BEFORE THE

PUBLIC SERVICE COMMISSION OF UTAH

In the Matter of the Investigation of the Costs and Benefits of Pacificorp's Net Metering Program	))))	**Docket No. 14-035-114**

DIRECT TESTIMONY OF BEN NORRIS

On the Topic of

The Joint Proposal for a Benefit-Cost Framework for

Net Energy Metering

On Behalf of Utah Clean Energy, The Alliance for Solar Choice, and Sierra Club

July 30, 2015

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I. INTRODUCTION AND QUALIFICATIONS

Q. Please state your name, title, and employer.

A. My name is Ben Norris. I am Senior Consultant at Clean Power Research, located at 1541 Third Street, Napa, California.

Q. Please describe Clean Power Research.

A. Clean Power Research (CPR) was founded in 1998 for the purpose of empowering utilities, energy agencies, and customers to make intelligent energy decisions. CPR's research and consulting groups are based in the company headquarters in Napa, California, while its software services group is based in Kirkland, Washington. CPR is a privately held company with 30 employees.

CPR is the industry leader in providing satellite-based solar data and modeling, covering North America and Hawaii. It is also the leader in software used by energy agencies and utilities for managing solar incentive programs and distributed generation interconnections (2.5 GW of distributed solar applications have been submitted through its PowerClerk software).

CPR provides a variety of economic evaluation software tools to enable customers to evaluate cost effectiveness based on specific rate schedules and other local factors. For example, its Clean Power Estimator and WattPlan software products have been developed in parallel with a rates database and bill calculation engine that handles the intricacies of several forms of net metering (such as monthly true up, annual true up, variations on compensation for excess production, etc.).

CPR leads the industry in solar valuation research and methodologies, some of which date back to the 1980's when its founder, Thomas Hoff, Ph.D., developed methods for determining effective capacity for intermittent resources at Pacific Gas and Electric Company. CPR has pioneered many of the concepts in solar net energy metering cost/benefit evaluations, such as methods for determining marginal loss savings using on utility data, the use of fleet production profiles, and methods for evaluating distribution capital cost savings.

Q. Please summarize your professional and educational experience.

A. I have 30 years of utility and consulting experience, have conducted numerous distributed generation valuation studies for utilities, regulators, energy agencies and industry organizations. I have led valuation studies in Minnesota and Maine, and was a lead technical contributor in both Austin studies as well as other utility studies. In the process, I have advanced several technical and economic methods for performing valuation studies. I currently manage the Consulting team at Clean Power Research, which is engaged in improving methods for solar fleet modeling, short and long term solar forecasting, and variability assessment for grid operators.

After earning a degree in Mechanical Engineering from Stanford University in 1985, I worked as a research engineer at Pacific Gas & Electric Company, and later as an independent consultant. I served on the Board of Directors for the Electricity Storage Association for 8 years, and am a licensed Mechanical Engineer in the State of California.

Q. On whose behalf are you testifying in this case?

A. I am providing testimony on behalf of Utah Clean Energy, The Alliance for Solar Choice, and Sierra Club ("the Joint Parties").

Q. Have you previously testified before the Utah Public Service Commission?

A. No.

II. PURPOSE AND OVERVIEW

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to provide an overview for calculating the benefits of solar electricity production under net energy metering (NEM).

Q. What benefits should be included?

A. My colleague Tim Woolf has identified the following key benefits in his testimony:

- Avoided energy costs.
- Avoided capacity costs.
- Avoided transmission costs.

- Avoided distribution costs.
- Avoided cost of environmental compliance, including compliance with the US Environmental Protection Agency Clean Power Plan.
- Reduced risk.
- Reduced transmission and distribution line losses.

I intend to address each of these individually.

III. AVOIDED COSTS

Q. How are avoided energy costs estimated?

A. Avoided energy costs are determined in two steps: (1) obtaining hourly technical data; and (2) performing the economic calculations.

The first step in performing the evaluation is to obtain hourly data for system loads and distribution loads over a defined Load Analysis Period (e.g., the most recent three years). In addition, a parallel set of data representing the Solar Contribution must be obtained. This can be either simulated or measured, but must accomplish the following:

- The data must accurately reflect the diversity of geographical locations and the diversity of design orientations (range of azimuth angles and tilt angles, etc.). Typically, this requires the aggregation of several hundred systems comprising a representative "fleet" of solar resources.
- The data must not represent "typical year" conditions, but rather must be taken from the same hours and years as the load data. It must be therefore "time

synchronized" with load. As an alternative, if "typical year" data is used for the load data, then the solar fleet simulations must be based on the same underlying meteorological dataset. For example, the same dataset of temperature, wind speed, global horizontal irradiance, direct normal irradiance, and diffuse horizontal irradiance must be used to generate both typical load and typical solar production. The result is a time-correlated set of load and solar production that share the same underlying assumptions.

- If the intention of the study is to determine compensation for a set of solar resources that includes existing solar resources, then the contribution of these existing resources should be removed from the load datasets. In other words, the data should only reflect load, not "net load."

The second step is the economic evaluation. Hourly marginal energy costs may be obtained through the use of a production cost model. This model would be run for all hours of a defined historical study period, such as the last year or the Load Analysis Period, and two runs would be performed: (1) without the hourly solar fleet production; and (2) with the hourly solar fleet production. In each run the total cost of energy over the study period is determined. Then, the total savings (costs without solar minus costs with solar) is divided by the rated capacity of the solar fleet (kW-AC) to yield the first year avoided energy cost in dollars per kW of rated solar capacity.

As an alternative to the above method, a simplifying assumption may be made that solar displaces a peaking marginal unit with a comparable capacity factor as the solar fleet. In this case, the heat rate of a selected unit would be multiplied by the current annual average burner tip fuel price and the annual solar production, divided by the fleet rated capacity, to yield the first year avoided energy cost in dollars per kW.

Regardless of method, an economic study period must be selected over which the benefits are to be evaluated. Normally, the study period is selected corresponding to the estimated useful service life of the asset—in this case the estimated life of a typical solar resource (e.g., 25 years). While the Load Analysis Period, used to perform technical calculations is necessarily in the past, the study period is in the future because it represents the period of potentially avoidable costs.

The first year avoided cost result is then adapted to future years of the study period as follows. Future year avoided energy costs are calculated by forecasting fuel prices for each year and calculating the corresponding annual avoided energy costs, or by doing production model runs for future years based on the time-synchronized typical meteorological data described above. In either case, the net present value (NPV) of the avoided cost stream is calculated by discounting each year's avoided cost.

The NPV is then levelized to yield the avoided energy cost in dollars per kWh. The calculation may include an assumption about annual solar degradation.

The result is adjusted to account for avoided losses in the transmission and distribution systems as described below.

Q. How are avoided capacity costs estimated?

Avoided capacity costs are determined in two steps. The first step is to calculate the effective capacity of a solar resource. This may be accomplished in one of several ways, but the simplest is to use the system load data and solar fleet resource data and calculate the average fleet production over the peak N load hours (e.g., the average fleet production during the peak 100 load hours). The effective capacity is then divided by the fleet rating to yield effective kW per rated kW.

The second step is to multiply the effective kW by the cost of capacity to yield the benefit in dollars per kW of rated capacity. The type of generation source used for the cost data must be the same as the assumed resource used for the displaced energy. For example, if in the energy calculation the heat rate for a peaking combustion turbine was used, then the capital cost for a peaking combustion turbine in dollars per kW would be used in the cost calculation. If a production cost model is used, then a blend of capital costs from multiple resources may be used, weighted by the types of production displaced.

This cost is then levelized and adjusted for avoided losses, similar to the avoided energy calculation.

Q. How are avoided transmission costs estimated?

A. The cost of avoided transmission is complicated by the fact that the future costs of transmission capacity depend upon the location of new (avoided) generating units. As a simplification, the historical cost of transmission may be used as a proxy of future costs.

To accomplish this, transmission costs allocated to Utah are calculated for two cases: (1) without the solar fleet, and (2) with the solar fleet. The total savings is the difference between the two. The savings is divided by the fleet rating to yield dollars per kW. Then, this cost is levelized and adjusted for loss savings similar to the avoided energy calculation.

The process of calculating allocation of cost may be performed using exiting allocation methods. Since these methods reflect the contribution of demand reduction by solar in coincident peak hours, the method reflects the effective capacity of solar during those peak hours. Therefore, it is not necessary to separately calculate and apply a metric for effective solar capacity for this benefit.

Q. How are avoided distribution costs estimated?

A. First, the effective peak load reduction due to the solar generation must be determined. Since every distribution planning area and feeder will have a different amount of load reduction due to a number of factors, one of two approaches should be followed. In the first approach, the avoided distribution costs should be calculated for each feeder and planning area separately. If this approach is taken, then the loss analysis, the solar fleet production data, and the load data should be taken for each study area separately. Since the data unique to each distribution area will affect the other benefits, such as energy and capacity, each of the other benefits should also be calculated separately for each area. For example, the generation capacity benefits may be calculated at a defined distribution planning area made up of a set of feeders. The loss factors, solar production, and load shapes for this planning area will be unique, so a unique calculation for generation capacity will be required.

If, on the other hand, a general result is desired in which a single estimate for avoided distribution costs is desired, then aggregate data may be used (aggregate loss data, load data, fleet production data, etc.). This approach is a simplification because it will not reflect the details of every location, but it will be representative of the fleet across the utility service territory.

Regardless of the geographic resolution desired, the approach for calculating the benefit is the same. First, the costs of new distribution capacity over the economic study period are projected. For example, if the study period is 25 years, then the cost of new distribution capacity within the geographical area of interest should be estimated for each year in this period. As detailed cost estimates are generally available only for areas facing near term capacity upgrades, future upgrades outside the planning horizon may be made based on a projection of costs and peak loads over a representative historical period, such as the last 10 years. Costs should be adjusted for inflation. Costs for reliability-related purposes should not be included because they are not avoidable by distributed solar.

The NPV of all years is calculated and divided by the assumed peak distribution load growth over the study period to yield the cost in dollars per kW of growth.

The effective capacity of the solar resource should be determined by examining solar production during the peak distribution load hours. For example, if the top five hours are used, then the effective distribution capacity of solar would be calculated by averaging the fleet production in kW during the top five hours and dividing that by the fleet rating to give the effective distribution capacity per rated kW. This is then multiplied by the NPV of cost per kW, and this result is then levelized and adjusted for losses similar to the energy benefit.

Q. How are avoided environmental compliance costs estimated?

A. This benefit is related to the utility's ability to avoid costs to install and operate pollution control measures that are necessary to comply with environmental regulations such as the Regional Haze rule, ambient air quality standards, water quality standard, and possible greenhouse gas reductions stemming from Section 111(d) of the Clean Air Act. For example, once implemented, Section 111(d) will require Utah to develop standards of performance for existing carbon sources and PacifiCorp/RMP would have to take measures to reduce carbon emissions. Distributed PV would partly reduce these compliance costs by reducing the amount of generation needed from carbon producing sources. Calculating this benefit with regard to 111(d) will become clearer once the specifics of the compliance plan are developed.

Q. How are the benefits of reduced risks estimated?

A. There are several sources of risk, which distributed solar either eliminates or mitigates. These include:

- The risk of uncertainty in future fuel prices.
- The risk of uncertainty in future peak load growth.
- The risk of cost overruns in future estimated capacity cost (e.g., uncertainty in the price of steel).
- The risk of future environmental compliance requirements.

These risks should be included in the cost impact evaluation. For example, the fuel price risk can be evaluated by calculating the cost of eliminating risk by hedging the energy that is displaced by solar for each year in the study period.

Q. How are avoided transmission and distribution losses estimated?

A. The economic benefits that result from avoided losses are associated with all of the above benefits, whether related to energy or capacity. For example, the benefit calculation of avoided generation capacity must take into account the fact that a portion of capacity is used merely to overcome losses between the generation source and the consumer.

To quantify the avoided costs of losses, each benefit must be calculated twice: (1) with losses included, and (2) without losses included. The difference between these two calculations are the loss savings for the associated benefit, and all such loss savings may be summed to aggregate loss savings into a single value. Alternatively, loss savings may be incorporated in each benefit category rather than creating a distinct category for avoided losses.

Each benefit category should be understood to take into account either the effect of avoided distribution losses or the combined effect of both avoided transmission losses and avoided distribution losses. For example, the avoided energy costs should include both avoided transmission and avoided distribution losses, whereas the avoided distribution costs should only include the avoided distribution losses (transmission losses are not avoided).

The calculations should observe the following:

1. Avoided losses are calculated on an hourly basis over the Load Analysis Period rather than assuming the same loss behavior for all hours. This is intended to account for the fact that solar generation may be correlated with load, for example, on sunny summer days.

2. Avoided losses in the transmission system and distribution systems are to be evaluated separately based on the most recent utility study data available.

3. Avoided losses should be calculated on a marginal basis rather than an average basis. The marginal avoided losses are the difference in hourly losses between the case without the solar fleet, and the case with the solar fleet. For example, if the solar fleet were to produce 10 MW during an hour in which total customer load is 10,000 MW, then the avoided losses would be the difference between the losses at 10,000 MW of customer load and the losses at 9,990 MW of customer load.

4. Distribution losses should be based on the power entering the distribution system, after transmission losses.

5. Avoided transmission losses should take into account not only the load reduced by the solar fleet, but also the avoided marginal distribution losses.

6. Calculations of avoided losses should not include no-load losses (e.g., corona, leakage current). Only load-related losses should be included.

7. Calculations of avoided losses in any hour should take into account the non-linear relationship between losses and load (load-related losses are proportional to the square of the load, assuming constant voltage). For example, the total load-related losses during an hour with a load of 2X would be approximately 4 times the total load-related losses during an hour with a load of only X.

Q. How does solar impact the allocation of costs to Utah versus the other PacifiCorp jurisdictions?

A. Costs that are avoided by Utah solar customers should be included in the benefits as outlined in the methods above. In addition, it may be possible that distributed solar customers cause costs to shift either into or out of Utah. Re-allocated costs can be calculated using the Jurisdictional Allocation Model with and without distributed solar generation to determine the impact. This would be based on the hourly load and solar fleet production data described above to determine energy and demand during required periods such as the coincident peaks. Then, to the extent that costs shift into or out of Utah, there may be costs or benefits associated with re-allocation that should be incorporated into the analysis.

Q. Does this conclude your direct testimony?

A. Yes.