather the necessary data. Net metering policy at the utility level was analyzed based on the following factors, focusing on Tier 1 policies applicable for residential scale DG prosumers: 1) size capacity limits; 2) application, inspection, and interconnection fees; 3) fixed monthly fees; 4) liability insurance requirements; and 5) rate design for compensating excess generation. Additional information was also collected, including an assessment of the quality and clarity of website presentation and the complexity of the net metering application, and this information was assessed qualitatively. The specific capacity limitation was recorded numerically, as were the exact application, inspection, interconnection, and monthly fees. Insurance was recorded as a categorical variable, as either not available if no information was found, no if not required, and yes if required, with a specific amount recorded whenever provided. The rate design for compensation was collected using the specific language of the utility (e.g., retail, wholesale, avoided cost, or time of use wholesale/retail), which was then assigned a secondary dichotomous code as retail or less than retail, although the specific language of each compensation scheme was also collected, coded, and analyzed, as reviewed below.

The interconnection and net metering policies for each IOU were analyzed for each state. Thus, for IOUs operating in more than one state, data was analyzed more than once; however, as the analysis demonstrates, this method provides additional clarity, given that the same IOU may (and some do) have different policies for different states. Thus, the analysis focuses on variation in policy at the utility rather than state level, but is still able to capture policy differences across states. In this way, it provides a glimpse into policy implementation across states and utilities, demonstrating how policies are being operationalized differently in varying contexts.

3. Results

Although the USEPA requires that states consider and establish standards for interconnection and net metering policies for each utility operating in each state, there are currently seven states without statewide net metering policies (Tennessee, Mississippi, Alabama, South Dakota, Texas, Idaho, and South Carolina). In addition, the results show that states that have instituted statewide policies do not necessarily have consistency across utilities operating within the state. Policy inconsistency across utilities operating within a state is not explained by a lack of statewide net metering policy, since even states with statewide net metering policy have inconsistent policies across utilities operating in the state. This analysis also found a major lack of publicly available data regarding utility net metering policy. Almost 20% (30/165) of the utilities analyzed have no publicly available data on system capacity limits. As can be seen in Table 1, many do not have data available regarding insurance requirements. Table 1 summarizes the analysis and includes determination if policy is state wide, the number of utilities included, the capacity limits, monthly fees, compensation and required insurance. The discussion of this analysis is organized below in terms of capacity limits, interconnection and fixed monthly fees, and compensation for excess generation.

Capacity Limits

There is clear inconsistency regarding capacity limits for Tier 1 policies (those applied to small scale or residential DG systems), even among utilities operating within the same state. As can be seen in Table 1, ten states with statewide policies for grid interconnections and net metering in place have inconsistency in capacity limits (Illinois, Kansas, New Hampshire, New Jersey, New Mexico, North Carolina, Ohio, Oklahoma, Oregon, Wisconsin), meaning that at least two utility companies operating in the state have different recorded limits on the system capacity of the DG system that can be net metered under their Tier 1 interconnection and compensation scheme. In 19 out of the 40 states with multiple utilities analyzed (almost 50%), there are inconsistent policies regarding capacity limits. These range from a limit to a 10-kiloWatt system to no limit at all.

Interconnection and Fixed Monthly Fees

There is also clear inconsistency in the application of interconnection fees, even among utilities operating in the same state. For example, the four IOUs operating in the state of Minnesota included in this analysis all have different monthly interconnection fees. Regarding monthly fees for solar customers, all four utilities analyzed in Minnesota charge different amounts; two out of three utilities analyzed in North Carolina charge customers (but only those who have PV capacity greater than 100 kW, which is unlikely to include any truly residential prosumers); one of the three utilities analyzed in North Dakota charges solar customers a monthly fee, as do one of the two utilities analyzed in both South Carolina and Virginia. Utilities in eight states charge customers for the installation of an additional meter (which is technically unnecessary for net metering because contemporary electric meters are bi-directional and can account for both electricity coming in for consumptive use and going out to the grid from DG), but even this is inconsistent both across utilities and across states. For example, if a Kansas City Power and Light customer installed a net metered solar electric system in Kansas, the utility will pay for the installation of the additional meter. Yet if a customer of the same utility living in Missouri installed the same system, the additional meter is installed at the customer's expense. Only 28 of the 166 utilities analyzed (17%) operating in 6 states explicitly state that they require that the customer pay for the installation of a bi-directional meter capable of handling net meter energy accounting if one is not already installed.

Based on publicly available information regarding net metering policies, there are only 16 utilities operating in six U.S. states in which utilities place additional monthly charge requirements on net metering customers (although in two of these six states, not every utility analyzed charges an additional monthly fee, again demonstrating the policy inconsistency). Standby rates and fixed charges, means of charging net metered DG prosumers additional monthly fees (which utilities often argue is necessary to cover the additional costs associated with net metering), are not currently a widespread practice. However, net metering customers in all states continue paying monthly customer service, accounting and billing, and other standard utility charges. Customers cannot avoid these monthly fees, even when they are producing all the electricity they consume and in general are providing benefit to the utilities by contributing electricity at peak cost times (e.g. midday in summer to meet AC loads) while using grid electricity in off peak times (e.g. night).

Compensation Schemes

Utilities operating in the same state do not necessarily offer the same compensation scheme for Tier 1 net metering DG, demonstrating that compensation schemes are also not being applied consistently at the state level. South Carolina and Wisconsin, for example, both have different recorded net metering compensation schemes for excess generation by net metering customers. Table 2 presents a more detailed analysis of compensation and rollover schemes for excess generation.

When a utility offers retail rates for compensation, the prosumer is given a rate worth the value equivalent of what they pay for electricity for all electricity produced in excess of what is consumed. When a utility offers wholesale rates for compensation, the prosumer is given a rate worth the wholesale price of electricity, or the price the utility company pays when it purchases electricity on the wholesale market, obviously less than retail. Prosumer compensation schemes can also be defined as worth the value of the avoided cost of electricity (defined based on cost saved to utility by not generating the power themselves, which is less than wholesale) or can be defined in terms of variable time of use rates (where rates change based on the relationship between use and demand at specified times), which time of use being calculated based on either wholesale or retail rates.

The process by which the value attributed to the electricity generated in excess of use is actually returned to prosumers further complicates compensation schemes. Utility company schemes typically involve crediting of the value to the prosumers account and can include rollover of that value indefinitely, expiration of that credit annually and at a time set either by the utility or by the customer (whereby a PV prosumer will benefit most from expiration in sunny summer months while a utility company arguably benefits most from setting expiration based on a calendar year), or pay back (where prosumers are actually provided generation, a value determined by the terms of the compensation scheme).

The results shown in Table 2 indicate that most utility companies weaken the economic benefits of DG for prosumers, meaning that even compensation schemes that are advertised as offering fully 1:1 compensation (where customers pay retail rates, but are also compensated for excess DG at retail rates) often do not involve fully equal compensation in actual practice. This analysis demonstrates that utility companies distort their own compensation schemes through ambiguous and/or inaccurate characterizations of their own net metering policies. These compensation or payback arrangements dictate the credits customers receive for excess electricity generation and when, how, and if they are ever paid back for energy they provide to the grid. The results show that most of the utility companies (almost 95%) included in this analysis claim to offer retail reimbursement compensation schemes for net metering prosumers; yet among the 110 utility

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companies claiming to offer retail reimbursement rates for excess generation, only four actually pay prosumers back at retail compensation rates (see Figure 1).

The most common net metering compensation agreement involves crediting excess generation from DG at a retail rate, but the utility actually pays lesser avoided cost or wholesale rates once a year when net metering accounts are balanced out. The second most common agreement involves indefinite rollover, where the prosumer never receives payment from the utility company for any excess generation. More detrimental for prosumers, 25% of the utilities that characterize their net metering agreements as offering retail rate reimbursement also have policies determining that excess credits expire annually; thus, these prosumers lose any credits for excess electricity generation to the utility every year.

Figure 2 illustrates that of the 26 IOUs that characterize their net metering compensation schemes as providing less than retail payback, 50% of utilities never offer any direct payback to customers, with 23% stipulating that credits expire annually and 27% requiring indefinite rollover of credits. Figure 3 aggregates all IOUs, illustrating that 25% of IOUs stipulate that credits expire annually, while only 3% actually provide retail payback to prosumers.

Even Vermont's net metering policy, characterized as "retail-plus," stipulates that customer's are credited at a minimum of \$0.20/kWh if the DG system is smaller than 15kW and \$0.19/kWh if system is larger than 15kW; but *credits not used by the end of the annual period is reverted to the utility with no payment* (emphasis added). This means that all credits for generation by prosumers in excess of consumption expire annually, benefitting the utility with electricity generated without compensation to the generator.

4. Conclusion and Policy Implications

This analysis of 166 IOUs operating in the U.S suggests that imposed monthly fees or standby rates for DG prosumers are not yet widespread structural disincentives to the interconnection and net metering of DG systems; while these kinds of policies have been the highlight of much recent media attention and they are certainly being considered by utilities and legislatures (see Stanton, 2015), they are not reflective of current net metering policy among IOUs in the U.S. However, existing net metering policies do appear to benefit utility companies through inequitable compensation schemes for excess generation. While the costs of net metering born by utility companies continue to be hotly debated, the concept of net metering as a one-to-one exchange is clearly not reflected in existing net metering policy. Further, the lack of clear publicly available information obscures information transfer about currently existing policies.

The results of this study found widespread inconsistencies in net metering policies throughout the U.S., within states and even within individual companies. In addition, accurate information on net metering is often unavailable to consumers. Previous qualitative interviews with DG adopters indicates that potential adopters do share experiences with compensation schemes within communities of information and that compensation schemes that offer less than what friends and neighbors are getting in return for excess generation do operate as barriers to adoption (Schelly 2014a; Schelly 2014b); thus, this lack of consistency in net metering policies and lack of clear publicly available data may operate as barriers for potential adopters.. In particular, focusing on inconsistency among utilities operating within a single state highlights potential failures in policy implementation, and these kinds of inconsistencies are likely more meaningful for potential DG adopters than differences across state policy.

This analysis is not meant to offer conclusive evidence on the effectiveness of net metering in promoting DG. Rather, it is intended to examine policies as they currently exist to elucidate the financial realities for DG prosumers in terms of net metering policies and compensation for excess electricity generated by prosumers that is ultimately provided to other utility customers (who themselves pay retail rates for electricity). Making policies consistent across utilities (including regulatory and permitting processes, not considered directly here but clearly presented in Burkhardt et al. (2015)), placing information in the public domain and streamlining all required application forms for net metering (Ardani et al., 2015) are clear and easily implemented mechanisms for accelerating the adoption of DGs (Krasko and Doris, 2013; Steward and Doris, 2014).

The results of this analysis suggest a lack of clearly described compensation for excess generation from DG prosumers. While most states (30 out of 50) have utilities that claim to offer retail reimbursement for excess electricity generation, only 4 of the 166 utilities analyzed actually offer full retail compensation. One quarter of utilities that characterize their payment programs as providing retail reimbursement actually stipulate that credits given at the retail rate expire annually at an arbitrary date.

Utility policies that do not compensate net metered prosumers for excess electricity generation at a 1:1 rate and allow prosumers to zero out their annual electricity bill, trading the benefit they provide to the utility for excess electricity for the benefit they receive from the utility from the grid infrastructure, distort the market forces that currently suggest the financial viability of DG for meeting electricity needs. Furthermore, both the existing service charges and the proposed standby rates and increases to fixed rate charges undermine

Preprint :Chelsea Schelly, Edward P. Louie, Joshua M. Pearce. Examining interconnection and net metering policy for distributed generation in the United States. *Renewable Energy Focus* 22–23, (2017), pp. 10–19. <https://doi.org/10.1016/j.ref.2017.09.002> the economics of DG adoption, as it may be economically advantageous for adopters to produce their own electricity, but not when there are fixed monthly charges that cannot be paid for with excess generation provided to the utility. As states consider changing or abandoning net metering policies entirely, DG supported by the rapidly battery storage rather than grid interconnection may become an increasingly viable option (Kantamneni et al., 2016). As battery costs are decreasing rapidly leading to the potential for economic PV hybrid systems (Mundada, et al., 2016), policy that discourages grid-tied DG may result in mass grid defection and the so-called utility death spiral (Costello and Hemphill, 2014; Graffy and Kihm, 2014; Kantamneni et al., 2016).

Federal policy to establish clear compensation schemes for net metering could eliminate the utility practice of advertising that their compensation schemes are providing different payback than they actually do. Until this is implemented at the federal level, more nimble state officials have an opportunity to provide policies for clear and equitable guidelines. While states have focused efforts on RPS mandates, this analysis supports previous work suggesting that effective interconnection and net metering standards may be higher priority and more foundational policy tools for ensuring development of the DG PV market (Krasko and Doris, 2013; Steward and Doris, 2014). Furthermore, even local energy policies can be effective (Li and Yi 2014), and given that utilities already have variability in their net metering policy implementation across state lines, local efforts for fair and transparent net metering agreements may be effective. Finally, it is also important to note that there are other factors that shape DG adoption as well, including current electricity prices, the availability of solar radiation, and the values of individual homeowners (Sigrin et al., 2016; Schelly, 2010; Zahran et al., 2008); effective policy alone may not be enough to fully develop DG adoption potential.

It is admittedly complicated to calculate the true costs of any energy system, and furthermore to consider tradeoffs between DG and the need to maintain existing energy infrastructure. Future work is needed to determine the real value of DG technologies using a full cost accounting of environmental and security benefits as well as costs of grid system maintenance and oversight. However, even before this work is done, net metering policies should be clear, consistent, and offer potential prosumers compensation in that is, at the very least, transparent and clearly as advertised.

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TABLE 1: ANALYSIS SUMMARY¹

	Utilities Included	State-Wide ²	Capacity Limit (in kW) ³	Monthly Fee (in US dollars) ⁴	Compensation	Required Insurance (in US dollars)
AL	1	NO	100	0	Avoided cost (1)	No data
AK	0	-----	-----	-----	-----	-----
AZ	3	YES	None (3)	0.7/kWh (3)	Retail /avoided ⁵ (3)	No data (1) None required (2)
AR	3	YES	25/300 (3)	0	Retail (3)	No data (2) None required (1)
CA	5	YES	1000 (5)	0	Retail /avoided (3) Retail (2)	Standard Insurance (1) No data (5)
CO	2	YES	No data (1), 120% of consumption (1)	0	Retail (1) No data (1)	No data (2)
CT	2	YES	2000 (2)	0	Retail /avoided (2)	No data (2)
DE	1	YES	25/100/2000	0	Retail	None
FL	4	YES	2000 (4)	0	Retail /avoided (3) Retail (1)	No data (4)
GA	1	YES	10/100	2.82-11.20	Avoided cost (1)	No data (1)
HI	3	YES	100 (3)	0	Retail (3)	Needed (3)
ID	3	NO	100 (1) 25/100 (2)	0	Retail (3)	No data (2) 1,000,000 (1)
IL	3	YES	No data, 40, 2000	0 (2) No data (1)	Retail (2) No data (1)	Standard insurance (1) No data (2)
IN	5	YES	50 (1) 1000 (4)	0 (4) No data (1)	Retail (5)	100,000 (5)
IA	3	YES	No data (1) 500 (2)	0 (2) No data (1)	Retail (2) No data (1)	No data (1) Needed (2)

KS	4	YES	No data (1) 15/100 (2) 25/200 (1)	0 (3) No data (1)	Avoided cost (3) No data (1)	Standard Insurance (2) No data (2)
KY	4	YES	30 (4)	0 (4)	Retail (4)	Standard Insurance (4)
LA	4	YES	25/300 (4)	0 (4)	Retail (4)	No data (4)
ME	3	YES	660 (3)	0 (3)	Retail (3)	No data (3)
MD	4	YES	2000 (3) 3000 (1)	0 (4)	Retail (4)	No data (4)
MA	5	YES	60 (5)	0 (5)	Retail (5)	Needed; amount varies with system size (5)
MI	6	YES	20 (6)	0 (6)	Retail (6)	None (6)
MN	4	YES	40 (4)	.48 + “standby svc fee” (1) 1.75 (1) 3.70 (1) 3.15-6.40 (1)	.0889/kWh (1) No data (3)	300,000 for 40 kw or less (4)
MS	2	NO	No data (2)	No data (2)	No data (2)	No data (2)
MO	3	YES	No data (1) 100 (2)	0 (2) No data (1)	Avoided cost (2) No data (1)	No data (1) 100,000 for systems larger than 10kW (2)
MT	2	YES	50 (2)	0 (2)	Retail (2)	No data (2)
NE	1	YES	No data	No data	No data	No data
NV	1	YES	1000	0	Retail	No data
NH	3	YES	100 (1) 100/1000 (1) 1000 (1)	0 (3)	Retail (3)	None (3)
NJ	4	YES	None (1) 10 (1) 100 (1) 2000 (1)	0 (4)	Retail /avoided (4)	None (2) Standard Insurance (2)
NM	3	YES	10 (2) 1000 (1)	No data (3)	Avoided cost (3)	Varies with system size (3)
NY	7	YES	25/2000 (7)	0 (7)	Retail /avoided (7)	None (7)

NC	3	YES	1000 (1) 20/1000 (2)	Standby charge of 1.20 for > 100 kw (2) 0 (1)	Retail (3)	100,000 (3)
ND	3	YES	No data (2) 100 (1)	3.25-5.5 (1) 0 (2)	Avoided cost (1) No data (2)	No data (3)
OH	6	YES	None (5) 50 (1)	0 (4) No data (2)	Generation rate (6)	None (3) Standard Insurance (3)
OK	2	YES	25/100 (1) 100/300 (1)	0 (2)	Avoided cost (2) ⁶	None (1) Standard Insurance (1)
OR	3	YES	25/100 (1) 25/2000 (2)	0 (3)	Retail (1) Retail /Avoided (2)	None (2) 1,000,000 (1)
PA	9	YES	50/3000 (9)	0 (9)	Retail (1) Retail /Avoided (8)	Standard liability Insurance (9)
RI	1	YES	5000 (1)	0	Avoided cost (1)	Varies based on system size
SC	3	NO	20/100 (3)	4.5 (3)	Time of use retail (1) time of use avoided (1) Retail (1)	100,000 (3)
SD	6	NO	No data (6)	No data (6)	No data (6)	No data (6)
TN	1	NO	10	No data	Retail (1)	100,000
TX	9	NO	No data (9)	No data (9)	No data (9)	No data (9)
UT	1	YES	25/2000	0	Retail	Standard Insurance
VT	1	YES	500	0	Retail plus	100,000
VA	2	YES	25/500 (2)	Standby dist. and trans. charges⁷ (2)	Retail	100,000 (2)
WA	3	YES	100 (3)	0 (3)	Retail (3)	No data (3)
WV	4	YES	25/500/ 2000 (4)	0 (4)	Retail (4)	100,000 (4)
WI	6	YES	20 (5) 100 (1)	0 (6)	Avoided cost (2) Retail /avoided (2) Retail (2)	300,000 (6)

WY	3	YES	No data (1) 25 (2)	0 (2) No data (1)	Retail (2) No data (1)	No data (3)
DC	1	YES	100	0	Retail	None
	Range: 0-9 per state Total: 166		Range: 10kW-no limit			

¹ This table reports on TIER 1 Categorization of utility policies as these are the most likely to impact residential solar electric customers. Numbers in parentheses in each cell represent the number of utilities for which that policy data apply.

² NO = No state-wide requirement for net metering policy. All others have state- wide requirements for policy.

³ Reported in kilowatt (kW). Number in parenthesis is number of utilities in the state with that reported limit.

⁴ None reported unless noted.

⁵ Throughout, “retail/avoided” is used when customers are credited at retail rates but only reimbursed avoided cost rates if they opt for annual payback of credits.

⁶ OK utilities are not required to purchase excess generation. If customer requests and utility agrees to, it is at avoided cost

⁷ “Standby distribution and transmission charges” – amount not specified.

Table 2: Roll-over Policies

Policy	Number of Utilities	States (# of Utilities in that state)
Retail credit, but annual payback at avoided cost	35	Arizona (3) California (3) Connecticut (2) Florida (4) New Jersey (4) New York (7) Pennsylvania (8) Wisconsin (2) Wyoming (2)
Credit at retail rate, indefinite rollover	34	Iowa (2) Indiana (5) Kentucky (4) Louisiana (4) Michigan (6) Massachusetts (5) Nevada (1) Oregon (1) Tennessee (1) West Virginia (4) DC (1)
Retail credit, credits expire annually	18	Arkansas (1) Hawaii (3) Idaho (3) Illinois (2) Maine (3) Montana (2) Utah (1) Washington (3)
Credit at avoided cost, indefinite rollover	7	Alabama (1) Georgia (1) New Mexico (2) Rhode Island (1) Wisconsin (2)
Credited at unbundled generation rate; customer may request payment for excess at end of 12-month billing period	6	Ohio (6)
Avoided cost credit, credits expire annually	5	Kansas (3) Missouri (2)
Credited to customer's next bill at retail rate; reconciled annually in April at the commodity energy supply rate	4	Maryland (4)
Credited to customer's next bill at retail rate; granted to utility at beginning of summer billing season	4	North Carolina (3) South Carolina (1)
Credited kWh credit and carried forward indefinitely. Customer may elect to receive payment (at avoided-cost rate) for credit remaining at the end of an annual period	3	New Hampshire (3)
Credited at retail rate. After 12-month cycle, customer may opt to roll over credit indefinitely or to receive payment at avoided-cost rate	2	Virginia (2)
	2	Arkansas (2)

Retail credit, annual carry over up to 4 months		
Retail credit, and annual payback at retail cost	2	Delaware (1) Pennsylvania (1)
Credited at retail rate; unused credits accumulated through March are transferred to low-income assistance program at avoided cost rate	2	Oregon (2)
Credited at retail rate. After 12-month period, customer may opt to have net excess generation roll over indefinitely, or to have the utility pay for any excess at rate determined by the rate-making authority. If customer makes no decision, excess generation will be granted to utility with no compensation	1	California (1)
Credited at retail rate. After 12-month cycle, customers may opt to roll over credit indefinitely or to receive payment at average hourly incremental cost	1	Colorado (1)
Credited at retail rate. After 12-month cycle, customer may opt to roll over credit indefinitely or to receive payment for credit at a rate equal to the 12-month average spot market price	1	California (1)
Offset monthly kwh usage charges, no credit or compensation for excess generation	1	Oklahoma (1)
Purchased by utility at avoided cost or granted to utility monthly (varies depending on whether purchase agreement has been made)	1	Oklahoma (1)
Credited to customer's next bill at avoided-cost rate + REC price at \$0.035/kW	1	New Mexico (1)
Credited at avoided-cost; reconciled monthly	1	North Dakota (1)
Credited at specified time-of-use avoided cost rates	1	South Carolina (1)
Credited at TOU retail rate; granted to utility at beginning of summer billing season	1	South Carolina (1)
Retail credit to next bill if less than \$100, check if greater	1	Wisconsin (1)
Retail credit to next bill if less than \$25, check if greater	1	Wisconsin (1)
Credited to the customer's next bill at minimum of \$0.20 if system is < 15kW; \$0.19 if system is > 15kW; <i>credits not used by the end of the annual period is reverted to the utility with no payment</i>	1	Vermont (1)
No Data	14	Iowa (1) Illinois (1) Mississippi (2) Missouri (1) North Dakota (2) South Dakota (6) Wyoming (1)

Figure 1. Utility Reimbursement of DG at Retail Rates (n = 110).

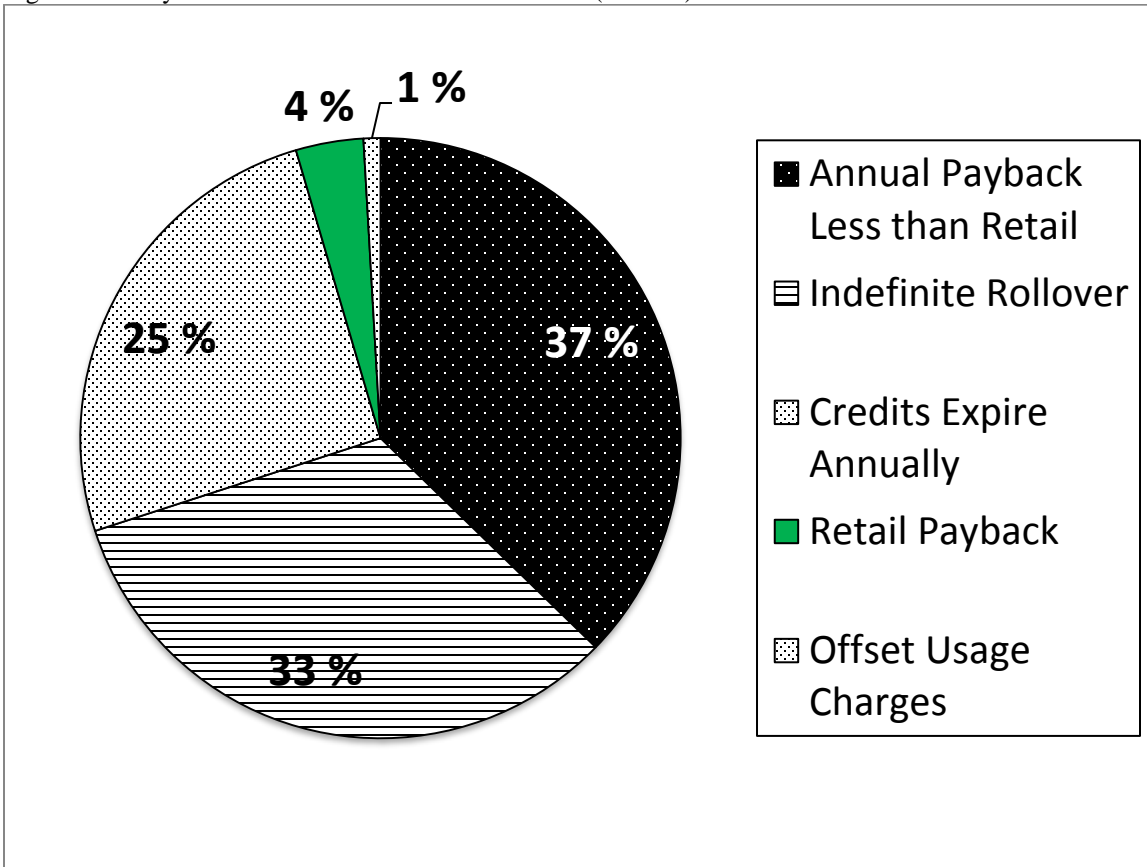


Figure 2. Utility Reimbursement of DG at Less than Retail Rates (n = 26)

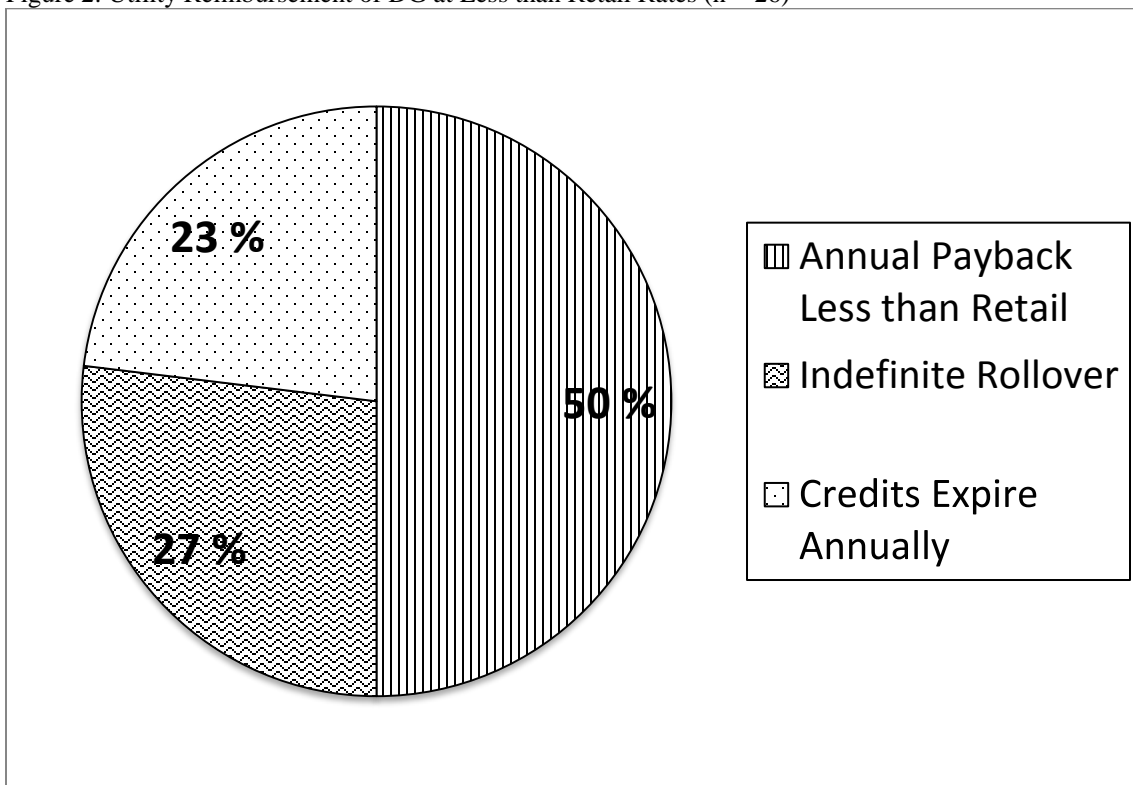


Figure 3. Utility Reimbursement of DG, all utilities included (n = 136).

