NATIONAL RENEWABLE ENERGY LABORATORY

MEMO

Date: Friday, July 18, 2014

To: Gary Bernfeld, Austin Electric Utility Commission

From: Solar Technical Assistance Team

Subject: Considerations for Value-of-Solar Methods

Mr. Bernfeld,

Thank you for your request to the Solar Technical Assistance Team (STAT). STAT is a project of the United States Department of Energy Office of Energy Efficiency and Renewable Energy Solar Balance of System Costs subprogram and is implemented by the National Renewable Energy Laboratory (NREL). The purpose of STAT is to provide credible and timely information to policymakers and regulators for the purpose of solar technology-related decision support.

Through the STAT program, the Austin Electric Utility Commission requested assistance with examining the Austin Value-of-Solar Tariff with specific reference to how those tariffs are evolving nationwide. This response includes a brief background on net energy metering (NEM) and value-of-solar (VOS) tariffs, as well as a summary of the Minnesota experience in developing and implementing the state's tariff to date. This document summarizes the current literature related to the request, and does not advocate for one approach. Several NREL staff contributed to the development of this response, including Alexandra Aznar, Elizabeth Doris, Erin Nobler, Sarah Truitt, David Hurlbut, Lori Bird, and Karlynn Cory. The contributors thank the technical editing expertise of Alexis Powers.

Definitions: Net Energy Metering and Value-of-Solar Tariffs

Electricity markets are rapidly evolving with increased distributed generation (DG) on the grid as well as improved information exchange between utilities and customers. Policymakers and regulators in some jurisdictions are adjusting by structuring laws and rate designs that attempt to adapt to these changes, especially in relation to the growth of distributed photovoltaic (PV) generation (Figure 1). One example of this market development is the emerging interest in VOS tariffs, which has evolved from Austin's original VOS tariff implemented in 2006.

NEM is currently the most common form of valuing DG contributions to the grid, and is implemented in some form in 43 states (DSIRE, 2014). While policies vary between states, generally speaking, in net metering, self-generating customers are provided payment from the

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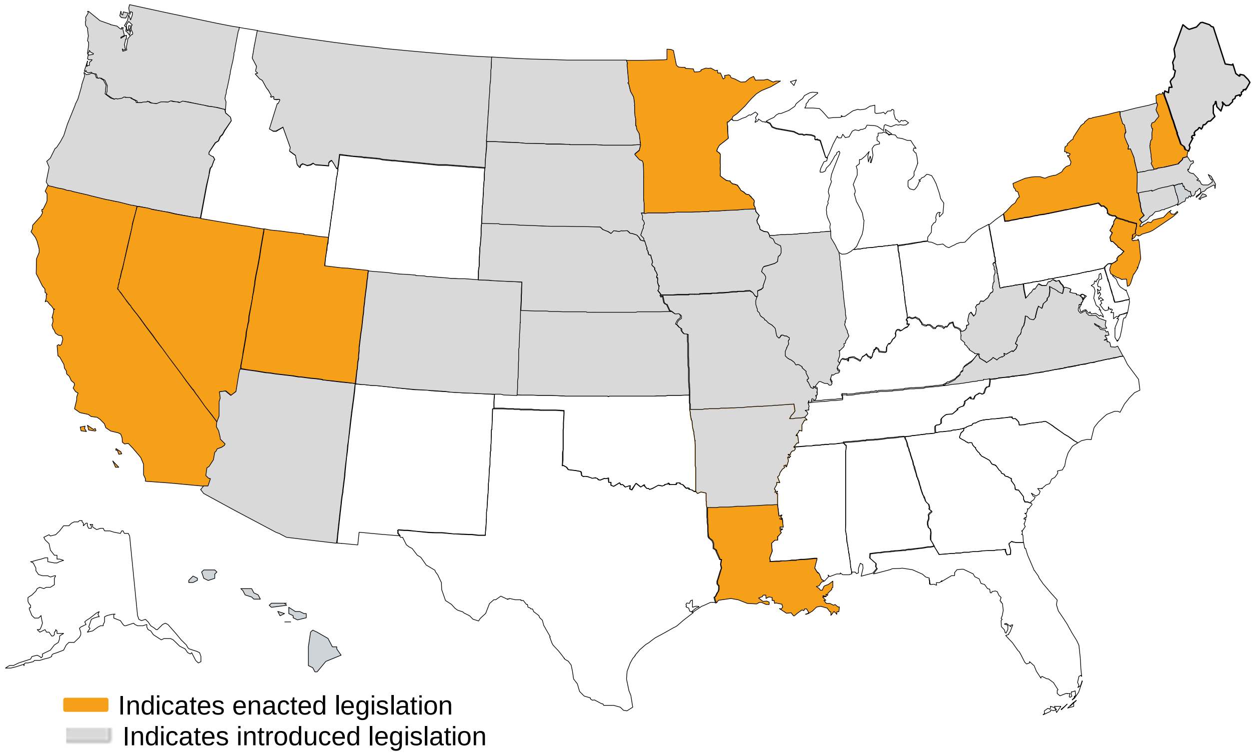
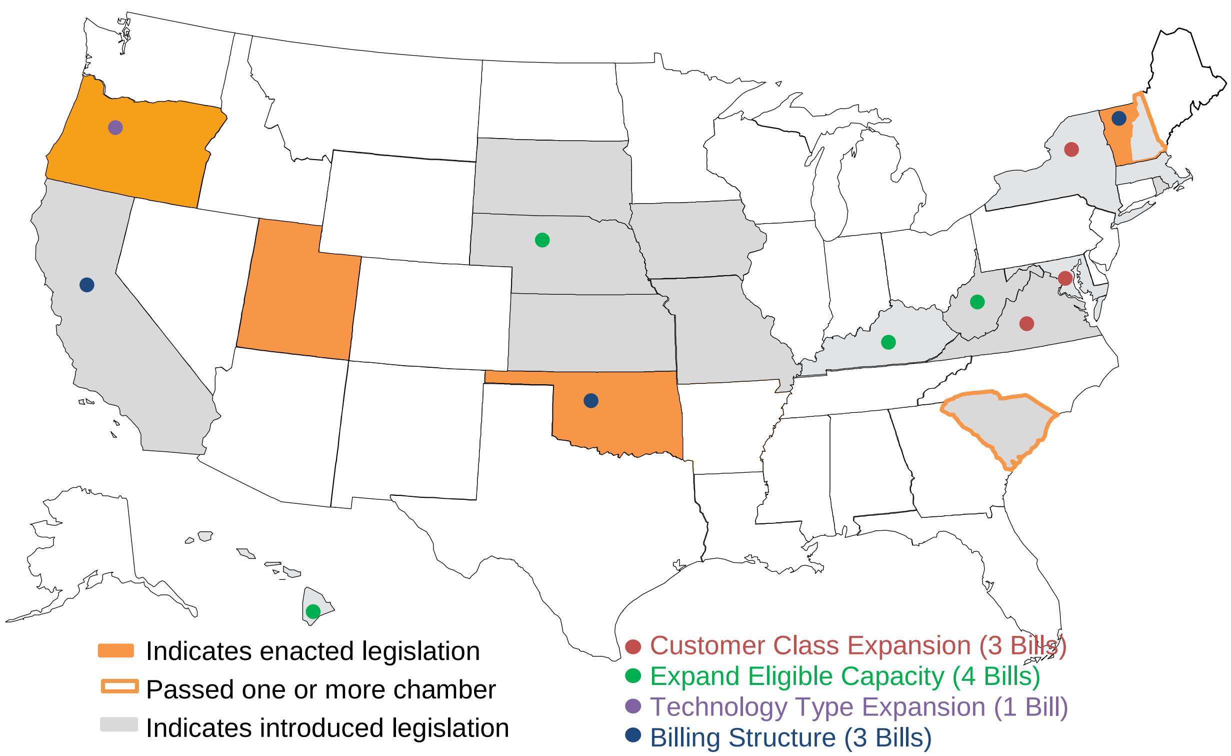
utility for electricity produced in excess of what is used on site. As more renewable systems are added to the electric grid, NEM policies have the potential to create challenges, such as utility revenue erosion and cross-subsidization of grid operation costs, because net metered systems are connected to the grid. NEM supporters suggest that such policies support emerging solar markets and provide a rough approximation of the benefit provided by solar production (Bird et al. 2013). As DG penetration increases, revisiting and developing new policies is increasingly common at the state legislative (Figure 1) and regulatory level. In addition, NEM has arisen in 125 public utility commission dockets between January 2013 and July 2014 (Advanced Energy Economy, 2014).

A VOS policy or tariff is an alternative policy option for addressing some of the potential challenges of NEM. It is important to acknowledge the difference between the broadly utilized terminology "valuation of solar" and a VOS tariff. A valuation of solar method strives to determine the market value of distributed generation projects. Numerous studies across the United States have sought to quantify the value of solar to the grid. A VOS tariff is the actual policy enacted wherein a rate is calculated and then utilized in crediting solar customers for their generation. There is limited experience, and therefore published literature, associated with VOS policies and tariffs given that only two jurisdictions have implemented these to date—Austin in 2006 and Minnesota in 2014. There is, however, increasing market interest and discussion surrounding this approach. Currently, in the two jurisdictions with VOS policies, customers pay the utility's retail rate for all the energy they consume and are compensated at a different VOS rate for all of the energy that their solar PV system produces.

A VOS rate attempts to monetize solar PV's benefits net of its costs to participating stakeholders (who can include the utility, the broader community, and the DG electricity producer). Factors that are typically included in value of distributed solar PV are the utility's variable energy costs (mostly fuel and purchased power), fixed costs (mostly generation capacity, transmission and distribution), losses on the distribution system, transmission line losses, the use of ancillary services to maintain reliability, and environmental impacts (mostly carbon and criteria pollutant emissions). Some solar valuation methodologies also account for financial factors such as fuel-price hedging, resource diversity, and market price suppression, and still others include factors such as energy security and other social externalities such as economic development (Hansen, et al. 2013).



Net metering legislation enacted or introduced in 2013.



Net metering legislation enacted, passed, or introduced as of May 19, 2014.

Figure 1. NEM and Solar Valuation Activity in the United States 2013-2014. ***Source: Center for the New Energy Economy, 2014***

Calculating the Value of Solar

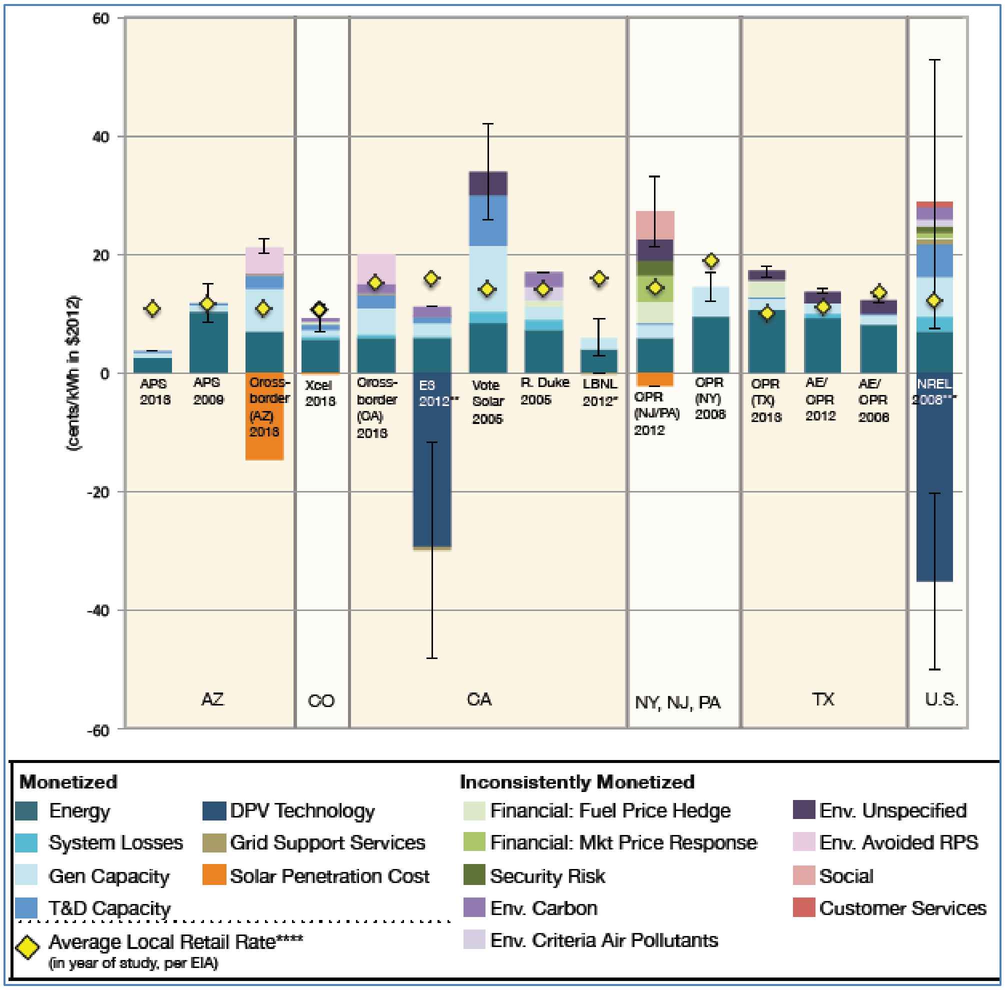
There can be multiple ways to quantify the value of distributed solar generation in terms of costs to the utility, the electricity-generating customer, and the non-electricity generating customer. Outcomes of the calculations of the VOS depend on the importance of the factors being measured to the decision maker and the complexity of methods used. Although commonalities exist among analyses used to calculate the costs and benefits of distributed solar generation (DSG), no standard methodology currently exists.

Value of Solar Studies and Methodologies

A number of recent studies have focused on strategies and methodologies for understanding the VOS to the broad variety of stakeholders. The Rocky Mountain Institute (RMI) prepared a review of VOS studies and methods in 2013 that examines ranges of estimates and discusses differences in methods. The Interstate Renewable Energy Council (IREC) and NREL have also analyzed value of solar methodologies and rates. These sources are summarized below. In addition, a comprehensive summary of solar valuation studies and methodologies is forthcoming from NREL in the fall of 2014. A brief summary of the published studies follows.

A Review of Solar PV Benefit and Cost Studies: Second Edition (Hansen et al., 2013)

This RMI report summarizes findings from 15 different distributed solar generation cost-benefit studies. Figure 2 illustrates both the range in valuation as well as the range of categories included in the calculations, reflecting the lack of uniformity in the market on appropriate valuation.



*The LBNL study only gives the net value for ancillary services.
** E3's DPV technology cost includes LCOE + interconnection cost.
*** The NREL study is a meta-analysis, and not a research study. Customer Services, defined as the value to [the] customer of a green option, was only reflected in the NREL 2008 meta-analysis and not included elsewhere in this report.
**** Average retail rate included for reference; it is not appropriate to compare the average retail rate to total benefits presented without also reflecting costs (i.e., net value) and any material differences within rate designs (i.e., not average).

Figure 2. A comparison of the benefits and costs of distributed PV calculations by study.
Source: Hansen et al., 2013

Notably, RMI finds:

> There is a significant range of estimated value across studies, driven primarily by differences in local context, input assumptions, and methodological approaches. Because of these differences, comparing results across studies can be informative, but should be done with the understanding that results must be normalized for context, assumptions, or methodology.

However, despite differences in the calculation of the majority of factors, most studies agree on an overall approach to estimating energy value.

A Regulator's Guidebook: Calculating the Benefits and Costs of Distributed Solar Generation (Keyes and Rábago, 2013)

Produced by the Interstate Renewable Energy Council, this guidebook provides suggestions for valuing distributed solar generation. According to IREC, when determining the value of solar for net-metering, value of solar tariffs, feed-in tariffs, or other incentive policies, calculations are most effective if they include assessments of:

- Energy
- System losses
- Generation capacity
- Transmission and distribution capacity
- Grid support services
- Financial: fuel price hedge and market price response
- Security: reliability and resiliency
- Environment: carbon and other factors
- Social: economic development

Regulatory Considerations Associated with the Expanded Adoptions of Distributed Solar (Bird et al., 2013)

This NREL technical report examines regulatory issues associated with the expansion of distributed solar PV. It discusses the costs and benefits of distributed PV systems (see Appendix A), regulatory models, and rate designs. Chapter 5 includes a discussion of the strengths and limitations of VOS tariffs to different parties. Specific to VOS tariffs, the strengths for different stakeholder groups include:

- Utilities: Separates electricity generation from consumption allowing utilities to better understand customer load
- Generators: Compensates PV generators based on specific benefits and costs within utility region, not fixed retail rates
- Regulators: Addresses cross-subsidization concerns associated with net metering policies as the customer continues to pay fully embedded electricity rates.

Limitations for different stakeholder groups include:

- All: Challenging to gain consensus on methodology for valuing solar and determining the compensation rate
- PV Owners: Creates revenue uncertainty for PV owners if recalculation of VOS is calculated on an annual basis.

Minnesota Value-of-Solar Tariff

The implementation of the Minnesota VOS tariff is more recent than the RMI, IREC, and NREL studies on solar valuation, so that state's experiences are not included in those documents. This section provides an overview of the VOS-related Minnesota activities in relation to those in Austin.

Minnesota legislation enacted in 2013 called for the Minnesota Department of Commerce to develop a methodology for calculating a "value-of-solar tariff," which is a rate alternative to net metering that investor-owned utilities can request from the public utility commission (Clean Power Research, 2014.) The legislation required that the value of solar methodology:

> …must at minimum, account for the value of energy and its delivery, generation capacity, transmission capacity, transmission and distribution line losses, and environmental value. The department [of Commerce] may, based on known and measurable evidence of the cost or benefit of solar operation to the utility, incorporate other values into the methodology, including credit for locally manufactured or assembled energy systems, systems installed at high-value locations on the distribution grid, or other factors. (Minn. Stat. 216B.164. Subd. 10. 2013.)

According to Farrell (2014), the original value of solar proposal, was part of a broader policy proposal crafted by a coalition of businesses, industry groups, labor groups, consumers, and environmental advocates called Solar Works for Minnesota, looked much like a traditional feed-in tariff.[1] The final VOS methodology looked much more like a traditional net-metering policy, refined by the legislative process and a two-month period of stakeholder engagement (Farrell, 2014). The following three components were discussed in the most detail during the stakeholder engagement process:

Environmental Value: Electrical utilities, including Xcel Energy and Minnesota Power, held that environmental externalities should not be included in ratemaking because these externalities are costs that society bears as a whole. Because no one utility or industry incurs these environmental costs, they cannot be passed onto customers. The utilities had additional concerns about using the social cost of carbon for environmental calculations. Until state and federal laws put a price on carbon, utilities maintained that the environmental value within the VOS should be zero. The Minnesota legislation, however, specifically directed environmental value to be included in the VOS methodology. Supporters of the VOS environmental value claimed that this element accounts for the cross-subsidy utilities receive from its customers and society for environmental degradation caused by non-renewable energy sources. Furthermore, proponents noted that the Minnesota Pollution Control Agency and the Minnesota Public Utility Commission have recommended using the social cost of carbon values as they are the most up to date.

Payment for Solar Renewable Energy Credits (SRECs): The Minnesota statute specified that SRECs “belong to the electric utility providing the credit” (Minn. Stat. 216B.164. Subd. 10. 2013). Utilities held that no additional, distinct SREC component should be added to the VOS methodology because the environmental cost component already captured the SREC value. The utilities argued that additional payments from utilities to solar producers for SRECs may be a double payment. Opponents countered that SRECs have an environmental value to society and a business value to the utility in the form of compliance savings. If the VOS methodology did not include this additional value, utilities would be receiving SRECs without fully paying for them.

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[1] “A feed-in tariff (FIT) is an energy supply policy that has been shown to promote the rapid deployment of renewable energy resources. A FIT offers a guarantee of payments to renewable energy developers for the electricity they produce. Payments can be composed of electricity alone or of electricity bundled with renewable energy certificates. These payments are generally awarded as long-term contracts set over a period of 15-20 years” (NREL, 2014).

Fuel Hedge Value: The Minnesota VOS assumed that solar replaces a utility's marginal fuel—natural gas. The VOS methodology placed value (a fuel hedge value) on solar energy as a price-stable resource, while natural gas prices are subject to fluctuation and volatility. Utilities, however, contended that they have never compensated solar producers for fuel hedge value and this should be an optional component of the VOS.

Some original elements of the Minnesota VOS proposal were retained through the rulemaking process as shown in Table 1. The adopted VOS tariff differs from current net-metering practices in Minnesota as shown in Table 2.

Table 1. Minnesota Value of Solar: Selected Proposed and Adopted Elements

Proposed	Adopted
• Customer is paid for solar energy in a separate transaction	• Customer earns bill credits
• Solar production is not limited by onsite production	• Solar production cannot exceed 120% of annual on-site consumption
• Customer is paid for all solar energy production, regardless of on-site electricity use	• Net excess generation is sold to utility
• Utility must offer value of solar but customer may choose between it and net metering	• Utility chooses whether to adopt value of solar or keep net metering
• Solar customer retains solar renewable energy credit (SREC)	• Utility automatically obtains SRECs, with zero compensation to customer

Source: Farrell, J., 2014.

Table 2. Net Metering vs. Value of Solar (as implemented in Minnesota)

Net Metering	Value of Solar
• Customer earns bill credits	• Customer earns bill credits
• Credit value= Retail electricity rate	• Credit value=Value of solar rate
• Credit value fluctuates with retail price	• Value of solar locked in on 25-year contract
• Solar production cannot exceed 120% of on-site annual production	• Solar production cannot exceed 120% of on-site annual consumption
• Net excess generation paid at retail rate (for <40kW) or avoided rate (for <1MW)	• Net excess generation sold to utility
• Net excess generation (in kWh) paid at retail rate (for <40kW) or avoided rate (for <1MW)	• All generation sold to utility. Customers pay retail rate for all electricity consumption (kWh) and receive bill credit at VOS rate for excess generation

Source: Farrell, J., 2014.

Comparison: Austin and Minnesota Value of Solar Tariff Structures

The Minnesota VOS proceeded from a directive by the state legislature, while Austin Energy designed its VOS which was approved by the Austin City Council in 2012. Minnesota's final value-of-solar methodology incorporated many of the factors Austin Energy integrated into its own VOS methodology, with some distinctions, as detailed in Table 3.

Table 3. Factors considered in determining VOS components in Austin and Minnesota

VOS Component	Austin	Minnesota
Energy Production	Included	Included
Generation Capacity	Included	Included
Transmission and Distribution Capacity Deferrals	Included	Included
Transformer and Line Losses	Included	Included
Environment	Included	Included
Natural Gas Price Hedge	Included	Implicitly included in avoided fuel costs methods
Disaster Recovery	Included	Not included
Reactive Power Control	Included	Not included
Voltage Control	Not included	Placeholder; can be developed in future
Solar Integration Costs	Not included	Placeholder; can be developed in future
Credit for Local Manufacturing and Assembly	Not included	Considered, but not adopted
Market Price Reduction	Not included	Considered, but not adopted
Avoided Fuel Costs	Captured in energy production	Included
High-Value Location Credit for PV System	Not included	Optional for utility

Source: Clean Power Research, 2006, 2014.

Value of Solar Components Calculated: Minnesota and Austin

VOS calculation charts and examples of VOS values for Xcel Energy (Minnesota) and Austin Energy are provided here for comparison. The three largest components of Minnesota's VOS tariff are avoided fuel costs, avoided generation capacity costs, and avoided environmental costs, while those for Austin Energy's VOS tariff are energy (guaranteed fuel value), environmental costs, and avoided generation capacity. Importantly, local differences between Austin and Minnesota can affect fuel costs, generation capacity costs, and other factors, resulting in different values for the same VOS components.

Minnesota and Austin include both distinct and overlapping components in their VOS calculations. Figure 2 provides an example from a VOS 25-year levelized calculation chart produced by Clean Power Research as part of the Minnesota VOS methodology. Xcel Energy's preliminary VOS for its Minnesota service territory is $0.145/kWh (Farrell, 2014), but it is not yet implemented.

25 Year Levelized Value	Economic Value ($/kWh)	Load Match (No Losses) (%)	Distributed Loss Savings (%)	Distributed PV Value ($/kWh)
Avoided Fuel Cost	$0.056		8%	$0.061
Avoided Plant O&M - Fixed	$0.003	40%	9%	$0.001
Avoided Plant O&M - Variable	$0.001		8%	$0.001
Avoided Gen Capacity Cost	$0.048	40%	9%	$0.021
Avoided Reserve Capacity Cost	$0.007	40%	9%	$0.003
Avoided Trans. Capacity Cost	$0.018	40%	9%	$0.008
Avoided Dist. Capacity Cost	$0.008	30%	5%	$0.003
Avoided Environmental Cost	$0.027		8%	$0.029
Avoided Voltage Control Cost				
Solar Integration Cost				
				$0.127

Figure 2. Minnesota: Example VOS Levelized Calculation Chart

Source: Clean Power Research, 2014.

Austin Energy used a similar 25-year levelized calculation chart (Figure 3) to determine its 2014 VOS. Although some categories in this chart match those in the Minnesota VOS chart, Austin's VOS methodology labels certain categories differently, or does not include components found in the Minnesota VOS methodology. Austin's 2012 VOS rate was $0.128/kWh, and the 2014 rate has decreased to $0.107/kWh after the annual recalculation process.

	Economic Value ($/kWh)	Load Match (No Losses) (%)	Distributed Loss Savings (%)	Distributed PV Value ($/kWh)
Guaranteed Fuel Value	$0.053		4%	$0.055
Plant O&M Value	$0.005		4%	$0.005
Gen. Capacity Value	$0.026	62%	6%	$0.017
Avoided Trans. Capacity Cost	$0.015	62%	6%	$0.010
Avoided Dist. Capacity Cost	$0.000	39%	7%	$0.000
Avoided Environmental Cost	$0.020		0%	$0.020
	$0.119			$0.107

Figure 3. Austin Energy 2014 VOS Results

Source: Austin Energy, 2014

Despite the different categories and nomenclature employed by Minnesota and Austin, it is possible to compare their VOS components if certain elements are grouped together. For example, in the following chart (Figure 4):

- Fixed and variable avoided plant operations and maintenance (O&M) cost categories in the Minnesota VOS have been consolidated into a single avoided plant O&M category to compare with Austin's Plant O&M Value.
- Minnesota's Avoided Generation Capacity and Avoided Reserve Capacity can be combined into a single Avoided Generation Capacity category, which is comparable with Austin's Generation Capacity Value.
- Austin's Guaranteed Fuel Value has been altered to Avoided Fuel Cost, which is the term Minnesota uses for this same component.

By grouping together components and altering names for consistency, Austin and Minnesota's VOS tariff components can be compared in monetary terms (Figure 4) and as a percentage of the total VOS tariff (Figure 5). Figures 4 and 5 reflect components of Austin's 2014 VOS and an example of a Minnesota VOS tariff produced by Clean Power Research.

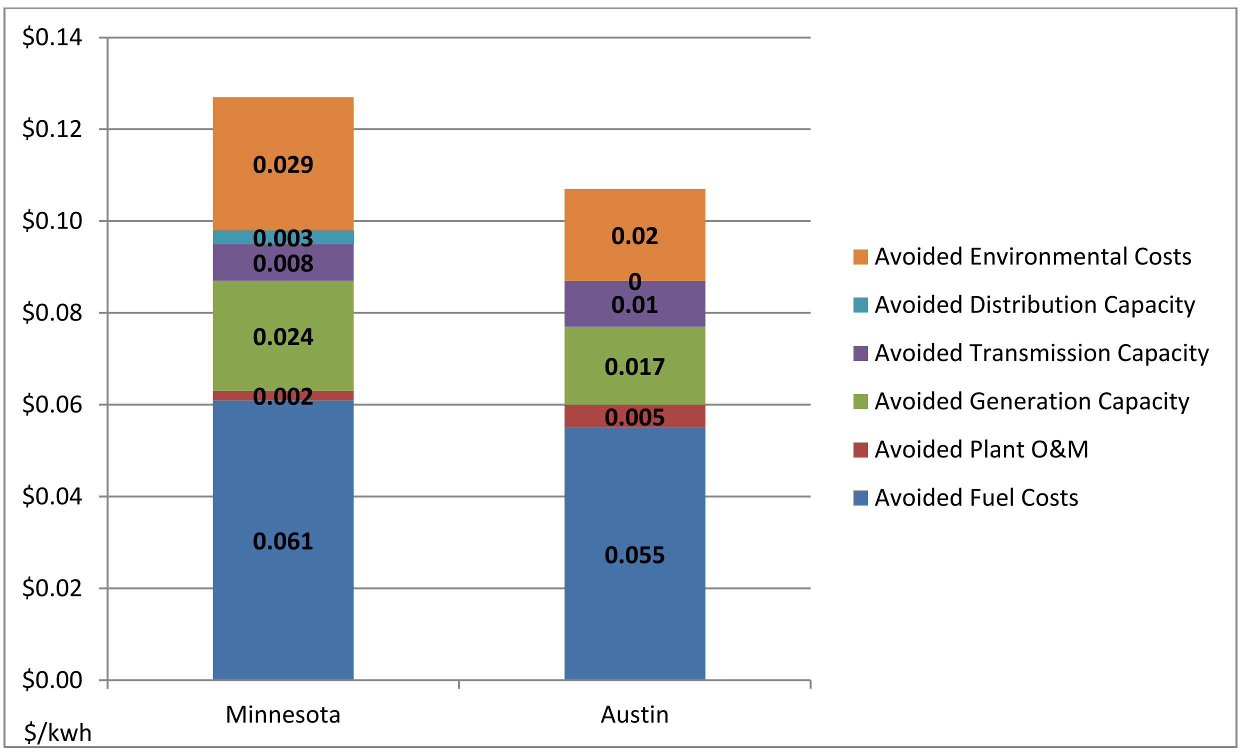
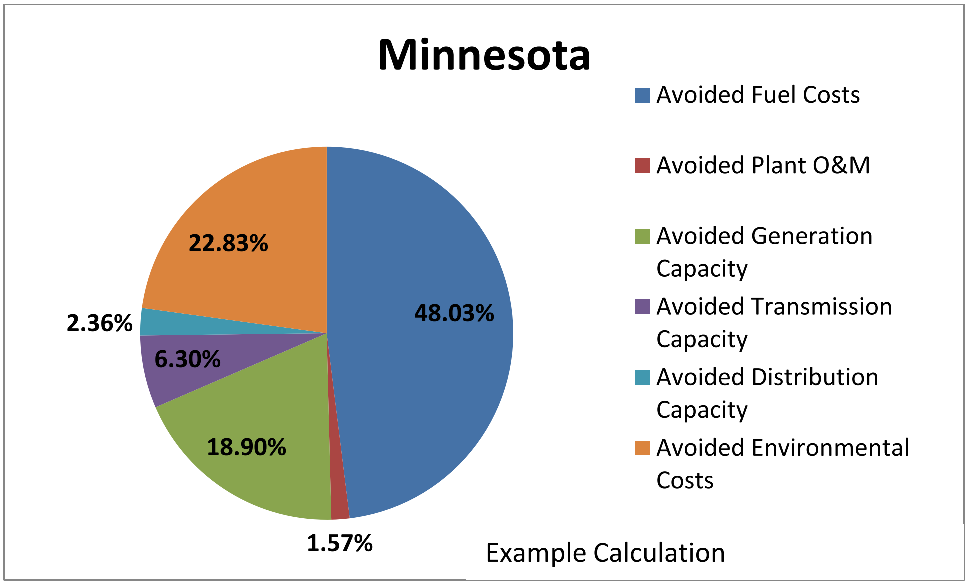


Figure 4. Value of Solar: Value ($/kWh)

Source: Austin Energy, 2014; Farrell, 2014.



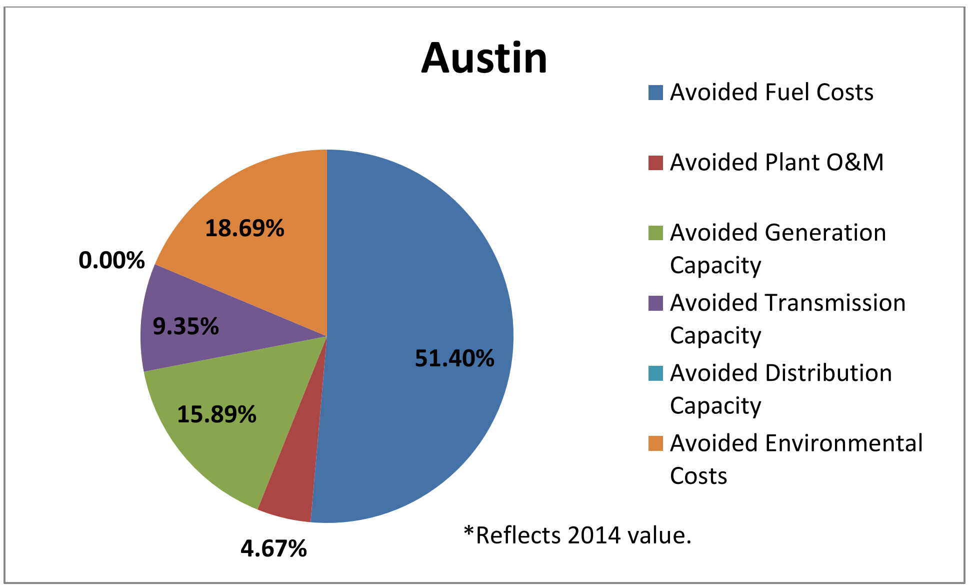


Figure 5. Value of Solar: Percent of Total Rate

Conclusion

In 2013 and 2014, state legislative and regulatory bodies have been discussing the potential for VOS as an alternative or additive policy for the support of solar markets. To date, only Minnesota and Austin have implemented the policy, and Minnesota's implementation is in the very early stages. There is limited published literature on standardizing calculations in different jurisdictions and methodologies are rapidly evolving. This memo highlights some key pieces of literature and summarizes the currently available examples of VOS tariffs in Austin and Minnesota. While reports from RMI, IREC, and NREL as well as the Minnesota case study provided here can be informative, the value of solar is dependent on location-specific considerations and jurisdictional priorities. Clearly laying out those priorities, therefore, is an important step to creating transparent policies.

Appendix A

Table 4. Key Benefits and Costs of DSG as Described by Bird et al 2013

Benefit	Notes	Associated Savings
Energy Value	Energy value exists when PV produces kWh that displace the need to use another generation source	Estimates of value range from $0.05-$0.10/kWh
Capacity Value	Capacity value exists when PV defers the need for other generating capacity	Estimates of value range from $0.00-$0.10/kWh with average at $0.01-$.02/kWh
Transmission and Distribution Deferrals	• Benefit if PV can serve local loads and relive capacity constraints or defer transmission and distribution (T&D) upgrades—especially when PV is installed where there is transmission congestion or in regions with summer peaking • Cost are incurred if PV results in additional upgrades of the distribution system	Value of deferring T&D upgrades is less than $0.02/kWh
Line Loss Savings	PV reduces line loss by producing energy near to where it is consumed	Savings from PV are estimated between $0.005 and $0.01/kWh
Fuel Price Hedge	• Difficult to measure due to fluctuating price of natural gas (and coal) • Most studies acknowledge but do not quantify	Can quantify by determining the cost to the utility to purchase natural gas futures contracts
Environmental Benefits	Benefit from avoided nitrogen oxide, sulfur dioxide and overall reduced carbon	Average estimate of benefit is $0.02–$4.18/kWh
Grid Security/Reliability	• PV can reduce the risk of power shortages and brownouts by serving peak demand • However, almost all PV systems go offline during an outage problem	Most studies have not tried to quantify this cost/benefit

Cost	Notes	Associated Cost
Direct Costs	• Fixed and variable costs of installation and maintenance are generally covered by the PV system owner • Some of these costs are supported by the Investment Tax Credit, accelerated depreciation, Renewable Portfolio Standard, rebates, and performance-based incentives	Varies depending on location
Administration Costs	• Include billing, customer communications, incentive program costs • Paid by utility ratepayers	Generally very minimal costs ($2–$3/net metering customer)
Interconnection Costs	• Costs associated with infrastructure needed for safe/reliable interconnection of the power plant to the grid • Minimal costs, but as distributed generation (DG) on the system increases, they could rise • Investments necessary in the future may	

	include the following: – Supporting voltage regulation – Upgrading transformers – Increasing available fault duty – Providing anti-islanding protection through advanced communications technology • General assumption that no additional investment (special study) is required until DG capacity exceeds 15% of peak load (some locations can handle more than 15%, so not a technical limit)	
Integration Costs	• Operating costs associated with managing DG on the utility system—generally are continually occurring costs related to maintaining system integrity • PV variability may lead to need for additional balancing reserves • PV variability may lead to increased stress on conventional generating units due to more frequent cycling • Assigning integration costs to PV could be warranted if the PV integration costs exceed those of traditional resources (because all generation imposes costs and benefits on a system)	High penetration of wind and solar can increase operation and maintenance costs by \$0.48–\$1.28/MWh (generally small compared to the fuel cost savings of wind and solar)

References

Advanced Energy Economy. 2014. "Docket Dash." http://powersuite.aee.net/dockets. Accessed July 15, 2014.

Austin Energy. Prepared by Babu Chakka. 2014. "Value of Solar Methodology-Presentation."

Bird, L., McLaren, J., Heeter, J., Linvill, C., Shenot, J., Sedano, R., Migden-Ostrander, J. 2013. *Regulatory Considerations Associated with the Expanded Adoptions of Distributed Solar*. National Renewable Energy Laboratory.

Center for New Energy Economy. 2014. "Advanced Energy Legislation Tracker." http://www.aeltracker.org/. Accessed July 15, 2014.

Clark, C. 2013. Xcel Energy. Comments: Draft Value of Solar Methodology.

Clean Power Research. 2006. *The Value of Distributed Photovoltaics to Austin Energy and the City of Austin.* Austin Energy.

Clean Power Research. 2014. *Minnesota Value of Solar Methodology*. Minnesota Department of Commerce, Division of Energy Resources.

Farrell, J. 2014. "Minnesota's Value of Solar: Can a Northern State's New Solar Policy Diffuse Distributed Generation Battles." Institute for Local Self-Reliance.

Farrell, J. 2013. Comments to the Division of Energy Resources. Institute for Local Self-Reliance.

Hansen, L., Lacy, V., & D. Glick. *2013. A Review of Solar PV Benefit and Cost Studies: Second Edition*. Rocky Mountain Institute.

Hubbard, J. 2013. Minnesota Renewable Energy Society. Comments: Value of Solar Methodology.

Keyes, J. and K. Rábago, 2013. *A REGULATOR'S GUIDEBOOK: Calculating the Benefits and Costs of Distributed Solar Generation*. Interstate Renewable Energy Council.

Minn. Stat. 216B.164. Subd. 10. 2013.

Minnesota Solar Energy Industry Association. 2013. Final Round Comments on Establishing the Methodology for a Minnesota Value of Solar Rate.

National Renewable Energy Laboratory. Technology Deployment. State and Local Governments. "Feed-in-tariffs." http://www.nrel.gov/tech_deployment/state_local_governments/basics_tariffs.html. Accessed June 26, 2014.

Podratz, M. 2013. Minnesota Power. Minnesota Power's Comments on the Proposed Value of Solar Methodology.

Union of Concerned Scientists. 2013. Value of Solar Tariff Methodology Stakeholder Engagement.

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