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BEFORE THE PUBLIC SERVICE COMMISSION OF UTAH

In the Matter of the Application of Rocky Mountain Power to Establish Export Credits for Customer Generated Electricity	**DOCKET NO. 17-035-61**

DIRECT TESTIMONY OF CHRISTOPHER WORLEY FOR VIVINT SOLAR, INC.

March 22, 2018

I. INTRODUCTION

Q. Please state your name, business address and position with Vivint Solar.

A. My name is Christopher Worley. My business address is 1800 W. Ashton Blvd, Lehi, Utah 84043. I am Director of Rate Design with Vivint Solar.

Q. Please describe your education and professional experience.

A. I have a Bachelor's Degree in English from the University of Colorado at Denver, and a Master's Degree and Doctorate in Mineral and Energy Economics from the Colorado School of Mines. I have been with Vivint Solar for five months. Before joining Vivint Solar, I was the Director of Policy and Research for the Colorado Energy Office, where I led legislative and regulatory efforts, including testifying before the Colorado Public Utilities Commission.

II. SUMMARY AND RECOMMENDATIONS

Q. What is the purpose of your testimony?

A. My testimony provides the Commission with recommendations on the load research part of the export credit proceeding. Specifically, I identify deficiencies in Rocky Mountain Power's ("RMP" or "the Company") load research methodology and provide recommendations to improve it.

Q. What are your recommendations for the Commission?

A. I recommend (1) increasing the sample of customers participating in the study to increase the accuracy of the study, (2) using simple sampling instead of stratified sampling, (3) sampling based on RMP's distribution system topology rather than county-level sampling, and (4) collecting generation, load, and export data from study participants rather than generation from some and load and export data from others. Also, I provide recommendations on how to increase the sample at a lower cost than RMP's estimate for installing meters. It is vital that the load

research study collect enough data (a large enough sample) in Phase I to ensure parties can estimate costs and benefits in Phase II.

Finally, I have additional recommendations should the Commission choose stratified sampling instead of simple sampling. Under that methodology, I recommend (1) stratifying on gross consumption rather than on system capacity and (2) separately analyzing residential and commercial customers.

III. BACKGROUND

Q. What is the purpose of the export credit proceeding?

A. This proceeding was initiated as a result of the settlement stipulation in Docket 14-035-114. The Commission ordered that this proceeding "investigate the costs and benefits of the Company's net metering program."[1] Based on the cost benefit analysis, "the Commission will determine a just and reasonable rate for export credits for customer generated electricity."[2]

This proceeding gives the Commission an opportunity to better understand the impact, both costs and benefits, of DG on RMP's distribution system. It is an opportunity for the Commission to put hard numbers on how RMP's system operates and should inform how, where, and when RMP invests in its distribution system in the future. This proceeding has the potential of influencing hundreds of millions of dollars of customer and utility investment by answering critical questions. Questions like: Could system orientation (azimuth) help reduce RMP's peak demands, and therefore save money for RMP ratepayers? Does distributed generation over-tax distribution assets or does it reduce the need for using transmission assets? What impact does

[1] Direct Testimony of Kenneth Lee Elder Jr, page 2
[2] Settlement Stipulation, page 10

distributed generation have on air quality along the Wasatch Front? These are the types of questions that parties and the Commission should be asking and answering in this proceeding.

Q. What is the purpose of the load research study?

A. According to RMP, "[l]oad research gathers the data needed to study customer usage so the Company can effectively allocate costs, design rates, plan for load, appropriately size transformers and distribution circuits, and enhance customer service."[3] But more than just a simple process to estimate generation at customer-sited systems, this step of the proceeding is critical in ensuring the data needs of the study. As noted in the Commission's order on the settlement stipulation, parties have the burden to prove cost and benefit estimation.[4] Care must be taken in Phase I to ensure the research methodology is structured to allow costs and benefits to be estimated in Phase II of the proceeding. There is no way to retroactively fix suboptimal methodology two years from now during Phase II of the proceeding.

Q. Is the Company's proposed methodology sufficient to achieve the purpose of the load research study?

A. No. Unfortunately, the Company's methodology is likely to result in biased estimates that lack sufficient statistical power. Stratifying based on system capacity ignores DG system orientation, tilt, and shading, factors that have a strong impact on system production. Additionally, the Company is proposing to collect load and export data from one set of customers and generation data from another.[5] Moreover, given the small sample, the study would be fragile to unforeseen problems. If for any reason data are not collected from a small set of study participants, the study results could be wrong. Finally, such a small sample may lack

[3] Direct Testimony of Kenneth Lee Elder Jr, page 3.
[4] Docket No. 14-035-114, Settlement Stipulation, page 10.
[5] Direct Testimony of Kenneth Lee Elder Jr, page 6.

statistical power for estimating costs and benefits. For example, there may be avoided transmission benefits to DG solar, but the estimated benefits may not be statistically significant due to a small sample. This is the same problem parties had in Docket 14-035-114. RMP's sample size is too small to produce credible results.

Q. Did Vivint Solar expect this load research phase of the proceeding to be collaborative?

A. Yes. The settlement stipulation in Docket 14-035-114 states: "The Company will facilitate a workshop with the Parties and other stakeholders soon after the Export Credit Proceeding is initiated to discuss the type and scope of data expected to be considered in determining the appropriate export rate."[6] The Commission's scheduling order in this phase contemplated the possibility of having no hearing to determine the requirements for RMP's load research study because the parties might be able to reach agreement.

Q. Did RMP facilitate a workshop?

A. Yes, but the parties and other stakeholders met together just once to review how RMP proposed to conduct the study. Thereafter, RMP converted the second workshop meeting to a conference call to announce the minor changes it had accepted for its February 15, 2018 filing.

Q. What is the upshot?

A. There is significant disagreement over how RMP should conduct the study and the Commission will have to hear this matter April 17, 2018 to decide the contested issues.

IV. STUDY ACCURACY

Q. What level of accuracy does the Company propose?

[6] Docket No. 14-035-114, Settlement Stipulation, page 10.

A. The Company proposes accuracy of +/-10% at the 95% confidence level.

Q. Is that level of accuracy problematic?

A. Yes. While a 95% confidence level is appropriate, +/-10% is a very wide range for results. For example, the study will likely estimate the amount of exported power during RMP's Peak Hours.[7] Exports during peak hours are likely to be more valuable than exports during off-peak hours. With the Company's proposed level of accuracy, the estimate of Peak Hours exports could be up to 10% too high or 10% too low. That means ratepayers could be overcompensating or undercompensating DG customers by up to 10% for power exported to the grid during peak times.

Furthermore, as stated previously, with such a wide range for the study estimates, the study has low statistical power to estimate costs and benefits. Parties have the burden of proof to estimate costs and benefits. If the data lacks statistical power, parties may be unable to estimate some costs and benefits.

Q. What recommendations do you have on study accuracy?

A. I recommend increasing the sample so that the study is accurate to at least +/-5% at a 95% confidence level.

V. DATA COLLECTION

Q. How does the Company propose to collect data?

A. According to the discussion at the workshop, RMP plans on collecting generation data by installing large revenue-grade meters on customer homes and facilities. RMP described revenue-grade meters as large boxes, perhaps the size of a large residential breaker box. One of these

[7] Utah Time of Day Peak Hours are 1:00 PM to 8:00 PM Monday through Friday during the months of May through September https://www.rockymountainpower.net/ya/po/otou/utah/ph.html

large meters will need to be installed on the home or business of each study participant. Given the cost and the large, obtrusive size, the Company has expressed a desire to limit the number of meters to limit the number of customers that are inconvenienced.

A. METERS AND DATA ACCESS

Q. Are there problems with RMP's proposed data collection?

A. Yes. There are two main problems: the Company's description of revenue-grade meters and the inconsistent data collection from study participants.

Q. Are there other hardware-based options for data collection?

A. After doing a brief Google search, I found two small revenue-grade meters that seem much less obtrusive than what the Company described. For example, the Locus Energy LGate 120 is the size of a normal residential electricity meter, collects data at 5 minute intervals and is accurate to the 0.2% level (certified ANSI C12.20).[8] The LGate 120 is available for $299 with free shipping from Amazon.com, including five years of cell service for data collection.[9] I also found the Solar-Log 350, which is available from the Alt E store for $649.[10] Like the LGate 120, the Solar-Log 350 is the size of a residential electricity meter, has revenue-grade accuracy of +/- 0.2%, and comes with a five-year cell plan. These are just two examples that I found of meters that are roughly the size of a coffee can. There are likely more companies that sell similar solar monitoring systems smaller than the large meters described by RMP.

Q. What about installation of these meters?

[8] https://www.locusenergy.com/solutions/residential Accessed March 21, 2018.
[9] "Locus Energy LGate120 LGate 120 5 Year Monitoring" https://www.amazon.com/Locus-Energy-LGate120-LGate-Monitoring/dp/B06XB46VGJ/ Accessed March 21, 2018.
[10] "Solar-Log 350 & GE Revenue Grade Meter/Datalogger" https://www.altestore.com/store/meters-communications-site-analysis/solar-monitoring-systems/solar-log-350-ge-revenue-grade-meterdatalogger-p11759/ Accessed March 21, 2018.

A. Based on our installer estimates, it should take an electrician no more than four hours to install a meter similar to the LGate 120 or the Solar-Log 350.

Q. Are there software alternatives for data collection that would not require installing a new meter?

A. Yes. Solar installers monitor production data from systems using cellular or Wi-Fi connections. While production data is owned by customers, RMP could request customers disclose their production data. Once a customer has signed a disclosure form, the solar installer could give that data to RMP. Many customers might choose to participate in the study through production data because it avoids the installation of a separate meter.

Q. How accurate is the data from inverters?

A. Typically, data from inverters is accurate to +/- 5%.

Q. Would that level of accuracy be a problem for the study?

A. No. Data from inverters is less accurate than the revenue-grade meters, but the study is only accurate to +/-10%. So inverter data accurate to +/-5% won't reduce the accuracy of the study. To be clear, using revenue-grade meters accurate to +/-0.2% will not increase the accuracy of the study.

B. STUDY DATA

Q. What data does the Company propose collecting?

A. The Company proposes collecting exported energy from transition program customers, delivered energy from transition program customers, and DG system production from grandfathered net energy metering ("NEM") customers.[11]

Q. Are there problems with this approach?

[11] Direct Testimony of Kenneth Lee Elder Jr, page 6.

A. Yes. By collecting load and export data from one set of customers, and generation data from another set, the analysis compares average data rather than tracking the performance of DG systems. This is problematic. Using this approach, parties will not be able to estimate the direct impact of DG on RMP's distribution system.

C. DATA COLLECTION RECOMMENDATIONS

Q. What process do you recommend for the Company to follow for sampling and data collection?

A. The Company should collect delivered energy, exported energy and DG system production from each customer participating in the study. RMP should select a suitably large pool of potential study participants. I recommend a sample size large enough to ensure the number of actual study participants enables accuracy of +/-5% at the 95% confidence level. Of the pool of potential study participants, RMP should randomly select a number of customers to install meters, either the large, expensive revenue-grade meters RMP described at the workshop or smaller, cheaper meters like the Locus Energy or Solar-Log. For the remaining customers in the pool of potential participants, RMP should request participation in the study and obtain consent to work with their installer to collect production data. The pool of potential study participants should be sufficiently large to ensure a large enough sample if some customers decline to participate in the study.

Q. What are the benefits of this approach?

A. This would allow RMP to collect some data from customer meters but increase the sample without the added cost of installing meters. Data from customer inverters can increase the sample, increasing the accuracy of the study at a lower cost than installing meters.

VI. SAMPLING

Q. How does the Company propose to sample DG customers?

A. The Company proposes using stratified random sampling, separating solar customers into four bins based on system capacity: less than 6 kW, 6 to 12 kW, 12 to 80 kW, and greater than 80 kW. The Company notes that stratified sampling can increase the statistical precision and reduce sampling requirements.[12]

A. STRATIFIED SAMPLING

Q. Are there problems with the proposed stratification?

A. Yes. There are two main problems with RMP's proposed stratification. Firstly, while stratified sampling reduces the sampling requirements, decreasing the sample may make statistical testing difficult in Phase II of this proceeding. The second problem occurs with the stratification variable. Using system size as the stratification variable ignores important factors that greatly impact system generation, including azimuth (orientation), tilt, and shading from surrounding trees and structures.

Q. How will a small sample make statistical testing difficult in Phase II?

A. Parties have the burden of proof estimating costs and benefits of distributed generation. If the sample is too small, it may be difficult or impossible for parties to estimate costs and benefits. For example, let's assume that West-facing systems provide more exported power during peak times. If a party wanted to estimate the impact of West-facing systems during peak times, the sample would need enough West-facing systems for the estimated impact to demonstrate statistical significance. If the sample is too small, there may not be enough statistical power to test that question. Either the model would show no difference between West-facing systems and systems facing other directions, or the relationship would be too weak for the estimate to be statistically significant.

[12] Direct Testimony of Kenneth Lee Elder Jr, page 4

Q. Why is stratifying on system capacity problematic?

A. While system capacity is likely to be correlated with system output, a number of other factors impact system generation, like orientation, tilt, and shading. Ignoring these other factors will bias the results from a stratified sample. To demonstrate this, I used PVWatts to simulate the difference in total generation and hours of peak generation for a 10 kW system with different orientations. Developed by the National Renewable Energy Laboratory, PVWatts is an online tool that estimates energy production of solar at a specific location based on DG system characteristics.[13] Using the standard PVWatts inputs[14], a 10 kW system located at 1407 W North Temple, Salt Lake City, UT 84116 will have different estimated annual production depending on whether the system faces East, South, or West.

	AC Output (kWh) by System Azimuth		
	East	South	West
Jan	503	725	516
Feb	678	911	672
Mar	1,013	1,217	985
Apr	1,241	1,355	1,212
May	1,642	1,672	1,532
Jun	1,588	1,600	1,565
Jul	1,649	1,676	1,597
Aug	1,503	1,623	1,464
Sep	1,181	1,395	1,154
Oct	898	1,188	884
Nov	557	803	552
Dec	413	597	415
Total Annual	12,866	14,764	12,550
%Δ from South	-13%		-15%

Table 1: Total annual output (kWh) by system azimuth

[13] "PVWatts Calculator" http://pvwatts.nrel.gov/pvwatts.php Accessed March 21, 2018.

[14] Standard (crystalline Silicon) with 15% efficiency, fixed (roof mount) system, 14% system losses, and 20 degrees tilt

As shown in Table 1, total generation is maximized when the system faces South (14,764 kWh). East facing systems generate 13% less and West facing systems generate 15% less than South facing systems.

Q. What is the impact of system orientation on generation during peak hours?

A. The impact of system orientation on peak hours generation is even more dramatic. East facing systems produce 32% less and West facing systems produce 20% more than a South facing system baseline (see Table 2). This demonstrates that confounding factors, like system orientation, can greatly impact system generation. Stratifying on system capacity ignores confounding variables that greatly impact the level of generation, which will likely bias the study.

	Peak hours AC Output (kWh) by System Azimuth		
	East	South	West
1:00 PM	555	682	656
2:00 PM	446	605	632
3:00 PM	309	485	563
4:00 PM	171	333	451
5:00 PM	75	181	323
6:00 PM	32	50	161
7:00 PM	6	6	32
8:00 PM	-	-	-
Total Summer	1,593	2,343	2,817
%Δ from South	-32%	-	20%

Table 2: Summer peak hour output (kWh) by system azimuth

Q. Why is this a problem? If properly sampled, shouldn't variation in system orientation be averaged out?

A. Properly sampling should address this problem, however the sample size proposed by RMP is not large enough to adequately account for variation in installed DG systems. For example, RMP categorizes 10 kW systems in Strata 2, which covers more than 9,300 systems

sized 6 kW to 12 kW. The Company proposes sampling only 10 systems to characterize more than 9,300 systems.[15] Such a small sample may or may not be representative of the average system characteristics of the population. Generally, installers will try to install residential rooftop systems facing South (azimuth = 180°) since that orientation will maximize energy production, and therefore provide the quickest payback on the customer's investment. While not every system can be oriented South due to house orientation and roof shape, we should expect that on average systems will be oriented South. But given the small sample, it is possible the sampled systems may disproportionately contain West facing systems or East facing systems. Or some of the sampled systems may be shaded by trees or structures, disproportionately from the population of systems.

Q. How can the issue of disproportionate sampling be addressed?

A. Increasing the sample will address this issue, averaging out confounding factors.

B. GEOGRAPHIC SAMPLING

Q. How does the Company propose to ensure the sample is geographically representative to the RMP system?

A. The Company proposes county-level sampling based on the number of customers in each county.[16]

Q. Are there problems with this approach?

A. Yes. While sampling by county may represent the spatial distribution of DG throughout the state, it may not represent how exported power from DG performs on RMP's distribution system. The sampled systems may or may not be on the same distribution circuit. The cost on distribution circuits with many DG systems may be larger than the cost on distribution circuits

[15] Direct Testimony of Kenneth Lee Elder Jr, Exhibit RMP___(KLE-1) Page 4 of 4, Table 1
[16] Direct Testimony of Kenneth Lee Elder Jr, Exhibit RMP___(KLE-1) Page 4 of 4, Table 2

with only a few DG systems. The purpose of this proceeding is to estimate the costs and benefits on RMP's system. If the load research study doesn't sample according to system topology, then parties cannot assess the true costs on RMP's system.

C. SAMPLING RECOMMENDATIONS

Q. How would you recommend RMP sample and collect data from customers?

A. RMP should select a suitably large pool of potential study participants. I recommend a sample size large enough to ensure the number of actual study participants enables accuracy of +/-5% at the 95% confidence level. Using simple sampling at the +/-5% at the 95% confidence level would require a sample of 379. Using stratified sampling would require a sample of 179 to achieve accuracy of +/-5% at the 95% confidence level.[17]

Of the pool of potential study participants, RMP should randomly select a number of customers to install meters, either the large, expensive revenue-grade meters RMP described at the workshop or smaller, cheaper meters like the Locus Energy or Solar-Log. The remaining customers in the pool of potential participants would provide inverter data from the installer.

Next, RMP should obtain customer consent, either to install a meter or to request data from installers. The pool of selected customers should be sufficiently large to ensure a large enough sample if some customers decline to opt-in to the study.

Q. What sampling technique do you recommend the study use?

A. I recommend using simple sampling, not stratified sampling, to ensure the sample is large enough to estimate costs and benefits in Phase II of the proceeding.

Q. What if the Commission declines to approve simple sampling, instead using stratified sampling as proposed by RMP?

[17] RMP Response to Workshop Data Request 4

A. In that case, I recommend stratifying on gross consumption rather than on system capacity. As mentioned above, strata based on system capacity ignore a number of confounding variables, like system orientation, tilt, and shading.

Q. How can the Company stratify on gross consumption if they do not know what customers will consume prior to the study?

A. RMP could use historical gross consumption for customers that installed solar in 2017.

Q. Do you have any other recommendations for stratified sampling?

A. Yes. Additionally, given differing consumption profiles of residential and commercial customers, it would be appropriate to analyze residential and commercial customers separately.

Q. What recommendations do you have on the geographic stratification?

A. RMP should sample DG systems based on distribution system topology. Sampling should ensure a variety of scenarios, including distribution circuits with few DG systems and circuits with many DG systems. Additionally, the load research study should collect 15-minute circuit-level distribution system data to match the customer load, export, and generation data.

VII. CONCLUSION

Q. To summarize, what are your recommendations for the Commission?

A. I recommend (1) increasing the sample to increase the accuracy of the study, (2) using simple sampling instead of stratified sampling, (3) sampling based on RMP's distribution system topology rather than county-level sampling, and (4) using consistent data streams from customers rather than comparing estimated averages. Also, I provided recommendations on how to increase the sample at a lower cost than RMP's estimates, including working with installers to

access data from system inverters. It is vital that the load research study collect enough data (a large enough sample) in Phase I to ensure parties can estimate costs and benefits in Phase II.

Finally, if the Commission chooses stratified sampling instead of simple sampling, I recommend (1) stratifying on gross consumption rather than system capacity and (2) separating residential and commercial customers.

Q. Does this complete your testimony?

A. Yes.

/s/Christopher Worley

CERTIFICATE OF SERVICE

I hereby certify that on March 22, 2018, I sent a true and correct copy of the direct testimony of Christopher Worley on behalf of Vivint Solar, Inc. in Docket No. 17-035-61by electronic mail to the following:

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