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Issue: Weather Normalization
Witness: Mark Quan
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Sponsoring Party: Empire District Electric
Case No. ER-2014-0351
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Before the Public Service Commission
Of the State of Missouri

Rebuttal Testimony

of

Mark Quan

March 2015

REBUTTAL TESTIMONY
OF
MARK QUAN
ON BEHALF OF
THE EMPIRE DISTRICT ELECTRIC COMPANY
BEFORE THE
MISSOURI PUBLIC SERVICE COMMISSION
ER-2014-0351

Q. PLEASE STATE YOUR NAME, TITLE, AND BUSINESS ADDRESS.

A. My name is Mark Quan. I am a Principal Consultant for Itron's Forecasting Solutions group. My business address is 12348 High Bluff Drive, Suite 210, San Diego, California, 92130.

Q. PLEASE DESCRIBE YOUR EDUCATIONAL BACKGROUND AND PRIOR ACADEMIC EXPERIENCE.

A. I graduated from the University of California at Los Angeles with a Bachelor's Degree in Applied Mathematics with a specialization in Computer Studies. I graduated from Stanford University with a Master's Degree in Operations Research.

From 1989 to 1997, I was employed by Pacific Gas & Electric ("PG&E") in San Francisco, California. My responsibilities at PG&E were in the areas of electric resource planning, gas supply planning, power contracts, and revenue requirements.

In 1997, I joined the consulting staff of Regional Economic Research ("RER"). RER was acquired by Itron in 2002. My responsibilities at RER/Itron include performing and managing statistical analysis of client loads for the purpose of long-term forecasting and short-term forecasting. The

analysis includes developing time series, multivariate regression, and neural network models for use in short term system dispatch forecasts and long-term budget and planning forecasts. In addition to performing analysis for clients, I am responsible for portions of Itron's forecasting training curriculum. I teach introduction to forecasting, load modeling, and statistical software training classes.

Q. HAVE YOU PREVIOUSLY FILED TESTIMONY BEFORE THE MISSOURI PUBLIC SERVICE COMMISSION ("COMMISSION")?

A. Yes. I submitted testimony on behalf of The Empire District Electric Company ("Empire") in Case Nos. ER-2008-0093 and ER-2010-0130, on the subject of weather normalization.

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY?

A. The purpose of my testimony is to present analysis of the Missouri Public Service Commission Staff's ("Staff") weather normalization calculations. Staff's weather normalization calculations are contained in "Staff Report - Cost of Service, Revenue Requirement" submitted on January 29, 2015. My rebuttal testimony addresses the position statements of Staff witness Seoung Joun Won, which are located on pages 67-70 of Staff's Cost of Service Report. Specifically, I am addressing the calculation of normal weather.

Q. WHAT ARE THE RESULTS OF YOUR ANALYSIS?

A. Dr. Won's description of his normal weather calculation is generally found on page 70 of Staff's Cost of Service Report, and the calculations are contained

in his workpapers. I analyzed Dr. Won's normal weather calculation contained in the file "sgf_201101-201410 AVG.xlsb".

My analysis identifies an error located in the spreadsheet calculation resulting in a repetition of the normal coldest day five times in January 2014. Specifically, Dr. Won's calculation places the coldest normal day temperature, 8.94 degrees, on 1/3/2014, 1/6/2014, 1/7/2014, 1/24/2014, and 1/28/2014. The assignment is shown in Figure 1 taken from the "sgf_201101-201410 AVG.xlsb", "Normal WX" tab. I have added colors to highlight the repetition.

Figure 1: Repeated Normal Values in January 2014

	A	B	C	D	E	F	G
1	Date	YYYY	MM	DD	Mrank		Normal Wx
1098	1/1/2014	2014	1	1	115		33.99177419
1099	1/2/2014	2014	1	2	129		16.47669046
1100	1/3/2014	2014	1	3	133		8.947246014
1101	1/4/2014	2014	1	4	124		25.59499616
1102	1/5/2014	2014	1	5	127		21.08255182
1103	1/6/2014	2014	1	6	135		8.947246014
1104	1/7/2014	2014	1	7	134		8.947246014
1105	1/8/2014	2014	1	8	125		24.1946712
1106	1/9/2014	2014	1	9	117		32.18709421
1107	1/10/2014	2014	1	10	110		37.78224014
1108	1/11/2014	2014	1	11	109		38.4740681
1109	1/12/2014	2014	1	12	105		43.24215566
1110	1/13/2014	2014	1	13	106		42.03979903
1111	1/14/2014	2014	1	14	111		37.1392338
1112	1/15/2014	2014	1	15	121		28.69130387
1113	1/16/2014	2014	1	16	113		35.60327498
1114	1/17/2014	2014	1	17	122		27.73528096
1115	1/18/2014	2014	1	18	119		30.91555745
1116	1/19/2014	2014	1	19	112		36.49203612
1117	1/20/2014	2014	1	20	108		39.33676297
1118	1/21/2014	2014	1	21	123		26.5614694
1119	1/22/2014	2014	1	22	126		22.91448285
1120	1/23/2014	2014	1	23	130		10.96929671
1121	1/24/2014	2014	1	24	132		8.947246014
1122	1/25/2014	2014	1	25	118		31.66548856
1123	1/26/2014	2014	1	26	107		40.7517072
1124	1/27/2014	2014	1	27	120		30.06825057
1125	1/28/2014	2014	1	28	131		8.947246014
1126	1/29/2014	2014	1	29	128		18.4982289
1127	1/30/2014	2014	1	30	116		33.32342091
1128	1/31/2014	2014	1	31	114		35.05907393

Q. IS THIS ERROR ISOLATED TO JANUARY 2014?

A. No, the same error also occurs in April 2014, resulting in repeated values of the coldest day in April (Figure 2). A similar error occurs in October 2013 (Figure 3).

Figure 2: Repeated Normal Values in April 2014

	A	B	C	D	E	F	G
1	Date	YYYY	MM	DD	Mrank		Normal Wx
1188	4/1/2014	2014	4	1	424		49.37131539
1189	4/2/2014	2014	4	2	420		52.44030082
1190	4/3/2014	2014	4	3	409		60.70418757
1191	4/4/2014	2014	4	4	429		41.53128454
1192	4/5/2014	2014	4	5	433		40.40160978
1193	4/6/2014	2014	4	6	428		43.89990333
1194	4/7/2014	2014	4	7	422		50.8349872
1195	4/8/2014	2014	4	8	427		45.64110034
1196	4/9/2014	2014	4	9	426		47.07203149
1197	4/10/2014	2014	4	10	415		56.42288914
1198	4/11/2014	2014	4	11	408		61.99722222
1199	4/12/2014	2014	4	12	406		64.12879928
1200	4/13/2014	2014	4	13	414		57.0620028
1201	4/14/2014	2014	4	14	432		40.40160978
1202	4/15/2014	2014	4	15	434		40.40160978
1203	4/16/2014	2014	4	16	430		40.40160978
1204	4/17/2014	2014	4	17	425		48.0717598
1205	4/18/2014	2014	4	18	421		51.90894265
1206	4/19/2014	2014	4	19	417		55.12878136
1207	4/20/2014	2014	4	20	407		62.61645759
1208	4/21/2014	2014	4	21	412		58.49641639
1209	4/22/2014	2014	4	22	419		53.34132431
1210	4/23/2014	2014	4	23	416		55.7026583
1211	4/24/2014	2014	4	24	410		60.11677419
1212	4/25/2014	2014	4	25	418		54.15505504
1213	4/26/2014	2014	4	26	411		59.3794772
1214	4/27/2014	2014	4	27	405		65.56010753
1215	4/28/2014	2014	4	28	413		57.84804788
1216	4/29/2014	2014	4	29	423		50.2208715
1217	4/30/2014	2014	4	30	431		40.40160978

Figure 3: Repeated Normal Values in October 2013

	A	B	C	D	E	F	G
1	Date	YYYY	MM	DD	Mrank		Normal Wx
1006	10/1/2013	2013	10	1	1004		67.11812425
1007	10/2/2013	2013	10	2	1003		68.44715054
1008	10/3/2013	2013	10	3	1001		71.28483871
1009	10/4/2013	2013	10	4	1005		66.00067503
1010	10/5/2013	2013	10	5	1006		65.38976703
1011	10/6/2013	2013	10	6	1018		56.82909754
1012	10/7/2013	2013	10	7	1017		57.58169611
1013	10/8/2013	2013	10	8	1014		59.55691159
1014	10/9/2013	2013	10	9	1012		60.83097372
1015	10/10/2013	2013	10	10	1009		62.77263441
1016	10/11/2013	2013	10	11	1005		66.00067503
1017	10/12/2013	2013	10	12	1007		64.63427718
1018	10/13/2013	2013	10	13	1010		62.13275986
1019	10/14/2013	2013	10	14	1011		61.47235226
1020	10/15/2013	2013	10	15	1015		58.84449821
1021	10/16/2013	2013	10	16	1019		55.97086022
1022	10/17/2013	2013	10	17	1021		54.75746544
1023	10/18/2013	2013	10	18	1023		53.13996311
1024	10/19/2013	2013	10	19	1028		47.88488735
1025	10/20/2013	2013	10	20	1022		53.93515873
1026	10/21/2013	2013	10	21	1025		51.00080835
1027	10/22/2013	2013	10	22	1026		50.04553251
1028	10/23/2013	2013	10	23	1029		45.7775064
1029	10/24/2013	2013	10	24	1030		44.08352791
1030	10/25/2013	2013	10	25	1031		42.40180893
1031	10/26/2013	2013	10	26	1027		48.90940818
1032	10/27/2013	2013	10	27	1024		52.06489702
1033	10/28/2013	2013	10	28	1020		55.24017921
1034	10/29/2013	2013	10	29	1016		58.21313307
1035	10/30/2013	2013	10	30	1008		63.98482676
1036	10/31/2013	2013	10	31	1013		60.30342294

Q. ARE THESE ERRORS SIGNIFICANT?

A. Yes. The errors shift the normal temperatures four (4) days in January, four (4) days in April, and one (1) day in October. The cumulative effect of the shift increases the normal heating degree days during the heating season and decreases the normal cooling degree days during the cooling season.

In the heating season, Dr. Won's calculation results in 4,762 normal heating degree days ("HDDs") using a base temperature of 65 degrees. When the error is corrected, Dr. Won's calculation results in 4,507 normal HDDs. By correcting the error, normal HDDs are reduced by 255 or 5.3%. In other words, the error overstates the normal HDD values by more than 5%.

In the cooling season, Dr. Won's calculation results in 1,325 normal cooling degree days ("CDDs") using a base temperature of 65 degrees. By correcting the error, normal CDDs are increased to 1,340. In this case, normal CDDs are understated by 15 degree days or approximately 1%.

Q. WHY DOES THIS ERROR OCCUR?

A. The errors in January and April occur because the applied Excel functions attempt to locate the "Mrank" value. The Mrank value represents the ordinal ranking of the day in month based on temperature. When Excel cannot locate the Mrank value, it returns the closest value. For example, Figure 1 row 1100 shows a rank of "133". The rank is interpreted as the 33rd coldest day in January. Since January only has 31 days, the Mrank value cannot be located and the value for the 31st coldest day in January (Mrank = 131) is returned. The incorrect Mrank value occurs because Dr. Won is attempting to shift the ranking assignments in January and April.

In October, the error occurs because Dr. Won is shifting the hottest day of the month (October 4, 2013, MRank=1001) and reassigning it to the 5th hottest day in the month (MRank = 1005). However, the Excel file never reassigns

the original 5th hottest day (October 11, 2013), leaving duplicated 5th hottest day values.

Q. WHAT IS THE IMPACT OF THIS ERROR?

A. Correcting for this error, Staff's weather normal energy is reduced by 37,668,838 kWh in the update period (9/1/2013 – 8/31/2014). To measure the impact, I removed all shifts from Dr. Won's "sgf_201101-201410 AVG.xlsb" spreadsheet and calculated a set of corrected normal temperatures. I applied the corrected normal temperature to Dr. Won's weather normalization model (Average_Model.NDM) and Normal Sales Calculation spreadsheets (e.g. ResMO-NormalSalesCalculation.xlsb). The effect of this change for the update period is summarized in Figure 4. In this figure, "Staff Original" is Dr. Won's originally filed weather normal energy located in his direct testimony work papers. The "Staff Corrected" is my recalculation applying the corrected normal temperatures to Dr. Won's method.

Figure 4: Correct Staff Normalized Energy

Class	Staff Original* 9/13-8/14 (kWh)	Staff Corrected 9/13-8/14 (kWh)	Staff Revision 2/27/15** 9/13-8/14 (kWh)
Missouri CB Class	315,214,430	313,674,092	313,675,937
Missouri GP-Primary Class	112,605,663	112,557,474	112,556,486
Missouri GP-Secondary Class	722,055,839	721,919,069	721,919,441
Missouri Res Class	1,705,875,173	1,675,077,118	1,675,093,208
Missouri SH Class	92,176,642	90,925,107	90,925,451
Missouri TEB Class	372,188,821	368,294,870	368,296,268
Total	3,320,116,569	3,282,447,730	3,282,466,791
Difference from Staff Original		37,668,838	37,649,777

*GP Primary and GP Secondary actual values are corrected in Normal Sales Calculation Spreadsheets.

**GP Primary actual values are corrected in Normal Sales Calculation Spreadsheets.

Q. DID STAFF PROVIDE A REVISION TO ITS WEATHER NORMALIZATION TO CORRECT THESE ERRORS?

A. Yes. On February 27, 2015, Staff provided Empire with a revision to its weather normalization process. The revision is shown in Figure 4 in the "Staff Revision 2/27/15" column.

Q. WHY IS THERE STILL A DIFFERENCE BETWEEN YOUR CALCULATION AND STAFF'S REVISED CALCULATION?

A. Staff has reassigned normal temperatures out of the rank order for the update period. For instance, the coldest day in September 2013 was Saturday, September 21. Because this day was a Saturday, Staff assigned the coldest day to Monday, September 23. In all, Staff moved 33 days out of the rank order. The result is the normal weather year pattern no longer matches the update period weather pattern and increases the normalized energy by 19,061 kWh over my corrected calculations.

Q. ARE THERE OTHER DIFFERENCES BETWEEN THE STAFF'S AND EMPIRE'S NORMAL WEATHER CALCULATIONS?

A. Yes. Other differences in the methods are shown in Figure 5.

Figure 5: Differences in Staff and Empire Normal Weather Methods

Issue	Staff Method	EDE Method
Historical Period	January 1981 to December 2010	May 1984 to April 2014
Weather Variables	Two Day Weighted Mean Temperature (TDWMT)	Daily Average Temperature
Average Daily Temperature Calculation	(High + Low) / 2	Average of 24 hourly Temperature
HDD and CDD calculation	Calculate after average is performed	Calculate before average is performed
Assignment of Rank	Order averages by 2013 calendar, assign monthly order based on test year months	Orders and assigns averages by test year months
Shifting of Test Year Days	Alter test year weather pattern to move extreme weather from the weekends.	No Shifts in days

Q. WHAT ARE THE IMPACTS OF THESE ADDITIONAL DIFFERENCES?

A. The impact of these methodological differences as well as the differences in the weather normalization regression model constitute the remaining difference between the Staff revised weather normalized energy and Empire's weather normalization results.

Q. HOW DOES STAFF'S REVISION AFFECT WEATHER-NORMALIZED REVENUE FOR THE TEST YEAR?

A. The effect on revenue is discussed in the rebuttal testimony of Empire witness Todd W. Tarter.

Q. DOES THIS CONCLUDE YOUR REBUTTAL TESTIMONY?

A. Yes, at this time.

AFFIDAVIT OF MARK QUAN

STATE OF CALIFORNIA)
) **ss**
COUNTY OF SAN DIEGO)

On the 4th day of March, 2015, before me appeared Mark Quan, to me personally known, who, being by me first duly sworn, states that he is a Principal Consultant for Itron's Forecasting Solution Group and acknowledges that he has read the above and foregoing document and believes that the statements therein are true and correct to the best of his information, knowledge and belief.

Mark Quan

Subscribed and sworn to before me this 4th day of March, 2015.

Notary Public

My commission expires: Feb 16 2017

OFFICIAL SEAL
MAREK R. MACIEJEWSKI
NOTARY PUBLIC-CALIFORNIA
COMM. NO. 2007789
SAN DIEGO COUNTY
MY COMM. EXP. FEB. 16, 2017