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Net Metering PV Distributed Resources Benefits All Stakeholders on PJM

Peter Mark Jansson[1]

[1] Electrical and Computer Engineering/Bucknell University, Lewisburg PA (USA)

Abstract

This research documents that all stakeholders (utilities, shareholders, customers – participants and non-participants, society, etc.) benefit from the electric utility policy of net metering of photovoltaics at the distribution level on PJM. It is important to share this objective data given the current political activity across the nation which inaccurately represents that the net-metering policy is somehow harmful to the utility and its customers. The papers finding to the contrary is based upon analysis of real data from locational marginal pricing across the RTO and at specific nodes within it. While one would expect that power generated during the day for a summer peaking utility is of more value to the electric utility system (since demands tend to be relatively higher at that time) this research documents the difference in PV generation LMP to non-generation LMP on a daily, seasonal and annual basis. Further, the value of photovoltaic capacity is not zero since very often PV systems make a significant contribution at the time of the PJM summer utility system peaks. This paper evolves from multiple other research studies which analyzed similar capacity and energy values coincident with PV generation over the past decade but uses the most recent data available which is affected by lower energy and capacity values in general due to the economic downturn. Apart from the obvious benefits that utility customers accrue by being able to use the grid as virtual storage via the net-metering policy this paper looks at the nearest neighbor impact, the distribution feeder impact, capacity planning requirements, the utility system as a whole, the ISO/RTO, as well as all other ratepayers. In all categories net-metering provides positive benefits to all these stakeholders and at present poses no significant burdens or costs onto the utility system or other ratepayers. The research finds that, in fact, PV system owners provide a positive economic value to the grid for which they are presently inadequately compensated. It is clear that electric utility regulators in 42 states, D.C. and multiple territories are aware of this positive benefit accruing to all electric utility stakeholders since they continue to support net metering as an important public policy support for solar technology. This research provides important objective economic assessment data that they can use to defend their current policies.

Keywords: *Net metering, PJM, photovoltaics, electric utility, stakeholders, locational marginal price (LMP), regulators*

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1. Introduction

While it is not front page news across the United States it is clearly of great import to the solar photovoltaic community that legislatures and policy makers across the country are reconsidering their regulatory stance of net-metering solar photovoltaic systems as they back-feed local electrical distribution systems. This important public policy has been viewed since its conception as a “win-win” for utilities, their customers and the electricity grid as a system. This paper will develop these benefits more specifically for the nation’s largest interconnection, PJM, the regional transmission organization (RTO) and independent system operator (ISO) serving the northeastern U.S. The recent reversal of this policy in Nevada (Cardwell and Creswell 2016) is alarming to the industry and incomprehensible to policy makers who know the facts regarding the benefits that net-metering accrues to all utility stakeholders.

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By 2014 net metering of solar photovoltaic systems in the U.S. was the accepted standard in 43 states (as well as the District of Columbia, Guam, Puerto Rico, American Samoa and the US Virgin Islands) because of the significant distribution and energy benefits it was providing to all consumers of electricity. The status of net metering policies across the U.S. in September of 2014 is shown in Figure 1. Idaho, Texas and Georgia (orange in the figure) allowed each utility to voluntarily set their own net-metering policies, which most did. One can notice from Figure 1 the notation that net metering rules were being actively discussed in over a dozen public utility commissions. By December of the following year (2015) the U.S. Department of Energy's SunShot program was reporting that over a dozen states were considering net-metering reform. This is illustrated in Figure 2. From all of this "considering" it seems only Nevada took a step in the direction

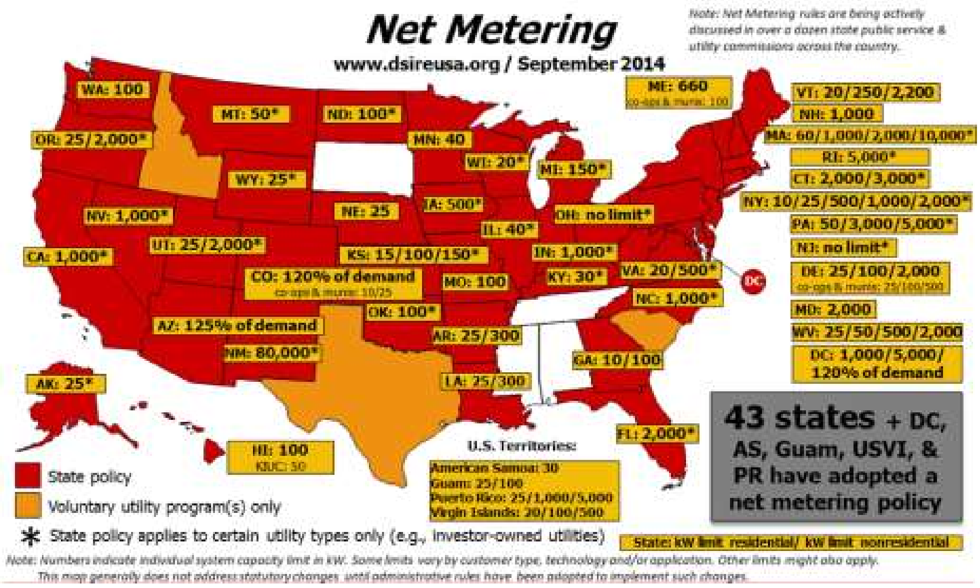

Fig. 1: DSIRE Database of State Net-Metering Policies for Solar PV

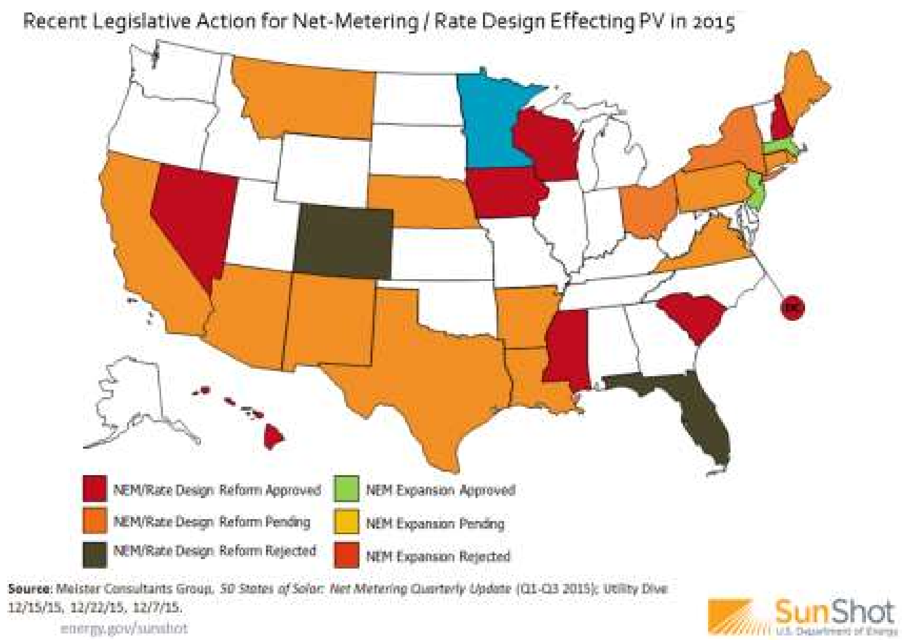

Fig. 2: U.S. Department of Energy SunShot Program – Legislative Action Affecting Solar PV

against the historic support that net-metering had received in 46 (now 45) states. According to the DSIRE website "Senate Bill 374 allowed the Nevada PUC to establish a separate customer class for distributed generation customers. The post-2015 net metering tariffs reflect this new customer class, with a higher monthly service charge and lower per-kilowatt hour (kWh) energy charge. The bill also gave the PUC broad authority to approve new tariffs that address cost shifts from net metered customers to other ratepayers. Such tariffs may vary from the previous requirements for billing, measurement, and treatment of net excess generation." (DSIRE, 2016) This bill passed the legislature in 2015 and the public service commission moved rather swiftly to "triple the fixed charges solar customers will pay over the next four years, and reduce the credit solar customers receive for net excess generation by three-quarters" (Pyper, 2016) While an increasing number of net-metering opponents argue on one side of the debate stating that PV customers are subsidized by the grid, the preponderance of evidence even to this date suggests that all customers benefit by PV systems producing electrical power during the high cost, high demand periods of summer peaking utility grids, often allowing the delay of building new peaking generation capacity. This research documents that over the past decade these same financial benefits accrue to all stakeholders of the electric utilities in the PJM region of the U.S.

2. PJM and Locational Marginal Price (LMP)

The PJM interconnection's load and locational marginal price has been used in this analysis since it is the largest utility interconnection in the continental U.S. It was at one time the largest in the world. It controls the transmission system that serves the loads of over 60 million people and operates in Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia. It represents a significant amount of the U.S. GDP within its dispatch regions. Previous objective financial analyses of PJM data (load, capacity and LMP) indicated that on average "the true value of distributed PV generation to the PJM system in recent years is $77 per MWh." (Diefenderfer, Prescott, et al, 2015) In essence, the Nevada ruling is saying that customers who generate PV electricity should be penalized financially for doing so, the referenced work says they ought to be compensated since they are in effect providing this distributed generation to their neighbors with no generation or delivery charges (or losses accruing to the distribution company's infrastructure). Except in an extreme case like the islands of Hawaii, where the grid may not have adequate stiffness to support high levels of DG, all of the continental U.S. has sufficient stiffness and generation assets to support decades of growth. In include two relevant graphics from the Diefenderfer, et al work below that illustrates. The first shows the correlation between PV generation and high utility system locational marginal costs from a PJM utility in 2014 (Figure 3) and the second tabulates data from 2008, 2009 and 2014 showing the magnitude of

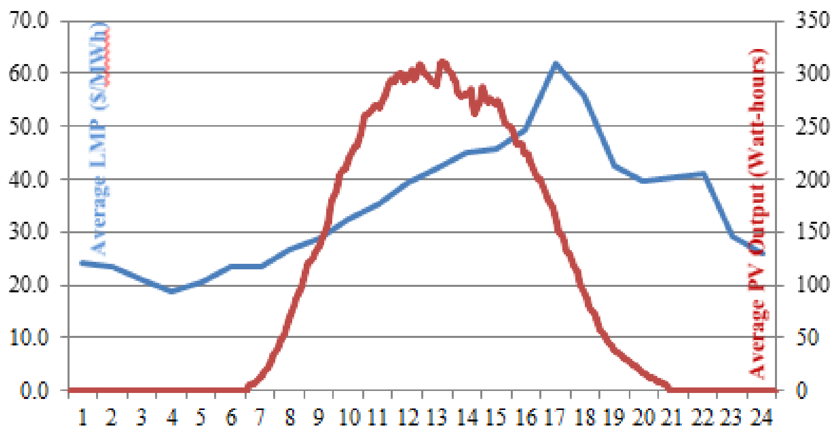

Fig. 3: Average Summer LMP on PJM vs. PV Generation

the differences in LMP between the on-peak solar generation hours and the other non-solar hours for contrast. The data from 2015 presented by this paper shows that the monthly system peak days from June and July 2015 continue to demonstrate that high demand periods and hot, sunny, summer days will always create high costs for all of the utilities (and their consumers) who operate in the U.S.

Tab. 1: PJM and PJM Utilities PV LMP Values ($/MWH)

	2008	2009	2014	2014 summer	AVE Value
PJM - RTO	22.1	4.6			13.4
PJM - AECO	33.7	8.3			21.0
PJM - PPL			9.0	12.1	10.6

These values clearly indicate that all customers and the utility company themselves experience lowering locational marginal prices as the PV generation is delivered into their distribution feeders. This is not a one year or one day event, this happens consistently on the grid when costs rise as daily demands increase the need to dispatch more costly generators. PJM is the most economically developed grid in the world [PJM, 2016a] providing approximately $3 billion dollars in value each year to its members and their customers for optimally operating the grid. The correlation between high demand and high system cost is obvious.

3. Coincidence of PV Generation with System Peak Demands

Figures 4 and 5 below demonstrate clearly the direct relationship occurring each summer for demand peaks electric utilities experience. This is no surprise since the peak is caused typically by high cooling demands placed on the grid by air conditioning devices which are driven by the solar gain and high ambient temperatures created on these peak days. Figure 4 is from June 2015, created by one of my students for a laboratory in our power system class (Viglino, 2015) and the other is created directly from the PJM LMP cost and load data freely available for download and analysis by the public. (PJM, 2016b)

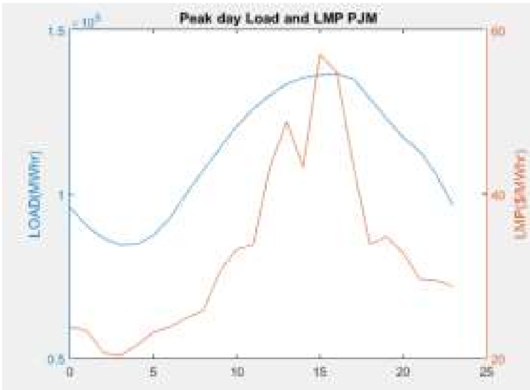

Fig. 4: Student Lab Analysis: PJM LMP vs Peak Day Load - June 2015

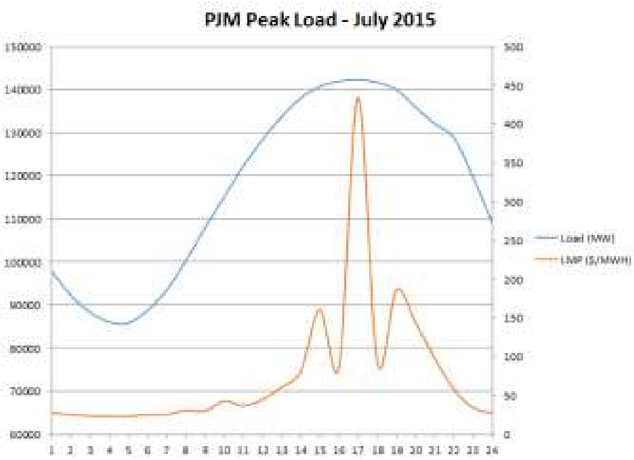

Fig. 5: PJM LMP vs Peak Day Load - July 2015

Over the recent decade (2004-2014) PJM has numerous monthly summer peaks with virtually all of them occurring before the sun had set and while PV systems were still generating significant electrical power. Table 2 (Diefenderfer, et al, 2015) illustrates that all of the system summer monthly peaks (Jun-Sep) occurred between 4-6pm when during summer the sun was still relatively high in the sky. Historically PJM offered a 38% capacity credit for PV systems to account for their still having a relatively high coincidence with required generation to support the customer peak demand. All of the highest summer peak monthly loads on PJM as provided in Table 3 are illustrated on Figure 6 (Deifenderfer, et al, 2015) where clearly they can be observed as having occurred in daylight hours. An update of the monthly summer peak data for 2015 and 2016 will show this trend is continuing.

Tab. 2: PJM Monthly System Peak Times (2004-2014)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2014	19:00	8:00	20:00	8:00	17:00	18:00	18:00	17:00	16:00	20:00	19:00	19:00
2013	19:00	19:00	8:00	8:00	17:00	16:00	17:00	18:00	17:00	17:00	8:00	19:00
2012	19:00	8:00	20:00	17:00	17:00	18:00	17:00	17:00	17:00	20:00	19:00	17:00
2011	8:00	8:00	8:00	15:00	17:00	17:00	17:00	16:00	17:00	9:00	19:00	19:00
2010	19:00	19:00	20:00	16:00	17:00	17:00	17:00	17:00	17:00	20:00	19:00	19:00
2009	19:00	8:00	20:00	17:00	17:00	17:00	17:00	17:00	17:00	10:00	19:00	19:00
2008	19:00	8:00	8:00	21:00	17:00	17:00	17:00	17:00	18:00	20:00	19:00	19:00
2007	19:00	20:00	20:00	8:00	17:00	16:00	17:00	16:00	17:00	17:00	19:00	19:00
2006	19:00	20:00	20:00	21:00	17:00	17:00	17:00	17:00	17:00	20:00	19:00	19:00
2005	19:00	8:00	20:00	14:00	17:00	16:00	16:00	17:00	17:00	17:00	19:00	19:00
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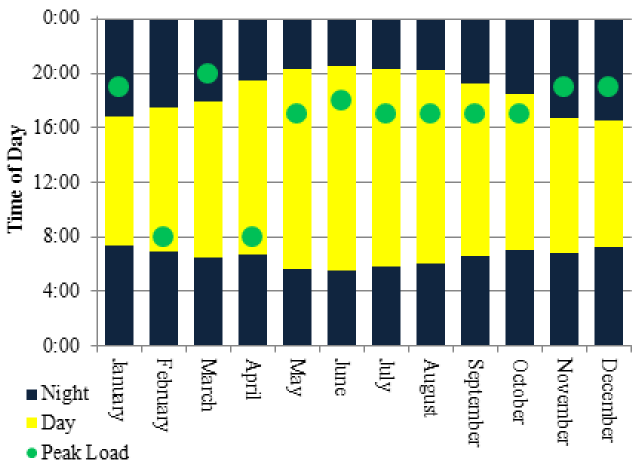

Fig. 6: PJM Peak Monthly Load Times vs. Daylight

When one considers the reduction in peak demand, the lowering of overall locational marginal price for all customers, the value of capacity required to offset the customer peak demand, the losses of the distribution and transmission systems correlating with these high demand periods it is clear that the utility system benefits of PV are significant.

4. Benefits Accrue to All Utility Stakeholders

According to the Energy Information Agency (EIA) around six (6) percent of all electrical energy made in the U.S. is consumed by wire and delivery equipment losses in the transmission and distribution system on an annual basis [EIA, 2015]. These delivery losses are borne by all consumers of electricity (residential, commercial and industrial) by increased electricity rates on average. These real losses are also borne by shareholders if the utility has publicly traded stock, or by the owners of the cooperatives, or by governmental entities depending upon the type of utility. The real system losses increase significantly during the summer fr summer peaking utilities due to higher line loading and ambient environmental temperatures which increase further the resistance of the transmission and distribution lines and decay equipment efficiency (transformers being a notable portion). It is well documented that summertime average losses can climb to over 10% with marginal losses reaching 20% when the utility system reaches 100% of its maximum system load [2]. It does not come as a surprise to most utility policy makers that distributed generation resources with significant summer availability have a beneficial effect on reducing utility system losses. The direct correlation between the peak energy production of PV systems with solar radiation has not gone unnoticed by rational rate-makers and regulatory entities continuing. Since for summer peaking utilities the sun has driven the demand high due to air conditioning loads in residences and businesses being used at maximum to compensate for it, a solar generator will be available during the day to reduce system delivery losses, strengthening the delivery network and providing voltage support and stability all along and at the end of distribution feeders where the utility system needs it the most at such times. In Table 3 a brief summary of dozens of the benefits that distributed photovoltaic systems provide to all major utility stakeholders. It has been provided as illustrative of what is widely known by most regulators, and therefore has led them to conclude that net-metering is not only a sound, well-justified and mutually beneficial public policy for customers and the utility, but is actually the least the grid can do to acknowledge the many uncompensated benefits that distributed generation can provide to better enable the grid operators in meeting their goal of safe, reliable and affordable electric power delivery.

Tab. 3: Benefits of Distributed PV to Stakeholder Groups

Stakeholder	Benefits
Customer – Participating w/ PV	Lower Electricity Bills Lower HVAC Loads – if roof mounted Rapid PV System Payback (ROI) Become More Aware of Electricity Use and Conserve Decreased Carbon Footprint Lower Utility System Costs (LMP, Peak Demand Reduction)
Customer – Non-Participant	Lower System Losses Lower Utility System Costs (LMP, Peak Demand Reduction)
Utility	Lower System Losses – T&D Lower Equipment Losses – Transformers, etc. Better Voltage Stability and Regulation No Generation Needed for PV Power Delivery No Delivery Losses for PV Power Delivery Increased Efficiency of T&D Operation Consumer Load Shifting from On to Off Peak Life Extension of Delivery Assets Capital Deferral for T&D System Expansion/Re-conductoring Capital Deferral for New Generation Increased System & Feeder Load Factors Increased Diversity in Generation Mix Customer Investments Allow Utilities to Meet RPS Requirements
Utility Shareholder	Increased Efficiency of T&D Operation Higher System Profitability Increased System Utilization Customers Share in Capital Generation/Investment
PJM	Higher Overall Transmission System Efficiency Lower Delivery System Losses
Society	Decreased Carbon-Based Electrical Generation Regional and Local Economic Growth (PV jobs, etc.) Cleaner Air Quality & Environment

5. Conclusions

It is clearly an anomaly that the State of Nevada has elected to attempt to reverse the national tide of broad-based regulatory, policy and legislative support for net metering of photovoltaic systems. The specific data described in this paper illustrate that costs are lowered for the system, losses are reduced when the power one consumes has been generated by a neighbor in their local area, everyone benefits from this sound and robust public policy. If we take a look again at Figure 5, last year's PJM average cost data for its July monthly system peak, we can observe that the average system cost (LMP) across the entire RTO exceeded 43 cents per kWh, a typical PV system was probably still back-feeding the grid at that point in time (5 pm) at half of its peak output (see Figure 3). The PV customer who was providing power to his/her neighbors would probably not consume more power until later that night (after 9 or 10pm when their PV system had completely stopped generating). At that point in time when they wanted to buy back the power they had sent to their neighbors at the time of the monthly system peak the PJM LMP had dropped to 5.8-9.8 cents per kWh. The idea that our regulators would feel it is rational and just to penalize such a customer for freely giving their clean, PV generated power to the network in its time of need and taking it back when the prices had plummeted by 80% is unconscionable. The cost to all consumers on PJM for the generation provided for that one hour of the July 2015 peak was nearly $62M, if consumers had been able to defer their load (like our PV customer did by generating during peak) and consume off peak power at 10pm that night it would have only cost a bit over $8M. While we are very far away from such a wholesale adoption of PV in the PJM or in the U.S. to experience such a massive load shift and high penetration of PV on the grid, it is excellent that we have the market based model of PJM to rely on for real locational system costs. For the foreseeable future on the continental United States PV producing utility customers should be compensated for the many benefits they provide to the grid for free. At the very least they should be able to continue to feed the grid back at times of high cost (which is true of all PV systems) and then buy it at the same retail credit they sold it at when the system prices have dropped substantially in the off-peak. Penalizing such customers has no basis in rationality when all of these real factors are considered. It is unfortunate that rational, pragmatic and sound public policy has been reversed in Nevada, hopefully the remaining regulators who are considering changes to their net-metering policies will realize that PV customers ought to receive additional compensation for the benefits they provide the grid, benefits that accrue to all stakeholders of the electric power system.

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