FTC Testimony, Solar Electricity Project P161200

Comments submitted by Ashley Brown, Executive Director, Harvard Electricity Policy Group, Harvard Kennedy School, Harvard University[1]

Introduction

I am submitting the comments below in response to the questions posed in the request for public comment in preparation for the FTC's upcoming workshop on competition and consumer protection issues in solar power. I have not answered every question, but I have organized my comments around the categories and questions suggested. After a brief discussion of my personal background and qualifications, I make the following main points:

- Current state of the solar industry: While the costs of rooftop photovoltaic panels have been declining very dramatically, the costs of installed systems have not kept pace. The fact is that the declining costs of the panels are simply not being passed on to consumers, as one might expect to happen in a competitive, or even a regulated cost based, market. Evidence from MIT and from the Lawrence Berkley National Lab suggests that American consumers of rooftop solar may be paying a premium, compared to other parts of the world. And despite the impressive declines in solar panel costs, rooftop solar remains the least cost-effective form of energy generation widely in use today. I review the additional non-energy benefits claimed for distributed solar generation, concluding that these either exist only for the solar dg customer themselves, or, where they do provide system benefits, they do so only in some specific cases, as opposed to generally providing the benefits. Indeed, in many cases, they cause additional costs to be incurred. Meanwhile, the technologies, such as solar tracking, energy storage, and smart inverters, that could help to enhance the value of distributed solar energy are not incentivized under retail net metering.

[1] I note my title for identification purposes only. My comments reflect my opinion only and do not purport to represent the views of the Harvard Electricity Policy Group or any other entity with which I may be affiliated.

June 6, 2016

FILED VIA ONLINE SUBMISSION

Federal Trade Commission
600 Pennsylvania Avenue, N.W.
Washington, D.C. 20530

Re: "Something New Under the Sun: Competition & Consumer Protection Issues in Solar Energy," Project No. P161200

To Whom It May Concern:

My name is Ashley Brown, Executive Director of the Harvard Electricity Policy Group (HEPG), a program of the Mossavar-Rahmani Center for Business and Government at Harvard University's John F. Kennedy School of Government. I am submitting comments concerning the workshop entitled "Something New Under the Sun: Competition & Consumer Protection Issues in Solar Energy" taking place on June 21, 2016. The FTC has asked interested parties to file comments by June 7, 2016, in order to be considered at the workshop. I appreciate the opportunity to submit a comment.

Sincerely,

- Net Metering: Pricing Solar DG at Retail: Turning to retail net metering itself, I discuss the major problems with this pricing approach: cross subsidies, poor short term and long term incentives for optimizing distributed solar generation, and market distortions that create a bias toward distributed solar generation over competing alternatives (such as utility-scale solar) that provide the same benefits at a greatly reduced price. I outline some choices and factors to consider in reforming pricing for solar dg, briefly explaining the idea of a three part tariff and why it best meets the goal of applying the "cost causer pays" standard to solar dg customers.
- Competition issues: There are competition issues associated with RNM, I argue, but the competition is not between distributed solar generation and the utility. In fact, RNM is causing an absence of robustness in competition among solar providers, and between solar providers and providers of alternative ways of achieving energy savings and environmental benefits, the objectives being sought by customers who invest in distributed solar generation. By providing a benefit available only to rooftop solar, RNM puts more efficient utility-scale renewables, such as wind and solar, at a severe competitive disadvantage. It has the same adverse impact on the deployment of demand side technology and programs that enable greater efficiency in both the use of energy and reduce the need for capacity. Furthermore, simple RNM pricing fails to provide any incentives for technologies, such as storage, smart inverters, tracking, etc., that could enhance the value of rooftop solar itself, setting up an economic paradigm in which the rooftop technology has no incentive to evolve into a more efficient, more productive energy source and mainstreaming it into the nation's energy resource portfolio.
- Consumer protection issues: I touch on only a few points here: the importance of communicating to customers that all rates are subject to revision; the tricky issue of the resale of renewable energy credits, which may often not be well understood by customers; and the practice of robocalling with false information by solar dg vendors, with which I have painful personal experience.

Personal Background and Qualifications

I am the Executive Director of the Harvard Electricity Policy Group (HEPG) at the Harvard Kennedy School, at Harvard University. HEPG is a "think tank" on electricity policy, including pricing, market rules, regulation, environmental and social considerations. HEPG, as an institution, never takes a position on policy matters, so this paper represents solely my opinion, and not that of the HEPG or any other organization with which I may be affiliated.

I am an attorney. I served 10 years as a Commissioner of the Public Utilities Commission of Ohio (1983-1993), where I was appointed and re-appointed by Democratic Governor Richard Celeste. I also served as a member of the National Association of Regulatory Utility Commissioners (NARUC) Executive Committee and as Chair of the NARUC Committee on Electricity. I was a member of the Advisory Board of the Electric Power Research Institute. I was also appointed by the U.S. Environmental Protection Agency as a member of the Advisory Committee on Implementation of the Clean Air Act Amendments of 1990. I am also a past member of the Boards of Directors of the National Regulatory Research Institute and the Center for Clean Air Policy. I have served on the Boards of Oglethorpe Power Corporation, Entegra Power Group, and e-Curve, and as Chair of the Municipal Light Advisory Board in Belmont, MA. I serve on the Editorial Advisory Board of the *Electricity Journal*.

I have been at Harvard continuously since 1993. During that time I have also been Senior Consultant at the firm of RCG/Hagler, Bailly, Inc. and have been Of Counsel to the law firms of Dewey & LeBouef and Greenberg Traurig. I have also taught in training programs for regulators at Michigan State University, University of Florida, and New Mexico State University (the three NARUC sanctioned training programs for regulators), as well as at Harvard, the European Union's Florence School of Regulation, Association of Brazilian Regulators, and a number of other universities throughout the world. I have advised the World Bank, Asian Development Bank, and the Inter-American Development Bank on energy regulation, and have advised governments and regulators in more than 25 countries around the world, including Brazil, Argentina, Chile, South Africa, Costa Rica, Zambia, Ghana, Tanzania, Namibia, Equatorial Guinea, Liberia, Mozambique, Hungary, Ukraine, Russia, India, Bangladesh, Saudi Arabia, Indonesia, and The Philippines. I have written numerous journal articles and chapters in books on electricity markets and regulation, and am the co-author of the World Bank's *Handbook for Evaluating Infrastructure Regulation.*

I hold a B.S. from Bowling Green State University, an M.A. from the University of Cincinnati, and a J.D. from the University of Dayton. I have also completed all work, except for the dissertation, on a Ph.D. from New York University. My current CV is provided as an attachment.

The Current State of the Solar Industry

Costs of Solar DG: Fast declines in technology costs, slower declines in system costs

MIT's *Future of Solar* study, published in 2015, presents a good overview of recent developments in solar costs in the United States, including costs specific to rooftop solar systems. Although the fundamental PV technology is the same for both rooftop and utility-scale solar, MIT researchers found that, while both sectors benefitted from declining panel costs, there is a significant gap in how much of this decline has translated into lower prices for installed PV systems and benefits for consumers, solar and non-solar alike.

The following are some highlights of the MIT findings:

- Steep declines in the price of panels. To pick one illustrative time interval, panels that cost $4 per watt in 2008 cost less than $1 per watt in 2014.[2]
- Slower decline in the cost of installed rooftop solar system
- An ever-growing share of costs are "balance of system" costs (labor, customer acquisition, profit margins);

After noting the steep declines in the price of the panels themselves, cited above, the study goes on to review trends in overall system costs (including installation costs)—again, declining in recent years, but far more slowly than the costs of the panels themselves. MIT found about a 50% decline in total solar costs for residential systems over the 2008-2014 time period.[3] Most of this decline, MIT notes, has been driven by declining solar panel costs—and as these costs have declined, the "balance of system" (BOS) costs have become a larger and larger share of the total costs of a PV system:

> *In 2008, BOS costs accounted for a little more than half of a residential system's price and about 40% of the price of a utility system. By 2014, the relative importance of BOS costs had grown to the point where these costs accounted for 85% of the price of a typical residential PV system and nearly 65% of the price of a utility-scale system.*

What this means is that the scope for cost reductions driven by cheaper solar technology is limited. Even if the hardware for residential solar were suddenly free, this would only reduce

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[2] MIT *Future of Solar* study, p. 79, available online at https://mitei.mit.edu/system/files/MIT%20Future%20of%20Solar%20Energy%20Study_compressed.pdf

[3] MIT *Future of Solar,* p. 80.

residential system costs by 15%. As the MIT study, *The Future of Solar Energy,* observes, "the future of PV technology will be strongly influenced by the PV industry's ability to sustain recent price declines." (77) It is likely that this will become increasingly challenging as balance of system costs become an ever greater share of the cost of a pv system—labor costs, customer outreach costs, and profit margins may not be susceptible to the kind of startling price declines that have been seen in solar pv technology.

Evidence suggests that prices charged for rooftop solar systems in the US may be inflated

Evidence suggests that net metering as it is currently implemented in the United States is not helping to reduce the costs paid by solar customers. The MIT *Future of Solar* researchers compared the 'bottom up" costs of a system (established by adding known or estimated costs associated with pv panels, labor, profit margins, etc.) with the actual prices charged for these systems, and found, specifically in the residential pv sector, a "striking differential" between MIT's estimate of the cost of installing residential PV systems (including a profit margin) and the reported average prices for residential PV systems—actual prices for residential systems were approximately 150% of MIT's cost estimate—a difference between cost and price not observed for utility-scale installations. (86) This may have something to do with why a recent study by Lawrence Berkeley National Labs found that out of six countries it compared to the U.S. (Germany, Japan, Italy, China, France, and Australia), only France had higher costs for installed residential PV systems.[4] This phenomenon of dramatically declining costs of the panels coupled with the reality of installed costs declining (if declining at all) at a much slower pace is almost certainly caused by the fact that retail net metering sets an arbitrarily high price for panel vendors and installers that obviates any competitive need to pass on declining cost to consumers. RNM simply removes any meaningful market and/or cost based regulatory pressures to pass on declining costs to consumers. The absence of those pressures means that declining costs are not only retained by the solar vendors and not passed on to the public, but also means that rooftop solar technology will not evolve into a fully competitive, highly productive mainstream energy source. In short, RNM has become a tool for enriching an entrenched corporate interest, not only at the expense of consumers, but also at a severe cost to the very technology they are trying to sell.

It is worth noting that the MIT study finds no similar pattern in the costs of utility-scale solar technology. This sector relies on the same basic pv technology, subject to the sme price

[4] Barbose, Galen and Naim Darghouth. *Tracking the Sun VIII: The Installed Price of Residential and Non-Residential Photovoltaic Systems in the United States.* Lawrence Berkeley National Laboratory (August 2015).

declines that have been seen in rooftop solar, but here balance of system costs are only 65% of the total costs of the system, and actual installed system prices closely match MIT's bottom up estimate of actual system costs.[5]

Comparative Cost of Residential Solar DG

The sharp declines in solar panel costs and slower declines in solar system costs to date have not been enough to make residential solar competitive with other generation sources. The latest annual update of Lazard's *Levelized Cost of Energy Analysis* (like the analysis of previous years) shows this, with a levelized cost for rooftop solar ranging from $184-$300 per MWh, higher than all other energy sources analyzed, including fuel cell, solar thermal, utility-scale solar, geothermal, biomass, wind, and energy efficiency.[6] To put this number in context, thin film utility scale solar pv came in at $50-$60 per MWh, and combined cycle natural gas at $52 to $78 per mWh.[7] This is a very significant gap.

Additional costs and benefits of residential solar pv

It is common at this point to ask whether a brute comparison of levelized costs is really fair to residential solar pv. Are important benefits being left out of the calculation here? For example, what about the benefits associated by the fact that residential solar pv has no marginal carbon emissions when it generates electricity? A number of other possible benefits are also suggested.

To address this question, I will do the following:

- Review a number of specific benefits attributed to residential solar. Some, I will argue, do not provide value at all, or do not provide value to anyone other than the individual solar panel owner. Other "values" depend greatly on particular circumstances.
- Review some potential additional costs imposed on the system in order to incorporate rooftop solar

[5] MIT *Future of Solar*, pp. 85-86.

[6] *Lazard's Levelized Cost of Energy Analysis-Version 9.0.* November 2015. Data cited is from p. 2 table, "Unsubsidized Levelized Cost of Energy Comparison." Full report available online at https://www.lazard.com/media/2390/lazards-levelized-cost-of-energy-analysis-90.pdf

[7] The "levelized cost" is an imperfect comparison—one problem is that it does not account for the greater value provided by a dispatchable vs. non-dispatchable resource (thus, it would be a mistake to leap to the conclusion, based on the above numbers, that utility-scale solar is a better investment than natural gas). However, this flaw suggests that, if anything, levelized cost analysis overstates the value of rooftop solar.

- Step back from the assessment of individual benefits and costs to note that all of the above kind of analysis should be treated with extreme caution, as inherently arbitrary, and lacking the vital context of knowing what other resources might be able to provide in a truly competitive market.
- Review some of the opportunities to enhance the benefits provided by rooftop solar through appropriate technology.

Benefits attributed to rooftop solar

There are a number of different ways potential benefits and costs of rooftop solar are addressed in different studies. In many cases, the "values" proposed are either non-existent or presented in a one-sided manner that ignores offsetting costs as well as market realities.. Even benefits such as avoided energy costs (which seem undeniable), can be very hard to quantify reliably, especially when attempts are made to look decades into the future. In what follows, I review a number of possible benefits frequently mentioned when a "Value of Solar" analysis is urged. Generally speaking, whether benefits to the system arise from distributed generation is a highly context-specific question, as I explain below.

Avoided energy use

Avoided energy use is one impact of rooftop solar that seems to have the virtue of clearly existing and being positive in value. However, there are often contentious issues regarding how to calculate those energy savings. The issue is whether the savings should be calculated on an average basis, or calculated more precisely by establishing the energy costs saved in the hour the rooftop solar system generates electricity. Since rooftop solar is almost always non-coincident with peak, crediting rooftop solar at average prices fails to precisely capture the market value of the energy. Thus, determining the value of the energy becomes a subject for debate. Hence, every VOS study will have to make assumptions about how to calculate energy value, and those assumptions are both controversial and can, in and of themselves, be manipulated in order to drive the value calculations up or down.

Moving from short term analyses to calculations projected out in time, assessing energy value becomes largely unreliable. That circumstance is not necessarily remedied by the use of futures markets and forecasts of natural gas prices, resources that many VOS analyses rely upon. These are, to understate the point, far from infallible. For example, I don't believe any of them predicted the current natural gas prices of approximately $2/MMBtu. The fact is that the price of energy is in a constant state of hourly flux, but authors of VOS studies typically ignore the

realities of those market prices and substitute some proxy that helps achieve a desired outcome.

Avoided system losses and congestion

Whether or not rooftop solar systems reduce the amount of energy lost in generation, long distance transmission and distribution is a fact specific question. While there may be circumstances where that is true, it is flat wrong to claim that solar PV systems, *ipso facto*, reduce losses. On distribution systems, even the theory underlying this claim is controversial among experts. The truthful answer appears to be that sometimes rooftop solar reduces energy losses on the distribution system, but often does not, and, indeed, could in some circumstances actually cause more losses. The validity of the claimed loss avoidance is very situation specific.

With regard to transmission losses, it is certainly true that solar PV installations on distribution systems do not rely on high voltage transmission. Despite that, rooftop solar does, in fact, impact the transmission system because of its intermittent nature and its steep ramps up and down, which require utilities to be able to quickly bring other resources on line in ways that can have impacts on transmission congestion, depending on the specific configuration of the system at a particular location. . Rooftop solar also can have very real impact on congestion because the amount of energy being imported or not imported into the low voltage distribution grid inevitably makes its impact felt in the flows on the transmission grid. That value could be positive or negative depending on precisely what is occurring, so the *ipso facto* presumption of a positive value for congestion is simply baseless.[8] The same is true in regard to system losses, at both the distribution and transmission levels.

Generation capacity value

Utilities have an obligation to meet the energy demands of customers at all times. To do this, they need generation capacity available sufficient to meet demand, including a reserve margin to handle contingencies—unexpected demand spikes, power plant outages, etc. Having this capacity available when needed is important, and costs money, which may be collected through capacity markets or other means.

[8] Congestion is a real cost on all transmission systems. While Arizona is not part of an organized market that explicitly prices congestion, that fact does not alter the reality that congestion costs are incurred.

Many VOS studies assign a value to the capacity provided by rooftop solar. In some cases, this value is quite large.[9]

But the capacity value of a generating asset is derived from its availability to produce energy when called upon to do so. By its very nature, rooftop solar on its own, without its own backup capacity (e.g., storage), can only produce energy intermittently. It is completely dependent on sunshine in good atmospheric conditions. Unless sunshine is guaranteed at all times at which rooftop solar is called upon to produce, it cannot be relied upon to be available when needed. Moreover, even if all days were reliably sunny, the energy derived from the sun is only accessible at certain times of the day. In addition, of course, dg produced energy is only available for the system when the solar host is producing more than he/she consumes, something which exacerbates even further the difficulties of managing intermittency in a system that is required to be highly reliable. Utilities, however, are required to serve all of the demand of customers in their service territory at all times. That means utilities must plan for the capacity needed to serve peak demand, largely without regard to the existence of rooftop solar.

The capacity value of rooftop solar is even further diminished by the fact that the presence and potency of sunshine is not coincident with peak demand. Rooftop solar capacity is generally at its peak in the early afternoon, while peak demand occurs later in the afternoon or in early evening. The chart below prepared by Opower, based on data from California, nicely illustrates what this disjunction looks like:[10]

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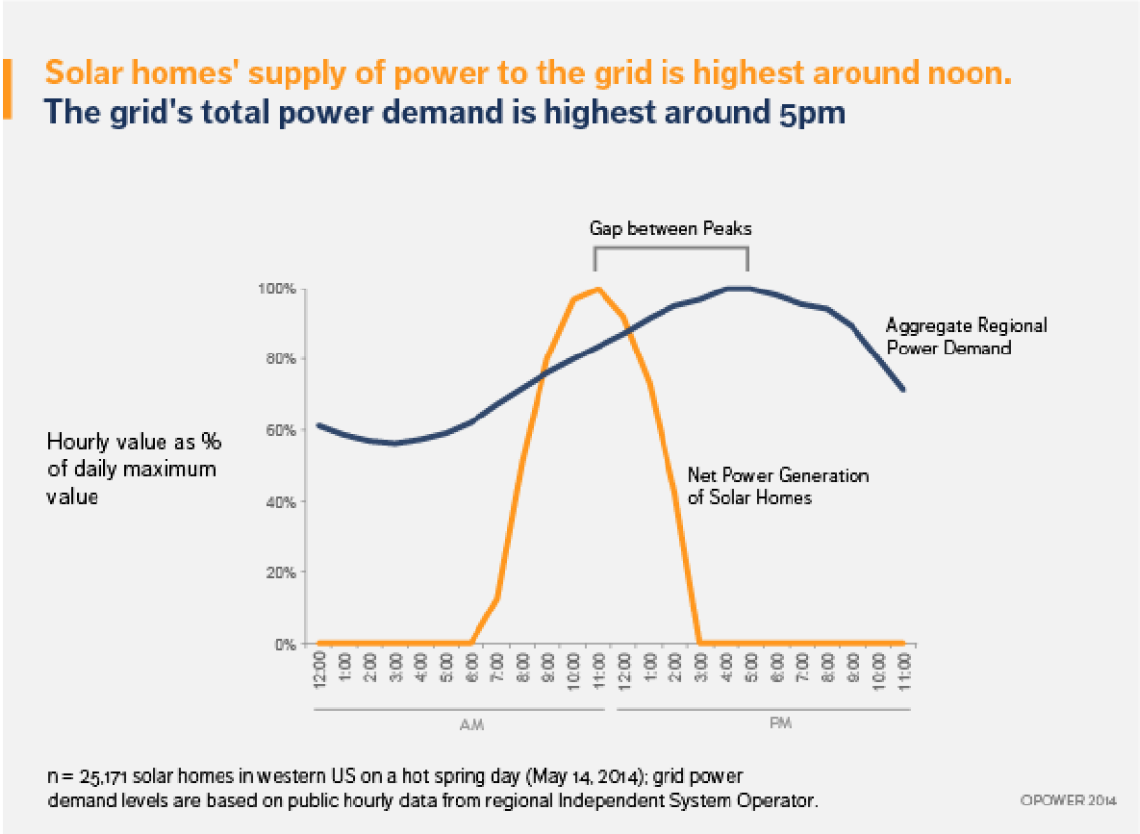
[9] For an example of a study that finds a large capacity value, see Beach, Thomas R., and Patrick G. McGuire. *The Benefits and Costs of Solar Distribution Generation for Arizona Public Service*. Crossborder Energy Consulting (May 8, 2013). (*Crossborder Arizona Study) Please see*: http://www.solarpowerdemocracy.org/wp-content/uploads/2014/03/Crossborder_AZ_2013.pdf

[10] Fischer, Barry and Ben Harak. *9% of solar homes are doing something utilities love. Will others follow?* Opower blog December 1, 2014. *Please see*: https://blog.opower.com/2014/12/solar-homes-utilities-love/.(Downloaded 2016).



Analysts point out that the gap between solar peak production and demand peak is likely to grow as higher penetrations of solar depress demand more and more during solar producing hours—further eroding the capacity value of rooftop solar.

Because utilities can't count on it to be available, and because the utility's peak demand occurs well after peak solar production, rooftop solar can play only a limited role in offsetting capacity costs, either for transmission or generation.[11] At best, capacity value would be only a small

[11] Capacity value can be enhanced by adding battery storage or optimizing the solar installation's orientation to capture the maximum amount of sunlight at peak. Ironically, neither of these actions are routinely undertaken, in large part because net meter pricing fails to provide inappropriate signals to do so.

fraction of nameplate capacity. In fact, some studies find that adding rooftop solar increases costs associated with reserve requirements significantly.[12]

Despite this disjunction between solar production peak and actual peak demand, and the other weather-related uncertainties of solar power, it has become fairly common practice among utility planners and many VOS analysts to calculate an "effective load carrying capacity" (ELCC) percentage based on the capacity of rooftop solar discounted for its intermittency. Typically, ELCC numbers are in the 50%-60% range—but it is acknowledged that the higher the solar penetration, the lower the ELCC is likely to be. Estimates for California have gone as low as 17%. Determining the ELCC adjusted value of rooftop solar is a fact-specific question that, if it is to be used, needs to consider capacity availability resulting from the timing of generation and less than optimal placement of photovoltaics.[13]

While it is true that one can develop probabilistic models for utility planning purposes that are theoretically sound, that is quite different matter than how to price rooftop solar from a regulatory/consumer protection perspective. The regulator needs to determine what is used and useful for providing service to the customer before requiring consumers to pay. In my view, a capacity provider should stand ready to deliver energy when called upon to do so, and if the provider is unable to deliver, then he must assume responsibility for replacing what he is unable to provide, or, alternatively, reimburse the utility for the marginal costs it incurred in remedying his default. Thus, any "capacity" that fails to meet that test is "phantom capacity," entitled to, at best, minimal, if any, compensation.. As a regulator, I would apply a very strict scrutiny to the amount of cost recovery for capacity for a resource that is not readily dispatchable, and whose provider assumes no liability for an inability to be dispatched when called upon. The real question is how much benefit of the doubt should we give to an intermittent, non-readily dispatchable resource, whose provider assumes no liability for

[12] A study of the Duke Carolina system by Pacific Northwest National Laboratory cited by the Brattle group "found that adding distributed solar capacity equal to 20% of the peak load caused planning reserve requirements to increase by 30% and regulation to increase by 140%, compared to a case without PV capacity added. These increases led to a system cost increase of $1.43 to $9.82 per MWh of PV energy…" *See* Brattle Group Study at 35; and *Duke Energy Photovoltaic Integration Study: Carolinas Service Areas*, Pacific Northwest National Laboratory (March 2014). *Please see:* http://www.duke-energy.com/pdfs/carolinas-photovoltaic-integration-study.pdf.

[13] *See* Baker et al, at. 405, who cite study by Lamont (2008).

inability to be dispatched. The question for regulators is how they assess capacity value in light of these factors. As a former regulator, my conclusion is that such "capacity" provides no benefit to consumers.

The value of capacity is also, of course, driven by whether capacity is required. If, for example, a utility has sufficient capacity[14] to meet all anticipated demand (including reasonable reserves), voluntarily paying for more capacity would raise questions about prudency. Thus, there is no basis to assume, as many VOS authors do, that the installation of new rooftop solar units renders them automatically entitled to capacity payments. Indeed, I know of no other circumstance where any generator would be entitled to such a presumption, without actual examination of the particular circumstances. Even in the context of where the utility has a need for new capacity, economies of scale are important. New plants might be built that could have scale economies and serve multiple purposes, but do so at lower unit costs than small plants, such as rooftop solar, which lack economies of scale. Given the lack of scale economies in rooftop solar, prevailing in a competition would be difficult. Capacity markets are, and ought to be, competitive; thus, even if rooftop solar possessed capacity value, it should have to compete to monetize that value. This is entirely contrary, however, to the way that most VOS authors approach the issue of capacity value. They simply assume that solar installations are entitled to compensation for being there, without having to be capable of producing energy and of competing with other possible capacity providers. They simply assume value associated with a deferral of capacity procurement, despite the fact nothing may be deferred at all. Moreover, the value calculation is often made at nameplate capacity levels, as opposed to ELCC. Using nameplate capacity levels serves the purpose of driving up the "value" calculations they make, but does so in a context entirely outside the realities of the capacity market, and outside of any principles of regulation..

Transmission and distribution capacity benefits

Advocates of a "VOS" approach often assert that real transmission savings are achieved through the deployment of DG. The argument is that by producing energy at the distribution

[14] From a regulatory perspective, utility capacity includes both units owned by the utility and units owned by a third party entity with a contractual obligation to provide the utility with capacity. I note this because solar advocates sometimes argue that utilities are opposed to rooftop solar because it competes with the utility's generation. For regulatory purposes, capacity owned by another company, but contractually obligated to the utility to serve capacity requirements, has the same system worth as utility owned generation for purposes of capacity. Ownership has nothing to do with it.

level, less transmission service will be required, thereby reducing or deferring the need for new transmission facilities. It is also, as already noted above, often contended that rooftop solar will reduce congestion costs, and perhaps even provide some ancillary services. All of that is theoretically possible, but certainly not uniformly or even inevitably true.

Of course it is true that, absent any adverse, indirect effect rooftop solar might have on the operations of the high voltage grid (e.g., congestion), rooftop solar does not incur any transmission costs in bringing its energy to market. However, as discussed above, avoiding transmission delivery charges is quite different from asserting that rooftop solar provides actual transmission savings. In fact, it would be incorrect to simply conclude that rooftop solar will achieve transmission savings.

It is possible that there could be transmission savings associated with rooftop solar deployment, but that can only be ascertained on a fact- and location-specific basis. Such savings, as already discussed, would most likely be derived from reducing congestion or providing ancillary service of some kind. It is also theoretically possible, but highly unlikely, that massive deployment of rooftop solar will eliminate (or defer) the need to build new transmission facilities. However, for a variety of reasons, including the complexities of transmission planning, the time horizons involved, the complex interactions of multiple parties, economies of scale in building transmission, and the politics of siting, it is improbable that rooftop solar actually saves any investment in transmission capacity. Indeed, as noted in regard to generation, the intermittent and off peak nature of rooftop solar renders it useless as a means of offsetting the costs a utility must incur to fulfill its obligation to be able to meet its customers' full electricity requirements. The system must be planned for meeting all needs at peak, and a resource that cannot deliver on peak, and which even off peak is intermittent, by definition cannot offset capacity needs in transmission and generation.

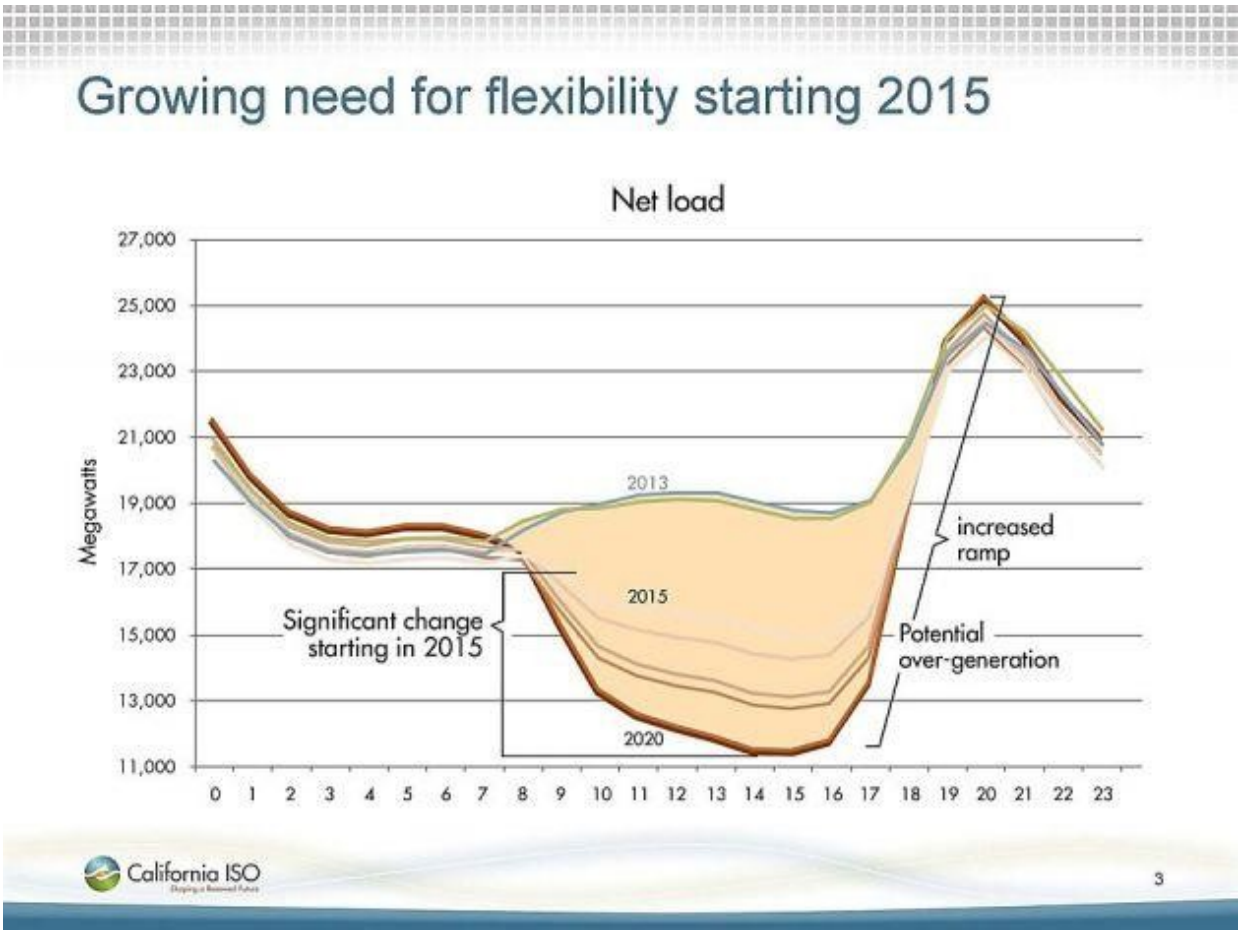
The fact is that transmission is built for the bulk power market, sized for the long term, and designed to capture economies of scale. It is built, not based on incremental, year by year, needs, but with a view toward the long term. Since rights of way are generally scarce and hard to obtain, transmission lines are built to maximize scale so that future line siting battles can be avoided or at least deferred. Thus, the addition of rooftop solar, absent a truly massive amount of installation, will almost inevitably have no impact on transmission capacity planning. Indeed, since transmission must be sufficient to serve peak load, the fact that rooftop solar is intermittent, and non-coincident with peak, means that it will have no real impact on transmission capacity. In addition, with new technologies being deployed on the grid, the most

common form of transmission expansion relates to technological enhancements, the deployment of which is completely unaffected by rooftop solar.

Indeed, a mere glance at the California ISO duck chart, which shows the need for ramping capacity to make up for the intermittent availability of rooftop solar, is almost a prima facie case for believing that the opposite is true-that rooftop solar may actually cause a need for more transmission to be built.

For anyone not already familiar with California's famous fowl, here is the "duck chart," which shows the dramatic and increasing ramp needed to meet residential demand as the sun sets-a ramp that taxes the resources of the system and may well put significant strains on the transmission system:[15]

[15] *See* Rothleder, Mark. *Long Term Resource Adequacy Summit*. California ISO (February 26, 2013 at slide 3. *Please see:* https://www.caiso.com/Documents/Presentation-Mark_Rothleder_CaliforniaISO.pdf.



It is virtually impossible to demonstrate that rooftop solar will obviate the need for transmission, much less quantify the cost savings associated with this purported benefit. At the same time, the development of this "duck" pattern creates new costs for the grid—it is not easy or free to arrange for large amounts of generation to come on line quickly ("ramping"). Keeping up with the steep ramping curve created as solar power drops off the grid is an additional expense that would need to be included in VOS analysis.

Value of Avoided Distribution Costs

It is more likely that rooftop solar will cause more distribution costs than it saves. That is because these generation sources could change voltage flows in ways that will require adjustments and maintenance. It will also inevitably increase transaction costs for the utility to execute interconnection agreements and do the billing for an inherently more complicated transaction than simply supplying energy to a customer. If utilities could choose exactly where rooftop solar would be installed, the utility might be able to identify specific locations where rooftop solar would have distribution value; however, this is not how the rooftop solar market

works. Rooftop solar is installed wherever customers who can afford it are located, often in places which may just as easily add to burdens on the distribution system as lessen them. In short, the location of rooftop solar units is random, and the likelihood that it will produce distribution system benefits is perhaps less likely than that it will increase costs. If there is a pattern, it may be that rooftop solar tends to cluster in higher-income neighborhoods—and there is no reason to believe this is optimal for the distribution system. Thus, it is incorrect to assume that rooftop solar, installed without guidance from the utility, would effectuate distribution savings.

In a number of states, regulators are working to introduce more market elements in the distribution grid in order to handle the additional costs and complexities (as well as to create efficiency opportunities) related to distributed energy resources. This project itself, of course, represents a significant cost.

Ancillary service provisions

It is technically possible that smart inverters could provide ancillary services to help stabilize energy flow on the distribution grid. However, in the absence of a properly designed incentive to provide these services, this is a theoretical possibility, not an actual value. Indeed, retail net metering actually discourages such investments, because it is so generous in its subsidies to the most basic of solar installations and offers no "carrot" to increase value to the grid. In the meantime, the more intermittent resources are on the grid, the more ancillary services are needed to preserve power quality and reliability.[16] Hence, under retail net metering, solar is likely to produce more costs than savings.

Fuel hedge value

Another argument is that there is a "hedging value" for rooftop solar that is realized by the utilities. The argument is based on the true observation that the marginal cost of solar electricity production is zero, whereas the marginal cost of the production of electricity from a natural gas plant goes up and down with the price of natural gas.

So solar power potentially does have a value as a hedge against natural gas, but only for the <u>owner</u> of the solar panels. For a utility that will be buying power from solar panel owners, the hedge value under net metering is nil. The reason is that the price to be paid by the utility for power from rooftop solar will include all of the elements included in the monthly electric utility bill, including the full cost of energy. When gas is expensive, this price paid by non-solar

[16] Baker et al., at 404-405.

customers will be higher; when it is cheaper, it will be lower. There is no mechanism envisioned by anyone on either side of this debate (as far as I am aware) under which gas prices would be high, but solar producers would be compensated at a rate lower than the cost of electricity produced from gas generators. So, if it is worth hedging against variations in the price of natural gas, the utility should buy the same hedge against variations in the price of rooftop solar power. From the utility's and the non-solar customer's point of view, the two costs will vary together. Thus, the hedge value is not only zero, any consideration paid for such a hedge would be more expensive than incurring the risk from which protection is sought.

With that said, solar can provide a hedge for the owner of the solar panels. Thus, in the case of larger-scale, utility-owned solar plants, there could be a hedge value, and that value is passed on to consumers because it is internalized into the competitive bidding for power purchase agreements. But for rooftop solar panels, under a net metering regime, whatever hedge value may exist stays with the owners of the solar panels—it does not transfer to the non-solar customers.

Market price suppression

Another supposed value attributed to rooftop solar in many VOS studies is that by reducing demand, rooftop solar will suppress the market price for energy. This argument is seriously flawed in more than one way.

In the first place, under retail net metering, the price of rooftop solar is not market-based, or even cost-based. In fact, where there is retail net metering, the rooftop solar price is unreasonably and arbitrarily linked to the full retail price of delivered electricity, as opposed to the level of energy prices, where it should be. In effect, net metering requires non-solar customers to pay retail prices for a wholesale product. While, arguably, the availability of highly-subsidized rooftop solar could have the effect of reducing demand for wholesale energy (although considering the scales involved it seems improbable that the reduction would materially impact wholesale energy prices), there would be no price benefit for consumers since rooftop solar, priced at full retail levels, or at the levels dictated by the inflated claims of many VOS papers, would consume all of the "savings" and leave little or no benefit for customers.

Setting aside the high price customers are being asked to pay for this "savings," the second problem to flag here has to do with the different market effects of a low-priced competitive resource and a low-priced subsidized resource. If a competitively priced, not heavily subsidized, source of energy caused prices to decline, that would be a good thing, but that is not at all what

VOS studies are suggesting will happen with rooftop solar. Rooftop solar is subsidized by tax credits, REC/SREC markets, and by the cross-subsidy inherent in net metering and volumetric rate design. It is hard to find any economic logic to support the notion that markets are well served by using heavily subsidized products, such as rooftop solar, to drive down prices in the competitive marketplace. In effect, VOS authors claiming such price suppression effects are promoting the use of tax dollars, plus cross-subsidies from non-solar customers, to drive down the prices emanating from the marketplace. Rather than producing a salutary market benefit, what is actually being sought is a government mandated technology preference for rooftop solar over more efficient technologies. To the extent that highly subsidized products compete with unsubsidized products in the marketplace, this distorts the market, rather than strengthens it, making it hard for otherwise competitive energy generators to stay in business. In the long run, this distortion exacerbates the capacity issues that many markets struggle to correct through capacity payments. Thus, if one assumes that rooftop solar somehow suppresses prices in the energy market, this would be highly unfortunate—it could do very serious damage to the power sector. The claimed price suppression "value" is not a value at all.

Reliability

Many rooftop solar advocates assert that rooftop solar enhances overall reliability because the units are small and widely distributed, but close to load and not reliant on the high voltage transmission system. It is argued that they are somehow less impacted by disasters and weather disturbances. These claims are highly speculative and, for the reasons I will explain, inaccurate.

It would be a mistake to simply assume that rooftop solar improves reliability. First, it should be noted that the vast majority of outages are distribution (not transmission related), thus the fact that rooftop solar does not use the transmission grid is almost completely irrelevant to the reliability issue. Beyond that, rooftop solar is subject to disaster as much as any other installation. Strong winds, for example, can harm rooftop solar as much as any other facility connected or not connected to the grid. Cloudy conditions can disrupt solar output while not affecting anything else on the grid.

Solar's intermittency makes it unable to assure its availability when called upon to deliver energy. Indeed, it is far more likely that a thermal unit will have to provide reliability to back up a solar unit than the other way around. It is also important to examine rooftop solar reliability issues in two contexts: that of the individual customer and that of the system as a whole. Solar vendors, as part of their sales pitch, claim that reliability is increased for a customer with a

rooftop solar unit because on-site generation provides the possibility of maintaining electric power when the surrounding grid is down. When the sun is shining, this claim is likely to be true. Conversely, without the sun, the claim has no validity.

That argument ignores one highly relevant fact: in a system outage the power inverter, an electronic device or circuitry that converts direct current to alternating current, is automatically switched off to prevent the backflow of live energy onto the system. That is a universal protocol to prevent line workers from encountering live voltage they do not anticipate. Thus, if a rooftop solar unit is functioning properly, when the grid goes down, the rooftop solar customer's inverter will also go down, rendering it useless in an outage. If the inverter is not functioning properly, then the unit may be producing, but will do so at a considerable risk to public safety and to workers trying to restore service. The result, of course, is that the solar panel provides virtually no reliability to anyone.

In fact, when it comes to reliability, it is much more accurate to say the grid provides reliability to rooftop solar than the other way around. Not only does the grid ensure service when the sun is not shining, but in case of an outage, a solar-powered home does not, on its own, have the ability to re-start the home's systems without a boost of energy from the grid. As contrasted with the reliability provided by the grid, there are virtually no reliability benefits for the system from distributed solar, and therefore there is no basis for calculating a payment for such service.

Attributing reliability benefits to an intermittent resource is a stretch. By definition, intermittent resources are supplemental to baseload units. The only possible exceptions to that are, as noted above, where there are individual reliability benefits or where the availability of the unit is coincident with peak demand. Absent those circumstances, and absent storage, it is almost certainly the case that the system provides reliability for rooftop solar, rather than the other way around. That is particularly ironic given that in the context of net metering, rooftop solar hosts do not pay for that service while generating electric energy, and collect payments for distribution service they rely upon rather than provide.

Indeed, from a reliability perspective, net metering and most other VOS formulations are truly perverse, because non-solar customers pay rooftop solar providers for reliability benefits that rooftop solar does not provide them, while rooftop solar customers do not pay for the reliability benefits they actually do receive. From an investment perspective, rooftop solar pricing methods like NEM, which redirects distribution revenues from utilities to rooftop solar

providers who offer no distribution services, are detrimental to reliability because they deprive utilities of the revenue needed to maintain high levels of service.

Environmental benefits

Many VOS studies include one or more values related to environmental impacts (or lack of impact) of rooftop solar.

There are many potential issues here. First there is no certainty that rooftop solar reduces carbon emissions. There is, for example, the case of Germany, where a massive switch to solar and wind resulted, in some years, in an increase in the use of coal, and stalled reductions (and in some years increases) in carbon emissions.[17] While the German experience was also influenced by the closing of the country's nuclear plants, the point is that one simply cannot assume that increasing the amount of intermittent renewable generation, including rooftop solar, will, ipso facto, lead to reductions in emissions.

Moreover, the degree to which rooftop solar does reduce carbon is not an easy figure to derive. To correctly ascertain the amount of reductions per dollar spent, one would have to identify what generation and emissions are being avoided by rooftop solar generation. In today's market, the marginal resource is likely to be natural gas—with emissions much less than other resources on the grid, such as coal—resulting in significant consequences for the value of the emissions averted by rooftop solar. To try to ascertain a meaningful number, a VOS researcher would have to do a location (or at least region) specific analysis with substantial granularity. VOS papers typically do not do that; rather they simply make assumptions, the factual basis for which are at best suspect and at worst meaningless.

Second, as in other issues, VOS studies almost never look at the opportunity cost associated with rooftop solar. In specific regard to carbon emissions, VOS studies assume a reduction and try to assess a monetary value for that achievement. What they rarely, or ever do, is look to see if that money is well spent in the context of alternative ways of achieving the same result. As noted earlier in my testimony, rooftop solar is a remarkably expensive way to reduce carbon emissions. Energy efficiency, grid-scale solar, and wind, for example, all reduce more emissions per dollar spent on rooftop solar, and do so without having to prepare VOS studies to make the case for special compensation. Thus, a balanced VOS would discount the claimed value of

[17] *DW.Com*. "German CO2 Emissions Targets at Risk." (November 19, 2015). *Please see:* http://www.dw.com/en/german-co2-emissions-targets-at-risk/a-18862708

emissions reduction to compensate for the opportunity cost of not having chosen the least cost option. Most (if not all) studies fail to do this.

Third, the methodology used to quantify emissions reductions in VOS studies often suffer from serious flaws. There appears to be the potential double counting and paradoxes among the different categories of analysis suggested for the "environmental services" category. For example, IREC suggests a list of values within the "environmental services" category that includes both "utility avoided compliance costs" and "carbon." The "carbon" category suggests that additional value attaches to rooftop solar because it reduces the amount of carbon emissions in the state; on the other hand, the "avoided compliance cost" category suggests that there is value to rooftop solar because it reduces the amount of other renewables in the state. Puzzling through the relationship between these two arguments is like trying to make sense of an Escher print—at first glance, the steps seem to be going up, but at second glance, they are going down, and it is impossible to resolve the contradiction.

Economic development and jobs

In the case of economic impact, benefits are frequently claimed for rooftop solar without regard to costs. Advocates for rooftop solar claim this will give rise to many good solar energy jobs. Maybe that's true, maybe that's not true. We certainly have some reason to doubt this, given that as of 2015, the US produced only about 2% of pv cells and pv modules in the world, while making up 16% of PV installations. (China dominates worldwide solar pv cell and pv module production, with a more than 60% share of the world market).[18] Rooftop solar may have produced more jobs in China than in the U.S. Regardless, if one is to consider the economic development or jobs aspects of rooftop solar, any study of the issue must be balanced and look not only at solar jobs, but also at secondary impacts on the job market. These include job loss caused by the increased electric rates that come with selecting a higher cost technology over a lower cost technology to provide electricity (e.g., rooftop solar instead of utility scale solar or wind). Employment impacts are a two-edged sword when it comes to green energy. The one-sided, myopic view of the jobs issues found in VOS studies are strangely reminiscent of people who argue that we ought not to regulate carbon emissions because doing so would lead to job loss in coal mining. That argument is one dimensional and myopic in the same sense that the green jobs argument is one dimensional and myopic.

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[18] IEA, *Trends 2015 in Solar Photovoltaic Applications.* Report IEA-PVPS T1-27:2015. Available online at http://www.iea-pvps.org/fileadmin/dam/public/report/national/IEA-PVPS_-_Trends_2015_-_MedRes.pdf. See pages 31 and 40.

In fact, recent research modeling on the effects on the Arizona economy of rooftop solar subsidies highlights what is missed with a one-dimensional look at rooftop solar jobs. This study found that subsidies for rooftop solar, over the years, lead to significant job losses and decreased wealth for the state.[19] The central problem is that the money spent on DG reduces the amount available to be spent in other sectors of the economy. Thus, while the model does predict additional jobs associated with rooftop solar installation and other services, "Any benefits emanating from each scenario are at best temporary, only coincident with the timing of the solar installations, and quickly counteracted by their long-run/legacy effects."[20] Over the twenty-year period studied, with results varying depending on the level of penetration of rooftop solar, the model in fact predicts billions of dollars of lost gross state product and thousands of "job years" lost.[21] The effort of the ASU Study to examine both sides of the economic impact of expenditures on distributed solar is unfortunately rare in VOS analyses, which almost never balance predictions of job growth against job costs. The usual VOS jobs argument simply lacks balance and credibility.

Potential cost of rooftop solar

If one is serious about examining and quantifying all of the potential non-energy benefits of rooftop solar, there are a number of costs it may impose on the system that would have to also be valued. Some that spring to mind include the additional wear and tear on generation that must undergo frequent cycling to cope with swings in renewables generation.[22] Furthermore, as new forms of generation provide a greater share of energy on the grid, and old-fashioned large turbine generators (such as coal and wind) provide less, there is a corresponding loss of some of the frequency regulation that previously had been provided by the sheer physical

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[19] Evans, Anthony, Tim James, and Lora Mwaniki-Lyman. "The Economic Impact of Distributed Solar in the APS Service Territory, 2016-2035." Report, L. William Seidman Research Institute, W.P. Carey School of Business, Arizona State University, February 16, 2016. (ASU Study). (Attachment ACB-2DR).

[20] ASU Study at i.

[21] A job year is not the same as a job. It is one year of employment.

[22] For more on the wear and tear costs of ramping, see, e.g., Kumar, N., P. Besuner, S. Lefton, D. Agan, and D. Hilleman, *Power Plant Cycling Costs* NREL, April 2012, available online at: "http://www.nrel.gov/docs/fy12osti/55433.pdf" ; Wogrin, Sonja. Presentation to the Harvard Electricity Policy Group's 82nd Plenary Session. Washington, DC, March 11, 2016, available online at: "*The Impact of Cycling Costs Due to Fatigue Damage on Optimal CCGT Operations*" and Lew, Debra. Presentation to the Harvard Electricity Policy Group's 82nd Plenary Session. Washington, DC, March 11, 2016, available online at "*Coal/Gas Plant Cycling: Costs, Causes, Impacts*."

inertia of large turbines turning.[23] And any serious effort to value and reward some of the potential benefits identified above—such as transmission savings, or capacity savings—requires an analytical effort whose costs will not be trivial.

"VOS" analyses also tend to be one dimensional, identifying benefits without balancing that off against related costs. Frequently (though not always), the discussion does not include any serious consideration of costs associated with rooftop solar and policies enacted to support it—lost utility revenues, which must be made up for by non-rooftop solar customers; costs to the rest of the system incurred in order to integrate intermittent renewable energy while keeping power supply steady; the need for additional reserves to back up a pool of generation that can vary unpredictably with the weather;[24] the need to maintain standby generation (spinning and non-spinning reserves) to maintain system frequency, despite solar intermittency; transaction costs; distribution changes required to accommodate bidirectional flows; and costs to the economy as a whole (including job losses) associated with higher energy costs.[25]

Vulnerability of all analyses of additional costs and benefits

To step back from the detailed analysis of potential additional costs and benefits of rooftop solar, all such analysis, in my view, must be treated with cautious skepticism. This kind of "value of solar" analysis is inevitably subjective, readily manipulated, and inherently skewed.

Studies of the "VOS" are highly subjective and readily manipulated because there is no established methodology, and, furthermore, given the complexity of the analyses needed to assess all the various "VOS" claims, no analysis can effectively avoid the need to make multiple subjective analytical judgments. Thus, every such analysis is subject to the biases and policy predispositions of the authors and/or sponsors of such studies. This reality is well illustrated by the extraordinarily wide variance in the conclusions of such studies. The range is dramatic, with

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[23] See, for example, http://energystorage.org/energy-storage/technology-applications/frequency-regulation; and talk at the Harvard Kennedy School on September 21, 2015, by Professor Michael Caramanis of Boston University, slides available at http://www.hks.harvard.edu/m-rcbg/cepr/CaramanisHarvardSept21%202015.pdf .

[24] "Unexpected short-term changes in solar generation require additional backup capacity to avoid temporary mismatches between supply and demand." Baker, Erin, Meredith Fowlie, Derek Lemoine, and Stanley S. Reynolds. "The Economics of Solar Electricity." American Review of Resource Economics vol. 5 (June 2013), p. 404.

[25] *Id.* at 405.

a VOS study in Louisiana which found a negative value, while a VOS study in Maine calculated a value of 33.7 cents/kWh.[26,27,28]

The reason we see such wide variation is that VOS studies are inherently subjective and arbitrary. Study findings are easily distorted in subtle ways to match any agenda. There is no commonly accepted methodology for doing VOS analysis. Indeed, there are not even any commonly accepted criteria to assess in ascertaining value.

VOS analyses are inherently skewed because they don't look at multiple resources

VOS studies are technology specific (almost always limited to rooftop solar). This makes them one-sided. As noted earlier, the studies never answer the question of why, if we would use value-based pricing for rooftop solar why we don't use value-based pricing for every other resource? Why are we singling out rooftop solar? VOS studies rarely, if ever, look at the opportunity costs associated with spending money on rooftop solar, as opposed to using that money on something that produces energy and/or reduce emissions more efficiently, incentivizes rooftop solar to be more efficient and more productive, and promotes overall market efficiency and system benefits.

If we're going to use a VOS analysis to establish prices, then why in the world don't we do that for nuclear, coal, natural gas, wind, and every other resource? Or, for that matter, establish a value for the grid itself? It is very difficult to discern any justification for singling this technology

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[26] Dismukes, David E. *Estimating the Impact of Net Metering on LPSC Jurisdictional Ratepayers. Prepared on behalf of the Louisiana Public Service Commission.* Prepared on Behalf of Louisiana Public Service Commission Draft, February 27, 2015. *Please see:* http://lpscstar.louisiana.gov/star/ViewFile.aspx?Id=f2b9ba59-eaca-4d6f-ac0b-a22b4b0600d5

[27] Grace, Robert C., Philip M. Gruenhagen, Benjamin Norris, Richard Perez, Karl R. Rabago, and Po-Yu Yuen. *Maine Distributed Solar Valuation Study.* Prepared for the Maine Public Utilities Commission. Revised April 14, 2015. *Please see:* http://www.maine.gov/mpuc/electricity/elect_generation/documents/MainePUCVOS-ExecutiveSummary.pdf.

[28] To put the 33.7 cents /kWh valuation in perspective, that number is roughly double the full retail rate of Maine's largest electric utility. In other words, the authors of that study calculated that the "value" of the energy produced by each rooftop solar installation is worth double the full delivered cost of electricity. That is the equivalent of saying that the value of a part of a product is worth double the value of the entire product.

out for an analysis that is completely different from and, frankly, historically foreign to, the way that we set prices for energy in the U.S.[29]

A classic example of the kind of problem this single focus of "value" analysis relates to the question of whether distributed solar has extra value because it does not emit carbon. While rooftop solar does not, in the process of producing energy, emit carbon, VOS studies do not even address the question of its cost of doing so in comparison with other non-emitting energy sources, despite the fact that much has been written on the efficiency of using various methods to reduce carbon emissions, and distributed solar generally ends up at the low end.

Current financial analysis, in fact, finds that rooftop solar is the most expensive form of renewable generation widely used in the U.S. today. The latest annual update of Lazard's *Levelized Cost of Energy Analysis* continues to show this, with a levelized cost for rooftop solar ranging from $184-$300 per MWh, higher than all other energy sources analyzed, including fuel cell, solar thermal, utility-scale solar, geothermal, biomass, wind, and energy efficiency.[30] The Lazard analysis goes on to compare the cost of carbon abatement per ton for different alternative energy resources. As one would expect based on its levelized cost, rooftop solar power had the highest cost per ton of carbon emissions avoided ($335 per ton, assuming gas is the comparison generation). In contrast, Lazard's calculations found that utility-scale solar pv could abate the same ton of carbon emissions at a cost of only $15 per ton. The difference here is staggering. A ton of abated carbon emissions from rooftop solar costs more than 22 times the cost of abatement using utility-scale solar.[31] And opening up the competition to other resources, such as wind, makes the comparison even more dramatic—Lazard calculates that wind energy can abate carbon <u>and</u> save money—to the tune of $50 savings per ton of carbon abated.

A recent study by the Brattle Group comparing generation costs of utility-scale and residential-scale PV in Colorado confirms the superior cost-effectiveness of utility-scale solar: "Simply

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[29] At a minimum, if one were determined to pursue a value analysis (which I do not in any case recommend), competing renewables should be considered.

[30] *Lazard's Levelized Cost of Energy Analysis-Version 9.0.* November 2015. Data cited is from p. 2 table, "Unsubsidized Levelized Cost of Energy Comparison." Full report available online at https://www.lazard.com/media/2390/lazards-levelized-cost-of-energy-analysis-90.pdf

[31] *Lazard's Levelized Cost of Energy Analysis-Version 9.0.* November 2015. Data cited is from p. 6 table, "Cost of Carbon Abatement Comparison." Full report available online at https://www.lazard.com/media/2390/lazards-levelized-cost-of-energy-analysis-90.pdf

stated, most of the environmental and social benefits provided by PV systems can be achieved at a much lower cost at utility-scale than at residential-scale."[32] Utility-scale solar systems, Brattle found, not only had predictable economies of scale, making them cheaper per MW of capacity; they also were far more likely to be oriented optimally to the sun and to include productivity-enhancing technologies, such as solar tracking technology.[33] RNM pricing completely distorts those hard facts. RNM is a subsidy which assists only rooftop solar. To provide a cross subsidy, through RNM, to rooftop solar, perhaps the least cost effective technology for reducing carbon emissions, and which is already heavily subsidized through tax incentives and REC markets, transforms rooftop solar into perhaps the most financially attractive renewable investment from the standpoint of financial returns. That means that in continuing this approach, we would be making the least cost effective means of reducing carbon the most attractive renewable energy for investors, a policy which will inevitably divert capital from more efficient to less efficient ways of reducing carbon. That result, from any perspective, is a perverse and socially undesirable outcome. Stated quite simply, it constitutes a kind of highest cost strategy that will inevitably lead to less carbon reduction and seems likely to exhaust the willingness of the public to pay for emissions reductions. It also constitutes a severe risk of misallocating capital and increasing electricity prices with all of the adverse secondary effects that could have.

That is, of the renewable generation choices commonly available, rooftop solar is the highest cost way of reducing carbon emissions. Nevertheless, VOS papers almost always ascribe significant value to the carbon reduction value of rooftop solar. What is never asked, however, is how that value compares with the stepped up utilization of grid-scale renewable or energy efficiency in reducing emissions, and what the opportunity cost is for diverting capital from more efficient means of carbon reduction to the less efficient means of rooftop solar. What most, if not all of these studies lack, is context; VOS study authors, as general rule, ignore context and view rooftop solar as if it exists in an almost perfect vacuum.

A major risk of an approach that only looks at the benefits of a single resource, without comparing the potential benefits offered by other resources, is losing sight of the big picture, and making decisions without considering the overall context and alternatives. Whatever "value" you are pursuing, you should think about multiple ways to get there, and what the most

[32] Bruce Tsuchida, Sanem Sergici, Bob Mudge, Will Gorman, Peter Fox-Penner, and Jens Schoene, "Comparative Generation Costs of Utility-Scale and Residential-Scale PV in Xcel Energy Colorado's Service Area." The Brattle Group, July 2015, p. 3.
[33] Tsuchida et al, pp. 1-2.

cost-effective approach will be to obtain the value in question. I discuss the huge example of carbon emissions. The problem with promoting rooftop solar as a solution to carbon emissions is not only inefficiency, but that doing so is a threat to the goal itself. If you choose pathways that are not cost effective, if effective at all, you run the very real risk of exhausting resources and public support without really impacting the problem. It is important to note that not a single VOS paper I have reviewed even looks at this very critical question.

Other technologies relevant to the future of solar dg

In terms of the actual benefits provided to the grid by solar DG, technology can play a role in enhancing these: from the simplest measures, like orienting the solar panels to catch, not necessarily the most sunlight, but the highest-value sunlight, to more demanding measures, such as leveraging battery storage, smart inverters,

Net metering: Pricing Solar DG at Retail

Definition of "retail net metering"

In this report, the terms "retail net metering" and "RNM" are used interchangeably. What these terms mean is that the meters run forward when solar PV DG customers are purchasing energy from the grid. When those customers produce energy and consume it on premises, the meter simply stops, and when the customer produces more energy than is consumed on premises, the meter runs backwards. Thus the solar PV DG customer pays full retail value[34] for all energy taken off the grid, pays nothing for energy or distribution when self-consuming energy produced on premises, and is paid the fully delivered retail price for all energy exported into the system. At the end of whatever period is specified, the meter is read and the customer either pays the net balance due or the utility pays the customer for excess energy delivered. The reconciliation is made without regard to when energy is produced or consumed. Perhaps of more economic significance, it is also, in most cases, made without regard to the fixed costs

[34] In some jurisdictions the full retail value includes the entire bill, while in others, it refers to the variable portion of the bill, but does not include any fixed charge that may be assessed. It should be noted, of course, that, as a general rule historically, not all fixed costs are recovered through fixed charges, so in RNM, that critical distinction between fixed and variable costs is lost. In reality, most forms of payment under any regime for solar PV DG are netting something. This paper argues it should be an energy netting. Many solar advocates prefer full retail price netting, and as noted, there may be variations in between. To be clear, SRP's proposal is not to get rid of netting, but simply to focus on those things that in fact have an economic justification for netting, particularly energy.

that are incurred to provide service to the solar host. This is how transactions between owners of DG and utilities have traditionally been handled.

There are other forms of net metering such as wholesale net metering, where exports into the system are compensated at the wholesale price, but in this report, the terms “RNM” or “retail net metering” will refer to the retail variety.

Origins of retail net metering

Although RNM has become the prevalent form of tariff for solar PV DG in the U.S. today, it was not developed as part of a fully and deliberatively reasoned pricing policy. RNM was simply never a conscious policy decision. It is basically a default product of two no longer relevant considerations, one practical and the other technological. The practical reason was that distributed generation had such an insignificant presence in the market that its economic impact was marginal at best. Thus, no one was seriously concerned about “getting the prices right.” The second, technological, reason was that the meters most commonly deployed, especially at residential premises, until recently have had very little capability other than to run forward, backward, and stop. Thus, for technical reasons, RNM was simple to implement and administer, and, as a practical matter, given the paucity of DG, there was no compelling reason to go to the trouble of remedying a clearly defective pricing regime. Many states have recognized the problems with RNM, but seeing no alternatives to it, have put in place production caps to limit any harm caused by a clearly deficient pricing regime.

Problems with retail net metering

RNM, as practiced, significantly over-values distributed solar generation in ways that have serious negative impacts on the efficiency and fairness of the electricity pricing system. Using RNM to reimburse solar PV DG hosts for the energy they export into the grid creates a cross-subsidy from non-solar to solar customers which is socially regressive. It distorts the energy market by advantaging solar PV DG relative to other forms of generation, including alternative renewable resources, and by failing to account for the fact that the value of energy varies widely depending on when it is actually produced, with the result that it distorts price signals for energy efficiencyCross subsidies

There are several ways in which RNM for solar PV DG results in non-solar-owning customers subsidizing customers with solar generation. The first has to do with how non-energy utility costs (for distribution, reliability, and administration) are paid for. A utility can be thought of as providing a number of different services. There is the purchase and resale of energy, of course, (and associated capacity payments)—but making this possible, there is also the service of

distributing the energy from the point of wholesale purchase or generation to individual households, the service of ensuring system reliability, and the administrative services of billing and other customer service work. Utilities must collect retail revenue that covers the costs of all these services.

Most U.S. utilities have long adopted a practice of including only a small fixed charge on the monthly bill, and collecting most of the money necessary to cover all their expenses through a per kWh rate (i.e. on a variable basis). In the absence of wide use of net metering, this is a workable approach that means that those who use the most energy bear more of the costs of the system and that creates incentives for energy efficiency.

Under RNM, however, this approach becomes a problem. When DG providers export energy into the system, consumers are required to pay them full retail rates for a wholesale product. Everyone agrees that solar PV DG provides an energy value, although there is considerable disagreement about what that value is. Solar proponents argue that it has a capacity value as well. (As I have argued above, that value, if it exists at all, is minimal, but for the moment it will assume some level of capacity value.) Both energy and capacity are wholesale products and should be compensated as such. While, as is discussed below, there may well be reasons to treat DG differently from wholesale generation for transmission purposes, there is, absent a solar host leaving the grid, absolutely no reason to discriminate between wholesale and DG producers in regard to the fixed costs of the distribution system and its operations. Under RNM, however, solar PV DG providers are compensated at full retail prices for what they provide. That includes the not-insignificant cost of services that they, indisputably, do not provide, including distribution, administrative, and back office operations. There simply can be no justification whatsoever for forcing consumers to pay a provider for service they not only do not provide, but, in fact, have no capability to provide.

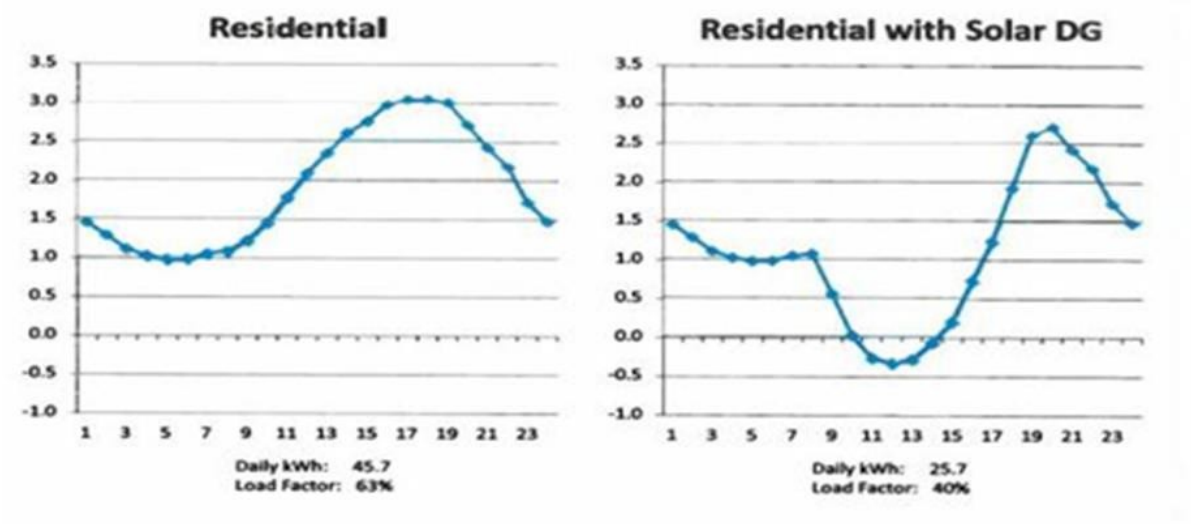
Solar PV DG producers remain connected to the grid and are fully reliant upon it during most hours of the day, when solar energy is not available. In fact, there is virtually no time at which they are not using the grid either to import or to export energy. Under RNM, that solar PV DG producer is excused from paying his/her share of the costs of the distribution system when energy is being produced on premises. If the costs of the distribution system were variable with energy production, that would be sensible, but they are not. Distribution costs are fixed and do not vary with energy production or consumption. All distribution utilities must construct and maintain sufficient capacity to serve each and every customer in its service territory at their peak demand, regardless of whether the customer chooses to avail himself/herself of that

service at any given moment in time. Thus, excusing solar PV DG customers from paying for their own distribution costs at the time their solar units are functioning has no justification in either policy or economics. Utilities have to either reallocate these costs to non-solar customers or absorb them by cutting other services, such as conservation programs or operations and maintenance. Either outcome is unjustifiable and unacceptable. There simply is no reason why solar PV DG customers should receive free backup service compliments of their neighbors. It is an unacceptable cross-subsidy.

Two additional types of cross-subsidy relate to the intermittent nature of solar energy. Given the intermittent nature of solar energy, no utility with an obligation to serve can afford to be fully reliant on the availability of solar when it is needed. The first cross-subsidy that results from this fact arises when the distributor relies on the availability of solar for making day-ahead purchases, and the other arises when it does not do so. When it does rely on the availability of solar and it turns out that solar energy is not available when called upon, the utility is compelled to purchase replacement energy in the spot market at the marginal cost, which is almost certainly higher than the price of the solar energy on whose availability it had relied. In notable contrast to what happens in the wholesale market when a supplier who is relied upon fails to deliver, those incremental costs have to be borne by the utility, which passes them on to all customers, as opposed to being borne by the specific solar PV DG customer whose failure to deliver caused the costs to be incurred. If the distributor, in recognition of solar's intermittency, instead chooses to hedge against the risk of solar's unavailability, the cost of the hedge is likewise passed on to all customers rather than simply those whose supply unpredictability caused the cost to be incurred. The fact is that one way or another, a utility buying solar output must simultaneously contract for back-up in case of unavailability, or, in the alternative, be prepared to pay the incremental cost of buying in the spot market when the solar is not available.

A fourth kind of cross-subsidy comes from the additional ramping demands solar PV DG customers often place on the electricity system. Unlike typical residential customers, in some regions solar PV DG users use little or no grid power when solar production peaks, but quickly ramp up demand on peak, when, as will be discussed below, PV production wanes. Utilities must be able not only to serve full load on days when solar PV is not performing, but also to ramp up resources quickly to address the peak created by solar PV DG users. In order to ramp up as needed, utilities will purchase energy at the marginal price and then distribute those costs across all users, not just solar PV DG users. Thus, users without solar PV DG may be penalized for the use patterns of their solar PV DG neighbors. An illustration of this may be found below,

in the PacifiCorp chart showing a comparison of residential electricity consumers in the western United States to residential consumers. with solar PV DG:



All these forms of cross-subsidy violate a bedrock principle of regulation -- that costs should be allocated to the cost causer. The function of that principle, of course, is to provide price signals to improve performance, but RNM fails to provide such signals and essentially holds solar PV DG providers harmless for their own very low capacity factors and inefficient performance.

The impact of net metering is not simply the creation of a cross-subsidy from non-solar PV DG customers to solar PV DG customers, but, as has been pointed out in a recent study by E3, a prominent economic consulting firm, it is a cross-subsidy from less affluent households to more affluent ones. Indeed, the average median household income of retail net metering customers in California is 68% higher than that of the average household in the state, according to the study.[35] Net metering is "Robin Hood" in reverse. In order to install rooftop solar panels, often individuals must be homeowners with high credit ratings or sufficient capital. Leasing arrangements are also widespread, but are generally available only to customers who own their own premises, and they require the assignment of most of the rooftop solar benefits to the lessor. Leasing arrangements also customarily transfer most of the subsidy benefits from the solar host to the lessor. Thus, more affluent solar PV DG customers derive disproportionately higher benefits from DG than their less affluent peers. Many electricity customers, particularly less affluent ones, do not own homes or lost their homes in the most recent recession. The

[35] Energy+Environmental Economics, Inc., *California Net Energy Metering Ratepayer Impacts Evaluation*, October 28, 2013, p.11.

electricity customers who are unable to afford rooftop solar are forced to subsidize those who are already in a more favorable financial position. Thus, it is accurate to characterize RNM as a wealth transfer from less affluent ratepayers to more affluent ones.[36]

No incentives to improve efficiency and value to the grid

One of the more interesting aspects of net metering is that it subsidizes, and therefore incentivizes, a highly inefficient use of solar PV DG. Without getting into a debate over whether subsidies in general are a good or bad idea, it seems obvious that if a subsidy is to be deployed to support some technology, that it ought to be designed to enable resources to be more efficient and more commercially viable so that the subsidy can eventually be eliminated.

RNM fails by this standard of encouraging development towards efficiency and commercial viability, in large part because it compensates solar PV DG at flat rates that fail to track the realities of supply and demand. Electricity prices can be quite volatile over the course of every day, and, of course, vary seasonally as well. Rather than reflecting those prices, RNM simply treats all energy the same regardless of the time during which it is produced. For example, it fails to differentiate between energy produced on peak and off peak. It pays off-peak solar PV DG a price that is averaged with on-peak prices. Given, as will be shown below, that peak solar production is not coincident with peak demand, flat payments reflecting average costs retail rates have the effect of very significantly over-valuing the energy produced by solar PV DG. Conversely, were solar PV DG actually produced on peak, which is not generally the case, RNM would average that price with off-peak prices, thus undervaluing the energy. Any form of dynamic pricing, ranging from time of use (as deployed in SRP) to real time, could address this issue with more precision than the flat, averaged prices produced by RNM. Interestingly, under the first scenario, cross-subsidies would be paid to solar producers, while, in the second, far less likely scenario, solar producers would be cross-subsidizing the other ratepayers. Importantly, to the extent that solar PV DG is produced off-peak, owners would have an incentive to invest in storage or other technologies to allow them to sell more on-peak electricity, increasing the overall efficiency of the solar resource. To the extent that RNM fails to capture the real time

[36] The staff report to the Arizona Corporation Commission cites the socially regressive effect of net metering in Arizona. It is intuitively obvious that more affluent people are more likely to own their own homes and control their own rooftops, as well as more likely to have access to the capital necessary to finance solar installations and/or to qualify for leasing arrangements. (*Arizona Public Service Company – Application for Approval of Net Metering Cost Shift Solution (Docket No. E-01345A-13-0248*)*)*

prices in the energy market, the price signal, and the efficiency that would flow from that, is at best, diluted, and in the case of flat prices, completely lost.

Under RNM, compensation at retail rates is not cost-reflective because net metering means that solar PV DG energy exported into the distribution network is compensated at the full bundled retail rate on an averaged basis rather than at a price based on the unbundled cost of producing the energy at the actual time of production. Thus, it does not reflect the obvious fact that the energy has greater value at peak demand than it does off peak. It is a deeply flawed value proposition from an economic point of view.[37] The fact is that the wholesale market produces hour-by-hour prices that provide generators (renewable and non-renewable alike) with important price signals that reflect real-time values. Solar PV DG-produced energy, by contrast, is compensated on a basis that lacks a foundation in either market or cost. The compensation is out of market because it is a flat price regardless of when it is produced. It is hard to avoid the conclusion that on an economic basis, the net meter-derived price paid for solar PV DG energy completely misses the value of solar during most hours of the day.

In fact, as a recent *New York Times* article explains, this flat RNM pricing has contributed to a nationwide misalignment of solar panels—they are generally installed facing south, to generate the largest total quantity of solar energy over the course of the day (and the greatest savings and/or revenue for homeowners under RNM). If solar were paid at a time variable rate that reflected the much greater value to the grid of energy provided during the late-afternoon peak demand period, these panels would face west, generating less total energy, but capturing the late afternoon power of the setting sun.[38] It would be impossible to think of a better example of why price signals are so important. RNM, with its flat pricing structure, incentivizes the production of KWh even if they are of marginal value when produced, while dynamic pricing of solar PV DG output, would provide incentives to produce energy of far greater value. Stated succinctly, RNM inevitably leads to less efficient and less valuable output.

Similarly, RNM provides no financial incentive for solar PV DG owners to address one of the critical shortcomings of solar from the point of view of the grid, which is its intermittent availability. Indeed, that intermittency not only reduces its economic value, but as discussed it

[37] It is also deeply flawed from an environmental point of view, because at peak, solar PV DG is far more likely to displace less efficient generation, with higher emission levels, than it would off peak. That is because, as a general rule, absent special circumstances, these less efficient plants tend to be dispatched more on peak than at any other time.

[38] Matthew L. Wald. "How Grid Efficiency Went South" *New York Times*. October 7, 2014.

also reduces the likelihood of attaining the desired environmental results. With RNM, there is no financial incentive provided to solar PV DG owners to do anything to mitigate intermittency—so even if a cheap battery technology, for example, came along, homeowners would have no incentive to invest in it.

Market distortions that disadvantage other renewables

Large-scale bulk power renewables (e.g. large-scale wind and solar farms, hydro, bio-mass, and geothermal) are put at a particular disadvantage by RNM pricing of solar PV DG independent of costs or market for three basic reasons. First, large-scale renewables are more efficient and more cost-effective than DG, yet net metering provides a subsidy to the least efficient form of renewable generation. In fact, solar PV DG providers are compensated for the energy they export from their premises at a price that is significantly higher than the market price for energy. Second, in those states with renewable portfolio standards) the entry of a critical mass of non-cost-justified solar PV DG units into the market could have the effect of driving more efficient, large-scale renewables out of a fair share of the renewable portfolio market. Third, as noted above, for renewables purchased in the wholesale market, the price paid by consumers reflects all of the transmission and distribution network costs incurred in delivering the energy. It is assumed for DG that there are no transmission costs. The effect, in a competitive market, is to bias the market to incentivize highly inefficient small-scale solar to the detriment of less costly larger-scale solar. The ultimate result is higher costs than necessary to keep the system reliable and stable and simultaneously reduce emissions of carbon and other pollutants.

Net energy metering provides the wrong long-term incentives to solar PV DG

In the short term, the cross-subsidies resulting from net metering help the solar industry by transferring wealth from SRP's non-solar customers to the solar industry. In the long term, however, they are actually harmful to solar energy because RNM provides absolutely no incentive to improve the performance of a generating resource that, among renewables, already ranks last in efficiency and in cost effectiveness for reducing carbon emissions. In effect, the solar industry is putting its short-term profits ahead of the long-term value of solar energy. If they prevail in seeking to maintain RNM, that victory will be short-lived, because markets, both regulated and unregulated, do not prop up inefficient resources over the long term.

Are the problems of cross subsidies and time invariant rates unique to net metering?

One of the questions raised in the FTC's invitation for public comment asks whether the cross-subsidy effect is unique to net metering, or whether it occurs to some extent whenever time invariant volumetric charges are used. The answer is a qualified no. Flat rate, time-invariant

pricing, to the extent it does not accurately reflect the costs of electric service provision, will not result in totally fair pricing, even without net metering. In effect, customers who concentrate their energy usage less during peak hours subsidize heavy peak energy users. And customers who use more energy subsidize those who use less, by carrying a proportionately larger share of fixed costs.

In the long run, as utilities work to create efficiencies and deal with the impacts of distributed generation on the grid, it may be worth addressing these kinds of pricing issues for all customers. However, it is eminently reasonable to prioritize net energy metering in addressing cross-subsidy problems. Net energy metering takes the distortions of imperfect rates to a new level, since customers not only can avoid paying their share of costs when they generate their own energy, but they can get additional generous payment for energy provided to the grid. Furthermore, the longer the large subsidies of RNM are left in place, the bigger and more intractable the problem is likely to get, particularly since utilities may reasonably be reluctant to change rates for customers who have made large investments in distributed generation. Finally, whereas in the absence of distributed generation, one might assume that a cross-subsidy by heavy energy users to low usage customers would tend to transfer money from richer households to poorer households, there is good reason to believe that the cross-subsidy of RNM is essentially a transfer of money from less well-off to more well-off customers.

The fundamental problem underlying RNM is the fact that utilities incur costs in three basic ways, fixed, demand, and variable, but, absent a token fixed charge, customers pay as if almost all costs all variable. While there are historic explanations for why that has occurred, the fact is that that variance between how costs are incurred and how they are paid for, has created a major tariff flaw that RNM, more than any other current practice in the industry, has made much more difficult to manage. Under RNM, solar customers simply pay none of their fixed or demand charges whenever they are generating energy. To make matters worse, when energy is exported onto the grid, the solar producers are compensated not only for the energy they sell, but also for the fixed and demand costs they do not provide. As market penetration of rooftop solar grows, those circumstances compel a reallocation of costs to non-solar customers. It, in fact, constitutes a shift of costs away from ratepayers who caused them to be incurred (i.e. their fair share of the fixed and demand costs) to those who are already paying their fair share of costs. The result is not only inequitable, but violates a basic regulatory principle, namely that the cost causer pays for the costs he causes to be incurred, thereby not only unfairly shifting costs, but also sending customers highly inefficient price signals. It is also quite important to note that the cost shift is socially regressive, in that, in the aggregate, it shifts wealth from less

affluent households to more affluent ones. While there may well be other cross-subsidies in tariffs, it s hard to think of any others that so distort regulatory principle, run contrary to basic notions of economics, and result in severe inequities.

Prioritizing reforms

Utilities across the country are trying different ways to address the inequities of retail net metering. The ideal reformed rate is one which best conforms to the principle that the cost causer pays—this kind of rate is the one that will best align the interests of the utility, of solar customers, and of non-solar customers. The new three-part rates being adopted by some utilities are good especially good in this regard. Components of such a reformed three part rate would be the following:

- A larger monthly fixed charge that more accurately reflects the fixed costs of service provision, including billing, metering, customer service, and some grid costs;
- A variable energy charge, reflecting the actual cost of energy itself (ideally, this cost would vary to reflect the changing price of energy over time);
- A "demand charge," reflecting the costs to the system of ensuring service for peak demand, which would include some transmission and distribution costs, along with power capacity costs.

Of course, a number of changes could be adopted, short of a three-part tariff, that would represent considerable improvements over RNM. For example, actual Net Energy Metering (where energy provided to the grid was compensated at the energy only rate, not the full retail rate) would be a significant improvement, although it would not eliminate all of the cross-subsidies associated with retail net metering.

The end target should be a tariff that bills customers as accurately as possible for their cost of service. Under such a system, distributed solar installations could grow at whatever rate the market would support without imposing burdens on other customers. Regulators will need to consider whether it is better to proceed gradually to this end, or move their as quickly as possible, weighing issues of fairness, efficiency, and the difficulty of change.

Does it matter how the utility itself is structured?

The overall analysis of the impacts of RNM does not change in any significant way for a vertically integrated utility or based on whether the utility is an IOU, a muni, or a coop. In all cases, RNM distorts prices and the signals they give customers and causes cross-subsidies among customer groups. Indeed, as noted, the adverse impact of retail net metering is not on

the utility itself, which has the ability to shift costs and make itself whole, but, rather, on the vast majority of consumers who do not have solar panels on their roofs, but are nonetheless compelled to pay those costs that are attributable to other customers. In short, the particular structure of the utility does not matter, because the issue, as I discuss further below, is not fundamentally one of utility profits vs. distributed solar profits—it is an issue of fair cost allocation among customer groups, a problem all utilities face, no matter what their governance structure.

The question of whether it matters if the utility is vertically integrated or not is of little consequence. Obviously, if a utility is solely a distributor, it has no stake, other than getting the best deal for its customers, in the outcome of competition in selling capacity and energy. That reality changes very little in regard to vertically integrated utilities, because regulatory oversight (or owner/political oversight for coops and munis) assures that vertically integrated utilities are subject to prudential and consumer protection reviews that include market analysis, such that their primary focus has to be on getting the best deal for their customers, and the decision as to whether to build or to buy energy and capacity is driven by marketplace realities. In that sense, rooftop solar is, for a utility, one more potential source of energy to buy (or, in the case of a solar customer, to not buy). The existence of rooftop solar means there is just another potential source of energy to purchase. The only caveat on that point is that, unlike any other energy source, the utility is free (subject, of course, to regulatory constraints) to contract with suppliers, but under RNM, it is not only compelled to purchase the energy exported into the grid, but must do so at a an arbitrarily inflated price. Retail choice and time varying pricing may both help to limit the distortions RNM produces. Retail choice programs can be structured in many different ways, but true retail competition in electricity provision may make it more difficult to bundle non-energy charges into the energy rate, setting the stage, potentially, for an energy-only reimbursement (such as is seen in Texas) that is closer to the actual value of what distributed solar customers provide to the grid. Similarly, time varying rates that do a good job of capturing the actual variations in the value of electricity (note this probably means rates that vary in real time), would help bring payments for solar energy provided to the grid closer to their actual value. Demand charges are also quite helpful, as they provide customers with a clear and transparent price signal regarding the capacity demands they impose on the system

However, as discussed above, only a three part tariff which includes a demand charge really sets the stage for getting customer costs and incentives fully into alignment.

Are DG penetration levels relevant to choosing an optimal pricing approach?

It is likely (and widely acknowledged) that the costs to the electric system of dealing with some of the ramping challenges of distributed generation get bigger at higher levels of dg penetration. So too, are the price distortion that were noted above. Thus, the incentives to manage peak demand provided by time varying pricing and demand charges will become increasingly crucial as solar penetration rates rise. However, this does not mean that it is a good idea to wait to impose demand charges until there is a crisis. The more people invest in solar systems under a rate without a demand charge, the harder it will become to address the problem fairly, even as it becomes increasingly urgent. Over time, some parties to the debate become increasingly invested in taking advantage of flaws in the tariffs, and become more resistant to reform of those flaws. Indeed, many, although not all, of the rooftop solar providers have developed a business model of exploiting tariff flaws, as well as chasing subsidies, rather than fully competing on price and service.[39] Most importantly, given all of the changes in technology and potential service offerings related to both energy and demand efficiency, it is simply vital to get the prices right as soon as practicable.

Should environmental externalities affect retail pricing?

Different jurisdictions have differing views on the role of externalities in ratemaking. While, for purposes of this submission, I am not taking a position one way or another on that philosophical/legal issue, because of the way the question is framed. I will address the question as if environmental externalities do play a role in ratemaking. As discussed above, distributed solar is an extremely expensive means of reducing environmental externalities associated with the generation of electricity through fossil fuel. An ideal policy would incorporate externalities into retail pricing in a way which gives all non-carbon resources an advantage proportional to their ability to efficiently reduce carbon emissions. Imposing a price on carbon and/or particulate emissions (for example, through a carbon tax or a cap and trade system) would be the optimal solution. Any second-best solution would need to at least treat all electricity sources equally in terms of how they are rewarded or penalized for their environmental externality impacts. Retail net metering does not pass this test. It simply pays the most for the least efficient means of reducing emissions. The absence of time sensitive prices and demand charges is harmful to the pursuit of energy and capacity efficiency and poses a severe barrier to

[39] The SolarCity 10K statement, discussed in more detail below, illustrates this business approach. See SolarCity Corp 10K, filed 2/24/15 for period ending 12/31/14, p. 38 (available at http://files.shareholder.com/downloads/AMDA-14LQRE/1445127011x0xS1564590-15-897/1408356/filing.pdf)

entry to suppliers of efficiency products and services. Given the important contribution of efficiency to carbon emissions reduction, that is a significant problem. Similarly, by paying a premium price for less efficient rooftop solar, as opposed to the prices paid for utility scale (not necessarily utility owned) solar and wind, we run the risk of allocating capital away from more cost effective ways of reducing emission to less cost effective ones. Similarly, in those jurisdictions that have renewable portfolio standards, we run the very real risk of skewing the composition of that portfolio in directions that will cost ratepayers more money to reduce fewer emissions. Stated quite simply, the economics of rooftop solar to reduce emissions, compared to the economics of relying more on efficiency and on utility scale renewables, make it simply unwise to promote solar dg as a means of reducing our carbon footprint. It simply reduces fewer emission per dollar spent than the alternatives do.

Competition Issues

Advocates of Retail Net Metering have sometimes argued that removing this subsidy is, in and of itself, a barrier to competition. This is a rather astonishing argument, and, if sustained, would set a perverse precedent about what competition requires. Traditionally, competition requires marketplace access and a level playing field—if competition is redefined to mean that less efficient resources must receive subsidies to make them competitive, the whole idea of what competition is and what is for seems to fall apart. To agree that subsidies must be maintained in order to preserve competition would set a strange, and in the end, indefensible and quite dangerous, precedent. Furthermore, the notion that rooftop solar is in direct competition with utility service provision is simply mistaken. The relationship between distributed solar generation and utilities is sometimes portrayed as essentially a relationship of business competition, on the theory that rooftop solar and utilities are competing to provide electricity to households.

However, this way of characterizing the situation is misleading. While rooftop solar provides electrons when the sun is shining, a utility, to be successful, must provide much more than this—dependable on-demand service, whenever demanded, as much as is demanded. To attempt an analogy, you could say the distributed generation is like an online grocery delivery service; a utility is more like a personal chef. Both services involve the provision of food, but they are not interchangeable. Distributed generation does not compete with the overall utility package—transmission, distribution, ensuring reliability and adequacy of electricity supply.

For regulated utilities, compensated based on their investment in generation and other customer service infrastructure, does distributed generation nevertheless represent a threat to profits? Any effect of this nature is likely to be small. As I argued above, in discussing the potential benefits of distributed solar generation, due to the intermittency and non-dispatchability of this generation, utilities cannot back down investments in other resources proportionally to the presence of distributed generation on the system. Actual impacts will vary on a case by case basis—in some cases, where changing and more varying load shapes require additional ramping and other capabilities, the end result may be to require new investment in generation and/or storage and/or other capital assets. .

Where competition might become more relevant is cases in which utilities are permitted to compete directly with solar vendors in financing and installing distributed generation for customers. Should this form of activity by utilities be permitted, thought should be given to how to ensure that non-utility vendors continue to have fair access to this market.

Although I do not believe competition with utilities is currently a major issue for solar dg, the issue of whether there is currently a functioning competitive market in residential solar DG systems is an urgent and troubling one. There are a few indications that the market may not be adequately competitive:

First, as discussed above, are empirical indications that costs for residential solar systems are out of line with international norms and economic benchmarks. The MIT *Future of Solar* study, discussed above, which found a pattern of high prices in the United States considerably above MIT's calculation of the bottom-up costs of residential solar pv systems;

Second are statements from the solar dg industry and its representatives, which do not seem to reflect an orientation to a competitive market, but, rather, a market in which the key competitive benchmark is not what other, competing companies can provide, but, rather, how much margin subsidies and cross-subsidies can create for solar providers.

In fact, emphasizing this very point, in a recent 10K filing, the large solar dg company clearly describes this as its business model:

> We compete mainly with the retail electricity rate charged by the utilities in the markets we serve, and our strategy is to price the energy and/or services we provide and payments under MyPower below that rate. As a result, the price our customers pay varies depending on the state where the customer is located and the local utility. The

> price we charge also depends on customer price sensitivity, the need to offer a compelling financial benefit and the price other solar energy companies charge in the region. Our commercial rates in a given region are also typically lower than our residential rates in that region because utilities' commercial retail rates are generally lower than their residential retail rates.[40]

SolarCity's 10K testimony is also quite revealing about its motivations for opposing pricing reforms:

> Modifications to the utilities' peak hour pricing policies or rate design, such as to a flat rate, would require us to lower the price of our solar energy systems to compete with the price of electricity from the electric grid.[41]

This is the business model of the leading player in the rooftop solar industry. They fail to even mention actual cost, or even market valuation, to provide service—it is all about charging as much as possible, depending on the utility rates and existing incentives that will leave a small incentive for the solar dg consumer. In short, RNM enables charging arbitrarily high prices for a product whose vendor is shielded from most market and performance risks by RNM, a severely flawed pricing methodology.[42] That necessarily results in what has already been noted, namely that declining costs are used to line the pockets of suppliers, rather than being passed on to consumers, and that those same consumers are required to pay a retail rate for full service electricity for a wholesale product that delivers only a fraction of the full service.

An egregious example of this non-competitive, indifferent to consumers thinking emerged in the testimony provided by a pro-RNM witness in a recent proceeding in Arizona focused on better understanding the pros and cons of "value of solar analysis." The testimony on this issue provided by VoteSolar witness Briana Kobor really demonstrates the problem here. Ms. Kobor

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[40] SolarCity Corp 10K, filed 2/24/15 for period ending 12/31/14, p. 38 (available at http://files.shareholder.com/downloads/AMDA-14LQRE/1445127011x0xS1564590-15-897/1408356/filing.pdf)

[41] SolarCity Corp 10K, filed 2/24/15 for period ending 12/31/14, p. 11 (available at http://files.shareholder.com/downloads/AMDA-14LQRE/1445127011x0xS1564590-15-897/1408356/filing.pdf)

completely denied that declining solar panel costs are relevant to the question of what costs non-solar customers should be willing to bear to support such installations, arguing that the important question is only "whether the price paid for exports is commensurate with the value received," and whether "the price paid for DG exports appropriately reflects the value of the energy provided."[43] This would harm both customers and the development of solar.

Ms. Kobor's view that declining panel costs need not be reflected in prices charged consumers is not only an extraordinarily anti-consumer sentiment worthy of a Charles Dickens novel, but is profoundly anti-solar. If costs are declining, that is good for solar, as it puts the panels within reach of more customers and will increase sales. That is exactly what markets do. Instead, she says it has no relevance in her construct of "value" pricing. It is also extraordinary, because it fails to recognize that the value proposition is enhanced by obtaining the same product at lower cost. Nor does she even acknowledge the fact that many of the values she assigns to rooftop solar may be obtained at lower cost by other means. She has inadvertently revealed a mindset that focuses solely on maximizing the price of solar regardless of consumer welfare and regardless of the future for the product she purports to advocate for. In essence, her view of declining costs not having to be passed on to customers removes the "value of solar" fig leaf and leaves exposed what value of solar pricing is all about to the rooftop solar industry: excessive short term profit taking by rooftop solar vendors/lessors regardless of costs to others and even to the product they sell.

The dearth of competition here has impacts that go beyond the costs imposed on consumers. It has a chilling impact on competition from innovative technologies, as well. As I have discussed above, utility-scale renewables, such as wind and solar, which are significantly more efficient, both at generating electricity and at avoiding carbon emissions, and which have the advantage for the system of being under the planning and dispatch control of the utility, are put at a competitive disadvantage by a subsidy that is available only to rooftop solar. The same is true for programs and technologies that enable greater efficiency in both energy and capacity requirements.

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[43] Briana Kobor testimony on behalf of Vote Solar, Docket No. E-00000J- 14-0023 before the Arizona Corporation Commission, February 25, 2016, p. 37. Available online at: http://images.edocket.azcc.gov/docketpdf/0000168551.pdf

Furthermore, technologies (including the simple optimized installation) that might enhance the value of rooftop solar are themselves put at a disadvantage by a system that rewards only the amount of production, without any sensitivity to the importance of producing electricity when the system most needs it. In fact, as a recent *New York Times* article explains, flat RNM pricing has contributed to a nationwide misalignment of solar panels—they are generally installed facing south, to generate the largest total quantity of solar energy over the course of the day (and the greatest savings and/or revenue for homeowners under RNM). If solar were paid at a time variable rate that reflected the much greater value to the grid of energy provided during the late-afternoon peak demand period, these panels would face west, generating less total energy, but capturing the late afternoon power of the setting sun.[44] It would be impossible to think of a better example of why price signals are so important. RNM, with its flat pricing structure, incentivizes the production of KWh even if they are of marginal value when produced, while dynamic pricing of solar PV DG output, would provide incentives to produce energy of far greater value. Stated succinctly, RNM inevitably leads to less efficient and less valuable output.

Similarly, RNM provides no financial incentive for solar PV DG owners to address one of the critical shortcomings of solar from the point of view of the grid, which is its intermittent availability. Indeed, that intermittency not only reduces its economic value, but as discussed it also reduces the likelihood of attaining the desired environmental results. With RNM, there is no financial incentive provided to solar PV DG owners to do anything to mitigate intermittency—so even if a cheap battery technology, for example, came along, homeowners would have no incentive to invest in it.

An opportunity for more competition

Solar and prospective solar customers are looking for cost effective means of meeting their need for electricity. In seeking cost effective means of reducing their electricity bills, such customers have a variety of options, most notably including energy efficiency and demand side management, as well as a solar panel on their roof. Their desire for reducing costs, however, is not necessarily technology specific, so going solar is but one option. Many may also be motivated by concerns for the environment (concerns that might be more cost-effectively addressed by investments in other renewables, such as wind or utility-scale solar). To the extent to which such activities are cross-subsidized, obviously, they would want to be the beneficiaries of the cross subsidy, although few if any of those customers are explicitly seeking

[44] Matthew L. Wald. "How Grid Efficiency Went South" *New York Times*. October 7, 2014.

rents from their neighbors. Again, however, a customer's desire to reduce his/her carbon footprint is not technology specific; it is results driven, and there are methods beyond solar that can accomplish the desired end.

RNM, which benefits only distributed solar generation, distorts the competition among resources to provide the cost saving and environmental benefits customers are seeking. Thus, it is not the utility which is suppressing competition by attempting to reform RNM; it is RNM which attempts to claim an unfair advantage for distributed solar among other technologies that might offer similar or greater benefits.

Consumer Protection Issues

The questions raised related to consumer protection issues in the invitation for public comment are highly relevant. A number of state Attorneys General, consumer protection agencies, and consumer organizations are working on these issues and should be well positioned to provide important input to the Commission. In particular, the Commission would be well advised to closely scrutinize leasing arrangements, as they have become a source of frequent consumer complaints and inquiries. Accordingly, I will make only a few general points:

On Risk

The question of who does and should assume the risk of changes in regulation is an important one. As a general regulatory principle, it should be recognized that pricing needs to be subject to change to reflect market realities. It is important that customers choosing to invest in distributed solar generation get accurate information about regulatory risks. It is not at all clear that rooftop solar providers make any effort to do so. Indeed, they often misrepresent regulatory realities to unsuspecting customers.

On Renewable Energy Credits

Greater clarity surrounding renewable energy credits would be of significant value in the context of customer protection. Where renewable energy credits are sold, it is important to note that any additional value associated with reduction in carbon emissions has been fully compensated, and should not be compensated again by using the renewable attribute to justify the subsidy provided by retail net metering. Many environmentally-motivated customers may also be confused about what is going on, as highlighted in a recent op ed piece by Severin Borenstein published in the *LA Times.* As Borenstein points out, it is misleading for distributed solar companies to tell customers they will be receiving "green" energy if the green attribute is

also being sold to someone else.[45] Borenstein's article suggests the FTC is already well aware of this issue. Given that "cashing in" on RECs by solar providers in lease transactions is such a common practice, Borenstein's admonition should be taken very seriously by the Commission. ,

On Robocalls

With respect to the practice of the use of robocalls by DG marketers, I will simply speak to my own experience as a Massachusetts resident. I receive these calls regularly, and I am concerned by the misrepresentations they generally contain. The calls I receive typically warn of imminent large utility rate increases (which I am in a position to know are not coming), misrepresenting the risks to consumers of not installing solar panels. If this is a common practice nationally, it is a serious problem that deserves attention.

Conclusion

In conclusion, vital issues of competition and consumer protection exist in connection with the practice of retail net metering, but it is crucial to be clear about what these issues are. Attempts by utilities to reform retail net metering, far from being anti-competitive efforts to squelch the development of rooftop solar power, are essential steps, in a new and far more sophisticated energy market, to establish fairness in customer bills, to promote fair competition among a number of resources that can provide customer savings and environmental benefits, and to establish a set of incentives that can promote increased productivity of distributed solar generation by leveraging new technologies and better matching solar production to demand.

[45] Borenstein, Severin. "Smug about your solar roof? Not so fast." Op ed. *Los Angeles Times.* (January 20, 2016). Available online at: http://www.latimes.com/opinion/op-ed/la-oe-0120-borenstein-solar-energy-credits-20160120-story.html.