Distributed Energy Resources: Status Report on Evaluating Proposals and Practices for Electric Utility Rate Design

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National Regulatory Research Institute

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Abstract

In many electric utility service territories, rapid growth in distributed generation, especially rooftop solar, is triggering both legislative and regulatory proposals for changes in rate designs. This paper reviews, summarizes, and catalogs over a hundred pending proposals and recently adopted changes, in 43 states and the District of Columbia. The four major types of proposals include, singly or in combinations: (1) higher fixed charges; (2) demand-charges for residential and small commercial customers; (3) higher minimum monthly bills; and (4) changes in the terms and conditions for net metering. Some proposals also include time-differentiated rates, changes in standby charges, tiered- or block-rate structures, and various alternatives to net metering, such as feed-in tariffs, two-way rates, or value-of-solar tariffs, possibly combined with value-of-service rates. Some of the regulatory proposals fall in the context of general rate cases, while others are being heard in single-purpose hearings. This paper lists and classifies the many different types of rate design proposals, including:

- A total of 25 states have seen proposals for fixed-charge increases, either for all customers, for solar photovoltaic (PV) self-generators only, for all distributed generation (DG) customers only, or for net metering customers only;
- Over a dozen states have recently-enacted changes to net metering policies, and 17 states are currently reviewing changes to net metering rules and standards, or considering possible successors to net metering;
- Eleven states have recently completed or ongoing studies of net metering, and in four of those states the efforts are explicitly intended to identify new program designs or replacements for net metering.
- Broader dockets about policies affecting all distributed energy resources have been recently decided in two states and are underway in ten others; and,
- Six states have recently enacted provisions and nine states and the District of Columbia have open dockets on community-shared solar.

Included is a brief review of several factors that are combining now to provide the impetus for so many proposals. The factors include: (1) aging utility infrastructure in need of replacement; (2) further tightening of federal environmental protections and the likelihood of greenhouse gas regulations; (3) flat or declining loads and load factors resulting from greater energy efficiency and the widespread slow-growing economy; (4) requirements for grid modernization; (5) declining costs and rapidly growing markets for distributed energy resources, particularly solar PV and battery storage; (6) state and utility net metering programs nearing or exceeding existing caps, thus triggering policy reviews, and (7) strong interest on the part of growing numbers of large corporate and institutional buyers and municipalities engaging in

community-choice aggregation, that want to take more control of energy purchases and obtain more or all of their electricity from renewable and low- or zero-emissions energy resources.

In addition, the paper reviews some early efforts to analyze rate design proposals, to understand the ranges of expected effects on different customer segments, on distributed energy resources (DER) businesses, and on utilities. The paper includes guidance about how best to model rate design effects on small, medium, and large energy users in different rate classes with and without: (a) higher fixed charges; (b) demand charges; and (c) small, medium, and large on-site DG or other DER. Techniques described include using actual customer data to identify billing determinants and then analyze the effects of changes on different customer groups, including analysis based on customer income levels. A technique is also reviewed, which uses simplified, pro-forma financial modeling for evaluating effects on utilities. Plus, financial analysis of PV system economics under different rate structures can be used to estimate effects on PV market growth and on the possibilities for customer load- and grid-defection.

While the need for redesigning network charges is real, that work should be approached thoughtfully, in light of multiple regulatory objectives. A major finding of this paper is a need for additional efforts to model the effects of rate design changes on different customer types and to understand more thoroughly ongoing DER market changes, prior to making major rate design changes. Also described are needs for: (a) coordinated, multi-stakeholder infrastructure planning and co-optimizing multiple network infrastructures such as systems for grid modernization and smart city services, plus natural gas, electric, and water utilities; and (b) additional modeling of policy changes for better understanding the economic impacts on utilities and their service territories, including feedback loops and spin-off effects.

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Any inaccuracies, mistakes, omissions, and oversights in this work are my responsibility. Comments, corrections, and recommendations for future work are always welcome and can be submitted to:

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I. Introduction and Background

A. Introduction and description of the project

All around the U.S., there are dozens of recent legislative and regulatory proposals for rate design changes targeting distributed energy resources (DER), especially rooftop solar photovoltaic (PV) systems. According to recent reviews (Inskeep, Kennerly, et al. 2015; Inskeep et al. 2015a and 2015b), 43 U.S. states plus the District of Columbia are engaged presently, or were recently, in legislative or regulatory reviews or actions, proposed to alter utility rates and programs affecting distributed solar. As Inskeep et al. (2015a, p. 3) explain:

> Despite strong near-term growth projections for distributed solar, mid- to long-term policy uncertainties pose a major challenge for the industry.
>
> - At the federal level, an important policy supporting residential solar, the 30% investment tax credit, is set to expire after December 31, 2016.
> - At the state level… solar rebate incentives are decreasing, solar tax incentives are expiring, renewable portfolio standards are nearing their final targets, net metering caps are being reached, and net metering and rate design are undergoing regulatory and legislative review.

Some rate design proposals and recent actions are narrowly focused on solar PV generation and net energy metering (NEM) policies. But, the total array of activity is broad, including proposals for different combinations of higher fixed charges, minimum bills, adding demand-charges for residential and small commercial customers, and offering or mandating time-differentiated energy rates. Also included are possible alternatives to NEM, such as feed-in tariffs, two-way (also called "buy all/sell all") rates, or value-of-solar tariffs, possibly combined with value-of-service rates.[1]

For example, Inskeep et al. (2015a) report legislative or regulatory actions, or both, in the first quarter of 2015, including:

- ***Net Metering*** changes under active consideration in 20 states, the District of Columbia, and two U.S. territories. Plus, six of those 20 states were also actively engaged, along with nine others (for a total of 29 states), in ongoing procedures to study and report on possible net metering changes.
- ***Residential Fixed Charge Increases*** for 20 utility companies operating in 11 states, either recently approved, pending, or awaiting approvals of proposed settlements.
- ***Specific solar-only or more general distributed generation charges*** for six utilities in five states.

In addition:

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[1] For basic rate design concepts, see: Alt 2006; Bonbright et al. 1988; Braithwait et al. 2007; Kahn 1988; Phillips 1993; and Public Utility Research Center 2015.

- Current legislative proposals for renewable portfolio standards are under review in more than half of all states, with eight states examining proposals for increasing standards, seven states for decreasing or rolling-back standards, and 11 more states with competing proposals, some calling for increases and others for decreases (Hoffer et al. 2015).[2,3]
- Community-based solar energy has been doubling each year for the past decade, with nearly 100 programs already in place in over a dozen states and under active review in several others (Community Solar Hub 2015; Lundin 2015b; Makyhoun et al. 2015, pp. 10, 14; Meza 2015; SharedRenewablesHQ 2015). In Minnesota, the first utility solicitation for community solar projects attracted proposals for over 430 MW (Inskeep et al. 2015). And, Maryland is enacting a three-year pilot program, which includes a review of best practices and a benefits and costs analysis (Trabish 2015e). Plus, where utility regulations allow it, peer-to-peer platforms are already in development, where customers with solar production in excess of their own needs might be matched with others who wish to purchase solar energy (Schiller 2015). Depending on details of community-shared solar program designs, the solar facilities might be owned by participating customers, sometimes by third party developers, and other times by utilities.
- Utility-scale solar energy is already cost-competitive, or even a least-cost source of new supply, for integrated resource planning purposes in about half of all states (Makyhoun et al. 2015, p. 13).
- Utility-owned rooftop-solar pilot programs are underway in Arizona (Trabish 2014, 2015a), Michigan (Brandt 2015a; DTE Energy 2015), Minnesota (Makyhoun et al. 2015, p. 10), and Texas (Inskeep et al. 2015, p. 35), and through a utility affiliate in Georgia (Georgia 2015; Georgia Power 2015; Trabish 2015b).
- Comprehensive reviews about the future of electric utility regulation and business models for utilities, about "grid modernization," or explicitly about distributed solar business models and their impacts on utilities and ratepayers, are already underway in Arizona, California, Colorado, Hawaii, Massachusetts, and New York and just starting in the District of Columbia (in Docket FC1130) and Minnesota (in Docket 15-556) (Berry and Ormond 2015, pp. 66-7; Lange et al. 2015; See also SEPA 2015 and Zinaman et al. 2015).[4]

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2 Hoffer et al. (2015, p.2) explain:

> Rollbacks include outright repeals, reductions to targets, delays in target dates, exemptions for [some] utilities, and bills to extend eligibility to non-renewable fuels… . Increases… would create a larger market by expanding renewable generation targets, creating new carve-outs, or requiring compliance by additional utility-types.

3 These RPS proposals are not included in the policies reviewed in the Appendix, nor the summary in Part II of this paper, because they do not explicitly change rate designs for solar PV users.

4 Many of these activities are much broader in scope than the more specific rate design concepts that are the focus, and thus they are not explored further in this report.

- California ISO (2015a, 2015b) is already establishing rules allowing distributed energy resources, including roof-top solar, to be aggregated together for the purpose of participating in wholesale electricity markets and a DER Task Force is studying a similar concept for the Electric Reliability Council of Texas (ERCOT, see Appendix).
- The general subject of rate design for distributed solar energy has even been raised in the context of the 2016 presidential campaign (Pyper 2015).

This paper reports on the many recent changes and pending proposals, focusing primarily on changes in utility rates for customers with on-site distributed generation. Also touched on briefly are utility and non-utility voluntary green pricing programs (Heeter et al. 2014a) and the related subjects of: (a) voluntary green power purchases by large commercial customers (Labrador 2015; World Wildlife Fund et al. 2014) and institutional customers (Brandt 2015b); and (b) community-shared renewable energy systems (Cappage 2015; CommunitySolarHub 2015; Coughlin, Grove et al. 2012; Feldman, Brockway et al. 2015; Funkhouser et al. 2015; NREL 2014; Trabish 2015h).

The remainder of Part I summarizes the major factors leading to these recent proposals and outlines the major responses to date. In Part II, this paper briefly summarizes and catalogs pending proposals and recently adopted changes, drawing from survey reports by the Advanced Energy Legislation Tracker (2015) system at Colorado State University's Center for the New Energy Economy (2014) and from North Carolina State University's Clean Energy Technology Center (Inskeep, Kennerly et al. 2015; Inskeep, Wright et al. 2015a and 2015b), supplemented by news reports. (The legislative and regulatory activities, by state, are described in the Appendix.) Part III relates the major methods available for reviewing and evaluating proposals, to explore how proposals might affect various groups of utility customers, utilities themselves, and the value-chains of firms that are producing and delivering distributed energy resources (DER). Finally, Part IV presents conclusions from this work and recommendations for future research.

B. Why now? Factors leading to proposals for rate design changes

Several factors are combining to create pressure for change in the electricity industry. Linvill, Shenot, and Lazar (2013, pp. 4-5) summarize:

> Some utilities have expressed concern that DG adopters are undermining the financial foundation of the electric system. They argue that DG is failing to pay its fair share for its use of (and the ongoing dependence of its owners on) the electric grid. DG developers and advocates argue that the value being provided to the electric system exceeds the cost that ratepayers contribute, and so, if anything, they are being under-compensated for the services they provide. And some consumers argue that they are unfairly subsidizing DG adopters.
>
> Regulators charged with protecting the public interest by fairly balancing the interests of stakeholders and consumers are listening and asking whether the compensation established when penetration of DG was relatively low remains appropriate at higher penetration levels. Regulators are looking for the well-designed tariff that compensates DG adopters fairly for the value they provide to the electric system, compensates the

utility fairly for the grid services it provides, and charges non-participating consumers fairly for the value of services they receive.

The major issues are: (a) whether NEM customers or others with on-site generation are paying their fair share of distribution system costs; (b) whether rate designs provide utilities with a reasonable opportunity to earn their regulated rate of return; and (c) whether, to what extent, and in which direction, current rate designs might be resulting in cross-subsidies, especially between NEM and non-NEM customers. The seven major relevant factors that are combining to foment change include: (1) aging utility infrastructure in need of replacement; (2) further tightening of federal environmental protections and the likelihood of greenhouse gas regulations; (3) requirements for grid modernization; (4) flat or declining loads and load factors; (5) declining costs and rapidly growing markets for distributed energy resources and self-generation, particularly solar photovoltaics (PV) and battery storage; (6) state and utility NEM programs nearing or exceeding existing caps, thus triggering policy reviews, and (7) strong interest on the part of growing numbers of large corporate and institutional buyers in taking more control of energy purchases and obtaining more or all of their electricity from renewable, low-emissions energy resources. There is a growing literature about these factors and the resulting pressures on existing utility companies (for example, Molena and Kushler 2015, pp. 1-2, and Oskvig, Chevrette, et al. 2015, pp. 45-46).

Zinaman et al. (2015, p. 1) summarize:

> Power systems would appear poised for a revolution. Yet the pathway to transformation is highly sensitive to each local situation and its technical, economic, and political factors. While rapid cost reductions have changed the economic landscape for what is feasible, established asset bases—and their supporting business models and regulatory frameworks—generate significant inertia in most power systems.

Similarly, Lehr (2015, p. 4) observes:

> A short list of the new pressures on electric utilities includes burgeoning environmental regulation, aging infrastructure, changing fuel and generation economics, cyber security demands and, importantly, reduced or flat load growth. As a result of these forces, utilities will need to deploy capital at an accelerated rate while simultaneously being deprived of the familiar engine of earnings – customer load growth. There is no precedent for this combination of pressures and challenges.

An Edison Electric Institute (EEI) report (Kind 2013, p. 1) explains that this recently emerging "convergence of factors" and "confluence of forces" could become "disruptive challenges" and "game changers" for the electric utility industry. Similarly, Queen and Shilad (2015) call these factors "growing pains," but other observers are not as sanguine. Rule (2014, p. 2) asks whether distributed solar presents an "existential threat." Martin et al. (2013) even claim that existing utilities are "doomed to obsolescence" and Carratturo (2015) says, "It's clear the old way of utilities doing business isn't going to work in the clean energy future, and everybody sees the writing on the wall." Oskvig, Chevrette, et al. (2015, pp. 10, 12) explain:

> Disruptive forces predicted by electric industry pundits have arrived and are redrawing the power supply and consumption chains in the United States and abroad. New technologies affecting both sides of the meter clash with a regulatory construct struggling to keep pace with rapid innovation. … Eighty percent of electric utilities believe that DG, particularly solar photovoltaic (PV), represents a serious challenge to their business.

Some observers express a need to consider a new model, variously called "utility 2.0" or "21st century electricity system," "modern grid," or "utility of the future" (e.g., Lisa Frantzis of Advanced Energy Economy, speaking in The Energy Gang 2015 podcast, at 2:35-3:25). Others are discussing the possibility of a utility death-spiral, where revenue losses cause utilities to raise rates, which then results in even more revenue losses as prices increase, which causes increasing energy conservation, and more loads and possibly even entire customer facilities might "defect" from the grid, leaving the remaining customers to cover all remaining fixed costs (Bronski, Creyts et al. 2015; Costello 2014b; Khalilpour and Vassallo 2015; Kind 2013). As Kelly-Detwiler (2015) observes, "The threat to utilities is obvious, real, and accelerating. … The genie is already out of the bottle."

The remainder of Part I.B. briefly describes each of seven major factors affecting the electric utility industry and more generally the entire energy industry, and then Part I.C. reviews the major responses on the part utilities. Generally speaking, the first three factors are about pressures that are driving utilities towards making large new capital investments, and the other four factors reflect some of the ways that consumer choices could be hampering utilities from raising the revenues needed to support those continuing investments.

1. Aging infrastructure

The American Society of Civil Engineers (2013) gives a "D+" grade to the country's energy infrastructure, and explains that "[t]he investment gap for distribution infrastructure is estimated to be $57 billion by 2020… [and] the investment gap for transmission infrastructure of $37 billion." As Walton (2015f) explains, utility industry professionals cite "old infrastructure" as one of today's most pressing problems, and spending on the infrastructure is expected over the next several years to hold steady at a rate of about $90 billion per year.

2. Environmental regulations

Second, more stringent environmental regulations are gradually coming into play, which will require some combination of equipment replacements or additions that are likely to require both substantial investment and increased operating costs for fossil-fuel combustion units. The set of environmental regulations poised to take effect already includes toxic and hazardous air pollutants, plus new standards for cooling water. (U.S. DOE, 2015a). And, whether or not the pending EPA Clean Power Plan (CPP) proceeds to implementation, and independent of what final form the CPP regulations might take, many observers expect in the not-too-distant future some form of greenhouse gas regulation or, at a minimum, pressure to internalize greenhouse gas emissions costs (Zarakas, Sergici, et al. 2014).

3. Requirements for grid modernization

Concurrent with those two major challenges, utilities are investing in advanced metering infrastructure, communications, monitoring, and control technologies, under the banner of what is called "grid of the future," "grid modernization," or "smart grid" (Madrigal and Uluski 2015; U.S. DOE 2015b). Major continuing expenditures will be needed to modernize the electric grid to meet emerging challenges (Stanton 2011; U.S. DOE 2015c). One of the major factors contributing to visions of a modern grid is the build-out of transmission assets needed to provide access to load centers for power coming from remotely-sited renewable resources, especially wind and utility scale solar (U.S. DOE 2015b, Chapter 3).

Another wildcard is the growth of electricity use in transportation. Plug-in electric vehicles represent for utilities both opportunities for sales growth and needs for additional expenditures. Opportunities exist for utilities to support electric vehicles in ways that integrate vehicle battery charging systems with the electric grid, thus increasing off-peak electricity sales resulting in improved load factors and ensuring that plug-in vehicles can be operated so that they are capable of producing valuable grid services (Cardwell 2015; Denholm et al. 2013; Richardson 2013; Stanton 2014).

4. Flat or declining loads and load factors

Over all, electric utility loads are largely flat or declining, and load factors are declining as peak loads are growing faster than average loads and sales (Queen and Shilad 2015, p. 26; Schueneman 2015). The *Quadrennial Energy Review* by the U.S. Department of Energy (U.S. DOE 2015b, p. S-1) reports, "U.S. electricity consumption was flat between 2005 and 2014, and total energy use declined 1.9 percent." DOE (2015b, pp. 1-8–1-9) projects electricity usage will grow at a bit less than 1 percent per year through 2040, largely because of "a decline in energy-intensive industries [and] increasing energy efficiency," and DOE shows flat and declining sales in 36 states. The Edison Electric Institute report (Kind 2013, p. 18) characterizes the situation as "anemic electricity demand." Unless some changes are made, utilities could face a dilemma: Revenues could stagnate at the same time that large expenditures are needed for the other factors discussed here, which would put upward pressure on rates.

5. Rapidly growing distributed energy resources

Distributed energy resources (DER) are also growing rapidly, especially customer-sited solar PV. U.S. DOE (2015b, p. S-1) notes electricity generation from solar has been doubling every two years, from 2003-2014, with the rate accelerating. Kann, Kimbis, et al. (2015, pp. 6-8., 15) report that both residential and utility markets for solar PV are growing rapidly, and that solar power accounted for 40 percent of all the electric generating capacity additions in the first six months of 2015. Plus, Kann, Kimbis, et al. note, the pending decline in the federal investment tax credit for solar is resulting in time-pressure for developers "to bring as much capacity on-line as possible" within the coming 16 months; there are over 11 GW of existing utility PV projects already operating, more than 16 GW more currently in development, plus over 28 GW more in projects that have been announced but do not yet have completed PPA contracts. As the most recent national survey (Barbose, Darghouth, et al. 2015, pp. 1-4) explains, PV system costs and associated soft costs are continuing to decline rapidly, so that even as utility and government sponsored financial incentives are decreasing in many jurisdictions, PV markets continue their rapid rates of growth. Makyhoun et al. (2015) point out, although solar activity is presently "heavily concentrated in particular utilities and states" – namely Arizona, California, Hawaii, Massachusetts, Nevada, New Jersey, New Mexico, New York, North Carolina, and Texas – nearly all areas of the country are experiencing rapid growth in residential, non-residential, community-shared, and utility-scale installations.

Given the fairly stable policy environment for the past decade or more, solar PV businesses are developing and implementing paths to faster market growth. PV system performance has improved, costs have declined, and low-cost financing has become more readily available, often with no money down; thus, increasing numbers of electricity customers are finding solar PV self-generation to be fully cost-effective. This is leading to rapid growth in solar PV installations, first in states and utility service territories that are home to combinations of the most intensive solar radiation, rate structures that convey the most utility cost-avoidance, plus generous state or local financial incentives (Stanton and Phelan, 2013).

Although it is too early to conclude that solar PV is becoming mainstream, in the true sense of the word, markets in a few locations are progressing through the traditional diffusion of innovations process, moving from the earliest true believers, to early adopters, and then starting to approach mass markets (Nygrén, Kontio, et al., 2015). Recent projections show as much as a quarter of the U.S. population is already in a jurisdiction where on-site PV can be fully cost-effective. Wesoff (2014) identifies three states where customer-sited solar is already fully cost-effective (Arizona, California, and Hawaii) and four more states that are near that point (Nevada, New Jersey, New Mexico, and South Carolina). Wesoff further forecasts solar PV at "grid parity" prices, or better, in 28 states by 2020, and estimates the potential "addressable market for solar in the U.S. will be 100 gigawatts of residential solar… 100 times today's market." Kennerly and Proudlove (2015) find that in 46 of the largest 50 U.S. cities, financed solar PV installations, as investments, are performing better than the recent 25-year average performance of the S&P 500 stock market index. Predictions are that more and more jurisdictions will soon find themselves in a similar situation, where PV growth could expand rapidly. However, changes in rate designs for customers using solar PV could diminish such favorable economics.

Solar PV is a harbinger, but other technologies are also adding more possibilities for changing the utility landscape, enabling increasing numbers of utility customers to supply more of their own needs while reducing their purchases of electricity from the grid. Closely related is progress in battery storage and combined PV plus batteries, and PV plus intelligent control technologies (Khalilpour and Vassalo 2015; SolarCity 2015; Walton 2015a). As Gifford (2015) explains, "the combination of distributed rooftop PV, plus storage, plus load management are set to reshape… the U.S. solar market… ." Six major solar companies are already "coupled with" energy storage companies for combining rooftop-scale PV systems with on-site battery storage (Lacey 2015; St. John 2015b and 2015c), some solar companies are working on offerings integrating small-scale PV with PEV battery charging (Edelstein 2014; Lacey 2014), and utility-scale storage installations are also proceeding (Stoker 2015). California, Hawaii, and New York (see Appendix) are prominently engaged in regulatory procedures intended to address the role of storage in grid operations and accompanying rate designs that may be needed to facilitate both utility and customer deployment of storage. Lehr (2015) provides preliminary recommendations for policy makers and regulators.

Combinations of many DER and grid modernization technologies are rapidly commercializing, producing new options for the design and operations of utility systems, whether or not grid-integrated (Bracco, Delfino et al. 2015). Many DER technologies, including micro scale combined heat and power (CHP) systems (Embury et al. 2015), small wind and hydroelectric generators, and more are progressing, and are likely to benefit from economies of scale in production plus lower-cost financing techniques (Bracco, Delfino et al. 2015). In fact, the idea of growing numbers of autonomous, "net zero energy," buildings is now gaining traction, with a broad proposal from the American Institute of Architects for mainstreaming zero energy buildings (AIA 2015; Architecture 2030 2015). California's Energy Commission and Public Utilities Commission have both established goals for all new residential construction to meet net zero goals by 2020 and all commercial construction by 2030 (CEC 2015).

6. Net metering caps

Another factor creating some urgency for reviewing rate designs is that many jurisdictions are approaching, and a few are already exceeding, the system-wide caps associated with existing NEM rules. In some jurisdictions, reaching the caps automatically triggers a review of existing rules. Makyhoun et al. (2015, pp. 9, 16-17) show that the average utility in the U.S. reports only about one-quarter of one percent of customers net metering, but Hawaii utilities lead the country with eight to 12 percent of customers net metering, one Washington and Idaho utility has reached five percent, and a handful of California and Arizona utilities have hit three percent of customers. Almost 60 more U.S. utilities report that one percent of customers are now net metering (Ryan Edge, Solar Electric Power Association, personal communication, 26 May 2015). Makyhoun et al. (2015, p. 11) report that net metering accounts for 672,732 cumulative solar projects, which represents 99 percent of all PV systems installed in the U.S., by number, and 44 percent of all installed solar PV capacity. Heeter, Gelman, and Bird (2014) and Heeter et al. (2014) explore progress towards net metering caps.

7. Corporate and community clean energy purchasing

A final factor pressing towards rate design changes is the growing interest in corporate and institutional purchasing of renewable energy, which one analyst (Gifford 2015) calls "offsite wholesale solar." Plus, community-shared solar is growing rapidly, frequently as an adjunct of NEM, especially for the large numbers of electric utility customers whose properties make on-site solar installations difficult (CommunitySolarHub 2015; Feldman, Brockway et al. 2015; Funkhouser et al. 2015; Honeyman 2015; NREL 2014).

Reportedly, as many as 60 percent of the Fortune 100 companies and 43 percent of the Fortune 500 have established voluntary corporate targets for clean energy, energy efficiency, and renewable energy, as part of strategies to address global climate change and lock-in long-term contract prices for electric power. Such companies are increasingly looking to their electricity providers for options such as direct power purchase agreements (PPAs) and utility green pricing options, that will lock in for the participating customers the benefits associated with long-term, fixed price renewable resources. (Guevara-Stone and Bronski 2015; Labrador 2015; Miller, Bird, et al. 2015; World Wildlife Fund et al. 2014). Major internet companies such as Adobe, Amazon, Apple, eBay, Cisco, Dell, Facebook, Google, Hewlett-Packard, IBM, Intel, Microsoft, Oracle, Yahoo, and more are publicly committed to using increasing quantities or even 100 percent renewable energy, and increasing numbers of smaller businesses are also asking to have their cloud-computing facilities powered with renewable energy. Some companies are adding on-site generating technologies. As Motyka and Clinton (2015, pp. 1-2, 10-11) report, interviews with small, medium, and large businesses indicate growth of about ten percent per year in the numbers of companies reporting they are producing some of their electricity supply on-site. Over half of all businesses now say they are self-generating, and the percentage increases to about two-thirds of all businesses with "critical…operations, requiring a high degree of reliability." Plus, over a quarter of all businesses interviewed say they are installing battery storage to help manage demand charges. In addition, many businesses are asking utilities and regulators to make the policy changes needed to reduce or eliminate any locked-in price premium associated with delivering renewable or cleaner power, when the customers engage in long-term, bilateral PPAs. (Cook and Pomerantz 2015, pp. 6, 19, 31).

Community-shared solar is also growing rapidly, with expectations that installed capacity will triple between 2014 and 2015, and then more than doubling again between 2015 and 2016 (Honeyman 2015). Community-shared systems are constructed by utilities or third-parties, and ownership of the individual solar panels is often transferred to individual utility customers, who are then credited as if they were engaged in on-site net metering (CommunitySolarHub 2015; Feldman, Brockway et al. 2015; NREL 2014; see also Appendix).

C. Major responses

All in all, these factors are leading to a sense of urgency on the part of some parties, for exploring and implementing changes to rate designs, utility business models, or both. To the extent that utilities have to invest new capital to replace aging infrastructure, meet new environmental regulations, add new modern grid capabilities, and interconnect more distributed energy resources, the short term effect will be rate increases. At the same time, as demand remains flat or grows slowly while more customers self-generate or enter into direct PPAs, there is simultaneously less revenue available for utilities to recover the costs of and earn returns on past investments and less need for utilities to build new power plants upon which returns could be earned, thus plausibly threatening the century-old electric-utility business model. (Bronski, Creyts, et al. 2015; Khalilpour and Vassallo 2015; Propper 2015, p. 9). Given the major factors presently weighing on regulated utilities, the stage is set for the flurry of proposals for near-term legislative and regulatory changes, which are described in Part II.

The responses to today's challenges are by no means uniform. Propper (2015) generally identifies three major types of responses among utilities: (1) a "wait and see" mode, primarily "utilities [that] tend to be in markets with less distributed energy resources and lack a compelling need to evaluate their business models today;" (2) "actively engaged in reevaluating business models and seeking new opportunities;" and (3) attempting to hold back or slow the move towards increased load defection and customer defection.

Among the second group are utilities working on new opportunities. In a 2014 survey of utilities, Makyhoun et al. (2015, p. 12) find more than half "are either already employing or planning, researching, or considering improved strategies for integrating solar into their grid operations, including: (1) locational deployment, to minimize interconnection costs and difficulties and maximize grid benefits; (2) advanced inverters capable of producing and delivering valuable ancillary services such as "reactive power support, voltage and frequency ride-through support, and curtailment;" (3) energy storage; and (4) improved solar forecasting. Another 2014 survey of utilities (Propper 2015, pp. 17-34) already identifies many new services provided by utilities or utility affiliates, including: (a) in-home equipment such as appliances and whole-house surge protectors and standby electrical service; (b) indoor and outdoor lighting systems; (c) bundled TV, internet, telecomm, and home security services; (d) home repair and warranty plans; (e) landscaping and tree services; (f) home and other building financing for energy retrofits; (g) solar system maintenance; (h) economic development loans; and even (i) scouting for locations for films. Plus, Deign (2015) reports on one utility pursuing a role in behind-the-meter electricity storage and thermal storage, Walton (2015a) reports on a utility combining efforts with third party demand-response equipment and service providers, and a few utilities are already branching out into distributed solar ownership (Brandt 2015a; Makyhoun et al. 2015, p. 10; Trabish 2015a, 2015b, 2015h). Utility executives surveyed in 2015 indicate that new business models are high on the agenda for action in the coming months (Lundin 2015a, 2015d). And, a recent consumer survey (Motyka and Clinton, 2015, pp. 19-22) shows substantial interest in additional products and services from electricity providers, such as internet, cable TV, telephone, home security, and home automation.

The third group of utilities is engaged in what Neuhauser (2015, pp. 376, 386) identifies as "efforts to frustrate the growth of DG," what Barone (2015) and Trabish (2015d, 2015g) call a "solar showdown," and what Warrick (2015) calls a "war against rooftop solar." Those monikers reflect journalistic hyperbole, but it is not too much of a stretch to think they might illustrate the posture of some utilities and policy makers (Tomich 2015; Walton 2015b). As Rule (2015, p. 10) reports, "Seemingly overnight, solar-friendly policies are now being replaced with limitations and fees that are likely to slow the pace of… growth."

An EEI report (Kind, 2013, p. 1) first raised the concern that the current "convergence of factors" and "confluence of forces" could become "disruptive challenges" and "game changers" for the electric utility industry. Among the solutions proposed (Kind, 2013, pp. 5-11) are:

- ending subsidies for distributed solar;
- instituting higher fixed charges;
- increasing charges for interconnection, for utilities managing variability, and for backup supply;
- revising NEM programs "so that self-generated DER sales to utilities are treated as supply-side purchases at a market-derived price";
- considering an exit-fee for partial load and "fully departing" customers, "to recognize the portion of investment deemed stranded as customers depart;"
- identifying "new business models and services that can be provided by electric utilities;" and,
- recognizing "the threat of disruptive forces" in cost-of-capital determinations.

Reporting for EEI, Kuhn, Owens et al. (2015, pp. 5-7) assert:

- Rooftop solar is "the most expensive form of electricity generation" and will remain so, while utility solar is much cheaper;

- "[R]ooftop solar is being subsidized through extensive federal and state tax credits and other incentives… [including] state net energy metering policies that were approved to encourage the introduction of these systems and technologies when they first came to market years ago, and have since outlived their intended use;"
- "Current state net energy metering policies that compensate at the retail price for electricity sales to the utility are outdated and need to be updated;"
- "[I]nstalling rooftop solar does not reduce grid investment needs;"
- "[I]f today's policies fail to evolve and to keep pace with technology, grid costs will continue to be shifted to customers who do not install DG systems, whether for technical or financial reasons;" and,
- "Going forward… [u]tilities must be able to go 'behind the meter,' so to speak, in order to provide full customer service and a range of options… including rooftop solar, microgrids, storage, and also energy efficiency and demand response… ."

Together, Edison Electric Institute and Natural Resources Defense Council issued a *Joint Statement to State Utility Regulators* (EEI/NRDC 2014), which explains, in part:

> Net metering" programs in wide use across the United States have helped valuable 'distributed' technologies such as rooftop solar power gain traction and improve performance, but additional approaches are needed now. … When they use distribution and transmission systems to import and export electricity, owners and operators of on-site distributed generation must provide reasonable cost-based compensation for the utility services they use, while also being compensated fairly for the services they provide.

Also, the Electric Power Research Institute (EPRI) is engaged in "value of grid" studies. EPRI (2014, p. 7) reports:

> [T]he cost of providing grid services for customers with distributed energy systems is about $51/month on average in the typical current configuration of the grid in the United States; in residential PV systems, for example, providing that same service completely independent of the grid would be four to eight times more expensive.

EPRI (2015, p. xviii) "recognizes the need for the industry to systematically and thoroughly address the implications of DER," and concludes that "[b]enefits and costs must be characterized at [both] the local level and the aggregated level of the overall power grid."

Many, if not all, of these concepts are echoed in utility positions on legislative and regulatory proposals across the country, for example in Arizona (Trabish 2015g), Connecticut (Cummings 2015), Michigan (Comer 2015; Dimitri 2015; Popa 2015), Minnesota (Trabish 2015d), Ohio (Kowalski 2015), and Wisconsin (Content 2015).

Recently, U.S. DOE Secretary Ernest Moniz told electric utility company executives that he wants DOE to help forge a consensus on how to value grid services. In particular, Moniz is quoted as saying he wants DOE to help convene stakeholders to devise "transparent and broadly accepted methods for characterizing the value of services provided to the grid by existing and new technologies" (Kuckro 2015).

II. Summary and Typology of Proposals

A. Summary

Included here is a brief review of recent proposals or actions affecting rate design for distributed solar PV. The purpose is to highlight the types of changes being considered around the country.

Readers should note that this is not a comprehensive listing of all policies that affect solar PV business models: Other policies affect solar PV businesses, in addition to rate designs. As Holt and Galligan (2015, pp. 2, 4-5) and Stanton and Phelan (2013, pp. 1, 39-41) report, the cumulative effects of policies that are in play for a given place and time form the predicate for solar PV business models, especially including: financial incentives; federal, state, and local government tax treatment; and state renewable or other clean energy portfolio standards.[5] Furthermore, this paper presents only one snapshot view of a fast-changing environment in which new information is arriving practically daily.

The data summarized here is presented in more detail in the Appendix. The intent of this review is not to present conclusions, but to illustrate the similarities and differences among states and the breadth of the ongoing discussions.

Since 2014, as detailed in the Appendix, 43 states and the District of Columbia have made recent changes or have pending proposals, or both, that would change rate designs for customers with distributed energy resources. The proposals mainly include variations of:

- Fixed charge increases for all customers, solar-only charges, DG-only charges, or minimum bills (either for all small customers or for all net-metering or all DG customers);
- NEM policy proposals or benefit-cost studies, specific value of solar (VOS) studies, and DER policy proposals;
- Community-shared solar;
- Utility ownership of customer-sited PV and third-party ownership.

B. **Fixed-charge increases, solar-only charges, DG-charges, and minimum-bills**

A total of 25 states have seen proposals for fixed-charge increases, either for all customers, for solar photovoltaic (PV) self-generators only, for all distributed generation (DG) customers only, or for NEM customers only. Twenty dockets have been closed in a dozen states, including Connecticut, Kentucky, Maryland, Minnesota, Nevada, New Mexico, New York, Oklahoma, Pennsylvania, Utah, West Virginia, and Wisconsin. Some of those states are home to multiple utility companies, sometimes with different utilities asking for different kinds of rate

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[5] For directories of policies, state-by-state, readers can check the Database of State Incentives for Renewables & Efficiency (www.dsireusa.org), curated for the U.S. Department of Energy by the North Carolina Clean Energy Technology Center. For policy guidance, see, for example, Bird, McLaren, et al. 2013, and Bird, Reger, and Heeter 2012.

treatment. Several cases have been closed without new charges being assessed, and some others approved increases less than the utilities had initially requested. In addition, new laws that authorize state commissions to approve DG-only charges have been enacted in Kansas and Oklahoma. Nearly two dozen state regulatory utility authority dockets containing proposals for one or more of these rate design changes remain open, in 17 states (see Appendix).

A half-dozen states have applications for charges that would apply only to solar self-generators. In Table A-1, these are encoded "Solar-only charge" or in the case of Hawaii, "Minimum bill." The states include Arizona, Hawaii, Kansas, Montana, Nevada, New Mexico, and Wisconsin. Or, in the case of Kansas, Westar is requesting approval to initiate either a fixed-charge increase for all residential customers or a solar-only charge that would take the form of either a customer demand charge or a quadrupled fixed charge. One of the Arizona companies, UniSource, proposes that solar customers should be required to take service under a rate with a mandatory demand charge. Another Arizona utility, Arizona Public Service, proposes increasing its existing solar-only charge, which is a fixed-charge per kW of installed solar capacity. In New Mexico, Public Service New Mexico proposed a new solar DG interconnection fee based on system capacity, plus an increased fixed-charge for all residential customers. The Wisconsin PSC approved for Wisconsin Electric Power Company a monthly demand-charge of $3.79/kW for net metering customers with "intermittent generation," but that Order is currently under appeal in Wisconsin Circuit Court. Plus, two other states have proposals for a distributed generation (DG-only) monthly charge that would apply to all customers using DG (Oklahoma) or a similar charge that would apply to all net energy metering customers (NEM-only, in Utah).

C. NEM policy changes and NEM studies

Over a dozen states have recently-enacted changes to NEM policies, and 17 states are currently reviewing changes to NEM rules and standards, or considering possible successors to NEM. Proceedings on these issues have been initiated in Massachusetts, Minnesota, Nevada, New Hampshire, New York, Pennsylvania, South Carolina, and Vermont. In six states, including California, Hawaii, Maine, Massachusetts, Oregon, and Vermont, efforts are underway to study possible successors to NEM. Colorado and Nevada Commissions both recently closed dockets without making changes to the existing net metering program rules at this time.

In a few states, NEM policy changes have been requested by utility companies. These include Arizona, Florida, Hawaii, Nevada, New Mexico, South Carolina and Wisconsin. In Iowa, an NEM policy docket is the result of a complaint filed by a solar company and in Massachusetts a docket was opened by a solar company requesting an advisory ruling.

In 19 states, NEM reviews have been triggered by legislation. These include Arkansas, California, Illinois, Louisiana, Maine, Massachusetts, Minnesota, Montana, Nevada, New Hampshire, New Jersey, Oregon, Pennsylvania, Rhode Island, South Carolina, Utah, Vermont, Virginia, and West Virginia. And, some dockets were initiated on a commission's own motion. These include actions in Colorado, Mississippi, and Pennsylvania. Eleven states are home to legislative or regulatory requirements to study NEM benefits and costs (encoded "NEM study"). These include Louisiana, Maine, Massachusetts, Mississippi, Montana, Nevada, New Hampshire, Oregon, Pennsylvania, South Carolina, and Utah. Net metering is new to

Mississippi and South Carolina, bringing the total number of states with net metering provisions to 46 plus the District of Columbia.

A report completed for Louisiana finds the costs of net metering outweigh the benefits to ratepayers and a report for Pennsylvania finds that net metering does not pass the standard total resource cost (TRC) benefit-cost test, given the methodology and assumptions prescribed in state law. Recent reports for Mississippi and Nevada generally find that the benefits from net metering outweigh the costs (see also: Hansen et al. 2013; and Hallock and Sargent 2015). And, South Carolina has been tasked with completing a value of solar ("VOS") study.

D. DER policy changes

Dockets about policies affecting all distributed energy resources, whether net metering or not, have been recently decided in two states, Colorado and Nevada, and are underway in ten others, including Arizona, Arkansas, California, Florida, Hawaii, Iowa, Michigan, New York, Tennessee, and Texas. A decision whether to go forward with a similar study is pending in Nevada. In Michigan, Consumers Energy proposes a program where the utility would help commercial customers interested in DG to find pre-qualified solar PV vendors and financing.

E. Community-shared solar

Seven states and the District of Columbia have recently enacted legislative provisions for community-shared solar. The states include California, Connecticut, District of Columbia, Hawaii, Illinois, Maryland, New Hampshire, and Oregon. Seven states and the District of Columbia have open commission dockets on community-shared solar. Those states include California, Connecticut, Illinois, Kansas, Maryland, New York, and Oregon. Seven states, Colorado, Hawaii, Michigan, Minnesota, New Hampshire, South Carolina, and Wisconsin are home to recently closed commission actions with respect to community-shared solar.

F. Utility-ownership of customer-sited solar PV, and third-party ownership

Decisions have been made in Arizona and Georgia. In Arizona, utilities can be owners and in Georgia an unregulated affiliate company is offering customer-sited solar. Many of the community-shared solar programs will also allow utility or affiliate ownership. Decisions are pending in Florida, Kansas, North Carolina, and Virginia.

In Iowa, the State Supreme Court ruled that a third-party owner is not subject to state regulation as a public utility. A similar question is pending before the North Carolina Utilities Commission.

III. Concepts for Systematically Evaluating Rate Designs

The purpose for this review is not to prescribe any particular rate designs.[6] Instead, it is to describe techniques, identified from a literature review, which can be used in analysis of rate design proposals and options. The objective is to be able to test hypotheses and best understand and predict the effects: (a) on differently situated customers, (b) on utility shareholders, and (c) on the DER industry value chain; and (d) on society as a whole.

EEI (Kind, 2013) and others (Dismukes 2015; Eid et al. 2014; Kuhn, Owens, et al. 2015) argue that customers using on-site PV under existing NEM rules are: (a) causing unfair cost-shifting to non-participating customers, relying at least in part on cost transfers from lower-to higher-income customers; (b) resulting in utility lost revenues; (c) requiring incremental investment by electric utilities for grid interconnections and operations; (d) possibly necessitating extra costs for interconnections and for managing the operations of other utility assets to adjust for solar panels' variable output; and (e) using the electric grid while avoiding paying their fair share of fixed-costs. These are all plausible outcomes under particular circumstances, so the analytic techniques proposed here are intended as reality checks: The objective is to avoid taking arguments at face value and jumping to conclusions, by collecting and analyzing the requisite data to enable, as best as practical: (a) determining the current extent of such factors and their likely trajectories and growth projections; and (b) predicting the results of proposed rate changes on utility revenues, on customers, and on DER business value-chains.

The kinds of questions to be addressed include:

- Are existing rates and policies creating inequitable cross-subsidies between differently situated customers, if so in which direction do the cross-subsidies flow (from customers without to customers with solar PV or other distributed energy resources, or vice versa), and if they do exist, are those subsidies now, or will they soon be, large enough to warrant corrective action?
- What kinds of evidence should alert parties that there is a need to alter existing rates and incentive policies, to better reflect the costs and benefits associated with distributed solar PV?
- What are the likely effects associated with different rate-design changes (See, for example, McLaren et al. 2015a and 2015b)?
- As Duthu and Bradley (2015) ask, how can rate designs best influence both utility and DG operational decisions, to come as close as practical to optimizing economic benefits to both the DG owners and operators, and to provide the greatest utility system benefits?

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6 Principles applicable to DER ratemaking are reviewed in: Bird, McLaren et al. 2013; Costello 2014a; Faruqui 2015; Glick et al. 2014; Jenkins and Pérez-Arriaga 2014; Kennerly, Wright, et al. 2014; Kihm, Lehr et al. 2015; Kirsch and Morey 2015; Lazar and Migden-Ostrander 2014; Linvill et al. 2013; Mandel 2015; Parry, Heine et al. 2014; Peregrine Energy Group et al. 2015; Pérez-Arriaga and Bharatkumar 2014; Picciariello et al. 2015; and Taylor et al. 2015. See also note 1.

Some techniques for analyzing the effects on customers, on utilities, and on the DER business value chains are described here, but readers should understand that these are not single-purpose techniques: Each technique can provide information that might prove helpful to understanding the total effects on all interested parties.

A. Effects on differently situated customers

Understanding the effects of rate designs on customers necessitates disaggregating customers into different groups for study. With respect to rates for NEM or solar PV, modeling should consider customers with low, medium, and high energy use, with and without small, medium, and large PV systems. For example, Table 1 presents a generic matrix illustrating five customer usage levels for study. The major idea is to analyze effects under a wide range of typical usage amounts. For example, Darghouth's (2013, p. 24) analysis of data from over 200 NEM customers showed usage ranging from less than 400 to more than 1,200 kWh per month. In studying minimum monthly charges, for example, it can be meaningful to model customers who have zero or very-low energy use, at least several months a year (see McLaren et al. 2015a). That would be typical of seasonal usage in vacation homes, for example.

Table 1: Example of five customer usage levels for rate effects studies

Usage levels	**Lowest Energy Use**	**Low Energy Use**	**Medium Energy Use**	**High Energy Use**	**Highest Energy Use**
Examples	Lowest 5-10% or -2 standard deviations	About 25-35% or -1 standard deviation	Mean or mean plus or minus about 5%	About 65-75% or +1 standard deviation	Highest 5-10% or +2 standard deviations

Similarly, Table 2 shows different levels of PV system sizes. The example shown in Table 2 is loosely based on what might be considered small, medium, and large PV installations, which could be as small as a single PV panel, about 250 Watts, and then increasing up to an extra large size, which is loosely based on the provision found in several state NEM programs, that an NEM customer should not produce more than 125 percent of their annual energy usage.

Table 2: Example of four PV system sizes for rate effects studies

PV size	**Smallest**	**Medium**	**Large**	**Extra Large**
Examples	1-2 kW or up to 60% of annual usage	Up to 80% of annual usage	100% of annual usage	125% of annual usage

Peregrine Energy Group et al. (2015) and Poullikkas (2013) employ this type of analysis. There are no hard and fast rules for selecting different PV production levels for analysis. The levels could just as easily be determined by statistical analysis of data representing all, or a large enough representative sample of, PV installations in a particular utility service territory.[7]

Measured data about energy usage (Table 1) and installed PV system sizes (Table 2) would provide an accurate picture of present circumstances. Such data is necessary to understand how NEM is actually playing out: How many NEM customers are effectively net-zero energy users, and how do NEM customers compare to non-NEM customers? The ideal approach to these questions is to obtain and analyze data for all customers. If total data sets cannot be obtained for any reason, then it is best to use the largest available sample sizes of both net metered and non-net metered customers, to ensure the data represent the total customer base.

In addition to broadly analyzing the entire customer base, it could also be important to understand how variability in usage and PV production relate to different customer groups. That is especially true because of the concern that low-income customers could be disadvantaged by NEM. Farrell and Lyons (2015) propose methods for evaluating incentive mechanisms and rate structures to determine social welfare and distributional effects, focusing primarily on customer income, dividing the population into deciles for analysis, but also taking into account variations in household size and employment status.

A first step is to determine the extent to which current rates could be negatively affecting certain income groups; for example, does the data show that low- or moderate-income customers are not participating in NEM and NEM is resulting in cost shifting to non-NEM customers (Borenstein 2013; Fowlie 2015; Rule 2014, pp. 21-24)? If those effects are occurring, then a second step is to explore approaches to alleviating that concern: Rate design changes could be one option, but another could be opening new opportunities for NEM or community-shared solar participation by lower-income customers. For example, positive cash flow opportunities using low-interest, no-money-down financing are already showing some success in facilitating participation by lower-income customers (Jospé, Probst, et al. 2014). Also, Agarwal (2015) and Hanhan (2015) present preliminary models that attempt to combine analysis of customer demographic characteristics with different policies, including financial incentives and different utility rate structures, to predict effects on the markets for solar PV installations.

In considering effects on customers, there are a few special cases that warrant attention, too, in addition to thinking through how tariffs apply to individual customers with on-site DG. These include customers who do not have the opportunity to put DG on their own facilities, who might benefit from participating in a community-shared solar project or utility voluntary green pricing, depending on the details of how those programs provide benefits to participants. Also, depending on NEM system size limits and other tariff provisions, large corporate and institutional green power purchasers might participate in utility voluntary green power purchasing programs, or engage in bilateral power purchase agreements combined with some mechanism to have the power delivered by a utility company. The latter can be under contract by a competitive energy supplier in restructured states or by a regulated utility company in a vertically integrated state. More research is needed to clearly describe all of the different mechanisms being used for

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7 The publicly available California database, for example, includes system size. (See Stanton et al. 2014, pp. 6-7). And, utilities have access to relevant data through interconnection requests.

voluntary green power purchases and define the main concerns for regulatory decision making. Decisions about the specific approaches to apply towards customer segmentation should be made based on the rate design proposals under consideration. For example, segments could be determined depending on usage, load shape, and other demographic characteristics.

B. Effects on utility shareholders

Using a simplified, pro-forma financial model of utility costs and revenues, Satchwell et al. (2014) model the likely effects of larger quantities of NEM, ranging from 2.5 percent to ten percent of retail sales, on two prototypical electric utility companies. The assumed two different utility types reflect broad differences in industry structure and solar resource availability. This modeling checked for the potential impacts on three major variables: (1) utility achieved return on equity; (2) utility achieved earnings; and (3) customer average rates. The study is not definitive or conclusive, by any means, but it does illustrate the kind of analysis that is necessary to better understand how utility shareholders are affected by the kinds of changes associated with NEM in specific or increased applications of DER in general. The study explicitly does not investigate cost-shifting among customer groups.

One important finding from this study is the extent to which similar NEM policies and numbers of customers will have different effects on utilities, depending on a suite of particulars including, for example: (a) changes in sales levels occurring without respect to NEM customers; (b) the extent to which distributed PV can offset utility generation and non-generation capacity expenditures; and (c) the regulatory lag between rate cases or use of historic test years in rate setting. Also of prominent effect will be the utility's underlying cost structure and how that relates to costs avoided by net metered PV, including whether the utility is a vertically integrated monopoly or a restructured wires-only provider, plus major differences depending on the timing of PV production and how closely PV production coincides with peak demands and high power costs, ideally measured for each relevant location on a utility's distribution system and for the grid as a whole. Although it is not likely that hourly production costs or power purchase prices will vary much based on location within a service territory, fixed costs are likely to vary over a broad range. (See, for example, Calloway et al. 2015 and Cohen et al. 2015.) Another important finding is that some variables show opposite effects on ratepayers versus shareholders (Satchwell et al. 2014, pp. 34-37). For example, a high value of PV generated electricity results in generally lower ratepayer impacts and at the same time higher shareholder impacts. This means that when PV production happens to coincide well with higher cost time periods and when PV provides a higher capacity value, utility expenditures on other traditional generation, transmission, and distribution assets are deferred or reduced, thereby reducing utility ratebase and earnings potential, and putting downward pressure on utility rates.

The researchers also study the extent to which the potential impacts of increased NEM could be mitigated through regulatory measures and rate designs. They model mitigation measures that some states are already using with energy efficiency programs, which have a similar effect of reducing sales. Those measures include, among others: (a) lost-revenue adjustment mechanisms; (b) shareholder incentives; (c) reducing regulatory lag; (d) utility ownership of customer-sited PV; and (e) increasing demand-charges or fixed-charges. The analysis generally shows that such mitigation measures can reduce impacts on utility ratepayers and shareholders, but the measures also "entail important tradeoffs, either between ratepayers and shareholders or among competing regulatory and policy objectives." For examples: (a) some of the techniques intended to increase shareholder benefits, at sufficiently high levels of PV NEM, could trigger pressures for overall rate increases; and (b) combining higher fixed charges and lower variable charges reduces the benefits customers can gain through energy efficiency and self generation.

As a result of this preliminary analysis, Satchwell et al. (2014, pp. 61-62) describe these six future research questions and needs:

(1) understanding how customer-sited PV compares to other factors that affect utility profitability and customer rates;

(2) examining the combined impacts from customer-sited PV, along with growing energy efficiency and other DER;

(3) examining rate impacts among different customer groups, including possible cost-shifting between groups;

(4) examining a broader range of mitigation options and combinations of options;

(5) improving methods for estimating the avoided costs from customer-sited PV; and

(6) identifying strategies for maximizing those avoided costs.

These last two are particularly important because of the broad ranges identified in existing studies (Hansen et al. 2013; Satchwell et al. 2014, p. 37). Ideally, complete data sets by customer class, from actual customers both with and without self-generation, could be used to analyze: average annual energy demand; relative values of retail rates versus hourly avoided energy cost during the hours of solar production; weighted by solar production by hour; and measured revenue loss to the utility by customer and for the system as a whole.

C. Effects on DER value chain participants

In a separate study (Darghouth et al. 2015), Lawrence Berkeley National Laboratory researchers use an economic analysis model developed by the National Renewable Energy Laboratory, *Solar Deployment System* (Denholm, Drury, and Margolis 2009; NREL 2015), to forecast solar deployment to explore the effects of possible "feedback loops" between NEM customers and the markets for distributed PV. The objective is to estimate the potential chilling effects on PV markets that might result from some of the rate design changes utilities and regulators are presently investigating. The model assumes that customer adoption rates, for residential or commercial customers under different typical and proposed rate designs, will vary based on the expected cash flow from solar PV investments. The analysis compares the customer's avoided cost of electricity to the cost of the solar PV installation, to determine the estimated return on investment under different conditions. Given that information, the model uses "highly non-linear customer adoption curves linking payback and rate of return" to estimate solar PV market share from the present until 2050.

In particular, the study examined the effects on residential solar markets of $10 per month and $50 per month fixed charges, and of reducing credits for net excess generation from the full retail price to a lower estimated wholesale avoided cost price. Compared to the status quo NEM tariffs, those changes, respectively, were forecast to reduce PV deployment by about 20 percent (roughly 20GW by 2050, associated with a $10/month fixed charge), 80 percent (almost 80GW, with a $50/month fixed charge), or 30 percent (about 30GW, under a reduced NEM credit for excess generation). The modelers also looked at the effects that might be associated with flat versus time-differentiated rates, and under lower and higher feed-in tariffs. These modelers conclude:

> Differences in the types of rates that are offered, the level of those rates, and PV deployment levels ensures that feedback effects vary [by state]… [A] number of utilities have proposed increased fixed customer charges, especially for the residential sector, and/or a phase-out of net energy metering. … [A] natural outcome of these changes would be a substantial reduction in the future deployment of distributed PV… .

In a different kind of study, Bronski, Creyts et al. (2015) use a solar PV financial model to explore the role of changing utility rate designs. The authors review both "load defection," meaning that customers might serve some of their load, or even particular dedicated end uses, using on-site solar PV and other DER, and "grid defection," implying the possibility that some customers might disconnect from the grid altogether. Looking at the situation in five different cities with important differences in existing electricity rates and solar radiation resources, these researchers model the most cost effective way to serve residential and commercial loads, using utility-grid only, combined grid plus PV, or combined grid plus PV plus on-site battery storage.

This modeling (Bronski, Creyts, et al. 2015, pp. 7-9) points towards a future where increasing quantities of customer demands can be served most economically using on-site PV or combined PV plus batteries. One of the major findings from this analysis is that the falling cost of solar PV systems is already making on-site PV fully cost effective for serving some load in service territories with higher utility rates, and that potential is likely to grow to as much as 60-80 percent of residential load and 60 to100 percent of commercial load in all service territories by 2050.

Furthermore, and most important for rate design considerations, this modeling (Bronski, Creyts, et al. 2015, p. 10) estimates expected changes if NEM is abolished or fixed charges are increased or added. The conclusion reached is that "eliminating net metering merely delays inevitable significant load loss... [and] fixed charges—which some utilities have recently proposed—don't 'fix' the problem." Not only that, but proposed changes in rate design could set up a perverse growth in grid defection, where some portion of customers could experience what is effectively a "tipping point," after which they might permanently switch to on-site PV with batteries, rather than remaining interconnected with the grid. Ironically, that effect, if large enough, could thwart a utility's purpose in trying to ensure that fixed costs are fully covered. And, at the same time a trend towards grid defection would likely exacerbate any concerns about cost shifting towards lower income customers.

Moreover, Bronski, Creyts, et al. (2015, p. 12) point out:

> [A]lthough they could represent significant load loss, customers' grid-connected solar-plus-battery systems can potentially provide benefits, services, and values back to the grid, especially if those value flows are monetized with new rate structures, business models, and regulatory frameworks.

Thinking through the possible effects of rate design changes on the DER value chain, the solar PV industry is benefitting now from long-term technology improvements and cost reductions. In certain parts of the country the customer-facing portions of the industry, such as dealers and installers, are progressing, too, as a result of fairly long-standing policies that have created fertile environments that sprouted successful business plans. In this context, any big changes or sudden reversals in support policies can have long-term chilling effects, making capital formation more difficult and higher-cost. If the policy changes are too rapid, boom and bust cycles can be the result. For that reason, a preferable approach can be to make several incremental changes over a longer time period, guided by long-term goals and objectives.

Utility ownership of distributed solar resources also deserves special attention because of concerns regarding the potential for anti-competitive behavior. Neuhauser (2015, pp. 397-402) reports concerns about: assuring fairness in the process for retaining contractors; uneven access to low-cost capital; and providing on-bill financing, which could be a unique utility option. Related issues include whether a portion of the market might be set aside for non-utility providers, and how to ensure fairness in interconnection procedures.

D. Effects on society as a whole

Modeling the effects on society as a whole is the purpose for the standardized "societal test" that attempts to capture a full spectrum of benefits and costs, in this case associated with DER (California PUC 2001, p. 18-21). Under this test, the benefits to be quantified include "the avoided supply costs, the reduction in transmission, distribution, generation, and capacity costs valued at marginal cost for the periods when there is a load reduction." Costs include expenditures by both participating customers and their utility. In addition, most notably, the societal test includes benefits from avoided environmental damage and of increased reliability and resilience, plus any identified non-energy benefits that might accrue. The test has been criticized, however, for practices thought not to include ample attention to non-energy benefits (Neme and Kushler 2010).

Considering environmental benefits, the MIT Energy Initiative (2015, p. xiii) notes, "massive expansion of global solar generating capacity to multi-terawatt scale is very likely an essential component of a workable strategy" for addressing greenhouse gas emissions. DER, most especially solar PV, are seen as increasingly important components of any all-of-the-above energy strategy or for focusing particularly on zero-emissions electricity production.

IV. Conclusions and Recommendations for Future Research

Today's state public utility commissions face a difficult task, regulating in the best public interest while the electric utility industry progresses, one way or another, through the biggest changes in more than a century. Reorienting rate structures and utility business models is a thorny task, frequently pitting parties with competing interests against one another, in contentious clashes, in what first appears to be a zero-sum game with multiple, conflicting goals. As Cory and Aznar (2014, pp. 66-7) explain, there are many current needs for improving capabilities for understanding costs, benefits, risks, and possible rewards associated with DER, under current or possible future utility business models. Ideally, major changes in rate design will await more complete understanding of these issues, which will lead to much greater consensus on both means and ends.

Pérez-Arriaga and Bharatkumar (2014, pp. 24-6) observe that regulators are being asked to reconcile differences between short- and long-term costs and benefits, and between rate stability and the need for major changes to the existing distribution system. Berry and Ormond (2015, p. 63) question whether today's regulatory systems are "up to the task of resolving conflicts among rapid innovation, expanded customer options, and financial security for utilities that make large investments."

Not surprisingly, some utilities believe that the existing regulatory construct and business model "has worked rather well," such that only minor alterations to the status quo will be needed, not "wholesale reform" to accommodate the anticipated changes (Bade 2015a).

Meanwhile, "grid reformers" are proposing substantial, even "transformative" makeovers of today's regulatory structures and utility business models (Bade 2015b). Fundamental natural monopoly conditions and economies of scale in construction led to the 20th century electricity industry infrastructure that relied almost exclusively on centralized generation, long-distance high-voltage transmission with limited redundancies, and uni-directional distribution. Presently, at least some portions of the historical natural monopoly are under threat by nascent or extant new technologies, most notably combinations of distributed generation, storage, and smarter-grid intelligence (Bronski, Creyts, et al. 2015; Khalilpour and Vassallo 2015; Stanton 2012). The major elements grid-reformers propose for an overhauled utility industry structure include: independent distribution system operators; highly-localized integrated resource planning; independent third-party ownership of distributed energy resources with strictly applied functional separations between regulated and unregulated subsidiaries of utility holding companies; utility earnings for the still-regulated portions of the industry dependent on the achievement of strict performance standards; and widespread applications of transactive energy systems and markets (e.g., Bade 2015b; Kihm, Lehr et al. 2015; Lehr 2015).

Rather than making a series of smaller adjustments, tacking from point to point in an attempt to avoid the horns of multiple dilemmas, many researchers, observers, and practitioners are showing a preference for longer term, more holistic overhauling, potentially involving all interested stakeholders working together to develop win-win solutions for customers, utilities, the DER value chain, and society at large (Abdullah and Kennedy 2015; Martin and Rice 2015; and Uddin and Manas 2015). Berry and Ormond (2015, p. 63) conclude:

> Resolution of conflicts among innovation, customer options, and fixed-cost recovery requires building new capabilities for regulatory and other institutions through leadership and learning... incorporating multiple perspectives, establishing a vision, developing trust, addressing low-income issues, assessing impacts of new practices, understanding customer demand, and evaluating business model options.

Along these lines, several broad "revisioning" efforts are underway, including state projects in California, the District of Columbia, Hawaii, Massachusetts, Minnesota, and New York, plus discussions under the auspices of America's Power Plan (2015b), the University of Washington's Clean Energy Institute (2015), the 51st State Project of the Solar Electric Power Association (Bade 2015a), and GTM Research (Propper 2015).

In working towards longer-term, comprehensive, win-win solutions, participating parties need to keep in mind that utility rates, terms, and conditions of service interact with existing government incentives and support policies, effectively forming something like force fields that shape DER value chains and business models (Duthu, Zimmerle et al. 2014; Overholm 2015, p. 27; Stanton and Phelan 2013, pp. 39-41). U.S. DOE (2015b, p.S-4) urges:

> Full consideration must be given to the interaction of policy at all levels of government with private sector incentives and capabilities and include attention to opportunities for well-designed, purpose-driven, public-private partnerships.

As Kester et al. (2015, p. S52) explain:

> [A] vast array of combinations of policies and programs… foster a dynamic space for evaluation of the efficacy and effectiveness of such policy options and their implementation practices as well as… opening… [a] theoretical discussion on policy innovation, learning, adoption, and diffusion.

Understanding the precise nature of ongoing market changes and modeling the likely effects of rate design changes is no simple matter, however. Research is ongoing to more clearly understand the nature of current concerns and potential problems, and to explore various proposed rate design solutions. Some states have already made some rate design changes and many others have decisions pending in active proceedings (see Appendix). Thus, all interested parties will have opportunities in the near future to learn from early experiences with different rate designs, observing changes in market conditions unfolding in different jurisdictions.

In this context, it helps to recognize that rate structures have always been imperfect. Ultimately, there is no purely objective means of establishing the ideal proportions of utility charges based on the three major components of: (1) numbers of customers; (2) average and peak system infrastructure usage by each customer; and, (3) energy usage by each customer. Perhaps some future transactive energy system will enable precision in measuring and paying for electricity usage and grid usage, customer by customer and time-interval by time-interval, but for the time being, imperfect rate designs must suffice. Pérez-Arriaga and Bharatkumar (2014, p. 1) summarize:

> Regulators are faced with the challenge of ensuring that a level playing field exists for electricity service business models that align with a range of policy goals including the assurance of reliability and quality of electricity supply, affordability of electricity services, encouragement of innovation and economic growth, and the development of clean energy technologies for decarbonization. As the distribution system transitions from a passive network of consumers to a more actively managed system of network users with diverse consumption and production behaviors, price signals will play a crucial role in shaping the interactions between the physical components of the distribution system and network users. … [R]egulators are likely to face a range of new cost drivers and new uses of the system, increased uncertainty regarding the evolution of network uses and the efficient cost of network investments and maintenance, as well as an increased informational disadvantage *vis-à-vis* the regulated utility. These challenges are important for both cost of service… and incentive regulation… ."

Fortunately, there are already at least some signs pointing towards workable solutions. Two kinds of more sophisticated modeling capabilities are needed to guide the transition towards more sustainable utilities, helping to design and operate more sustainable energy systems: (1) models of distribution systems capable of analyzing customer loads in light of all variety of modern-grid DER; and (2) models of the economic environment for utilities and their service territories that capture important feedback loops.

A. The need for comprehensive, integrated, and localized resource planning

For the first type of modeling, utilities, customers, urban planners, DER value chain participants, and utility regulators all need mechanisms for accurately and thoroughly understanding power flows, demands, and how supply and demand might be co-optimized by employing all varieties of cost-effective DER. EPRI's *Integrated Grid* project (EPRI, 2014 and 2015) is an important example of the kinds of modeling efforts needed. Although optimizing could be considered too expansive as a near-future goal, the capability needed is at least to better understand how best to satisfy economic and reliability planning criteria. As Martinot et al. (2015) explain, the changing markets for DER are forcing the need to change distribution system planning. For examples: Jenkins and Pérez-Arriaga (2014, pp. 40-42) cite the need for regulators to overcome the long-standing information asymmetry, by having more open, transparent access to comprehensive modeling of the physical infrastructure; SolarCity Grid Engineering (2015) offers a preliminary guide for integrated distribution planning; and, Fine, De Martini, and Robison (2015, pp. 4-5) identify the need for advanced distribution system planning "in an integrated and multidisciplinary fashion, with the participation of relevant stakeholders" as one of the keys to optimizing utility resources. One company (Fitzsimons 2014) is already developing such an integrated modeling platform that can be used for system planning, interconnection studies, asset optimization, analysis of existing or proposed financial incentives, market studies, and more. As Gimon and Aggarwal (2015) discuss, regulators can insist that utility modeling will be transparent to stakeholders, use the best available data, and reflect appropriately the rates of change in different important variables.

Importantly, Duthu and Bradley (2015, pp. 71-72, 82) review some of the needs for coordinated planning, including the need to identify optimum locations for DG and to identify new kinds of "policy and customer-utility interactions, beyond the traditional business models."

Cosmi, Dvarionenė, et al. (2015, p. 694, footnote omitted) cite the need for sufficiently complex modeling capabilities:

> …to find environmentally friendly, institutionally sound, socially acceptable and cost-effective solutions of the best mix of energy supply and demand options for a defined [geographic] area to support long-term regional sustainable development. It is a transparent and participatory planning process, an opportunity for planners to present complex, uncertain issues in structured, holistic and transparent way, for interested parties to review, understand and support the planning decisions.

Already, this new type of infrastructure planning is making important inroads, encouraging community engagement in planning and enabling the deferment or possibly abandonment of alternative transmission and distribution expenditures (Khalilpour and Vassallo 2015; St. John 2015a; Stanton 2015). The needs are becoming more visible, for preventing expenditures on what might become stranded assets, and for planning to co-optimize multiple network infrastructures such as communications systems for electric grid modernization, but also for natural gas and water and wastewater utilities and for emerging smart city services. Planning these networks in individual silos, without comprehensively recognizing and accounting for all of their major interactions and feedback loops, is inherently inefficient, and state regulators are in an auspicious position to help lead parties in a move towards better planning.

B. The need for modeling utility and utility service territory economies

Utilities worried about losing sales to new DG and other DER could be seeing only one part of the big picture. At least some of the sales lost to individual customers are recovered through the extra business activity in a service territory, as there are sales to all of the customers who make up the DER value chain, which can include at least manufacturers, distributors, dealers, installers, and operations and maintenance contractors. Utilities, regulators, and policy makers need better economic input-output models to understand those effects. Bell et al. (2015) discuss modeling challenges and propose a modeling framework for future evaluations.

One important factor is that DER equipment manufacturing is a fast-growing sector, with possibilities for large export opportunities, which could be exports to other utility service territories or other countries. Manufacturing and related value chains are growing rapidly now as DER gains market share in the developed world. At the same time, though, there are important indications that DER systems are critical-path resources for relieving energy poverty for the estimated one to three billion people who presently lack adequate access to safe, affordable energy for meeting the most basic human needs (Alstone et al. 2015, p. 305). For example, Byrne and Taminiau (2015) discuss the effort needed to "lift the 'bottom billion' out of their 'energy poverty trap.'" And, Chattopadhyay et al. (2015) explain that distributed micro-grids or mini-grids using solar power are critically important economic development tools for helping to lift the presently un-served and under-served people out of poverty.

A second aspect is that the move towards DER opens many opportunities for utilities and their affiliated companies that are already developing new business models that can be used to grow revenues. Lawler (2015) reports on one promising example of utility companies engaging in systematic efforts to build the economies in their own service territories. Duthu, Zimmerle et al. (2014, p. 51) are among those investigating utility business models, trying to understand how utilities could peacefully coexist with DG and other DER, searching for "new business models and rate structures… that can provide a healthy, sustainable incentive for well-sited and operated DG facilities." Khalilpour and Vassallo (2015, p. 220) recommend "policies… devised to help electricity network operators develop other sources of revenue from future small-scale prosumer[s]." As Propper (2015, p. 36) points out, utilities in about half of all states report that they are already moving, one way or another, towards DER business opportunities. Cory and Aznar (2014, p. 77) identify needs for: (a) "utility case studies that highlight success stories and new ways for utilities to benefit from the evolution of the electric sector;" and (b) "a discussion of future utility business models to move the broader conversation along in the market."

The possibility, yet to be determined, is that a growing market for DER inside a utility's service territory could result in measurably lower sales per customer while simultaneously more than compensating because of the associated growth in sales to value-chain participants in the same service territory. If that is a real possibility, then policy makers are likely to want to know how to design the DER policy environment to maximize the chances for achieving such economic development.

C. Conclusion

A major driver, if not *the* major driver, for the rate design proposals discussed in this paper has been the success of existing NEM policies: NEM has helped to induce customers to install rooftop PV, leading to the situation where the vast majority of small-scale solar PV systems are engaged in net metering and over 98 percent of all NEM customers are generating power using solar PV (Stanton and Phelan 2013, pp. 1-3, 5). As Shah (2015) explains, NEM started as a simplifying compromise, based in part on the limited capabilities of last-century utility metering and billing systems. Additional data, he says, are needed "to consider the full array of costs and benefits to the retail customer and the utility."

Modern, digital meters and the associated data collection and billing systems should be readily capable of providing the complete data needed, and it makes sense to work expeditiously towards a time in the near-future when NEM can give way to a better system for accurately assigning benefits and costs. Smart-inverters and related communications and control technologies are enabling small, distributed generators to produce and deliver ancillary services, and new distribution system modeling capabilities are making it more practical to assess the costs and benefits associated with all kinds of DER and ancillary services. Therefore, information will gradually become available to help with the design of NEM or possible replacement approaches, to more accurately reflect all costs and benefits. MIT Energy Initiative (2015 p. xviii) concludes, the need remains for "pricing systems… that allocate distribution network costs to those that cause them, and that are widely viewed as fair."

Pérez-Arriaga and Bharatkumar (2014, pp. 1-2) observe, "As the nature of network use is transformed, regulators must entirely rethink the design of network charges." As they note, however, regulators must do so while trying to serve multiple regulatory objectives, such as:

> increased socialization and equity... decarbonization… infrastructure investment deferral, reliability, resilience, …and opportunities for enhanced power quality and more customer-tailored electricity service offerings.

The changes discussed in this paper are like the tip of the spear for a clash of two very different world views that Patterson (1999) observed many years ago, between the traditional model of monopoly services, centralized decision making, and centralized infrastructures, versus a new model based on technical innovation and broadly distributed, collaborative decision making and distributed technologies.

As Patterson (1999, pp. 180-182) pointed out, the two world views could be mutually exclusive, but "only experience will reveal." Fifteen years later, the electric utility industry and its regulators are still grappling with the two important questions Patterson (1999, pp. 16, 117) asked: (1) "How can we make the benefits of electricity, universally, reliably, and affordably available, without doing serious damage to the planet?"; and (2) "What might sustainable electricity look like, and how to we get there from here?" At present, the world looks substantially the same as the "chaotic panorama" that Patterson (1999, pp. 35-6) observed:

> [E]lectricity [is] in upheaval. Wherever you look, the immediate foreground is full of turmoil, turbulent and incoherent, with little clear indication of what might eventually emerge from the confusion. The guiding premises that have shaped electricity systems for the past century are now under challenge, where they have not already been overturned. The traditional system configuration… operating as a franchised monopoly, still dominates the scene. But its effortless preeminence is threatened.
>
> Long-accepted ground rules for technology, fuels, ownership, operation, management and finance are changing by the day. Technical innovation is altering options and priorities. … New participants are joining the fray, with aims and assumptions that often differ markedly from those traditionally taken for granted. Heart-stopping sums of money are changing hands. Power and influence are at stake, and incipient losers will struggle to the death. Two billion people are watching from the sidelines, waiting for electricity.

Kiesling (2015, p. 2) optimistically proposes that the technology advances already exist, capable of producing profound, positive changes in electricity infrastructure and markets, including lower costs, environmental improvements, and "untold thousands of jobs in new industries that today we cannot even begin to imagine." But, he says, "[f]or it to happen, we must overhaul an outdated regulatory structure… [and] modernize our regulatory structure to keep pace with our technological advances." As Kiesling explains, a regulatory structure that was established a century ago to protect large-scale, vertically integrated electric companies by maintaining legal barriers to entry is now being challenged by new entrants that require "a new regulatory superstructure" that provides minimal barriers to entry, and all participants need incentives for innovation and experimentation. No matter what final forms are being created by the combination of technology advances and existing or new regulatory practices, the dozens of proposed and newly implemented changes that are the subject of this paper could be just the start of even bigger changes to come.

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Appendix:
Summary of Recent and Pending Proposals

Table A-1 lists states with recent and open policy proposals that would affect electric utility rates for distributed energy resources (DER). This is not a comprehensive list of all states that have a specific policy: It lists only proposals and actions since the start of 2014. Neither is it a list of all policies that affect the costs and benefits associated with DER. Rather, it lists only those policies that would most directly affect rate designs.

In Table A-1, the first column indicates the name of the state or territory. The second column lists the topics of proposals or actions, including:

- Fixed charge increases for all small customers (labeled “Fixed charge”);
- Minimum bills for all small customers (labeled “Minimum bill”);
- Solar-only charge;
- DG-only charge;
- Net energy metering policy revisions (labeled “NEM policy”) or, more broadly, DER policy revisions (labeled “DER policy”);
- Net metering cost-benefit studies (labeled “NEM study”) or Value of Solar studies (labeled “VOS study”);
- Community-shared solar;
- Utility ownership of customer-sited PV (labeled “Utility ownership”); and,
- Third-party ownership.

Data in the third column indicates the initiator of the described actions, whether “L” for the state legislature, “R” for the state public utility regulatory authority, or “U” for one or more utilities. In that column, “L, R” means an activity started with the state legislature, which passed a law directing action on the part of the state regulatory authority, and now the action has shifted to the regulatory authority. Where a number in parentheses follows a letter U, it indicates the number of utilities with similar proceedings.

The fourth column, status, indicates whether legislation is enacted or has passed only one house in the state legislature; In keeping with the practices reported by Hoffer et al. (2014a, 2014b, and 2015), Inskeep, Kennerly et al. (2015) and Inskeep and Wright (2015), legislative activities are included in Table A-1 only if a proposed bill has, at a minimum, passed one house of a state legislature (as happened in Connecticut and New Hampshire). For regulatory dockets listed, whether initiated by a regulatory authority or by a utility, the fourth column states either “Open” or “Closed” to reflect the case status. In a few instances (Arizona, Iowa, Ohio, Wisconsin), state or federal courts are now considering or have recently ruled on specific issues.

As used in Table A-1: AC means alternating current; DER means distributed energy resources; DG means distributed generation; DR means demand-response; kW means kilowatts; IRP means integrated resource plan; MW means megawatts; PPA means power purchase agreement; PV means photovoltaic; REC means renewable energy certificate; RES means renewable energy standard; and VOS means value of solar.

Table A1: Proposed and Recently Implemented Changes in DER Rate Design (Since 2014, by U.S. State and Territory)

State	Categories	L/R/U	Status	Notes
Arizona	NEM policy	U (2)	Open	Two utilities propose setting the rate for excess generation credits equal to the utility wholesale renewable energy price. Dockets E01933A-15-011 and E-04204A-15-0099
	Solar-only charge	U (2)	Open	Two utilities are proposing increases: (1) In its general rate case, UniSource proposes doubling residential and commercial fixed charges, plus a mandatory demand-based rate for solar customers and changes to net metering, Docket E-04204A-15-0142; (2) Arizona Public Service (APS) proposes raising its solar-only charge from $0.70 per kW-month to $3.00/kW-month, Docket E-01345A-13-0248.
	DER policy	R	Open	Docket E-00000J-14-0415 is investigating solar DG business models and practices and the related impacts on utilities and ratepayers.
	Utility ownership	U	Closed	In Decision No. 74949 in Docket No. E-01345A-13-0140, Arizona Corporation Commission (ACC) approves a 2015 renewable energy plan for APS. APS had proposed up to 20MW of company-owned DG systems. In its 2016 renewable energy plan case, ACC directs the Company to file a report comparing company-owned and customer-owned DG, including feasibility, costs, and benefits. APS had also requested funding for a battery-solar integration research project, but it was not approved.
	DG-only charge	U	Closed, appealed to federal court	Salt River Project (SRP) is a public power provider not regulated by ACC. SRP adopted a Customer Generation Price Plan in March 2015, which includes an energy charge, demand-charge, and monthly service charge. Average charges to residential customers with DG were raised by approximately $50/month. SolarCity filed suit in federal court, claiming violations of anti-trust law.

Table A-1 (cont.): Proposed and Recently Implemented Changes in DER Rate Design (Since 2014, by U.S. State and Territory)

State	Categories	L/R/U	Status	Notes
Arkansas	NEM policy	L, R	Enacted, Open	Act 1221 of 2013 authorizes AR-PSC to establish rates terms and conditions of service for net metering, that may include net metering fees or charges, expanding net metering to non-renewable-resource facilities, and increasing the size limits for individual net metering systems.
	DER policy	L, R	Enacted, Open	Arkansas Distributed Generation Act of 2015 requires utilities to consider distributed, renewable energy in IRPs. The legislation directs AR-PSC to require utilities to develop and maintain standard contracts for DG, up to 20MW.
California	DER policy	R	Open	California Rulemaking 14-10-003 will "Create a Consistent Regulatory Framework for the Guidance, Planning, and Evaluation of Integrated Demand Side Resource Programs." An Aug 2015 Proposal for Decision (p. 26) calls for "the integration of demand side resources in a holistic way that includes not only what the utilities offer customers (integrated demand-side management) but also what customers offer the utility (integrated demand side resources)." This proceeding is also closely related to Rulemaking 14-08-013, a Distribution Resources Plans proceeding, which is focused on how "to minimize overall system costs and maximize ratepayer benefit from investments in distributed resources."
	NEM policy	L, R	Enacted, Open	A successor to net energy metering is to be determined by 12/31/15 in Rulemaking 14-07-002, to apply when a utility reaches a cap of 5% of its aggregate customer peak demand, or 1 Jul 2017, whichever is sooner.
(continued on next page)	Community solar	L, R	Enacted, Open	CPUC is considering issues related to program design, rate design, and more. A proposed decision is expected Nov 2015, and investor-owned utilities are expected to begin offering Green Tariff Shared Renewables (GTSR) service in 2016. Docket A1201008

Table A-1 (cont.): Proposed and Recently Implemented Changes in DER Rate Design (Since 2014, by U.S. State and Territory)

State	Categories	L/R/U	Status	Notes
California (continued)	Minimum bill	R	Open	In Docket 1206013 CA-PSC is considering a new residential rate design that would include $10 monthly minimum bills for residential customers for 2015-2018. Proposed decisions are under review.
	Fixed charge	U	Open	Pacific Gas & Electric Co. (PG&E) proposes changes to its Rate A-6, including a fixed monthly charge. http://www.cpuc.ca.gov/PUC/energy/drp/
Colorado	Community solar	R	Closed	CO-PUC Decision No. C14-1505 in Proceeding No. 13A-0836E raises caps for capacity in Public Service Company of Colorado (Xcel) service territory to the range of between 6.5 and 30MW per year for 2014, 2015, and 2016.
	DER policy, NEM policy	R	Closed	CO-PUC considered issues related to retail renewable distributed generation and net metering in Docket 14M-0235E. In its 26 Aug 2015 meeting, the Commission announced its intention to maintain the current net metering program and close the docket; the decision is forthcoming.
Connecticut	Fixed charge	R	Closed	In Docket 14-15-06, Connecticut Power & Light proposed fixed charge increases. CT-PURA approved an increase of about half the requested amount.
	Community solar	L, R	Enacted, Open	S.B. 928, passed June 2015, directs CT-Department of Energy & Environmental Protection (DEEP) to create a 3-year pilot "shared energy facility program" for renewable energy systems with nameplate capacity of 4MW or less, and at least two subscribers. Aggregate capacity of the pilot program is capped at 6MW. Third-party ownership is authorized.
	Fixed charge	L	Passed one house	S.B. 570 would have limited residential fixed charges to not more than $10 per month. It passed the Senate.
District of Columbia	Community solar	L, R	Enacted, Open	Docket RM9-2015-01-E is considering net metering amendments to allow third-party ownership and community net metering for systems up to 5MW.

Table A-1 (cont.): Proposed and Recently Implemented Changes in DER Rate Design (Since 2014, by U.S. State and Territory)

State	Categories	L/R/U	Status	Notes
Florida	NEM policy	U	Open	Tampa Electric Co. filed proposed modifications to its net metering tariff, in Docket 150099. The request is suspended, pending further review.
	DER policy	R	Open	FL-PSC issued a request for comments on solar energy development and programs and received 143 responses.
Georgia	Third-party ownership	L	Enacted	H.B. 57 passed the Georgia legislature unanimously. It opens opportunities for PPAs and leasing. The bill explicitly addresses residential systems smaller than 10kW and commercial systems smaller than 100kW. Larger systems are allowed, if they meet additional compliance rules. Georgia Power's unregulated affiliate, Georgia Power Energy Services, began selling and installing solar systems in July.
Hawaii	Community solar	L, R	Enacted, Open	Act 100 of 2015 establishes the Hawaii community-based renewable energy program, which provides for "a variety of community-based renewable energy projects, models, and sizes." The law directs utilities to collaborate with stakeholders on tariff design, prior to filing with the HI-PUC by 1 Oct 2015.
(continued on next page)	DER policy	R	Open	In August 2014, HI-PUC issued Order No. 32269 in Docket 2014-0192, to investigate DER technical, economic, and policy issues pertaining to the state's electric utilities. The HI-PUC 31 Mar 2015 Order No. 32727 in this Docket: (a) grants ten parties status as intervenors; (b) directs the utilities to "submit monthly reports on key technical developments to enable DER market growth," including listing energy storage systems deployed, customer non-export systems, customers subscribed and participating in existing DR programs, and utility utilization of advanced inverter capabilities; and (c) establishes a preliminary Statement of Issues and Procedural Schedule. Parties were directed to file Preliminary Statements of Position on the Phase 1 Issues within 60 days and proposals for revisions to interconnection tariffs, self-supply tariffs, and a

Table A-1 (cont.): Proposed and Recently Implemented Changes in DER Rate Design (Since 2014, by U.S. State and Territory)

State	Categories	L/R/U	Status	Notes
Hawaii (continued)				DER transition plan including tariffs for grid-supply systems within 90 days. A 50-page Staff Report and Proposal is attached to the Order.
	NEM policy, Minimum bill, DG only charge	U (3)	Open	In both its Power Supply Improvement Plan, Docket 2014-0183, and Distributed Generation Improvement Plan, Docket 2014-0192, Hawaiian Electric Companies propose changes in DG-rates for Hawaii's three investor-owned utilities. Participating parties, including utilities and intervenors, filed "final statements of position" in this docket on 29 Jun 2015.
Idaho	Fixed charge	U	Open	In its general rate case, Avista proposes a 62% increase in the residential fixed charge. Docket AVU-15-05
Illinois	NEM policy, Community solar	L, R	Enacted, Open	Docket 15-0273 is continuing. This case, at the ICC's own motion, is to amend net metering rules to reflect recent legislative changes and other modifications "intended to improve the operation of the net metering programs offered by electricity providers" (8 Apr 2015 *Initiating Order*, p. 1).
Indiana	Fixed charge	U	Open	In its general rate case, Indianapolis Power & Light requests a 55% increase in residential monthly fixed charges. Docket 44576 - NONE
Iowa	DER policy	R	Open	Iowa Utilities Board has opened a proceeding to explore distributed generation, including net metering and interconnection rules. Comments from interested parties were received April 2015. An "information guide" was issued Jan 2015. Docket NOI-2014-0001
	Third-party ownership	Court	Decided, No. 13–0642	Iowa Supreme Court ruled that a third-party owner is not a public utility under state law. *SZ Enterprises LLC d/b/a Eagle Point Solar v. Iowa Utilities Board*
(continued on next page)	NEM policy	R	Open	In Docket No. FCU-2015-0009, Eagle Point Solar, LLC, has filed a complaint with the Iowa Utilities Board, seeking a ruling that: (a) a net metering a system financed by a third party does not constitute a "resale" of energy; and (b) "large general service"

Table A-1 (cont.): Proposed and Recently Implemented Changes in DER Rate Design (Since 2014, by U.S. State and Territory)

State	Categories	L/R/U	Status	Notes
Iowa (continued)				customers (i.e., customers with rates having a demand charge) are eligible to net meter.
	DG-only charge	U	Open	In Docket No. TF-2015-0305, Pella Coop. Electric Assn. proposed an increase in fixed charges from $27.50 to $85 per month, for all interconnected generators. The Coop is not subject to IUB rate regulation. Multiple parties objected to the increase on the grounds that Iowa Code § 476.21 prohibits discrimination against a customer based on the use of renewable energy. On 27 Aug 2015, Pella withdrew its proposal.
Kansas	DG-only charge	L	Enacted	HB 2101 of 2014 authorizes utilities to propose minimum bills, time-differentiated rates, and other rate structures, for DG customers.
	Fixed charge, *or* Solar-only charge; Utility ownership; Community solar	U	Open	Westar Energy, in Docket 15-WSEE-115-RTS, requested more than a doubling of residential fixed charges, and a solar-only option of either a demand-charge or a fixed charge quadrupling. A pending settlement agreement would increase fixed charges for residential customers about 20% to $14.50 per month, but defer until the next rate case any action on a solar-only charge. In the same Docket, Westar also requested approval for voluntary wind and solar tariffs and a community based solar program, all for utility-owned projects. The proposed settlement agreement regarding solar would authorize WeStar to solicit customer subscriptions (minimum 1kW each), and construction of systems 1MW or larger only when 100% of the capacity is subscribed, with rates designed so that participating customers will cover 100% of project direct costs. The proposed settlement does not include the community solar program.
Kentucky	Fixed charge	U (3)	Closed	For Kentucky Power, KY-PSC approved a residential fixed charge increase of nearly 40%. Docket 2014-00396
(continued on next page)				For Louisville Gas & Electric, in Docket 2014-00372, the KY-PSC accepted a settlement agreement that did not include

Table A-1 (cont.): Proposed and Recently Implemented Changes in DER Rate Design (Since 2014, by U.S. State and Territory)

State	Categories	L/R/U	Status	Notes
Kentucky (continued)				the initially-requested fixed-charge increase. In Docket 2014-00371, KY-PSC accepted a settlement agreement for Kentucky Utilities, which did not include the initially-requested residential fixed-charge increase.
Louisiana	NEM study	R	Open	Docket X-33192 examines the impact of solar net metering on ratepayers. A draft study, released Feb 2015, shows that the costs of solar net metering outweigh benefits to ratepayers.
Maine	NEM study, NEM policy, VOS study	L, R	Enacted, Open	Am April 2014 law, The Maine Solar Energy Act, requires the ME-PUC to determine the value of distributed solar energy in the state. The Commission's VOS study was provided to the Maine legislature in April 2015. A Legislative "Resolve," HP 863, passed in June 2015, directs the PUC to convene a stakeholder group for the purpose of creating an alternative to net energy billing. A report on this process is due to the Legislature in Jan 2016.
Maryland	Fixed charge	U	Closed	In Docket No. 9368, Choptank Electric Cooperative sought a 70% increase in monthly fixed charges. The MD-PSC Order No. 86994, 12 May 2015, limited fixed charge increases to $1.25/month for residential and 25% for non-residential customers.
	Community solar	L, R	Enacted, Open	House Bill 1087, effective June 2015, provides for the MD-PSC to establish by May 2016 a 3-year pilot program for community solar, open to all rate classes, using a virtual net metering approach. Projects must be 2MW or less.
Massachusetts	NEM policy	R	Open	In Docket 15-77, SolarCity requests an advisory ruling, whether combined solar and storage systems can net meter under current statutes and regulations.
(continued on next page)	NEM policy	L, R	Enacted, Open	Chapter 251 of the Acts of 2014 established a Net Metering Task Force, to "review the long-term viability of net metering and

Table A-1 (cont.): Proposed and Recently Implemented Changes in DER Rate Design (Since 2014, by U.S. State and Territory)

State	Categories	L/R/U	Status	Notes
Massachusetts (continued)				develop recommendations on incentives and programs to support the deployment of 1,600MW of solar generation." The Task Force submitted its *Net Metering and Solar Task Force Final Report to the Legislature* in Apr 2015.
	NEM policy	L, R	Enacted, Closed	MA-DPU issued a Jan 2015 Order in Docket No. 14-104, establishing rules changes for net metering, including provisions for agricultural net metering and neighborhood net metering, setting a 10MW maximum sum-of-nameplates capacity for net metering by a municipality or other governmental entity.
	NEM policy	L, R	Enacted, Open	Docket No. 14-118 is investigating adding small hydro and increasing aggregate caps on net metering.
Michigan	Community solar	R	Closed	Consumers Energy proposed a 10MW program in Docket 17752. MI-PSC approved the tariff in its 14 Aug Order.
	Fixed Charge	U	Open	Detroit Edison, in general rate case Docket 17767, requests a 2/3 increase in residential fixed costs.
	DER Policy	U	Open	In Docket 17875, Consumers Energy proposes to facilitate customer DG applications, by matching interested customers with pre-qualified PV vendors and financing.
Minnesota	Community solar	R	Closed	An approved settlement in Docket No. 13-867 limits to not more than 5MW(AC) the size of co-located community solar installations.
	NEM policy	L	Enacted	The 2015 Minnesota Jobs and Energy Act changes the state's net metering program (pp. 74-75). Beginning 1 Jul, a municipal utility or co-op can begin charging new net metering customers a "reasonable and appropriate" fee for customers who generate their own electricity through wind or solar.
(continued on next page)	NEM policy	R	Open	Docket No. 13-729 proposes rules to allow optional kilowatt-hour credits for monthly net excess generation, in place of the

Table A-1 (cont.): Proposed and Recently Implemented Changes in DER Rate Design (Since 2014, by U.S. State and Territory)

State	Categories	L/R/U	Status	Notes
Minnesota (continued)				avoided cost rate. The proposal also clarifies standby charges and REC ownership.
	Fixed charge	U	Closed	In a general rate case E-002/GR-13-868, Xcel requested monthly fixed charge increases for residential and small commercial customers. On 26 Mar 2015 (see Press Release, 27 Mar), MN-PUC rejected the increase.
Mississippi	NEM policy, NEM study	R	Open	Mississippi is considering net metering. Public comments were requested by 1 Jul 2015 in Docket No. 2011-AD-002. A Sep 2014 report prepared for MS-PSC, Net Metering in Mississippi, found net benefits from net metering under almost all scenarios and sensitivities studied.
Missouri	Fixed charge	U (2)	Open	In Docket ER-2014-0351, Empire District Electric proposed a residential monthly fixed charge increase of about 50%. In June 2015, parties filed a unanimous "Revised Stipulation and Agreement and List of Issues," stipulating there will not be a fixed charge increase "at this time." In Docket ER-2014-0370, Kansas City Power & Light requested almost a tripling of residential fixed charges. A "Non-Unanimous Stipulation and Agreement" (to which KCP&L objects) recommends no increase in the residential fixed charge.
Montana	NEM study	L	Enacted	Montana Legislature passed a Joint Resolution Apr 2015. An interim committee will study net-metering costs and benefits by Sep 2016. S.J. 0012
	Fixed charge, Solar-only charge	U	Open	In its general rate case, Montana-Dakota Utilities requests a nearly 40% increase in the basic residential service charge, plus a demand-charge for net metering customers of $1.50/kW of maximum demand. Docket D2015.6.51
Nevada (continued on next page)	NEM policy	L, R	Enacted, Open	S.B. 374 changes the aggregate capacity limit for net-metering from 3% of total peak capacity for all utilities to a total of 235MW. Net metering tariffs may now include separate rate classes or monthly

Table A-1 (cont.): Proposed and Recently Implemented Changes in DER Rate Design (Since 2014, by U.S. State and Territory)

State	Categories	L/R/U	Status	Notes
Nevada (continued)				fees. Electric utilities were to submit by 31 Jul new net metering tariffs to take effect once the 235MW cap is reached.
	NEM policy	U (2)	Open	Proposals are being reviewed in Dockets 15-07041 for Nevada Power and 15-07042 for Sierra Pacific Power. A draft order discussed in the NV-PUC 26 Aug 2015 meeting would provide for interim net metering tariffs and for an additional hearing to commence on 18 Nov 2015.
	DER policy, NEM study	R	Closed	In Docket No. 14-06009, Mar 2015 Order 44816, NV-PUC, accepted a report exploring whether a separate customer class should be established for net metering or distributed generation customers. The report calls for cost-of-service studies, prior to making a determination. A previous Net Metering Study found that net metering benefits exceed costs in Nevada.
	Fixed charge	U	Closed	In Docket 14-05004 NV-PUC approved a general rate case settlement for NV Energy's southern service territory, which includes a residential fixed-charge increase of about 1/3, roughly half the initial request.
New Hampshire	NEM policy, Community solar	L, R	Enacted, Closed	2013 N.H. Laws Ch. 266 (SB 98) authorizes group net metering up to 1MW, and directs NH-PUC to establish a process for verifying group requirements and registering group hosts. Those provisions were added to NH Net Metering Rules, adopted 7 Jan 2015 in Rulemaking Docket DRM 13-311.
	NEM study, Utility ownership	L	Passed one house	Proposed SB 117 would have required NH-PUC to initiate a proceeding for the study of net metering, standard offer contracts, and feed-in tariffs for customer-sited resources. Plus, the bill would have provided for electric utilities to seek recovery for owning or investing in DER.
New Jersey	NEM policy	L	Enacted	A new law, S2420, raises the trigger for net metering review from 2.5% of peak demand to 2.9% of each provider's prior-year sales. NJ net metering already surpassed the previous 2.5% trigger, but had not been capped by NJ-BPU.

Table A-1 (cont.): Proposed and Recently Implemented Changes in DER Rate Design (Since 2014, by U.S. State and Territory)

State	Categories	L/R/U	Status	Notes
New Mexico	NEM policy, Fixed charge, Solar-only charge	U	Closed	In Docket 14-00332-UT, Public Service NM proposed: (a) eliminating the carry-over of customer credits for net excess generation; (b) implementing a solar DG interconnection fee based on system size; and (c) increasing its residential fixed charge by 2-1/2 times. The request was rejected by NM-PRC because the application was incomplete. PNM is expected to refile its rate case in Sep 2015.
	Fixed charge	U	Open	In Docket 15-00127-UT, El Paso Electric requests about a 40% fixed-charge increase, from $7 to $10/month.
New York	NEM policy	R	Closed	Dockets 14-E-0151/14-E-0422 change remote net metering rules from a monetary to a volumetric credit. A NY-PSC 27 Feb 2015 Order postpones action on aggregate net metering, until additional review is completed.
	NEM policy	R	Open	NY-PSC initiated proceedings in Dockets 15-01056/15-E-0267, to consider whether remote net metering can be restricted to host-satellite relationships involving a single generator.
	Community solar	R	Open	NY-PSC initiated Docket 15-E-0082 to develop a community net metering program.
	Fixed charge	U (2)	Open	Two cases are Open: (1) in Docket 15-00262, PSEG Long Island requests a near-doubling of fixed charges for residential and small commercial customers; and (2) in Docket 15-01094/15-E-0285, New York State Electric & Gas Corp. requesting a 36% increase for residential,
(continued on next page)	Fixed charge	U (2)	Closed	Two cases have Closed: (1) In Docket 14-01484/14-G-0319, Central Hudson Gas & Electric requested a 21% increase, which was not approved; and (2) In Docket 15-00270/15-E-0050, Consolidated Edison proposed a 14% increase, but an approved settlement freezes rates at current levels.

Table A-1 (cont.): Proposed and Recently Implemented Changes in DER Rate Design (Since 2014, by U.S. State and Territory)

State	Categories	L/R/U	Status	Notes
New York (continued)	DER policy	R	Open	In the New York Reforming the Energy Vision (REV) process in Case No. 14-M-0101, the NY-PSC Staff issued a 28 Jul 2015 Report on Ratemaking and Utility Business Models. The Report's purposes are to "(1) describe the limitations embedded in current ratemaking practices in the context of REV, (2) describe the direction of comprehensive ratemaking and business model reforms, and (3) make recommendations for near-term reforms where possible" (p. 4). Comments are due 15 Oct, and Reply Comments 2 Nov 2015.
North Carolina	Third-party ownership	R	Open	Docket SP-100 Sub 31 is a request for declaratory ruling to NCUC, for a proposed solar PPA with a church. The question is whether, under NC law, the solar provider will be considered a "public utility." NC General Statutes § 62-3(23)
Ohio	NEM policy	Court, R	Open rulemaking	OH Supreme Court Case 2014-1290 directs the PUCO to consider changes in net metering. The Court briefing schedule is suspended, awaiting the outcome of PUCO rulemaking, which is open in Case No. 12-2050-EL-ORD. A technical workshop was held 5 May 2015.
Oklahoma	DG-only charge Fixed charge	L U	Enacted Closed	S.B. 1456 of 2014 authorizes a utility option to request a new rate class for service to customers with DG. The first utility filings are expected in 2015. The law allows utilities to apply for a higher fixed charge or demand charge on net metering customers. Oklahoma Gas and Electric Co. is expected to file a DG tariff in its rate case, and Public Service Co. of Oklahoma is expected to file a stand-alone DG tariff, before year-end. In Docket PUD 201300217, a residential fixed charge increase of almost 25% was approved for Public Service Co of OK.
Oregon (continued on next page)	Community solar	L, R	Enacted, Open	H.B. 2941 directed OR-PUC to open a proceeding on community solar, Docket No. UM-1746, to examine program designs and consider ratepayer access, the role of utilities, and program costs. OR-PUC shall recommend a community solar program design to the Legislature, by 1 Nov 2015.

Table A-1 (cont.): Proposed and Recently Implemented Changes in DER Rate Design (Since 2014, by U.S. State and Territory)

State	Categories	L/R/U	Status	Notes
Oregon (continued)	NEM study, VOS study	L, R	Open	Docket No. UM 1716, in response to 2013 Oregon Law H.B. 2893, is a Commission proceeding to determine the resource value of solar energy and whether net metering results in cost shifts. H.B. 2893 directs the PUC to: (a) Investigate the resource value of solar energy, (b) Investigate the costs and benefits of the existing solar incentive programs, (c) Forecast future costs for solar energy systems, (d) Identify barriers to the development of solar energy systems, and (e) Recommend new programs or program modifications that encourage solar development in a way that is cost effective and protects ratepayers.
	Fixed charge	U	Open	In a general rate case, Docket UE 294, Portland General Electric requests a 10% increase in residential fixed charges.
Pennsylvania	NEM policy	R	Open	PA-PUC proposes many clarifications and revisions to the state's existing net metering and interconnection rules. Docket L-2014-2404361
	Fixed charge	U (4)	Closed	Four utilities requested increases. Joint settlements were approved, including increases ranging from about 15% to 25%. Dockets: R-2014-2428745, R-2014-2428743, R-2014-2428742, and R-2014-2428744.
	Fixed charges	U (2)	Open	Two utilities are requesting increases, respectively of about 40% and 70%, in Dockets R-2015-2468981 and R-2015-2469275.
	NEM study	L, R	Enacted, Report filed	The State, under Act 129 of 2008, commissioned a DG Potential Study including total resource cost (TRC) standard benefit/cost testing. Based on methodology prescribed in the law, most notably a prescribed maximum 15-year measure life, solar PV does not presently pass the TRC test. But, the report notes customer willingness to pay and added customer benefits can allow for PV to have low acquisition costs and produce value to ratepayers.

Table A-1 (cont.): Proposed and Recently Implemented Changes in DER Rate Design (Since 2014, by U.S. State and Territory)

State	Categories	L/R/U	Status	Notes
Rhode Island	NEM policy	L, R	Enacted, Open	S.B. 0081, passed Jun 2015, directs RI-PUC to consider rate design and cost allocation taking into account the effects of net metering and increasing distributed energy resources. The PUC is hearing this issue in Docket 4545. The law directs RI-PUC to issue an order before March 2016, with the new rates taking effect after April 2016.
South Carolina	DER policy, DER study	L, R,	Enacted, Closed	2014 Act No. 236 (S.1189) establishes voluntary DG programs for utilities. Under Act. 236, the SC-Office of Regulatory Staff (ORS) requested public input regarding "the fixed costs, fixed charges, and the extent of cost-shifting attributable to distributed energy resources within current utility cost of service ratemaking methodologies, cost allocations, and rate designs." Responses were due 15 Sep.
	DER policy, Community solar	U (3)	Closed	Also under Act 236, three SC utilities filed Distributed Energy Resource Program (DERP) applications. The cases are: Duke Energy Carolinas, in Docket 2015-55-E, SC Electric & Gas Co. in Docket 2015-54E, and Duke Energy Progress, Inc., in Docket 2015-53E. The Duke company settlements provide for: issuing RFPs for new renewable capacity; up-front solar rebates; NEM incentives; and shared-solar programs. Plus, SC-ORS is "strongly encouraged" to establish a task force for education and consumer protection related to the DERP.
(continued on next page)	NEM policy, NEM study	R	Open	A settlement agreement makes SC the 44th state to approve net metering. Docket 2014-246-E. The SC-PSC Order No. 2015-194 approves a settlement agreement that includes a comprehensive list of components to be included in calculating DG benefits and costs. In that same Order, SC utilities are directed to provide net metering tariffs.

Table A-1 (cont.): Proposed and Recently Implemented Changes in DER Rate Design (Since 2014, by U.S. State and Territory)

State	Categories	L/R/U	Status	Notes
South Carolina (continued)	NEM Policy	U (3)	Open	Proposed utility tariffs would use on-peak and off-peak rates for net metering and valuing net excess generation. Docket 2015-205-E (SC G&E), Docket 2015-204-E (Duke Energy Progress), and Docket 2015-203-E (Duke Energy Carolinas)
Tennessee	DER policy	R	Open	Tennessee Valley Authority (TVA) is not regulated by the Tennessee Regulatory Authority, but TVA provides power to utilities in most of Tennessee, plus parts of Mississippi, Kentucky, Alabama, Georgia, North Carolina, and Virginia. TVA's goal is to develop new residential and commercial DER programs by 2016. A public report is forthcoming.
Texas	DER policy	R	Open	Electric Reliability Council of Texas (ERCOT) proposes allowing DER to earn wholesale prices for energy, if aggregated in areas where power delivery is expensive. A DER Task Force is formed within ERCOT's Reliability and Operations Subcommittee.
	Fixed charge	U	Open	In Docket 43695, El Paso Electric seeks a 25% increase.
Utah	Fixed charge, Minimum bill, NEM-only charge	U	Closed	In general rate case Docket No. 13-035-184 PacifiCorp (Rocky Mountain Power) requested increases in monthly customer charges and in minimum bills, and proposed a new facilities charge of $4.65 per month for net metering customers. In its 29 Aug 2014 Order, UT-PSC increased both monthly charges and minimum bills, each by $1 per month, but did not implement the facilities charge.
	NEM study	L, R	Enacted, Open	2014 SB 208 set the structure for benefit/cost studies, to be completed by 3Q15. UT-PSC opened Docket No. 14-035-114 to review net metering costs and benefits. A PacifiCorp residential load study is expected by Sep 2015, and an analytical framework for cost-benefit study will be set by the end of the third quarter 2015.

Table A-1 (cont.): Proposed and Recently Implemented Changes in DER Rate Design (Since 2014, by U.S. State and Territory)

State	Categories	L/R/U	Status	Notes
Vermont	NEM policy	L	Enacted	2015 Act 56 changes the default owner of RECs from net metered systems from the generator to the utility, effective Jul 2015. The utility will be obligated to retire those RECs, toward RES compliance. Beginning Jan 2017, net metering credits will be reduced for customers who keep ownership of their RECs.
	NEM policy	L, R	Enacted, Open	2014 Act 99 directs VT Public Service Board to hold stakeholder workshops and then propose revised net metering program rules by 1 Jan 2016.
	NEM policy	L	Enacted	SB 1395, effective Jul 2015, doubled the eligible size, from 500kW to 1MW, for non-residential customer net metering.
Virginia (continued)	NEM Policy	U	Open	In Docket PUE-2015-00040, Appalachian Power Company (APCo) proposes an experimental program for certain large, non-residential customers. Instead of net metering, APCo would buy all system production under a Renewable Output Credit (ROC), which would vary monthly, based on PJM market prices for energy, capacity, and transmission. Participating customers will also incur an extra monthly charge of $30.
	Third-party ownership	L	Enacted, Open	Previously, S.B. 1023 of 2013 directed VA-CC to implement a third-party PPA pilot program with an aggregate cap of 50MW.
Washington	Fixed charge	U	Open	In Docket UE-150204, Avista Utilities requested a fixed charge increase. A settlement agreement reached in May 2015, still pending before the Commission, would drop the fixed charge increase.
West Virginia	NEM policy	L, R	Enacted, Open	H.B. 2201 net metering amendments passed in March 2015, prohibiting intra-class cross-subsidies and requiring WV-PSC to review net metering for the purpose of adopting rules. The case number is 15-0682-E-GI.
	Fixed charge	U (2)	Closed	In general rate cases, WV-PSC approved 60% fixed-charge increases for two companies. Dockets 14-1152-E-42T and 14-1151-E-D

Table A-1 (cont.): Proposed and Recently Implemented Changes in DER Rate Design (Since 2014, by U.S. State and Territory)

State	Categories	L/R/U	Status	Notes
Wisconsin	Solar-only charge	U	Closed, Court appeal open	In Docket No. 5-UR-107, WI-PSC approved for Wisconsin Electric Power Co. a monthly demand charge of $3.79/kW-month for net metering customers with "intermittent generation." That order was appealed in Dane County Circuit Court, in Case No. 15-CV-0153.
	Fixed charge, NEM policy	U	Closed, Court appeal open	In a 2013 general rate case Docket No. 6690-UR-122, Wisconsin Public Service (WPS) requested and was granted increases in monthly customer charges and demand charges along with decreases in energy charges. In addition, WPS requested changes to net metering rules, including reducing the maximum system size from 100kW to 20kW. The Commission decisions regarding net metering were appealed, and the Circuit Court remanded the decision for additional fact finding. The Commission has appealed the Circuit Court decision in Wisconsin Court of Appeals Docket 2015AP0911.
	Fixed charge	U	Closed	In a general rate case Docket No. 6690-UR-123, WI-PSC approved, for most Wisconsin Public Service Corp. customer classes, fixed charge increases combined with energy cost decreases.
	Fixed charge	U	Open	Xcel (Northern States Power), in Docket No. 4220-UR-121, requests a residential fixed charge increase about 2-1/4 times, to $18 per month.
	Community solar	U	Closed	Xcel (Northern States Power) tariff is approved in Docket No. 4220-TE-101.
	Community solar	U (2)	Closed	Two municipal utilities received conditional approval of identical community solar tariffs: New Richmond in Docket No. 4139-TE-102 and River Falls in Docket No. 5110-TE-102.

Source: Author's construct based mainly on data reported in Hoffer et al. 2014a, 2014b, and 2015; Inskeep, Kennerly, et al. 2015; Inskeep, Wright, et al. 2015a and 2015b; with additional information retrieved from Advanced Energy Economy *PowerSuite* and Advanced Energy Legislation Tracker *Search Advanced Energy Legislation* [On-line databases].