Exhibit No. 2.0
Albert J. Lee, Ph.D.
Docket No. 17-035-61
April 10, 2018

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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 Phase 1** Vote Solar Exhibit 2.0

REBUTTAL TESTIMONY OF ALBERT J. LEE, PH.D.

ON BEHALF OF

VOTE SOLAR

April 10, 2018

I. INTRODUCTION

Q. Please state your name, business address, and title.

A. My name is Albert J. Lee. My business address is 601 New Jersey Avenue NW, Suite 400, Washington, DC 20001. I am the Founding Partner and Lead Economist at Summit Consulting, LLC.

Q. On whose behalf are you testifying?

A. I am testifying on behalf of Vote Solar.

Q. Would you summarize your background for the record?

A. I am an economist, with a Ph.D. (1999) and M.A. (1996) in economics from the University of California at Los Angeles (UCLA). My research, teaching, and professional practice have focused on econometric modeling and statistical sampling. I have designed and selected statistical samples and performed extrapolations for various federal agencies, including the Department of Defense, the Department of Housing and Urban Development, the Department of Labor, the Small Business Administration, and the Department of Transportation.

I have published articles in peer-reviewed and industry journals on mathematics and economics. I have lectured on statistics, advanced quantitative methods, and graduate-level econometrics at UCLA, the George Washington University, and Columbia University, respectively. I am a member of the American Economic Association (AEA), the American Statistical Association (ASA), and the Econometric Society. Since 2012, I have been an ASA Accredited Professional Statistician.

I have served as a sampling expert in a number of matters. I have testified regarding sampling in front of an administrative law judge, as well as in depositions and trial.

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to address the testimony submitted by Mr. Charles E.

Peterson.

Q. What was the scope of Mr. Peterson's testimony?

A. Mr. Peterson reviewed the statistical methods used to determine the sample design of Rocky Mountain Power's ("Company") proposed load research study, given the desired confidence level and margin of error.[1]

II. SUMMARY OF FINDINGS

Q. Please describe the sample design of the Company's proposed load research study in this docket.

A. The Company plans to use a stratified sample, using a systematic sample to select customers within strata. First, customers are grouped by nameplate power generation capacity into four strata. Within each stratum, customers are sorted by nameplate power generation capacity. A random starting position is determined, and customers are selected at fixed intervals to generate the desired sample size in each stratum.

Q. Do you have any comments regarding Mr. Peterson's opinions that the sample design for the Company's proposed research study is appropriate?

A. Yes, I do.

Q. Please state your opinions.

A. Mr. Peterson opines that the sample design is appropriate.[2] However, I find that the sample design has several major issues that make it inappropriate. First, the sample is not drawn from the population of interest. Instead, it is drawn from a subset of the population. Estimates from this sample

[1] Mr. Peterson references the sample design described in the direct testimony of Kenneth Lee Elder on February 15, 2018, pages 3-6 and 9-11.
[2] Direct testimony of Charles E. Peterson, Docket No. 17-035-61, March 22, 2018, page 3, lines 51-52.

cannot be used to provide inferences about the full population.

Second, more than half of the sample (36 out of 70) were originally drawn using a different sample design. Standard extrapolation formulas will fail to account for this difference, and no alternatives were provided.

Third, a number of factors indicate the planned sample size is too small to achieve a precision of plus or minus 10 percent precision at 95 percent confidence.

Finally, the use of systematic sampling is an unnecessary complication that, at best, adds untested assumptions without any proven benefit.

III. TARGET POPULATION

Q. What is the population of interest for this study?

A. The population of interest comprises two separate groups of customers: (1) the grandfathered Schedule 135 customers and (2) the transition program Schedule 136 customers.

Q. What population is the sample selected from?

A. The production metering sample is selected from the grandfathered Schedule 135 customers only.

Q. Mr. Peterson describes, but does not express any issues with, the target population to be sampled. Do you have any opinions regarding the target population to be sampled?

A. Yes. Generation data collected on Schedule 135 customers is not representative of the full population of Schedule 135 and Schedule 136 customers. As a matter of statistics, the extrapolation of a sample of one population (the Schedule 135 customers) to another population (the Schedule 136 customers) is not possible. Such extrapolation involves the untested assumption that the 135 and 136 customers' solar outputs are equivalent. Mr. Rick Gilliam, in his direct testimony in this docket filed on

March 22, 2018, points out that there are numerous differences that would result in differences in output (lines 226-235).

Q. What impact does this issue have on the estimates?

A. The estimates of output are likely to be wrong. Statistically speaking, they may be biased, meaning that they could be systematically too low or too high, depending on the (unknown) differences between Schedule 135 and 136 customers. Even with a large and precise sample of the Schedule 135 customers, this bias could exist since no 136 customers are sampled.

IV. SAMPLE COMPILATION

Q. Do you have an opinion on the fact that 36 of the proposed samples were previously selected in the Company's load research in Docket No. 14-035-114?

A. Yes. I share Mr. Peterson's concerns, and I also have additional concerns.[3]

Q. What are your additional concerns with the reuse of the 36 samples?

A. The 36 meters were selected using a different sampling design. This means that the 70 samples were not selected using the sample design reviewed by Mr. Peterson but by using two separate sample designs. Two problems can arise from this issue. First, without adjustment for the different designs, the sample estimate will likely be biased. Second, even if the appropriate adjustments are made, the precision of the estimates will likely decrease.[4]

In addition, and as Mr. Peterson points out, the customers in the two samples have inherent

[3] Direct testimony of Charles E. Peterson, Docket No. 17-035-61, March 22, 2018, pages 5-7, lines 95-132.
[4] Mr. Peterson's Direct Testimony points out that these sampled customers were stratified based upon usage, not capacity (lines 96-97). By automatically selecting all 36 of these customers in the new sample, it spoils the random nature of the sample and means that extrapolation will not be correct without re-weighting the sample items. Correctly re-weighting the sample items could result in an unbiased estimate, if the original sample design can be exactly determined. However, the precision calculations that are presented are based on a simple random selection within strata, and the inclusion of these items means that the precision calculations likely underestimate the margin of error.

differences including "physical degradation, some degree of technological obsolescence or other systematic differences."[5] This can further bias the estimates and reduce precision.

V. STRATIFICATION

Q. What is the proposed sample design?

A. The sample is designed as a stratified systematic sample. Stratified is synonymous with grouped. In this case, the stratification variable is nameplate capacity, so customers in the Schedule 135 population are first grouped by this capacity. Within each group, they are sorted by capacity. Customers are then selected using systematic sampling, meaning every k^{th} item is sampled within a group, with the number *k* varying based on the sample size in the strata. For example, if one in ten items is to be sampled in a stratum, then *k* will be 10, and if one in 20 items is to be sampled within a stratum, then *k* will be 20.

Q. Do you agree with Mr. Peterson that the systematic stratified sampling design is appropriate?

A. No, because systematic stratified sampling design would require an unnecessary assumption as compared to other sampling designs.[6]

Although stratification is a common method for statistical sampling, a systematic selection is not. Systematic sampling is typically performed only where a simple random method is infeasible. In this case, a stratified random sample is feasible because a complete list of the Schedule 135 customers is

[5] Direct testimony of Charles E. Peterson, Docket No. 17-035-61, March 22, 2018, page 6, lines 111-115.

[6] A drawback with systematic sampling is its reliance on an otherwise unnecessary assumption. For example, in the presence of periodic variation, the calculation of an unbiased variance is impossible. This is pointed out by standard sampling texts, such as Stephen Thompson's Sampling (p. 119) and William Cochran's Sampling Techniques, 3rd Edition (p. 223-224). Relevant quotes include: "Many surveys utilizing a systematic design select a single starting unit at random and then observe every secondary unit at the appropriate spacing from there. Thus the sample consists of a single primary unit selected at random. From a sample of size 1 it is possible to obtain an unbiased estimator of the population mean or total, but it is not possible to obtain an unbiased estimator of its variance." (Thompson, 2002) and "From the results of a simple random sample with n>1, we can calculate an unbiased estimate of the variance of the sample mean…Since a systematic sample can be regarded as a simple random sample with n=1, this useful property does not hold." (Cochran, 1977).

available.

Q. Do you believe the sample size is appropriate?

A. No. The sample design heavily relies on the assumption that the stratification, or grouping, of customers, will substantially reduce variation and allow for a sample of only 54 customers. If the stratification does not work as assumed, the precision of the sample will be far worse than estimated, and a sample of hundreds or thousands may be necessary to achieve the desired sample precision. In Mr. Elder's Testimony Appendix, Table 1 sets forth the assumed relative variation by stratum. The Workshop Data Request 11 contains accompanying calculations that show a simple random sample design would require a sample size of 2,927 to achieve plus or minus 10 percent precision at 90 percent confidence. In other words, if the stratification works exactly as assumed, the sample size could be as low as 54. However, if the variability calculations are correct but stratification is not helpful, the sample size should be 2,927.[7]

Mr. Peterson adopts Mr. Elder's view that with stratification, a sample size of 54 is sufficient to achieve 10% precision at a 95% level of confidence.[8] However, as explained above, this view relies on the untested assumption regarding stratification.

To understand how such a large difference (3,000 sample size for random sampling versus 54 with stratification) is even theoretically possible, consider Table 1 in the Appendix of Mr. Elder's direct testimony, which shows the strata and variation within strata that Mr. Peterson references.[9] The first two strata, comprising more than 90% (22,000 out of 24,000) of customers, are estimated to have a standard deviation less than 1.5 kW. The fourth stratum, with 70 customers, is estimated to have a standard

[7] This is still assuming the overall variability calculations are correct. Since these overall calculations are based on capacity and not output, it is unknown whether they are appropriate for measuring output.
[8] Direct testimony of Charles E. Peterson, Docket No. 17-035-61, March 22, 2018, page 5, lines 90-91.
[9] Direct testimony of Kenneth Lee Elder, Docket No. 17-035-61, February 15, 2018, pages 3-6 and 9-11.

deviation of 364 kW. Because of this large discrepancy, Mr. Elder calculates that the fourth stratum, with only 70 customers, requires a sample size of 18, while the first stratum, with 13,323 customers, requires a sample size of 14. These calculations rely strictly on variation of nameplate capacity and not on variation of output. The precision of the estimate will ultimately rely on output, and Mr. Elder's calculations will be correct only under the assumption that capacity is an appropriate substitute for output. If that assumption is not correct, the sample precision could be equivalent to or worse than a random sample of the same size, meaning the originally-calculated sample size of around 3,000 is required.

To further understand the nature and magnitude of this problem, consider the fact that a doubling of variation (as measured by standard deviation) means a quadrupling of required sample size. For example, if the standard deviation of output in the first strata is 2.76 rather than the assumed 1.38 (still far lower than the standard deviations in the third and fourth strata), the sample size would need to be 120, instead of 30, in that stratum alone.

Q. Are there any additional comments you have regarding the sample size determinations?

A. Yes. There are two additional issues.

First, the sample size calculations assume the goal is to determine an average output. However, as Mr. Elder explains in his testimony, the goal of the load study is to determine the output over time ("the intertemporal relationship," according to Mr. Elder, line 169). The study seeks to measure 15-minute intervals of output. The variation in these 15-minute intervals is unlikely to be the same as the average variation in output. Statistically, variation during higher output periods is generally greater than average variation.[10] The sample assumes that this variation is constant and only dependent on total

[10] This property is typical in most "unimodal" distributions. A unimodal distribution is a distribution of data with a single

capacity. If the variation follows the more typical statistical pattern, the sample size calculations will underestimate the required sample size.

Second, with sample sizes so small (30 or fewer) in each stratum, the typical margin-of-error assumptions may not apply. This is because the margin of error calculations assume that the output follows a symmetric distribution called a Normal distribution, which, among other things, requires that the number of customers with very high output is exactly balanced by those with very low output. Skewing of output toward either high or low output for a small number of customers would mean the margin of error is underestimated.

Q. Mr. Peterson suggests that it may be necessary to perform additional sampling.[11] Can the sample easily be supplemented to improve the precision?

A. No. First, supplementing at some future time generates issues similar to using the 36 prior customers. The population of customers, the equipment, and other items will have likely changed by then, and the data will not match temporally.

In addition, systematic samples are based upon a pre-defined structure. In this case, the population is stratified and sorted by nameplate capacity. A starting point is selected at random, and samples are selected at fixed intervals across the range of the population, *e.g.*, starting at the fifth sample and selecting every tenth sample based on nameplate capacity.

The issue with sample augmentation is that the sequential selection process does not allow for sequential replacement samples unless planned for ahead of time.

From the documents I have reviewed in this docket, there is no evidence that a contingency plan

peak. Typically for these distributions, the data spread out more at the extremes, and thus the variation at peak (or the lowest) loads would be the highest. The most common probability distribution, called the Normal distribution, has this property.

[11] Direct Testimony of Charles E. Peterson, Docket No. 17-035-61, March 22, 2018, lines 122-123.

is in place to augment the sample if the design falls short of the accuracy requirement. If the accuracy does not meet the requirement, the sample size would at least need to be doubled to work within the confines of the systematic sample.

Q. Are there any alternatives to systematic sampling that would avoid these challenges?

A. Stratified random sampling would reduce the risks and complications associated with supplementing the sample, but a better approach is to begin with a conservative sample size based on a conservatively computed margin of error.

Q. Overall, what are your conclusions to the Commission?

A. In summary, I disagree with Mr. Peterson that the sample design is reasonable and will yield the desired level of precision. I see several major issues that make this sample design unreliable.

First, the proposed sample will be unrepresentative of the population, and therefore, calculations of rooftop solar generation output derived from this sample will be incorrect.

Second, the sample uses data from a prior sample, and use of such data could further bias the results.

Third, the sample size is likely insufficient, and the appropriate sample size could easily be in the hundreds or the thousands, as suggested by calculations using Mr. Elder's figures in Table 1. If a better margin of error is desired, the appropriate sample size would be even greater.

Finally, the use of a systematic sample carries theoretical and practical problems that make the sample margin of error unknown and make the selection of additional sample items impractical.

Q. Does that conclude your testimony?

A. Yes.

VI. APPENDIX A. CV OF ALBERT J. LEE, PH.D.

ALBERT J. LEE, PH.D.

Lead Economist and Founding Principal, Summit Consulting, LLC

EDUCATION/CERTIFICATIONS

Ph.D. in economics, University of California, Los Angeles, 1999

M.A. in economics, University of California, Los Angeles, 1996

B.A. in economics (*cum laude*), University of Southern California, 1992

B.A. in mathematics (*cum laude*), University of Southern California, 1992

American Statistical Association (ASA) Accredited Statistical Professional, 2012

Relevant Experience

Founding Principal and Lead Economist, Summit Consulting, LLC, 2003–present

Senior Consultant, Bates White LLC, 2001–2003

Manager, KPMG Quantitative Analysis Group, 1999–2001

Academic Appointments

Adjunct Associate Professor, School of International and Public Affairs, Columbia University, spring 2013

Adjunct Assistant Professor, Department of International Public Affairs, Columbia University, spring 2004

Visiting Assistant Professor, Department of Legislative Affairs, George Washington University, fall 2003

Visiting Assistant Professor, Department of Statistics, UCLA, 1999

Publications

Lee, Albert J. 2015. "Predictive Analytics: The New Tool to Combat Fraud, Waste and Abuse." *Journal of Government Financial Management* 64 (2):12–17.

Wilkins, Charles, Maya Brennan, Amy Deora, Anker Heegaard, Albert J. Lee, and Jeffrey Lubell. 2015. "Comparing the Life-Cycle Costs of New Construction and Acquisition-Rehab of Affordable Multifamily Rental Housing." *Housing Policy Debate*: 1–31.

Lee, Albert J., Jonathan B. Glowacki, and Kenneth A. Bjurstrom. 2013. "Actuarial Review of FHA's Mutual Mortgage Insurance Fund for Forward Loans." Washington, DC: Summit Consulting, LLC.

Lee, Albert J., Jonathan B. Glowacki, and Kenneth A. Bjurstrom. 2013. "Actuarial Review of FHA's Mutual Mortgage Insurance Fund for HECM Loans." Washington, DC: Summit Consulting, LLC.

Lee, Albert J. 2012. *Taxation, Growth and Fiscal Institutions: A Political and Economic Analysis, Springer Briefs in Business*. New York, NY: Springer.

Lee, Albert J., Yvon Pho, and Colin Cushman. Under revision. "Testing the Double-Trigger Hypothesis Using Loan-Level Annual Financial Statement Data from an FHA-Insured Multifamily Program." *Real Estate Economics*.

Lee, Albert J., and Kenneth A. Baerenklau. 2011. "Strategic Defaults in Commercial Mortgages with a Cash-in-Advance Constraint: A Dynamic Programming Analysis." Working Paper. Washington, DC: Summit Consulting, LLC.

Lee, Albert J., and Alan Salzberg. 2010. "Law and Statistics of Combining Categories: Wal-Mart and Employment Discrimination Cases." 2010 Joint Statistical Meetings, Vancouver, British Columbia.

Professional Memberships

American Economic Association

American Statistical Association

Econometric Society

National Association for Business Economics

Washington Statistical Society

Prior Testimony

Albert Lee has testified in the matters below in the last five years:

1. [trial] *Mass. Mut. Life Ins. Co. vs. DLJ Mortg. Capital, Inc. & Credit Suisse First Bos. Mortg. Sec. Corp.*, Nos. 11-cv-30047 & 11-cv-30048 (D. Mass. 2017)

2. [deposition] *Mass. Mut. Life Ins. Co. vs. Goldman Sachs Mortg. Co.*, Nos. 11-cv-30126 & 11-cv-30285 (D. Mass. 2017)

3. [deposition] *HEMT Series (2006-1, 2006-2, 2006-4, 2006-5) by U.S. Bank Nat'l Ass'n solely in its capacity as Trustee vs DLJ Mortg. Capital, Inc. & Select Portfolio Servicing Inc.*, Nos. 156016/2012 & 653787/2012 (Sup. Ct. N.Y. Cnty. 2017)

4. [deposition] *Mass. Mut. Life Ins. Co. vs. DLJ Mortg. Capital, Inc. & Credit Suisse First Bos. Mortg. Sec. Corp.*, Nos. 11-cv-30047 and 11-cv-30048 (D. Mass. 2016).

5. [deposition] *Fed. Hous. Fin. Agency vs. Royal Bank of Scot.*, No. 11 Civ. 01383 (AWT) (D. Conn. 2016)

6. [deposition] *Krikorian vs. Great West Life & Annuity Ins. Co.*, No. 16-cv-00094-REB-MUW (D. Colo. 2016)

7. [declaration] *Fed. Hous. Fin. Agency vs. Nomura Holding Am., Inc.*, No. 11 Civ. 6201 (S.D.N.Y.)

8. [administrative hearing] Midlands Neurology and Pain Associates, P.A., 1-1415675783, 2014

9. [deposition] *Green et al. v. FedEx Nat'l, LTL, Inc.*, No. 8:09-cv-445-T-33TBM (M.D. Fla. 2013)