National Rural Electric Cooperative Association
Mary Ann Ralls. Associate Director Regulatory Counsel
4301 Wilson Boulevard
Arlington, VA 22203
maryann.ralls@nreca.coop
703-907-5837

Category 1: Net Benefits and Costs of Distributed Solar Energy.

1. **In general, what are the key benefits and costs that have the largest impact on the net valuation of distributed solar PV?**

The National Rural Electric Cooperative Association ("NRECA") strongly believes that discussion and analysis around distributed solar PV benefits and costs are unique to each utility and that a general focus is of limited value. As consumer-owned, not-for-profit utilities, electric cooperatives view any discussion of value through the multiple lenses of reliability, affordability, safety and environmental compliance. Therefore, there is no "standard" method for determining net benefits and costs (*i.e.* valuation) of distributed solar PV. Any valuation study of distributed solar PV should not be considered a method used, for example, in ratemaking. Rather, the study may inform a method but only if it: considers the purpose of the study; determines the perspective(s) to be represented (*i.e.*, stakeholder); defines when/if a purported benefit or cost meets the minimum criteria to be included; distinguishes benefits and costs by stakeholder classes, if appropriate; includes and evaluates other resource alternatives; requires the use of specific utility and regional characteristics when available; and, achieves a degree of transparency that allows for interpretation, comparison and assessment.

Valuations must not be used as substitutes for actual costs in setting electric rates which must be based on specifically-measurable, rather than implied or estimated, costs. Ratemaking requires actual costs to be fairly allocated on a non-discriminatory basis to prevent cross-subsidies among consumer classes; whereas identifying benefits and costs and their impact on the net valuation of distributed solar PV is dependent upon the purpose of the valuation and the perspective from which is it offered. Further, performing a cost-benefit analysis for distributed solar PV, without considering other options, may produce unreliable results. Alternative resource options, including demand-side management programs, can provide the same or even additional benefits (*i.e.* reliability) as distributed solar PV; and some may even do so at a lower cost (*i.e.*, utility scale solar). Abandoning comprehensive Integrated Resource Planning (IRP) evaluations that consider all alternatives could lead to a sub-optimal resource mix. A major reason for performing cost-benefit analyses is to compare alternatives on an apples-to-apples basis so that the best alternative can be discerned and selected, which is another reason why a standard valuation of any resource has no real value. [1]

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[1] In its September 2013 report entitled, "A Review of Solar PV Benefit & Cost Studies, 2nd Edition," e-Lab concluded that, "There is broad recognition that some benefits and costs may be difficult or impossible to quantify, and some accrue to different stakeholders."Reference http://www.rmi.org/elab_empower.

Benefits and costs that are external to a utility should not be included in a cost-benefit analysis being conducted for purposes of quantifying the value to the utility, which then serves as the basis for rates. Costs that reasonably could be included in performing the valuation from a societal perspective should not always be included in ratemaking. Further, benefits flowing to a solar PV participant may exceed the actual benefits to a utility or other stakeholders and result in unfair allocations of costs.[2] Table 1 provides a list of "potential" benefits and costs of distributed solar PV.

Table 1
Potential Benefits and Costs of Distributed Solar PV [3]

+ Benefit - Cost	Internal	External
Avoided Energy	+	
Avoided Generation Capacity	+/-	+
Avoided Transmission Capacity	+/-	+
Avoided Distribution Capacity	+/-	+
Avoided Losses	+	
Reduced Risk/Price Stability	+	
Grid Support	+/-	
Integration and Balancing	-	
Stranded Fixed Cost Recovery	-	
Incentives	+/-	-
Administrative & Overhead	-	
Environmental	+/-	+
Socio-Economic		+

a. Which benefits and costs have the highest uncertainty?

Only benefits and costs that meet the traditional regulatory standard of 'known and measurable' should be used in distributed solar PV cost-benefit analyses. Including benefits and costs that are neither known nor measurable tends to produce disagreement, volatility and uncertainty in the process. Socio-economic benefits and other externalities are very uncertain and are not easily monetized and should not be presumed to be benefits to a specific utility. If there are such benefits, they will accrue to society in general and are matters for public policy issues (*e.g.* tax policy).

Solar PV is a non-dispatchable and dramatically intermittent resource which may or may not be available during peak times with substantial variability within the hour or even minute. While on an annual average, solar PV can perform better in colder regions, a number of utilities experience annual peak demands during winter months at times when distributed solar PV is not producing at the highest efficiency. The determination of avoided capacity benefits must be given proper consideration to utility-specific characteristics, such as utility's generation mix, load profile, capital expansion plans, market structure, along with the forecasted PV fleet distinguished by location, orientation and tracking capabilities. The valuation must also consider that distributed solar PV capacity benefits vary inversely with penetration rates, and at higher penetration levels benefits may become significant costs and identified costs may increase.

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[2] A key distinction and assessment must be made in all such cases as to whether the benefit to one participant actually relates to cost avoidance or simply cost shifting to other ratepayers or cooperatives.

[3] Many items listed can be benefits or costs depending on penetrations rates and stakeholder perspective.

Even more uncertain and complex is the determination of grid support benefits. Simply interconnecting to the grid does not guarantee benefits. Distributed solar PV must actually be integrated rather than simply interconnected with the grid if benefits are to be recognized and maximized, which will come at a cost.

2. **What are the key costs that distributed solar PV impose on the electrical grid, and what are the key benefits distributed solar PV provides to the electrical grid?**

Key Costs PV Imposes on the Electrical Grid: Very real costs exist to safely and reliably interconnect and operate distributed solar PV with the electrical grid, including those that are embedded within utility operations to accommodate PV. Costs are incurred by the utility to develop interconnection policies, agreements, technical standards, and procedures. Utility staff must be trained and assigned to determine utility requirements, meet those requirements, work with interconnecting customers during the interconnection process, conduct any needed studies, administer agreements, test and inspect new interconnections, ensure ongoing requirements of distributed solar PV are met, track installations on the system, and maintain/operate the system with connected distributed solar PV. Distributed solar PV interconnected and operating in parallel with the utility system is often not the most efficient, cost-effective resource. At high enough penetration levels of PV, lower-cost utility central generation units may even need to be re-dispatched to match load and/or replaced by additional (new) fast-ramping generating resources in order to ensure reliability. Additionally, at higher penetration levels, distribution system costs will increase due to changes in system operation and system protection.

Because of the variability of distributed solar PV output, high penetrations on the grid increase the likelihood of power quality issues and utility equipment maintenance costs increases. The effects on the utility voltage waveform and the increased operation of the utility voltage regulating equipment attempting to counter those effects are well documented. All customers suffer from these negative consequences, and the utility must incur costs to maintain power quality levels.

Key Benefits Distributed Solar PV Provides to the Electrical Grid: Distributed solar PV has the capability to provide benefits to the electrical grid; however, these benefits are site-specific and cannot be generically assigned to all or even most installations. Again, it is imperative that in order to achieve and/or maximize any benefits to the grid, distributed solar PV cannot simply be interconnected, but must be integrated.[4] Key factors that will affect the electrical grid benefits derived from distributed solar PV include: the specific characteristics of the utility feeder (*e.g.*, length, conductor sizes, installed protection, and voltage regulating equipment, etc.); where on the feeder the distributed solar PV locates; the amount of distributed solar PV capacity compared to the load; the amount and types of other DG connected to the feeder; the daily and seasonal

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[4] A recent EPRI report, *The Integrated Grid Realizing the Full Value of Central and Distributed Energy Resources*, clearly explains how and why DG must be *integrated* and not just *connected* to the electrical grid offering greater value to all stakeholders.

load shape compared to the distributed solar PV output and capacity factors; the reactive power requirements and flows on the feeder; the type(s) of inverters the distributed solar PV systems are using; the knowledge the utility has of the specific distributed solar PV connected to its system; and the capability of the utility to communicate with distributed solar PV inverters and ultimately to dispatch and adjust the real or reactive power output from there.

A list of the potential benefits that the utility grid could possibly receive from distributed solar PV, subject to the list of key factors above, may include: voltage support; reactive power needs; deferred distribution/transmission/generation investment; reduced losses; and reduced transmission congestion.

"Smart inverters" that have the capability to respond to changing voltage and reactive power needs of the electrical grid are required in order for the full potential benefits of voltage support and reactive power to be realized. However, this requires a level of utility control that can only be achieved through communications and monitoring systems that are much more expensive than the capacitors and voltage regulators currently used by many utilities. The more distributed or spreadout the installations, the more likely these benefits will not be realized. Utility siting of the solar PV offers much more value because the utility can site the solar PV to most readily interconnect with the grid and provide system needs identified during the utility system planning process. The correlation of the distributed solar PV production in relation to the loads on the system or feeder is also a significant variable. If the distributed solar PV production is not consistently and reliably available during peak demand times, then distribution/transmission/generation investment likely cannot be deferred; and transmission congestion likely cannot be mitigated. Combining energy storage with PV may increase the benefit received in these areas, if cost-effective and adequately-sized energy storage systems were to become available.

3. Key benefits and costs that the electrical grid provides to distributed solar PV?

Key Benefits the Electrical Grid Provides to Distributed Solar PV: The electrical grid offers significant value to distributed solar PV: strong, stable, and reliable voltage and frequency source to which inverters can synchronize their output; a virtual battery bank with which to store excess energy produced; reliable backup/standby service to provide the energy needs when the distributed solar PV array cannot, including during motor start-up/inrush; and access to markets in which to sell excess energy produced.

Key Costs the Electrical Grid Imposes on Distributed Solar PV: To safely and reliably interconnect and operate distributed solar PV in parallel with the electrical grid, certain interconnection costs may be incurred and should be paid by the solar PV. The size of the distributed solar PV system and the penetration on any one feeder will determine if a system impact study will be required and whether costs to mitigate adverse impacts to the utility system will be incurred. Again, site-specific conditions and the size/penetration of distributed solar PV will significantly influence these costs. Because cooperatives only have on average 7 customers per mile of distribution line, the longer, lightly-loaded feeders will be more challenging to interconnect for higher penetrations of distributed solar PV, and may therefore lead to higher interconnection costs. Inverters meeting utility technical requirements (*i.e*., meeting IEEE Std. 1547 and UL 1741) must be used to provide proper protection of the electrical grid. Disconnect switches readily accessible to the utility are also required in most cases for safety of utility line workers and are a requirement for any distribution cooperative that borrows money through the Rural Utility Service. Minimal application or inspection fees, and certain insurance coverages requirements may also be required.

5. What are the primary differences in the methodologies used for the valuation of distributed solar PV that have the largest impact on the benefits and costs?

Variations in avoided energy cost methodology can have a significant impact on the valuation of distributed solar PV since it is frequently the largest benefit. Quantifying avoided energy costs using production cost models vs. market prices will impact results. Although natural gas is typically assumed to be the fuel on the margin, in some regions during certain times of the year, or at high penetration rates, distributed solar PV may be displacing baseload generation. The fuel price forecasts and heat rates used will impact the resulting energy cost benefits. Methods that use market prices need to recognize whether the market prices reflect energy only or energy and demand. Averaging market prices daily, monthly, annually vs. calculating prices weighted hourly by solar production will also impact the results.

There are various methods for determining avoided capacity costs that can have a large impact on valuation results. The methodology used to determine avoided capacity costs must consider the correlation between the utility’s load profile and the production curve of the distributed solar PV (either individual or as a “fleet”). Methods also vary in terms of whether value is attributed on an increment/partial basis or whether a minimum aggregate amount of capacity avoidance is required to defer a future capacity resource.

7. Developing a Stakeholder Process

The costs and benefits and value of solar PV are highly location- and utility-specific, and as noted earlier, there are different ways to make these assessments. However, NRECA does not believe that DOE has a role in facilitating a grand bargain between the stakeholders, or that DOE should convene groups or otherwise get involved in valuing solar PV, which should be left to state and local policymakers. DOE should continue to support R&D necessary to overcome the technological hurdles associated with PV, and to provide states with technical non-advocacy assistance to inform them about PV. Distributed solar PV may, on a case-by-case basis, have the potential to bring benefits to utilities and their consumers, and to support environmental policies within the United States. But these benefits will only be realized if decision makers encourage development and regulation of solar PV in ways that are cost-effective, do not unfairly shift costs among customers and do not risk degrading electric reliability or safety. DOE should leave it up to the state and local policymakers and regulators to undertake the net valuation, identifying the services solar PV will require from the utility and the grid and any benefits it will be providing to the utility and the grid.

Category 2: Innovative Solar Deployment Models.

1. **Please comment on alternative regulatory designs that have been proposed in consideration of their strengths and weaknesses from various stakeholder perspectives?**

a. Value of Solar Tariff: VOS tariffs can raise the cost of power for other retail consumers by requiring utilities to pay far more for resources than their avoided cost — the cost utilities would incur to purchase the power elsewhere. A VOS tariff could require a utility to purchase distributed PV at premium rates when the utility could otherwise have acquired power from an existing hydro resource or from a utility scale wind farm with equivalent environmental attributes at a significantly lower price. VOS tariffs are supposed to reflect the value PV offers to the grid, communities, and the environment; however, depending on how the calculation is done, these benefits can be easily inflated and the costs imposed on the system by the technology ignored. For example, proponents of VOS tariffs presume that distributed PV will help utilities defer or avoid investments in distribution, transmission, or new generation capacity. If VOS tariffs encourage significant investment in PV, the utility could actually bear higher costs for:

- Upgrading the local distribution or transmission system to integrate the PV generation reliably. Utilities will need to upgrade transformers, replace isolation devices to permit two-way flows on the distribution system, invest in distribution SCADA to permit the system to respond to greater uncertainty and variability in distribution loads and power flows, and install new communications networks in order to track and control smart inverters on the PV systems.

- Acquiring the reserves, ramping resources, reactive power resources, and other dispatchable generation required to integrate high levels of variable generation reliably. At higher levels of PV, the system can experience dramatic upramps during evening peak periods as solar generation tapers off at the same time that customers come home, turn on the air conditioning, turn on stoves, and begin to use hot water. Existing generation resources in some regions may not be able to meet those ramps and would have to be replaced. VOS tariffs could also drive up electricity costs for consumers by charging utilities — and thus their customers — for many values not presently incorporated in electricity rates. Utilities charge consumers for the cost of providing safe, reliable, and affordable power. They do not charge consumers for all of the benefits or "value" that consumers and the economy get from that power. Nor do utilities charge consumers the value that their other generation resources offer consumers, communities, and the environment. Utilities, for example, do not charge consumers more than their cost for nuclear power because it has no air emissions. Utilities do not charge consumers more than their cost for utility-scale solar power because it produces no pollutants. Utilities do not charge more than their cost for coal-power to reflect the number of good jobs the coal mine and the coal plant provide the community.

The VOS tariff requires the utility to in effect tax some of its consumers with such costs in order to subsidize others. This occurred in Germany, where residential retail rates are now north of 37 cents (vs. 12.5 in US), in no small measure due to the cost of subsidies paid for via non-PV customers in their electric rates.

b. Disaggregated Rate: Disaggregation or unbundling of rates means that power supply, transmission, distribution and sometimes other functions the utility provides are charged separately versus the more common and traditional approach of bundling costs. A strength of unbundling rates to the utility and ratepayers is that the utility would charge distributed solar PV customers (*i.e.* participants) for the cost of power supply, transmission and distribution services that they use and then credit the participants for the cost of services they actually avoided. Alternatively, unbundling can be combined with net metering which could, for example, mean the customer pays the rate for power supply based upon net consumption. In either case, the participants continue paying for grid services they continue using which can mitigate shifting those costs to non-participating ratepayers.

c. Fixed or Demand Charge Tariff: This type of rate design removes fixed cost recovery that is traditionally built into residential energy charges and puts it into a fixed charge, demand charge or combination. When properly designed, customer-related fixed costs will be recovered in customer charges and capacity-related fixed costs will be recovered in demand charges.[5] It is an effective way to avoid unfair cost shifting in net metering situations where customers can offset utility energy purchases with energy produced from their distributed solar PV system. If distributed solar PV customers are able to avoid paying their share of grid costs when reducing energy purchases, these costs will be shifted to other customers. This is especially difficult for rural electric cooperatives, since on average they have significantly higher plant investment requirements per residential customer than municipal and investor-owned utilities because of their low consumer density. This rate design also carries the benefit of being more cost of service-based which makes it generally a more fair and equitable rate design for all customers.

d. Net Electricity Energy Purchase and Sale: Commonly referred to as Net Energy Metering, NEM allows the solar participant to offset consumption with its distributed solar PV production and establishes a means of dealing with any excess generation (*i.e.* beyond the owner's level of consumption). As such, the PV participant receives full retail energy rate value for all solar PV production up to their level of consumption and excess solar PV production may receive up to retail value. Valuing the distributed solar PV at the retail energy rate does not provide an appropriate value for distributed solar PV because it allows PV customers to under-pay the fixed costs they impose on the system which are then borne by other non-PV ratepayers. This situation is made worse if excess generation of the distributed solar PV system is also valued at the retail energy rate versus the utility's wholesale avoided costs. Cost shifting from NEM is especially troublesome for rural electric cooperatives since, on average they have significantly higher plant investment requirements per residential customer than municipal and investor-owned utilities.

2. **What are the key considerations for incorporating utility costs with providing balancing and backup services (e.g. infrastructure investments, grid operation and maintenance costs)? Discuss these costs in both current and alternative regulatory designs or solar deployment models. What are the differences for utilities in regulated or restructured environments; and between investor-owned utilities, municipal utilities, and electric cooperatives?**

Customers with distributed solar PV essentially require a type of standby service from the utility, unless additional generation resources and/or batteries accompany the PV system. Utility costs for this type of service are usually charged using either demand charges in standard rate tariffs or reservation demand charges in standby tariffs. The purpose of these charges is to recover the costs for power supply, transmission and distribution facilities that the utility must "reserve" and

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[5] Retail class cost of service studies classify utility costs into cost causative categories of capacity, energy, customer based upon the driver or cause of the cost. Size related fixed costs are typically classified as capacity-related fixed costs. Non-size based fixed costs are typically classified as customer-related.

maintain for use when called upon. Distinctions can be made to accommodate a variety of situations, including supplemental service, backup service, maintenance service which are sometimes collectively referred to as standby services.

The incorporation of utility standby service costs must consider the type of service required and the cost of providing the service to distributed solar PV. Intermittent distributed resources like solar PV have substantial variability within short time intervals. Since the underlying load must be served, the grid will need to provide realtime balancing and service to the distributed solar PV system and load including during times that the grid is stressed. Consideration needs to also be given to the rate structure that the underlying load and distributed solar PV is served under. The need for additional standby or backup charges may or may not be needed depending on whether the basic rate structure or model adequately recovers the cost for this service.

There are two principle differences between rural electric cooperatives and most other utilities. First, cooperatives are consumer-owned and not-for-profit. Our "stockholders" are those we provide electric service to, and they and we are focused on controlling rate increases. Second, as formerly mentioned, because of the very low consumer density in co-op service areas the cost of distributing that power and providing other services can be relatively high. Anything that increases those costs is a matter of critical concern, particularly given that the average co-op-served household income is 11.5% lower than the national average.

3. **What alternative regulatory designs or deployment models could be employed to encourage the strategic placement of distributed solar PV (both residential and commercial-scale solar) in locations that reduce the costs and maximize the benefits of distributed solar PV?**

One way to reduce costs and maximize benefits of distributed solar PV is through strategic siting. Coordination between those who wish to install distributed solar PV and the utility is required to determine where facilities can most readily and cost-effectively be interconnected and provide the greatest benefit to the utility and its ratepayers. The utility has information and capabilities to make this determination; although they do not typically maintain a listing of the most desirable sites and available distributed solar PV hosting capacity. To do so would impose significant burden and costs on utilities with no mechanism to recover the costs. Electric cooperatives operate on a slim margin above their costs and do not often have the internal staffing and financial resources available to calculate hosting capacity across their systems. Unlike higher density, larger urban utilities, rural electric cooperative rates would likely need to be increased to the entire membership in order to subsidize the undertaking of the type of effort. This subsidy would only benefit those who actually install PV on the system and simply raise costs for the remainder of the membership.

Deployment models in which the utility sites and installs larger solar PV systems will likely provide the greatest benefit to all stakeholders at the lowest cost. Utilities are in the business of installing and operating generation resources in the most cost-effective and efficient manner and are therefore in the best position to install solar PV. The cost of the solar PV resource, though, must be competitive with other available generation resources, or there must be consumers willing to pay a premium for the solar PV energy, otherwise rates to all consumers will need to be increased to subsidize solar PV.

4. **What are the main challenges to the utility participation in shared solar, community solar, solar power purchasing, and/or investments of distributed solar PV?**

As highlighted in the 2013 NREL technical report, "Treatment of Solar Generation in Electric Utility Resource Planning,"[6] utilities experience a number of key challenges in incorporating solar into their resource planning due to the fact that solar PV is non-dispatchable, the lack of experience ramping issues, and uncertain economics, to mention a few. In addressing such issues, NRECA, through a DOE funded project (Solar Utility Network Deployment Acceleration – SUNDA), is evaluating possible pathways for utility-owned solar PV that will address the challenges of standardized technical designs, financing and insurance, economies of scale, and streamlined installation, with the goal of reducing costs significantly while giving the utility the capability to integrate solar PV into their resource planning. Other challenges faced by utilities are addressed in earlier responses as well as within the context of examples of solar programs discussed subsequently.

5. **What activities might DOE (or parties DOE could convene) undertake to assist regulators, utilities, customers, and other stakeholders as they analyze and develop alternative regulatory approaches and deployment models that address the impacts of and facilitate increasing levels of distributed solar PV and stable solar markets?**

NRECA is developing a state-of-the-art, open source, online platform, available to utilities, for analyzing and evaluating the technical benefits and cost of implementation of potential new grid technologies. The open modeling framework (OMF) provides a structure for running, comparing, reporting on and monetizing the results of the best available technologies such as Volt-VAr optimization systems, as well as evaluates distributed solar PV, distributed energy storage, and demand response on their own distribution circuits. For example, the OMF can be used to model how the addition of 15% distributed solar PV generation on a target feeder will affect the operations of the utility. DOE should continue supporting such tools, making them easily available to all stakeholders. DOE should also consider encouraging collaborations among stakeholders.

Community and Shared Solar-Specific Questions

1. **Which existing shared and community solar programs would you identify as models that could be successfully implemented elsewhere?**

Electric cooperatives big and small across the country are sponsoring innovative community solar projects to meet member demand for solar energy. Electric co-ops have structured the ownership of their community solar arrays in different ways. In some cases, the members own the panels. In others, the co-op does, or a third party and the member signs a contract that guarantees them power for 20 to 25 years.

Approximately 4 percent of electric co-ops now have community solar projects, but that number is expected to increase with numerous other projects under development. Through community solar projects, co-op members are acquiring the power from one or more photovoltaic panels, or in some cases, just a portion of a panel.

A survey by Farmers Electric Cooperative, in Kalona, Iowa showed the 3 most compelling member-consumer drivers for community solar to be: an easy way to invest in solar concern

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[6] http://www.nrel.gov/docs/fy14osti/60047.pdf

about the environment; and the importance of keeping money in the local community. The survey also found that more than 90 percent of the participants were satisfied with the program, which involves consumer ownership of the panels.

United Power constructed its first community solar array in Colorado in 2009. United Power's members lease the panels on a long-term basis from the cooperative. United Power's initial approach to financing their community solar project was using seed money from the State of Colorado Governor's Energy Office. But from there, it has expanded on a self-financing basis.

Other co-ops have sought to take advantage of the Federal government's Investment Tax Credit, a credit for 30 percent of the cost to build a solar facility. Because of their non-profit status, electric co-ops generally cannot take direct advantage of the credit. However, some co-ops have turned to solar partners who can use the tax credits and essentially pass the savings on to the co-op and its members. Wright-Hennepin Electric Cooperative, Rockford, MN, developed a community solar array, which also includes a battery storage component that allows some of the power to be used during peak periods late in the day. They chose to work with Clean Energy Collective on their first array. Clean Energy Collective owned the array and captured the 30 percent tax credit and sells the power to Wright-Hennepin. However, the cooperative's next project will crowd-funded and the members will own the array. Under the approach, the co-op is financing the construction upfront and then collecting the money from members as they purchase panels.

Lake Region Electric Cooperative in Pelican Rapids, Minn. took another approach known as a "tax equity flip." Under a program developed by the National Renewables Cooperative Organization (NRCO), Federated Rural Electric Insurance Exchange (Federated), and the National Rural Utilities Cooperative Finance Corporation (CFC), Lake Region created a "taxable special purpose entity" through which a co-op and a partner (Federated) can build and operate solar facilities, including community solar projects. In a tax equity flip, majority ownership of the facility resides with the partner until the tax benefits are exhausted and then transfers to the co-op.