Triennial Cost Allocation Proceeding Workpapers

Gregory Teplow

Southern California Gas Company

July 2015

Contents

San Diego Gas and Electric Residential End-Use Model

Weather for SoCalGas: Heating Degree Days – Average and Cold Year Designs; and Winter Peak Day Design Temperatures

July 2015

I. Overview

Southern California Gas Company's service area extends from Fresno County to the Mexican border. To quantify the overall temperature experienced within this region, SoCalGas aggregates daily temperature recordings from fifteen U.S. Weather Bureau weather stations first into six temperature zones and then into one system average heating degree-day ("HDD") figure. The table below lists weather station locations by temperature zones.

Table 1

Weather Stations by Temperature Zones and Weights

Temperature Zone	Weight	Station (After 10/31/2002)	Station (Before 11/1/2002)
1. High mountain	0.0061	Big Bear Lake	Lake Arrowhead
2. Low desert	0.0423	Palm Springs El Centro	Palm Springs Brawley
3. Coastal	0.1763	Los Angeles Airport Newport Beach Santa Barbara Airport	Los Angeles Airport Newport Beach Harbor Santa Barbara Airport
4. High desert	0.0747	Bakersfield Lancaster Airport Fresno	Bakersfield Airport Palmdale Visalia
5. Interior valleys	0.3813	Burbank Pasadena Ontario Rialto	Burbank Pasadena Pomona Cal Poly Redlands
6. Basin	0.3194	Los Angeles Civic Center Santa Ana	Los Angeles Civic Center/ Downtown-USC Santa Ana

SoCalGas uses 65° Fahrenheit to calculate the number of HDDs. One heating degree day is accumulated for each degree that the daily average is below 65° Fahrenheit. To arrive at the HDD figure for each temperature zone, SoCalGas uses the simple average of the weather station HDDs in that temperature zone. To arrive at the system average HDDs figure for its entire service area, SoCalGas weights the HDD figure for each zone using the proportion of gas customers within each temperature zone based on calendar year 2014 customer counts. These weights are used in calculating the data shown from January 1995 to December 2014.

Daily weather temperatures are from the National Climatic Data Center or from preliminary data that SoCalGas captures each day and posts on its internal Company web-site at the URL: http://utilinet.sempra.com/departments/massmarkets/weather/default.htm for various individual weather stations as well as for its system average values of HDD. Annual HDDs for the entire service area from 1995 to 2014 are listed in Table 2, below.

Table 2

Calendar Month Heating Degree-Days (Jan. 1995 through Dec. 2014)

	Month												Total
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**"Cal-Year"**
1995	318	136	179	128	108	39	2	1	2	14	67	246	1240
1996	264	201	169	57	14	3	1	0	1	68	145	263	1186
1997	283	206	113	97	5	4	1	0	0	27	120	298	1154
1998	269	283	186	184	87	20	0	0	5	43	167	323	1567
1999	266	246	284	234	77	38	1	2	5	8	128	247	1536
2000	247	243	209	80	25	5	2	1	3	64	248	242	1369
2001	379	338	195	207	25	6	4	3	3	20	146	360	1686
2002	335	202	225	148	78	10	2	4	8	77	92	315	1496
2003	142	233	165	179	73	17	1	1	3	16	201	306	1337
2004	293	301	85	84	17	8	3	2	4	73	228	293	1391
2005	288	209	176	115	35	11	4	1	9	44	100	235	1227
2006	272	200	338	162	28	3	0	1	5	36	104	279	1428
2007	348	214	124	116	49	16	1	1	12	37	125	354	1397
2008	348	263	148	123	75	8	1	0	2	23	75	334	1400
2009	196	259	193	133	18	15	3	4	1	43	117	320	1302
2010	255	220	173	163	71	13	8	9	13	42	204	268	1439
2011	251	308	211	104	80	26	2	3	5	39	207	350	1586
2012	224	236	221	117	38	11	5	1	1	16	111	301	1282
2013	330	264	125	65	17	4	1	2	2	44	104	258	1216
2014	142	148	90	76	19	4	0	1	1	6	67	224	778
20-Yr-Avg (Jan1995-Dec2014)													
Avg.	**272.5**	**235.5**	**180.5**	**128.6**	**47.0**	**13.1**	**2.1**	**1.9**	**4.3**	**37.0**	**137.8**	**290.8**	**1350.9**
St.Dev.[1]	**56.6**	**46.1**	**58.6**	**46.7**	**30.9**	**10.6**	**1.9**	**2.1**	**3.6**	**20.0**	**61.7**	**39.1**	**144.8**
Min.	**142.0**	**136.0**	**85.0**	**57.0**	**5.0**	**3.0**	**0.0**	**0.0**	**0.0**	**6.0**	**67.0**	**224.0**	**778.0**
Max.	**379.0**	**338.0**	**338.0**	**234.0**	**108.0**	**39.0**	**8.0**	**9.0**	**13.0**	**77.0**	**248.0**	**360.0**	**1686.0**

[1] Standard Deviation calculated from data for Jan 1994 – Dec 2013.

II. Calculations to Define Our Average-Temperature Year

The simple average of the 20-year period (January 1995 through December 2014) was used to represent the Average Year total and the individual monthly values for HDD. The standard deviation of the 20 years 1994-2013 of annual HDDs was used to design the two Cold Years based on a “1-in-10” and “1-in-35” chance, ***c***, that the respective annual “Cold Year” $\boldsymbol{hdd_c}$ value would be exceeded.

Our model for the annual HDD data is essentially a regression model where the only “explanatory” variable is the constant term. For example, the annual HDDs are modeled by the equation below:

$HDD_y = \beta_0 + e_y$; where β_0 represents the mean and the e_y is an error term.

It turns out (e.g., see *Econometrics*, Wonnacott and Wonnacott, 1970, Wiley & Sons, Inc., 1970, p. 254) that the average of the annual HDD_y estimates β_0 and that the standard deviation of these HDDs about the mean, β_0, estimates the standard deviation, s_e, of the error term, e_y. Further, a probability model for the annual HDD is based on a T-Distribution with N-1 degrees of freedom, where, N is the number of years of HDD data we use:

$U = (HDD_y - \beta_0)/s_e$, has a T-Distribution with N-1 degrees of freedom.

III. Calculating the Cold-Temperature Year Weather Designs

Cold Year HDD Weather Designs

For SoCalGas, cold-temperature-year HDD weather designs are developed with a 1-in-35 annual chance of occurrence. In terms of probabilities this can be expressed as the following for a “1-in-35” cold-year HDD value in equation 1 and a “1-in-10” cold-year HDD value in equation 2, with Annual HDD as the random variable:

(1) Prob { Annual HDD > “1-in-35” Cold-Yr HDD } = 1/35 = 0.0286

(2) Prob { Annual HDD > “1-in-10” Cold-Yr HDD } = 1/10 = 0.1000

An area of 0.0286 under one tail of the T-Distribution translates to 2.025 standard deviations *above* an average-year based on a t-statistic with 19 degrees of freedom. Using the standard deviation of 144.8 HDD from the 20 years of data for 1994-2013, these equations yield values of about 1,644 HDD for a “1-in-35” cold year and 1,543 as the number of HDDs for a “1-in-10” cold year (an area of 0.1000 under one tail of the T-Distribution translates to 1.328

standard deviations *above* an average-year based on a t-statistic with 19 degrees of freedom). For example, the "1-in-35" cold-year HDD is calculated as follows:

(3) Cold-year HDD = 1,644 which equals approximately

1,351 average-year HDDs + 2.025 * 144.774

Table 3 shows monthly HDD figures for "1-in-35" cold year, "1-in-10" cold year and, average year temperature designs. The monthly average-temperature-year HDDs are calculated from weighted monthly HDDs from 1995 to 2014, as shown as the bottom of Table 2, above. For example, the average-year December value of 290.8 HDD equals the simple average of the 20 December HDD figures from 1995 to 2014. SoCalGas calculates the cold--temperature-year monthly HDD values using the same distribution of average-year HDDs. For example, since 21.5 percent of average-temperature-year HDDs occurred in December, the estimated number of HDDs during December for a cold-year is equal to 1,644 HDDs multiplied by 21.5 percent, or 353.9 HDDs.

<u>Table 3</u>

Calendar Month Heating Degree-Day Designs

	Cold		**Average**	**Hot**	
	1-in-35 Design	**1-in-10 Design**		**1-in-10 Design**	**1-in-35 Design**
January	331.6	311.3	272.5	233.8	213.4
February	286.6	269.0	235.5	202.1	184.4
March	219.6	206.1	180.5	154.8	141.3
April	156.5	146.9	128.6	110.3	100.7
May	57.1	53.6	47.0	40.3	36.8
June	15.9	14.9	13.1	11.2	10.2
July	2.6	2.4	2.1	1.8	1.6
August	2.3	2.1	1.9	1.6	1.4
September	5.2	4.9	4.3	3.6	3.3
October	45.0	42.3	37.0	31.7	29.0
November	167.7	157.4	137.8	118.2	107.9
December	353.9	332.2	290.8	249.5	227.8
	1644	1543	1351	1159	1058

IV. Calculating the Peak-Day Design Temperature

SoCalGas' Peak-Day design temperature of 40.0 degrees Fahrenheit, denoted "Deg-F," is determined from a statistical analysis of observed annual minimum daily system average temperatures constructed from daily temperature recordings from the three U.S. Weather Bureau weather stations discussed above. Since we have a time series of daily data by year, the following notation will be used for the remainder of this discussion:

(1) $AVG_{y,d}$ = system average value of Temperature for calendar year "y" and day "d".

The calendar year, y, can range from 1950 through 2014, while the day, d, can range from 1 to 365, for non leap years, or from 1 to 366 for leap years. The "upper" value for the day, d, thus depends on the calendar year, y, and will be denoted by n(y)=365, or 366, respectively, when y is a non-leap year or a leap year.

For each calendar year, we calculate the following statistic from our series of daily system average temperatures defined in equation (1) above:

(2) $MinAVG_y = \min_{d=1}^{n(y)}\{ AVG_{y,d} \}$, for y=1950, 1951, …, 2014.

(The notation used in equation 2 means "For a particular year, y, list all the daily values of system average temperature for that year, then pick the smallest one.")

The resulting minimum annual temperatures are shown in Tables 4.1 and 4.2, below. Note that most of the minimum temperatures occur in the months of December or January; however, for some calendar years the minimums occurred in other months (the minimum for 2006 was observed in March).

The statistical methods we use to analyze this data employ software developed to fit three generic probability models: the Generalized Extreme Value (GEV) model, the Double-Exponential or GUMBEL (EV1) model and a 2-Parameter Students' T-Distribution (T-Dist) model. [The GEV and EV1 models have the same mathematical specification as those implemented in a DOS-based executable-only computer code that was developed by Richard L. Lehman and described in a paper published in the Proceedings of the Eighth Conference on Applied Climatology, January 17-22, 1993, Anaheim, California, pp. 270-273, by the American Meteorological Society, Boston, MA., with the title "Two Software Products for Extreme Value Analysis: System Overviews of ANYEX and DDEX." At the time he wrote the paper, Dr. Lehman was with the Climate Analysis Center, National Weather Service/NOAA in Washington, D.C., zip code 20233.] The Statistical Analysis Software (SAS) procedure for nonlinear statistical model estimation (PROC MODEL, from SAS V6.12) was used to do the calculations. Further, the calculation procedures were implemented to fit the probability models to observed *maximums* of data, like heating degrees. By recognizing that:

$$- \text{MinAVG}_y = - \min_{d=1}^{n(y)}\{\text{AVG}_{y,d}\} = \max_{d=1}^{n(y)}\{ -\text{AVG}_{y,d}\}, \text{ for } y=1950, \ldots, 2014;$$

this same software, when applied to the *negative* of the minimum temperature data, yields appropriate probability model estimation results.

The calculations done to fit any one of the three probability models chooses the parameter values that provide the "best fit" of the parametric probability model's calculated cumulative distribution function (CDF) to the empirical cumulative distribution function (ECDF). Note that the ECDF is constructed based on the variable "-MinAVG_y" (which is a *maximum* over a set of *negative* temperatures) with values of the variable MinAVG_y that are the same as shown in Tables 4.1 and 4.2, below.

In Tables 5.1 and 5.2, the data for -MinAVG_y are shown after they have been sorted from "lowest" to "highest" value. The ascending *ordinal* value is shown in the column labeled "RANK" and the empirical cumulative distribution function is calculated and shown in the next column. The formula used to calculate this function is:

$$\text{ECDF} = (\text{RANK} – \alpha)/[\text{MaxRANK} + (1 – 2\alpha)],$$

where the parameter "α" (shown as *alpha* in Table 5.1 and Table 5.2) is a "small" positive value (usually less than ½) that is used to bound the ECDF away from 0 and 1.

Of the three probability models considered (GEV, EV1, and T_Dist) the results obtained for the T_Dist model were selected since the fit to the ECDF was better than that of either the GEV model or the EV1 model. (Although convergence to stable parameter estimates is occasionally a problem with fitting a GEV model to the ECDF, the T_Dist model had no problems with convergence of the iterative procedure to estimate parameters.)

The T_Dist model used here is a three-parameter probability model where the varable $z = (-\text{MinAVG}_y - \gamma) / \theta$, for each year, y, is presumed to follow a T_Dist with location parameter, γ, and scale parameter, θ, and a third parameter, v, that represents the number of degrees of freedom. For a given number of years of data, N, then v=N-2.

The following mathematical expression specifies the T_Dist model we fit to the data for "-MinAVG_y " shown in Table 5.1 and Table 5.2, below.

(3) $\text{ECDF}(-\text{MinAVG}_y) = \text{Prob}\{ -T < -\text{MinAVG}_y \} = \text{T\_Dist}\{z; \gamma, \theta, v=N-2\}$,

where "T_Dist{ . }" is the cumulative probability distribution function for Student's T-Distribution[2], and

[2] A common mathematical expression for Student's T-Distribution is provided at http://en.wikipedia.org/wiki/Student%27s_t-distribution; with a probability density function

$$f(t) = \frac{\Gamma(\frac{\nu+1}{2})}{\sqrt{\nu\pi}\,\Gamma(\frac{\nu}{2})}\left(1+\frac{t^2}{\nu}\right)^{-\frac{\nu+1}{2}},$$

(4) $z = (-MinAVG_y - \gamma) / \theta$, for each year, y, and

the parameters "γ" and "θ" are estimated for this model for given degrees of freedom ν=N-2. The estimated values for γ and θ are shown in Table 5.2 along with the fitted values of the model CDF (the column: "Fitted" Model CDF).

Now, to calculate a *peak-day design temperature*, $TPDD_\delta$, with a specified likelihood, δ, that a value less than $TPDD_\delta$ would be observed, we use the equation below:

(5) $\delta = \text{Prob}\{ T \leq TPDD_\delta \}$, which is equivalent to

(6) $\delta = \text{Prob}\{ [(-T - \gamma) / \theta] \geq [(-TPDD_\delta - \gamma) / \theta] \}, = \text{Prob}\{ [(-T - \gamma) / \theta] \geq [z_\delta] \}$,

where $z_\delta = [(-TPDD_\delta - \gamma) / \theta]$. In terms of our probability model,

(7) $\delta = 1 - T\_Dist\{ z_\delta; \gamma, \theta, \nu=N-2\}$,

which yields the following equation for z_δ,

(7') $z_\delta = \{ TINV\_Dist\{ (1-\delta); \gamma, \theta, \nu=N-2\}$, where "TINV_Dist{ . }" is the inverse function of the T_Dist{ . } function[3]. The implied equation for $TPDD_\delta$ is:

(8) $TPDD_\delta = - [\gamma + (z_\delta)(\theta)]$.

To calculate the minimum daily (system average) temperature to define our extreme weather event, we specify that this COLDEST-Day be one where the temperature would be lower with a "1-in-35" likelihood. This criterion translates into two equations to be solved based on equations (7) and (8) above:

(9) solve for "z_δ" from equation (7') above with (1-δ) = (1 - 1/35) = 1 - 0.0286,

(10) solve for "$TPDD_\delta$" from $TPDD_\delta = - [\gamma + (z_\delta)(\theta)]$.

The value of $z_\delta = 1.938$ and $TPDD_\delta = - [\gamma + (z_\delta)(\theta)] = 40.0$ degrees Fahrenheit, with values for "ν=N-2"; along with "γ" and "θ" in Tables 5.1 & 5.2, below.

SoCalGas' peak-day design temperature of 41.8 degrees Fahrenheit, is calculated in a methodologically similar way as for the 40.0 degree peak day temperature. The criteria specified in equation (9) above for a "1-in-35" likelihood would be replaced by a "1-in-10" likelihood.

(9') solve for "z_δ" from equation (7') above with (1-δ) = (1 - 1/10) = 1 - 0.1000,

which yields a "z_δ" value of $z_\delta = 1.295$ and, $TPDD_\delta = - [\gamma + (z_\delta)(\theta)] = 41.8$ with values for "ν=N-2"; along with "γ" and "θ" in Tables 5.1 and 5.2, below.

A plot of the cumulative distribution function for $MinAVG_y$ based on "ν=N-2", the fitted model parameters, "γ" and "θ" with values in Tables 5.1 and 5.2, below, is shown in Figure 1.

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such that $T\_Dist\{z; \gamma, \theta, \nu=N-2\} = \int f(t)\, dt$, from t=-∞ to t=z. Also, the notation Γ(.) is known in mathematics as the GAMMA function; see http://www.wikipedia.org/wiki/Gamma_function for a description. Also, see *Statistical Theory*, 3rd Ed., B.W. Lindgren, MacMillian Pub. Inc, 1976, pp. 336-337.

[3] Computer software packages such as SAS and EXCEL have implemented statistical and mathematical functions to readily calculate values for T_Dist{ . } and TINV_Dist{ . } as defined above.

Table 4.1

YEAR	MINAVG	Month(MinAvg)
1950	40.8072	18264
1951	44.5430	18963
1952	43.0339	18994
1953	45.6564	19391
1954	45.6604	20059
1955	45.8387	20424
1956	44.8782	20486
1957	39.4936	20821
1958	46.2139	21490
1959	48.2384	21582
1960	42.2775	21916
1961	47.1619	22616
1962	43.3861	22647
1963	42.5588	23012
1964	45.1940	23682
1965	44.7682	23743
1966	46.6790	24108
1967	40.7181	24807
1968	40.6115	25173
1969	44.8150	25204
1970	46.8110	25903
1971	42.9710	25934
1972	41.4058	26634
1973	45.0304	26665
1974	42.9402	27030
1975	44.6228	27395
1976	44.8080	27760
1977	48.2869	28126
1978	41.6116	28825
1979	41.3705	28856
1980	50.3421	29221
1981	49.3286	29587
1982	45.3299	29952
1983	48.6608	30317
1984	46.9065	31017
1985	45.0880	31079
1986	48.5674	31444
1987	43.4247	32112
1988	43.2531	32478
1989	40.5753	32540
1990	38.9860	33208
1991	48.6837	33298
1992	47.3049	33939
1993	46.0713	33970
1994	47.1397	34639

Table 4.2

YEAR	MINAVG	Month(MinAvg)
1995	49.8028	35034
1996	44.9435	35096
1997	48.3957	35431
1998	43.5946	36130
1999	48.9896	36161
2000	48.7706	36586
2001	47.1614	36923
2002	45.8154	37257
2003	47.0515	37956
2004	48.1798	38292
2005	47.2514	38353
2006	45.7981	38777
2007	41.4814	39083
2008	45.7917	39783
2009	45.2534	40148
2010	44.6744	40513
2011	46.7442	40575
2012	46.7366	41244
2013	43.8579	41275

Table 5.1

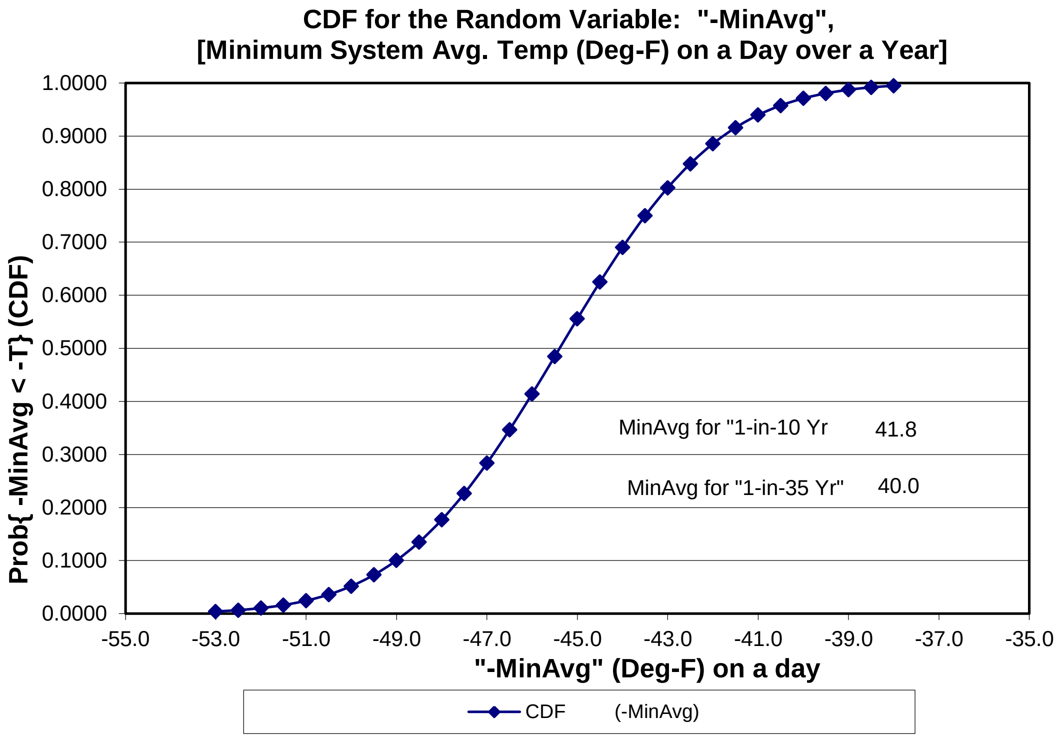
alpha= 0.375

YEAR	Month(-MinAvg)	Days/Yr	**-MinAvg**	Rank	Empirical CDF	Fitted Model CDF
1980	Jan	366	-50.3421	1	0.0096	-1.8878
1995	Dec	365	-49.8028	2	0.0249	-1.6885
1981	Jan	365	-49.3286	3	0.0402	-1.5131
1999	Jan	365	-48.9896	4	0.0556	-1.3877
2000	Mar	366	-48.7706	5	0.0709	-1.3068
1991	Mar	365	-48.6837	6	0.0862	-1.2747
1983	Jan	365	-48.6608	7	0.1015	-1.2662
1986	Feb	365	-48.5674	8	0.1169	-1.2316
1997	Jan	365	-48.3957	9	0.1322	-1.1681
1977	Jan	365	-48.2869	10	0.1475	-1.1279
1959	Feb	365	-48.2384	11	0.1628	-1.1100
2004	Nov	366	-48.1798	12	0.1782	-1.0883
2014	Dec	365	-48.0273	13	0.1935	-1.0319
1992	Dec	366	-47.3049	14	0.2088	-0.7648
2005	Jan	365	-47.2514	15	0.2241	-0.7450
1961	Dec	365	-47.1619	16	0.2395	-0.7119
2001	Feb	365	-47.1614	17	0.2548	-0.7117
1994	Nov	365	-47.1397	18	0.2701	-0.7037
2003	Dec	365	-47.0515	19	0.2854	-0.6711
1984	Dec	366	-46.9065	20	0.3008	-0.6175
1970	Dec	365	-46.8110	21	0.3161	-0.5822
2011	Feb	365	-46.7442	22	0.3314	-0.5575
2012	Dec	366	-46.7366	23	0.3467	-0.5547
1966	Jan	365	-46.6790	24	0.3621	-0.5334
1958	Nov	365	-46.2139	25	0.3774	-0.3614
1993	Jan	365	-46.0713	26	0.3927	-0.3087
1955	Dec	365	-45.8387	27	0.4080	-0.2226
2002	Jan	365	-45.8154	28	0.4234	-0.2140
2006	Mar	365	-45.7981	29	0.4387	-0.2077
2008	Dec	366	-45.7917	30	0.4540	-0.2053
1954	Dec	365	-45.6604	31	0.4693	-0.1567
1953	Feb	365	-45.6564	32	0.4847	-0.1553
1982	Jan	365	-45.3299	33	0.5000	-0.0345
2009	Dec	365	-45.2534	34	0.5153	-0.0062
1964	Nov	366	-45.1940	35	0.5307	0.0157
1985	Feb	365	-45.0880	36	0.5460	0.0549
1973	Jan	365	-45.0304	37	0.5613	0.0762
1996	Feb	366	-44.9435	38	0.5766	0.1084
1956	Feb	366	-44.8782	39	0.5920	0.1325
1969	Jan	365	-44.8150	40	0.6073	0.1559
1976	Jan	366	-44.8080	41	0.6226	0.1585
1965	Jan	365	-44.7682	42	0.6379	0.1732
2010	Dec	365	-44.6744	43	0.6533	0.2079
1975	Jan	365	-44.6228	44	0.6686	0.2269
1951	Dec	365	-44.5430	45	0.6839	0.2565

Table 5.2

				alpha=	0.375	
YEAR	Month(-MinAvg)	Days/Yr	**-MinAvg**	Rank	Empirical CDF	Fitted Model CDF
2013	Jan	365	-43.8579	46	0.6992	0.5098
1998	Dec	365	-43.5946	47	0.7146	0.6071
1987	Dec	365	-43.4247	48	0.7299	0.6700
1962	Jan	365	-43.3861	49	0.7452	0.6842
1988	Dec	366	-43.2531	50	0.7605	0.7334
1952	Jan	366	-43.0339	51	0.7759	0.8145
1971	Jan	365	-42.9710	52	0.7912	0.8377
1974	Jan	365	-42.9402	53	0.8065	0.8491
1963	Jan	365	-42.5588	54	0.8218	0.9901
1960	Jan	366	-42.2775	55	0.8372	1.0941
1978	Dec	365	-41.6116	56	0.8525	1.3404
2007	Jan	365	-41.4814	57	0.8678	1.3885
1972	Dec	366	-41.4058	58	0.8831	1.4165
1979	Jan	365	-41.3705	59	0.8985	1.4295
1950	Jan	365	-40.8072	60	0.9138	1.6378
1967	Dec	365	-40.7181	61	0.9291	1.6708
1968	Dec	366	-40.6115	62	0.9444	1.7102
1989	Feb	365	-40.5753	63	0.9598	1.7236
1957	Jan	365	-39.4936	64	0.9751	2.1235
1990	Dec	365	-38.9860	65	0.9904	2.3113
		"Gamma" (Fitted) =	**-45.39**			
		"Theta" (Fitted) =	**2.79**			
		Deg. Freedom=	**63**			

Figure 1



CDF for the Random Variable: "-MinAvg",
[Minimum System Avg. Temp (Deg-F) on a Day over a Year]
Prob{ -MinAvg < -T} (CDF)
1.0000
0.9000
0.8000
0.7000
0.6000
0.5000
0.4000
0.3000
0.2000
0.1000
0.0000
MinAvg for "1-in-10 Yr 41.8
MinAvg for "1-in-35 Yr" 40.0
-55.0
-53.0
-51.0
-49.0
-47.0
-45.0
-43.0
-41.0
-39.0
-37.0
-35.0
"-MinAvg" (Deg-F) on a day
CDF (-MinAvg)

V. Estimating the Uncertainty in the Peak-Day Design Temperature

The calculated peak-day design temperatures in section IV above also have a statistical uncertainty associated with them. The estimated measures of uncertainty recommended for our use are calculated from the fitted model for the probability distribution and are believed to be reasonable, although rough, approximations.

The basic approach used the estimated parameters for the probability distribution (see the results provided in Tables 5.1 and 5.2, above) to calculate the fitted temperatures as a function of the empirical CDF listed in Tables 5.1 and 5.2, above. These fitted temperatures are then compared with the observed temperatures by calculating the difference = "observed" – "fitted" values. The full set of differences are then separated into the lower third (L), the middle third (M) and the upper third (U) of the distribution. Finally, values of the root-mean-square error (RMSE) of the differences in each third of the distribution are calculated, along with the RMSE for the entire set of differences overall. The data in Tables 6.1 and 6.2, below, show the temperature data and the resulting RMSE values.

The formula below is used to calculate the RMSE for a specified set of "N" data differences:

$$\text{RMSE} = \text{SQRT}\left\{ \left(\sum_{i=1, ..., N} e[\,i\,]^{2} \right) / \, (N-2) \right\},$$

where e[i] = *observed* less *fitted* value of temperature, T[i]. The number of estimated paramters (3 for the GEV model, 2 for the T-Dist and EV1 models) is subtracted from the respective number of data differences, N, in the denominator of the RMSE expression.

Since both the "1-in-35" and "1-in-10" peak-day temperature values are in the lower third quantile of the fitted distribution, the calculated standard error for these estimates is 0.4 Deg-F.

Table 6.1

Quantile: (Lower, Middle, Upper 3rd's)	Observed $T_{[i]}$ Temp. Ranked	Fitted Value of $T_{[i]}$	Residual $e_{[i]}$: Obs'd. less Fitted Value of $T_{[i]}$	Square of $e_{[i]}$:
U	50.3421	52.1079	-1.7658	3.118117
U	49.8028	50.9791	-1.1763	1.383620
U	49.3286	50.3551	-1.0265	1.053653
U	48.9896	49.9063	-0.9168	0.840495
U	48.7706	49.5489	-0.7783	0.605776
U	48.6837	49.2480	-0.5643	0.318427
U	48.6608	48.9857	-0.3250	0.105601
U	48.5674	48.7515	-0.1842	0.033918
U	48.3957	48.5387	-0.1430	0.020454
U	48.2869	48.3427	-0.0557	0.003105
U	48.2384	48.1601	0.0782	0.006120
U	48.1798	47.9887	0.1911	0.036515
U	48.0273	47.8266	0.2006	0.040260
U	47.3049	47.6723	-0.3675	0.135029
U	47.2514	47.5247	-0.2733	0.074694
U	47.1619	47.3829	-0.2210	0.048828
U	47.1614	47.2460	-0.0847	0.007171
U	47.1397	47.1136	0.0261	0.000682
U	47.0515	46.9849	0.0667	0.004445
U	46.9065	46.8595	0.0470	0.002204
U	46.8110	46.7371	0.0739	0.005468
U	46.7442	46.6172	0.1270	0.016137
M	46.7366	46.4995	0.2370	0.056180
M	46.6790	46.3838	0.2952	0.087139
M	46.2139	46.2699	-0.0560	0.003131
M	46.0713	46.1573	-0.0860	0.007397
M	45.8387	46.0460	-0.2074	0.043012
M	45.8154	45.9358	-0.1204	0.014501
M	45.7981	45.8264	-0.0283	0.000801
M	45.7917	45.7177	0.0740	0.005472
M	45.6604	45.6095	0.0509	0.002589
M	45.6564	45.5016	0.1549	0.023980
M	45.3299	45.3938	-0.0640	0.004091
M	45.2534	45.2861	-0.0327	0.001068
M	45.1940	45.1782	0.0157	0.000248
M	45.0880	45.0700	0.0180	0.000322
M	45.0304	44.9613	0.0691	0.004771
M	44.9435	44.8519	0.0916	0.008383
M	44.8782	44.7417	0.1365	0.018646
M	44.8150	44.6304	0.1846	0.034076
M	44.8080	44.5178	0.2901	0.084181
M	44.7682	44.4039	0.3643	0.132748
M	44.6744	44.2882	0.3862	0.149137
L	44.6228	44.1705	0.4522	0.204523
L	44.5430	44.0506	0.4923	0.242401

Table 6.2

Quantile: (Lower, Middle, Upper 3rd's)	Observed $T_{[i]}$ Temp. Ranked	Fitted Value of $T_{[i]}$	Residual $e_{[i]}$: Obs'd. less Fitted Value of $T_{[i]}$	Square of $e_{[i]}$:	
L	43.8579	43.9282	-0.0703	0.004939	
L	43.5946	43.8028	-0.2082	0.043360	
L	43.4247	43.6741	-0.2494	0.062219	
L	43.3861	43.5416	-0.1555	0.024189	
L	43.2531	43.4048	-0.1517	0.023005	
L	43.0339	43.2630	-0.2291	0.052467	
L	42.9710	43.1154	-0.1443	0.020836	
L	42.9402	42.9611	-0.0209	0.000435	
L	42.5588	42.7990	-0.2402	0.057695	
L	42.2775	42.6276	-0.3500	0.122519	
L	41.6116	42.4450	-0.8334	0.694566	
L	41.4814	42.2490	-0.7676	0.589275	
L	41.4058	42.0362	-0.6304	0.397393	
L	41.3705	41.8020	-0.4315	0.186204	
L	40.8072	41.5397	-0.7325	0.536532	
L	40.7181	41.2388	-0.5207	0.271123	
L	40.6115	40.8814	-0.2699	0.072833	
L	40.5753	40.4326	0.1427	0.020358	
L	39.4936	39.8086	-0.3150	0.099206	
L	38.9860	38.6798	0.3061	0.093713	
			Overall RMSE ($e_{[i]}$):	0.4	°F
			Upper 3rd RMSE ($e_{[i]}$):	0.6	°F
			Middle 3rd RMSE ($e_{[i]}$):	0.2	°F
			Lower 3rd RMSE ($e_{[i]}$):	0.4	°F

VI. The Relationship between Annual Likelihoods for Peak-Day Temperatures and "Expected Return Time"

The event whose probability distribution we've modeled is the likelihood that the minimum daily temperature over a calendar year is less than a specified value. And, in particular, we've used this probability model to infer the value of a temperature, our *peak-day design temperature* ($TPDD_\delta$), that corresponds to a pre-defined likelihood, δ, that the observed minimum temperature is less than or equal to this design temperature.

(1) δ = Prob{ Minimum Daily Temperature over the Year < $TPDD_\delta$ }.

For some applications, it is useful to think of how this specified likelihood (or "risk level" δ) relates to the expected number of years until this Peak-Day event would first occur. This expected number of years is what is meant by the *return period*. The results stated below are found in the book: ***Statistics of Extremes***, E.J. Gumbel, Columbia University Press, 1958, on pages 21-25.

(2) E[#Yrs for Peak-Day Event to Occur] = 1 / δ,

1 / Prob{ Minimum Daily Temperature over the Year < $TPDD_\delta$ }.

For our peak-day design temperature (40.0°F) associated with a 1-in-35 annual likelihood, the return period is 35 years (δ=1/35). For the 41.8°F peak-day design temperature, the return period is 10 years (δ=1/10). Occasionally, a less precise terminology is used. For example, the 40.0°F peak-day design temperature may be referred to as a "1-in-35 year cold day"; and the 41.8°F peak-day design temperature may be referred to as a "1-in-10 year cold day."

The probability model for the *return period*, as a random variable, is a geometric (discrete) distribution with positive integer values for the *return period*. The parameter δ = Prob{ Minimum Daily Temperature over the Year < $TPDD_\delta$ }.

(3) Prob{ *return period* = r } = $(1 - \delta)^{(r-1)}\,\delta$, for r = 1, 2, 3, . . .

The expected value of the *return period* is already given in (2) above; the variance of the *return period* is:

(4) Var[*return period*] = (E[*return period*])^2 x (1- (1 / E [*return period*])),

(4') Var[*return period*] = (E[*return period*]) x (E [*return period*] - 1).

Equations (4) and (4') indicate that the standard deviation (square root of the variance) of the *return period* is nearly equal to its expected value. Thus, there is substantial variability about the expected value—a *return period* is not very precise.

VII. Attachment 1: SAS Program Execution Log

```
NOTE: Copyright (c) 1989-1996 by SAS Institute Inc., Cary, NC, USA.
NOTE: SAS (r) Proprietary Software Release 6.12  TS020
      Licensed to SAN DIEGO GAS & ELECTRIC CO, Site 0009311007.



WARNING: Your system is scheduled to expire on March 31, 2015, which is 1 days from now. Please contact your
installation representative to have your system
         renewed. The SAS system will no longer function on or after that date.

Title1 "Data Analysis for Maximum/Minimum Daily SysAvg Temperatures (Un-Rounded)." ;
Title2 "Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods." ;

/*********************************************************************************************************/
/*                                                                                                       */
/*                                                                                                       */
/*                                                                                                       */
/* FILE SAVED: "S:\Weather\2016Tcap-Phase II\SoCalGas\TDist4DlyTemp(NLReg2)_Scg4WP.sas"                  */
/*                                                                                                       */
/*             Mar. 30th, 2015 for Annual Max of Negative of Min. Temp.                                  */
/*             Also, separately for and each of twelve(12) calendar months Jan-Dec.                      */
/*             Fit GEV models (3-parameter and 2-parameter), plus a simple T-Dist. model.                */
/*                                                                                                       */
/*                                                                                                       */
/*  2016 TCAP-Phase II Work Paper:  Model Estimation for the 2-parameter T-Dist in this TCAP             */
/*             and same generic model as used for the 2013 TCAP.                                         */
/*                                                                                                       */
/*                                                                                                       */
/*********************************************************************************************************/






options mprint ;
/* %cour8p
   %cour8l ; */


 options ls=211 ps=69 ; **<<LANDSCAPE:  SAS-Monospace w/Roman 6pt. Font >>**;
*options ls=160 ps=90 ; **<<PORTRAIT:   SAS-Monospace w/Roman 6pt. Font >>**;

```

```
options date number notes ;

libname out2 'S:\Weather\2016Tcap-Phase II\SoCalGas\' ;
NOTE: Libref OUT2 was successfully assigned as follows:
      Engine:        V612
      Physical Name: S:\Weather\2016Tcap-Phase II\SoCalGas
  **<< Change library reference to use applicable daily data. >>**;

libname estout2 'S:\Weather\2016Tcap-Phase II\SoCalGas\MinTemp\' ;
NOTE: Libref ESTOUT2 was successfully assigned as follows:
      Engine:        V612
      Physical Name: S:\Weather\2016Tcap-Phase II\SoCalGas\MinTemp
  **<< Change library reference to use estimation results directory. >>**;

proc contents data=out2.DlySys_d ;
WARNING: The BASE Product product with which CONTENTS is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
run ;

NOTE: The PROCEDURE CONTENTS used 0.54 seconds.

data seriesD ;
WARNING: The BASE Product product with which DATASTEP is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
  set out2.DlySys_d ;
  year = year(date) ;
  month = month(date) ;
  posAvg = avg ;
  negAvg = -avg ;
run ;

NOTE: The data set WORK.SERIESD has 23741 observations and 8 variables.
NOTE: The DATA statement used 4.2 seconds.

proc means data=seriesD noprint nway ;
WARNING: The BASE Product product with which MEANS is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
```

```
 class year month ;
  var posAvg negAvg ;
 output out=mostat
                  mean=posAvg  negAvg
                   max=MxPosAvg MxNegAvg
                   min=MnPosAvg MnNegAvg    ;
run;

NOTE: The data set WORK.MOSTAT has 780 observations and 10 variables.
NOTE: The PROCEDURE MEANS used 0.26 seconds.


run proc sort data=mostat ;
WARNING: The BASE Product product with which SORT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
   by year month ;
run ;

NOTE: The data set WORK.MOSTAT has 780 observations and 10 variables.
NOTE: The PROCEDURE SORT used 0.21 seconds.


data mostat ;
WARNING: The BASE Product product with which DATASTEP is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
   set mostat ;
   MxPRatio = MxPosAvg/ PosAvg  ;
   MnPRatio = MnPosAvg/ PosAvg  ;
   MxNRatio = MxNegAvg/ NegAvg  ;
   MnNRatio = MnNegAvg/ NegAvg  ;
run ;

NOTE: The data set WORK.MOSTAT has 780 observations and 14 variables.
NOTE: The DATA statement used 0.26 seconds.
```

```
/****************
***<< Print Summary Tables of Means/Minimums/Maximums of daily NEGATIVE-Temperatures (degrees-F). >>*** ;

proc transpose data=mostat out=AvTData prefix=AvT_ ;  **<< Update "year" value as necessary! >>** ;
   where (year < 2015) ;
   by year;
   id month ;
   var NegAvg  ;
run ;

data AvTData ;
   set AvTData ;

 if (mod(year,4)=0) then do ;
        AvTyr = (AvT_1 + AvT_3 + AvT_5 + AvT_7 + AvT_8 + AvT_10 + AvT_12)*31
               + (AvT_4 + AvT_6 + AvT_9 + AvT_11)*30
               + (AvT_2)*29 ;
        AvTyr = AvTyr / 366 ;
        end ;
 else do ;
        AvTyr = (AvT_1 + AvT_3 + AvT_5 + AvT_7 + AvT_8 + AvT_10 + AvT_12)*31
               + (AvT_4 + AvT_6 + AvT_9 + AvT_11)*30
               + (AvT_2)*28 ;
        AvTyr = AvTyr / 365 ;
        end ;

run ;

proc print data=AvTData ;
 id year ;
 var AvTyr AvT_1-AvT_12 ;
title3 'Monthly Mean NEGATIVE Temperature (Deg-F) from 1950 thru 2014.';
run ;





proc transpose data=mostat out=MnTData prefix=MnT_ ;
   where (year < 2015) ;     **<< Update "year" value as necessary! >>** ;
   by year;
   id month ;
```

```
   var MnNegAvg ;
run ;

data MnTData ;
   set MnTData ;
 MnTyr = min(of MnT_1-MnT_12) ;
run ;

proc print data=MnTData ;
 id year ;
 var MnTyr MnT_1-MnT_12 ;
title3 'Monthly MINIMUM NEGATIVE-Temperature (Deg-F) from 1950 thru 2014.';
run ;
****************/






proc transpose data=mostat out=MxTData prefix=MxT_ ;
WARNING: The BASE Product product with which TRANSPOSE is associated will expire within 30 days. Please contact your
SAS installation representative to have it renewed.
   where (year < 2015) ;    **<< Update "year" value as necessary! >>** ;
   by year;
   id month ;
   var MxNegAvg ;
run ;

NOTE: The data set WORK.MXTDATA has 65 observations and 14 variables.
NOTE: The PROCEDURE TRANSPOSE used 0.2 seconds.


data MxTData ;
WARNING: The BASE Product product with which DATASTEP is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
   set MxTData ;
 MxTyr = max(of MxT_1-MxT_12) ;
run ;

NOTE: The data set WORK.MXTDATA has 65 observations and 15 variables.
NOTE: The DATA statement used 0.26 seconds.

```

```
proc print data=MxTData ;
WARNING: The BASE Product product with which PRINT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
 id year ;
 var MxTyr MxT_1-MxT_12 ;
title3 'Monthly MAXIMUM NEGATIVE-Temperature (Deg-F) from 1950 thru 2014.';    **<< Update "year" value as
necessary! >>** ;
run ;

NOTE: The PROCEDURE PRINT used 0.29 seconds.

/****************
***<< Descriptive Statistics: Maximums of daily NEGATIVE-Temperatures (Deg-F) for Year and each calendar month.
>>*** ;

proc corr data=MxTData ;
  var MxTyr MxT_1 - MxT_12 ;
title3 'Correlation Matrix of Monthly Maximum NEGATIVE-Temperatures (Deg-F) within same year.';
run ;

proc arima data=MxTData ;
  identify var=MxTyr ;
  identify var=MxT_1 ;
  identify var=MxT_2 ;
  identify var=MxT_3 ;
  identify var=MxT_4 ;
  identify var=MxT_5 ;
  identify var=MxT_6 ;
  identify var=MxT_7 ;
  identify var=MxT_8 ;
  identify var=MxT_9 ;
  identify var=MxT_10 ;
  identify var=MxT_11 ;
```

```
  identify var=MxT_12 ;
title3 "Auto-correlation analysis of each calendar month's Maximum NEGATIVE-Temperatures (Deg-F) within same year.";
run ;

proc univariate normal data=MxTData plot ;
  id year ;
  var MxTyr MxT_1 - MxT_12 ;
title3 "Probability plots and tests for NORMALity by each calendar month's Maximun NEGATIVE-Temperatures (Deg-F) time series.";
run ;


proc means data=MxTData ;
  var MxT_1 - MxT_12  MxTYr ;
run ;
****************/








***<< Statistical Estimation of 2-Parameter T-Dist Models: Maximums of daily heating degrees for Year and each calendar month. >>*** ;

%macro RankIt(file=MxTData,var=MxTYr,rank=RankYr,prob=PrMxTYr,Nobser=65,PltValue=0.375) ;
          **<< Update "Nobser" value as necessary! >>** ;
proc sort data=&file ;
  by &var ;
run ;

data &file ;
   set &file ;
   retain &rank 0     alpha &pltvalue ;

  &rank = &rank + 1 ;
  &prob =  (&rank - alpha) / (&Nobser +(1 - 2*alpha)) ;
run ;

proc print data=&file ;
  var &var &rank &prob alpha year ;
run ;
```

```
%mend RankIt ;




%macro GEVfit(file=MxTData,ofile=MxTNL1,outfit=fit1,outest=est1,depvar=PrMxTYr,var=MxTYr,typeGEV=1,
              KappaI=0.25,GammaI=-47.05,ThetaI=2.77,YrLo=1950,YrHi=2014) ;

          **<< Update "year" value as necessary! >>** ;

proc sort data=&file ;
   by year ;
run ;



proc model data=&file converge=0.001
           maxit=500 dw ;  outmodel=&ofile ;
     range year = &YrLo to &YrHi ;  **<< Dropped monthly data beyond 2014 data. >>** ;


     y = (&var - Gamma) / Theta ;

    %if &typeGEV=1 %then %do ;  ***<< 3-parameter GEV Model. >>>*** ;
        &depvar = exp( -(1 - Kappa * (y))**(1/Kappa) ) ;
        %let typmod = 3-parameter GEV Model. ;
        %end ;

    %if &typeGEV=2 %then %do ;  **<< 2-parameter "Double Exponential" or  "Gumbel" Model. >>** ;
        &depvar = exp( -exp(-(y)) ) ;
        %let typmod = 2-parameter Double Exponential or Gumbel Model. ;
        %end ;

    %if (&typeGEV NE 1) AND (&typeGEV NE 2) %then  %do ; **<< 2-parameter "T-Dist" Model. >>** ;
        dft=(&YrHi - &YrLo) +1 -2 ;
        &depvar = probt(y,dft) ;
        %let typmod = 2-parameter T-Dist Model. ;
        %end ;


  %if &typeGEV = 1 %then %do ;
  parms
        Kappa  &KappaI
        Gamma  &GammaI
```

```
      Theta  &ThetaI ;
  %end ;

  %if (&typeGEV NE 1)  %then %do ;
  parms
      Gamma  &GammaI
      Theta  &ThetaI ;
  %end ;

  fit &depvar   /out=&outfit  outall
               outest=&outest corrb corrs outcov ;

title3 "Non-linear Estimation of &&typmod: for Maximum NEGATIVE Temperature (Deg-F)." ;
run ;
%mend GEVfit ;

/****************
****************/

proc means data=MxTData ;
WARNING: The BASE Product product with which MEANS is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
  var MxT_1 - MxT_12  MxTYr ;
 output out=VarStat
      mean=mean1-mean12 meanYr
      std=stdev1-stdev12 stdevYr;
title3 "Calc. Means and Standard Deviantions to use as Starting Values in Non-Linear Estimations." ;
run ;

NOTE: The data set WORK.VARSTAT has 1 observations and 28 variables.
NOTE: The PROCEDURE MEANS used 0.12 seconds.

proc print data=VarStat ;
WARNING: The BASE Product product with which PRINT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
```

```
run ;

NOTE: The PROCEDURE PRINT used 0.01 seconds.



data _null_ ;
WARNING: The BASE Product product with which DATASTEP is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
   set VarStat ;

  call symput('gamma_Yr',meanYr) ;
  call symput('theta_Yr',stdevYr) ;

  call symput('gamma_12',mean12) ;
  call symput('theta_12',stdev12) ;

  call symput('gamma_11',mean11) ;
  call symput('theta_11',stdev11) ;

  call symput('gamma_10',mean10) ;
  call symput('theta_10',stdev10) ;

  call symput('gamma_9',mean9) ;
  call symput('theta_9',stdev9) ;

  call symput('gamma_8',mean8) ;
  call symput('theta_8',stdev8) ;

  call symput('gamma_7',mean7) ;
  call symput('theta_7',stdev7) ;

  call symput('gamma_6',mean6) ;
  call symput('theta_6',stdev6) ;

  call symput('gamma_5',mean5) ;
  call symput('theta_5',stdev5) ;

  call symput('gamma_4',mean4) ;
  call symput('theta_4',stdev4) ;

  call symput('gamma_3',mean3) ;
  call symput('theta_3',stdev3) ;

```

```
357    call symput('gamma_2',mean2) ;
358    call symput('theta_2',stdev2) ;
359
360    call symput('gamma_1',mean1) ;
361    call symput('theta_1',stdev1) ;
362
363  run ;

NOTE: Numeric values have been converted to character values at the places given by: (Line):(Column).
      324:26   325:26   327:26   328:26   330:26   331:26   333:26   334:26   336:25   337:25   339:25   340:25
342:25   343:25   345:25   346:25   348:25   349:25   351:25   352:25   354:25   355:25
      357:25   358:25   360:25   361:25
NOTE: The DATA statement used 0.28 seconds.



364
365
366
367
368
369
370  *********<<< Analysis for "Annual" Data  (i.e., SUFFIX "mm" = "_Yr"  >>>******************;
371
372
373
MPRINT(RANKIT):   **<< UPDATE "NOBSER" VALUE AS NECESSARY! >>** ;
374
375
376  %RankIt(file=MxTData,var=MxTYr,rank=RankYr,prob=PrMxTYr,Nobser=65,PltValue=0.375) ;
WARNING: The BASE Product product with which SORT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
MPRINT(RANKIT):   PROC SORT DATA=MXTDATA ;
MPRINT(RANKIT):   BY MXTYR ;
MPRINT(RANKIT):   RUN ;

NOTE: The data set WORK.MXTDATA has 65 observations and 15 variables.
NOTE: The PROCEDURE SORT used 0.18 seconds.



WARNING: The BASE Product product with which DATASTEP is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
MPRINT(RANKIT):   DATA MXTDATA ;
MPRINT(RANKIT):   SET MXTDATA ;
MPRINT(RANKIT):   RETAIN RANKYR 0 ALPHA 0.375 ;
MPRINT(RANKIT):   RANKYR = RANKYR + 1 ;
```

```
MPRINT(RANKIT):   PRMXTYR = (RANKYR - ALPHA) / (65 +(1 - 2*ALPHA)) ;

MPRINT(RANKIT):   RUN ;


NOTE: The data set WORK.MXTDATA has 65 observations and 18 variables.

NOTE: The DATA statement used 0.23 seconds.



WARNING: The BASE Product product with which PRINT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.

MPRINT(RANKIT):   PROC PRINT DATA=MXTDATA ;

MPRINT(RANKIT):   VAR MXTYR RANKYR PRMXTYR ALPHA YEAR ;

MPRINT(RANKIT):   RUN ;


NOTE: The PROCEDURE PRINT used 0.01 seconds.



377

378

379

380  *** <<  Call "GEVfit" with "typeGEV=0" which indicates a 2-Parameter, T-Dist probability model. >> *** ;

381  *** <<  Keep the other "suffix" values as "1" for convenience in the post-processing code.      >> *** ;

382  *** <<                                                                                         >> *** ;

383

384  %GEVfit(file=MxTData,ofile=MxTNL1,outfit=fit1,outest=est1,depvar=PrMxTYr,var=MxTYr,typeGEV=0,

MPRINT(GEVFIT):   **<< UPDATE "YEAR" VALUE AS NECESSARY! >>** ;

385          KappaI=0.25,GammaI=&gamma_Yr,ThetaI=&theta_Yr,YrLo=1950,YrHi=2014) ;

WARNING: The BASE Product product with which SORT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.

MPRINT(GEVFIT):   PROC SORT DATA=MXTDATA ;

MPRINT(GEVFIT):   BY YEAR ;

MPRINT(GEVFIT):   RUN ;


NOTE: The data set WORK.MXTDATA has 65 observations and 18 variables.

NOTE: The PROCEDURE SORT used 0.17 seconds.



WARNING: The SAS/ETS product with which MODEL is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.

MPRINT(GEVFIT):   PROC MODEL DATA=MXTDATA CONVERGE=0.001 MAXIT=500 DW ;

MPRINT(GEVFIT):   OUTMODEL%MXTNL1 ;

MPRINT(GEVFIT):   RANGE YEAR = 1950 TO 2014 ;

MPRINT(GEVFIT):   **<< DROPPED MONTHLY DATA BEYOND 2014 DATA. >>** ;

MPRINT(GEVFIT):   Y % (MXTYR - GAMMA) / THETA ;

MPRINT(GEVFIT):   **<< 2-PARAMETER "T-DIST" MODEL. >>** ;

MPRINT(GEVFIT):   DFT%(2014 - 1950) +1 -2 ;
```

```
MPRINT(GEVFIT):   PRMXTYR % PROBT(Y,DFT) ;
MPRINT(GEVFIT):   PARMS GAMMA -45.23653231 THETA 2.7044112855 ;

MPRINT(GEVFIT):   FIT PRMXTYR /OUT=FIT1 OUTALL OUTEST=EST1 CORRB CORRS OUTCOV ;
MPRINT(GEVFIT):   TITLE3 "Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-
F)." ;
MPRINT(GEVFIT):   RUN ;

NOTE: At OLS Iteration 3 CONVERGE=0.001 Criteria Met.
NOTE: The data set WORK.FIT1 has 195 observations and 6 variables.
NOTE: The data set WORK.EST1 has 3 observations and 5 variables.

           **<< Update "YrHi" value as necessary! >>** ;


NOTE: The PROCEDURE MODEL used 1.26 seconds.


proc print data=fit1 ;
WARNING: The BASE Product product with which PRINT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
run ;

NOTE: The PROCEDURE PRINT used 0.01 seconds.


proc transpose data=fit1 out=pred1 prefix=probP ;
WARNING: The BASE Product product with which TRANSPOSE is associated will expire within 30 days. Please contact your
SAS installation representative to have it renewed.
   where (_type_ = "PREDICT" ) ;
   by year;
   var prmxtyr ;
run ;

NOTE: The data set WORK.PRED1 has 65 observations and 3 variables.
NOTE: The PROCEDURE TRANSPOSE used 0.12 seconds.


data comb1 ;
WARNING: The BASE Product product with which DATASTEP is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
```

```
   merge MxTData pred1 ;
  by year ;
   ProbP = ProbP1 ;
  keep year MxTYr PrMxTYr ProbP ;
run ;

NOTE: The data set WORK.COMB1 has 65 observations and 4 variables.
NOTE: The DATA statement used 0.17 seconds.

proc print data=comb1 ;
WARNING: The BASE Product product with which PRINT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
run ;

NOTE: The PROCEDURE PRINT used 0.0 seconds.

proc plot data=comb1 ;
WARNING: The BASE Product product with which PLOT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
  plot prmxtyr*MxTYr='*'
       probP*MxTYr='-' / overlay ;
run ;

NOTE: The PROCEDURE PLOT used 0.03 seconds.

proc print data=est1 ;
WARNING: The BASE Product product with which PRINT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
run ;

NOTE: The PROCEDURE PRINT used 0.01 seconds.
```

```
/**************
data estout2.est0_Yr ;   ***<<< Save a copy of the "2-parameter T-Dist Model" estimation results!  >>>*** ;
                         ***<<<    Number "0" in output file "est0_Yr" identifies results for a T-Dist model. >>>*** ;
  set est1 ;
run ;
**************/



data comb  ;
WARNING: The BASE Product product with which DATASTEP is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
   merge MxTData pred1(rename=(ProbP1=ProbP1)) ;
  by year ;

 ***<< "Log(PrMxTYr) - Log(ProgP)" to calc. RMSE of Proportional Errors Models! >>** ;
   LgPrRat1 = Log(PrMxTYr/ProbP1) ;

 label   LgPrRat1 = "Log(PrMxTYr/ProbP1)- T-Dist" ;

   if (PrMxTYr <= (1/3)) then Quantile=1 ;  **<< "Lower Third" >>** ;
   if (PrMxTYr > (1/3)) AND (PrMxTYr <= (2/3)) then Quantile=2 ; **<< "Middle Third" >>** ;
   if (PrMxTYr > (2/3)) then Quantile=3 ;  **<< "Upper Third" >>** ;

  keep year MxTYr Quantile PrMxTYr ProbP1 LgPrRat1 ;
run ;

NOTE: The data set WORK.COMB has 65 observations and 6 variables.
NOTE: The DATA statement used 0.25 seconds.



proc print data=comb  ;
WARNING: The BASE Product product with which PRINT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
  var year MxTYr Quantile  PrMxTYr ProbP1  LgPrRat1 ;
title3 "Est'd CDFs and Logarithms of 'Empirical CDF rel. to Fitted CDF' values by Models." ;
run ;

NOTE: The PROCEDURE PRINT used 0.01 seconds.

```

```
proc means data=comb  n mean std min max var uss ;
WARNING: The BASE Product product with which MEANS is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
  var LgPrRat1 ;
title3 "Stats for Logarithms of 'Empirical CDF rel. to Fitted CDF' values by Models to calc. RMSE of Prop. Model
Spec" ;
run ;

NOTE: The PROCEDURE MEANS used 0.01 seconds.

proc sort data=comb ;
WARNING: The BASE Product product with which SORT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
  by Quantile ;
run ;

NOTE: The data set WORK.COMB has 65 observations and 6 variables.
NOTE: The PROCEDURE SORT used 0.18 seconds.

proc means data=comb  n mean std min max var uss ;
WARNING: The BASE Product product with which MEANS is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
  by Quantile ;
  var LgPrRat1 ;
title3 "Stats By Quantile for Logarithms of 'Empirical CDF rel. to Fitted CDF' values by Models to calc. RMSE of
Prop. Model Spec" ;
run ;

NOTE: The PROCEDURE MEANS used 0.01 seconds.

quit ;
```

VIII. Attachment 2: SAS Program Output

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CONTENTS PROCEDURE

Data Set Name:	OUT2.DLYSYS_D	Observations:	23741
Member Type:	DATA	Variables:	4
Engine:	V612	Indexes:	0
Created:	17:32 Friday, January 23, 2015	Observation Length:	32
Last Modified:	17:32 Friday, January 23, 2015	Deleted Observations:	0
Protection:		Compressed:	NO
Data Set Type:		Sorted:	NO
Label:			

-----Engine/Host Dependent Information-----

Data Set Page Size:	8192
Number of Data Set Pages:	94
File Format:	607
First Data Page:	1
Max Obs per Page:	254
Obs in First Data Page:	229

-----Alphabetic List of Variables and Attributes-----

#	Variable	Type	Len	Pos	Format	Informat	Label
4	AVG	Num	8	24			
3	CDD	Num	8	16			
1	DATE	Num	8	0	YYMMDD8.	YYMMDD.	DATE
2	HDD	Num	8	8			

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Monthly MAXIMUM NEGATIVE-Temperature (Deg-F) from 1950 thru 2014.

YEAR	MXTYR	MXT_1	MXT_2	MXT_3	MXT_4	MXT_5	MXT_6	MXT_7	MXT_8	MXT_9	MXT_10	MXT_11	MXT_12
1950	-40.8072	-40.8072	-44.9943	-50.7313	-53.8257	-54.7624	-60.3313	-68.4663	-67.9423	-64.1625	-63.2836	-52.1857	-51.8034
1951	-44.5430	-46.1925	-44.6781	-46.0278	-54.2129	-55.4962	-62.2007	-68.2982	-64.6206	-65.7145	-55.7701	-49.1872	-44.5430
1952	-43.0339	-43.0339	-46.8741	-45.9425	-53.2865	-61.0915	-59.8706	-68.6383	-69.5373	-62.0114	-61.1989	-46.8988	-47.0423
1953	-45.6564	-48.5182	-45.6564	-45.7659	-50.5803	-53.9681	-58.8774	-72.3961	-65.5668	-64.7080	-57.3488	-50.4250	-49.1774
1954	-45.6604	-47.6471	-49.5099	-49.0690	-56.7558	-56.4600	-61.5325	-69.9801	-67.5304	-64.1278	-58.4709	-51.3951	-45.6604
1955	-45.8387	-46.1290	-45.9550	-51.5425	-53.9033	-52.9296	-58.6297	-66.4324	-71.2852	-63.6127	-58.1674	-49.7401	-45.8387
1956	-44.8782	-48.5130	-44.8782	-51.4843	-50.4928	-58.3056	-65.1779	-66.3144	-66.5165	-70.5377	-53.5414	-53.4406	-48.6219
1957	-39.4936	-39.4936	-49.0096	-51.1495	-51.3080	-57.6943	-65.2956	-71.3550	-66.5925	-67.6759	-57.1667	-52.1970	-52.8299
1958	-46.2139	-50.2387	-53.6653	-49.7185	-51.1629	-60.7428	-66.3328	-69.7147	-72.9018	-66.5744	-62.8153	-46.2139	-52.9398
1959	-48.2384	-51.4371	-48.2384	-57.6974	-59.7462	-58.2314	-66.7195	-74.6307	-68.4773	-65.9366	-60.1276	-58.6033	-48.7166
1960	-42.2775	-42.2775	-48.3982	-52.2112	-53.3960	-57.4392	-66.4864	-69.4117	-69.6147	-67.3276	-59.0993	-50.3867	-45.6296
1961	-47.1619	-50.8110	-53.3544	-53.4279	-54.5486	-59.0372	-60.5432	-69.2848	-68.8912	-64.3197	-55.8018	-51.7871	-47.1619
1962	-43.3861	-43.3861	-45.2063	-46.9219	-57.9642	-54.9806	-57.8868	-68.4033	-70.2520	-66.2430	-60.9803	-54.8034	-47.8224
1963	-42.5588	-42.5588	-52.9651	-48.0672	-51.2203	-60.4956	-60.6573	-68.4339	-70.4461	-67.5869	-62.5043	-53.0150	-48.8658
1964	-45.1940	-47.5707	-49.7337	-48.1919	-52.1618	-52.5075	-59.0212	-68.5132	-67.9758	-65.8834	-61.5878	-45.1940	-45.6097
1965	-44.7682	-44.7682	-47.7925	-51.7334	-48.2654	-57.5947	-59.0778	-68.4861	-71.3377	-64.3986	-60.8953	-51.6345	-46.3493
1966	-46.6790	-46.6790	-48.1729	-47.3122	-57.5924	-58.5981	-62.9831	-69.9464	-68.7940	-66.8404	-63.4903	-52.6131	-47.2321
1967	-40.7181	-49.5353	-52.8321	-51.1798	-48.2385	-57.8784	-58.9090	-72.5068	-74.8077	-70.3731	-64.8867	-51.6278	-40.7181
1968	-40.6115	-46.2285	-52.4101	-53.7941	-55.4343	-56.9954	-61.6150	-68.0568	-68.4623	-64.8159	-59.6736	-54.2389	-40.6115
1969	-44.8150	-44.8150	-47.3905	-48.6202	-53.7470	-55.7109	-62.7623	-68.8039	-72.2456	-67.2626	-59.2221	-56.3578	-48.7758
1970	-46.8110	-46.9256	-54.2542	-51.9837	-51.7401	-57.6353	-62.1013	-71.6157	-71.4413	-66.0817	-58.2321	-53.2513	-46.8110
1971	-42.9710	-42.9710	-48.9303	-48.6970	-52.8030	-55.8854	-58.5894	-68.9225	-70.6937	-62.7865	-49.2319	-52.3616	-44.6609
1972	-41.4058	-45.9863	-49.8632	-55.4098	-54.2844	-56.8755	-65.9472	-70.1954	-70.1723	-66.2909	-55.9509	-53.8028	-41.4058
1973	-45.0304	-45.0304	-52.1193	-49.1251	-55.3620	-58.1827	-63.7819	-67.4281	-68.0300	-65.8939	-61.9443	-49.7061	-50.8609
1974	-42.9402	-42.9402	-51.8350	-48.2593	-55.6661	-58.3715	-65.5641	-68.7426	-70.9727	-66.8637	-56.3114	-55.0389	-44.7822
1975	-44.6228	-44.6228	-47.9696	-49.7502	-47.3639	-56.3483	-61.4134	-69.4239	-68.6332	-67.4537	-59.1986	-47.7186	-48.6275
1976	-44.8080	-44.8080	-49.5341	-45.4146	-50.4066	-58.0711	-60.5162	-70.7565	-67.7136	-67.5026	-62.8477	-51.6501	-51.2183
1977	-48.2869	-48.2869	-51.9094	-48.6823	-53.4509	-53.9733	-64.7609	-69.5556	-72.9812	-65.7061	-60.5979	-54.0486	-53.2405
1978	-41.6116	-51.0989	-48.2283	-54.1148	-51.2871	-59.4685	-65.9023	-68.8310	-68.7117	-65.8612	-59.3688	-49.0050	-41.6116
1979	-41.3705	-41.3705	-45.8329	-49.7146	-56.2775	-58.7696	-63.9629	-66.6176	-69.8544	-69.2665	-59.9759	-51.5816	-49.5030

1980	-50.3421	-50.3421	-54.7617	-52.8748	-53.2024	-57.2176	-60.6471	-71.9477	-70.0367	-66.2337	-59.0175	-56.0219	-51.6664
1981	-49.3286	-49.3286	-52.1301	-52.3736	-54.8583	-61.4136	-68.3402	-73.1790	-72.9987	-68.2724	-58.1122	-50.9040	-52.9609
1982	-45.3299	-45.3299	-52.3145	-49.2848	-50.3350	-57.8431	-62.8544	-66.7958	-69.7481	-63.7940	-61.7234	-52.0589	-48.3265
1983	-48.6608	-48.6608	-51.5568	-54.5976	-52.4893	-57.6944	-62.6328	-69.1252	-70.4816	-64.0338	-65.4353	-49.4462	-49.4507
1984	-46.9065	-49.5942	-53.8332	-56.9301	-54.9010	-59.4336	-66.1362	-73.1468	-74.8647	-70.7801	-60.6715	-50.0024	-46.9065
1985	-45.0880	-47.3663	-45.0880	-49.0940	-54.9197	-59.0962	-62.9023	-71.6085	-69.5253	-64.7417	-61.8089	-47.5245	-46.7204
1986	-48.5674	-56.1668	-48.5674	-50.3585	-57.7345	-59.4602	-66.4245	-69.1568	-72.3863	-61.1400	-61.4597	-58.2066	-52.9034
1987	-43.4247	-44.2588	-46.0334	-50.7445	-56.2879	-60.0274	-66.6811	-67.1249	-68.1981	-67.1020	-62.0578	-52.6794	-43.4247
1988	-43.2531	-49.9358	-51.3177	-54.3592	-54.0237	-55.3747	-59.1362	-70.9816	-70.1792	-64.2776	-64.0871	-50.9629	-43.2531
1989	-40.5753	-42.9394	-40.5753	-52.1890	-55.4461	-58.1996	-64.4928	-71.3258	-69.5387	-62.8603	-59.7874	-56.0269	-51.8875
1990	-38.9860	-48.7730	-43.3682	-49.1322	-58.2467	-61.1374	-63.2477	-72.1697	-69.8850	-69.0223	-63.4936	-52.3606	-38.9860
1991	-48.6837	-51.7135	-56.1746	-48.6837	-57.5543	-55.8830	-63.8363	-68.1028	-70.4398	-66.6602	-57.5474	-52.6162	-50.5120
1992	-47.3049	-48.1406	-51.8508	-53.3355	-61.2239	-66.6470	-64.4752	-68.0745	-69.0992	-70.1781	-63.4077	-55.3973	-47.3049
1993	-46.0713	-46.0713	-50.8321	-53.4612	-60.3093	-63.5225	-59.7529	-71.1713	-70.1824	-67.4979	-63.2787	-54.8993	-50.1148
1994	-47.1397	-51.5424	-50.0581	-51.7781	-54.2257	-57.1479	-66.9535	-71.1848	-73.6192	-67.1993	-62.0524	-47.1397	-49.9802
1995	-49.8028	-49.9320	-54.1174	-52.5794	-52.0628	-56.5546	-57.8265	-69.9636	-71.8429	-67.3222	-62.8173	-60.4613	-49.8028
1996	-44.9435	-47.7521	-44.9435	-55.0192	-59.6911	-62.8870	-63.9978	-71.8901	-72.0478	-68.9599	-54.4094	-53.3067	-52.4759
1997	-48.3957	-48.3957	-53.4586	-53.2979	-55.7065	-66.9514	-64.8205	-70.6195	-72.0421	-71.8844	-62.3915	-54.8671	-48.9567
1998	-43.5946	-50.7078	-52.3884	-49.8504	-50.0424	-55.2386	-61.1665	-70.3857	-72.6671	-65.0653	-60.8774	-55.3314	-43.5946
1999	-48.9896	-48.9896	-49.9822	-50.1233	-50.2269	-57.6433	-57.3338	-69.3715	-69.0144	-67.8626	-64.5056	-54.8744	-52.0539
2000	-48.7706	-49.7510	-48.9954	-48.7706	-55.6989	-61.3786	-64.7722	-69.3905	-69.5650	-67.2050	-57.2008	-50.3710	-51.1122
2001	-47.1614	-47.3335	-47.1614	-51.9520	-50.1016	-63.0881	-66.6358	-69.4137	-70.5816	-69.0708	-63.0781	-51.6579	-49.0871
2002	-45.8154	-45.8154	-48.9334	-50.2457	-56.2982	-57.7670	-65.0019	-70.2030	-70.1118	-63.3373	-58.9678	-58.5793	-48.7193
2003	-47.0515	-54.5740	-52.8282	-53.0589	-53.4306	-58.6375	-63.0502	-73.2373	-73.6748	-70.4071	-57.5599	-52.9711	-47.0515
2004	-48.1798	-49.0376	-50.7720	-53.6894	-56.6409	-63.7287	-65.9768	-68.9811	-70.3633	-65.6806	-56.1154	-48.1798	-48.2848
2005	-47.2514	-47.2514	-54.0025	-53.5962	-57.5433	-60.9947	-65.4746	-71.0428	-71.0089	-65.8699	-60.6008	-55.1875	-50.5880
2006	-45.7981	-51.5506	-48.3597	-45.7981	-53.6960	-62.5173	-68.5650	-74.8740	-72.2727	-68.2525	-62.2526	-52.0118	-48.0690
2007	-41.4814	-41.4814	-50.7755	-51.4107	-54.2593	-59.5930	-63.9881	-73.0528	-72.5395	-63.5142	-61.4428	-56.1131	-47.4808
2008	-45.7917	-47.4794	-49.8285	-54.5720	-55.1514	-57.5380	-64.0033	-72.7499	-73.0415	-68.8692	-60.3792	-58.5400	-45.7917
2009	-45.2534	-47.9867	-48.1410	-52.3802	-52.8129	-65.4355	-64.0146	-72.2836	-71.2183	-69.0160	-59.0679	-56.6504	-45.2534
2010	-44.6744	-48.7300	-50.9727	-52.1350	-52.0242	-59.1173	-65.8364	-68.1520	-67.5586	-66.6446	-60.3431	-49.6237	-44.6744
2011	-46.7442	-47.1630	-46.7442	-50.5046	-50.0933	-56.4660	-62.0575	-68.8487	-71.8589	-68.3919	-59.1522	-52.5591	-48.6722
2012	-46.7366	-50.8930	-49.5263	-49.0910	-52.7475	-60.3414	-66.9888	-69.9281	-74.1309	-71.4836	-63.0314	-53.2948	-46.7366

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Monthly MAXIMUM NEGATIVE-Temperature (Deg-F) from 1950 thru 2014.

YEAR	MXTYR	MXT_1	MXT_2	MXT_3	MXT_4	MXT_5	MXT_6	MXT_7	MXT_8	MXT_9	MXT_10	MXT_11	MXT_12
2013	-43.8579	-43.8579	-47.2407	-51.2111	-57.9399	-62.1328	-69.3016	-70.9813	-70.8557	-68.4646	-58.4172	-56.4368	-46.9527
2014	-48.0273	-55.2924	-51.8327	-56.1630	-54.5909	-61.1851	-68.9957	-72.2830	-72.7877	-69.2765	-65.3027	-59.2217	-48.0273

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Calc. Means and Standard Deviantions to use as Starting Values in Non-Linear Estimations.

Variable	N	Mean	Std Dev	Minimum	Maximum
MXT_1	65	-47.3664436	3.4591775	-56.1668333	-39.4936167
MXT_2	65	-49.5639541	3.1943504	-56.1745667	-40.5752667
MXT_3	65	-51.0213141	2.7994073	-57.6974333	-45.4145500
MXT_4	65	-54.0461649	3.0218124	-61.2238500	-47.3639333
MXT_5	65	-58.6737585	3.0300999	-66.9513667	-52.5075167
MXT_6	65	-63.3195367	3.0442636	-69.3016167	-57.3337667
MXT_7	65	-70.0447541	1.9712943	-74.8740333	-66.3143667
MXT_8	65	-70.3595059	2.1663051	-74.8646833	-64.6205500
MXT_9	65	-66.6798531	2.3656410	-71.8843500	-61.1400000
MXT_10	65	-60.1776205	3.0358725	-65.4353000	-49.2319333
MXT_11	65	-52.7168479	3.3146691	-60.4613000	-45.1939667
MXT_12	65	-47.7915956	3.2907446	-53.2404833	-38.9859500
MXTYR	65	-45.2365323	2.7044113	-50.3420500	-38.9859500

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Calc. Means and Standard Deviantions to use as Starting Values in Non-Linear Estimations.

OBS	_TYPE_	_FREQ_	MEAN1	MEAN2	MEAN3	MEAN4	MEAN5	MEAN6	MEAN7	MEAN8	MEAN9	MEAN10	MEAN11	MEAN12
1	0	65	-47.3664	-49.5640	-51.0213	-54.0462	-58.6738	-63.3195	-70.0448	-70.3595	-66.6799	-60.1776	-52.7168	-47.7916

OBS	MEANYR	STDEV1	STDEV2	STDEV3	STDEV4	STDEV5	STDEV6	STDEV7	STDEV8	STDEV9	STDEV10	STDEV11	STDEV12	STDEVYR
1	-45.2365	3.45918	3.19435	2.79941	3.02181	3.03010	3.04426	1.97129	2.16631	2.36564	3.03587	3.31467	3.29074	2.70441

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Calc. Means and Standard Deviantions to use as Starting Values in Non-Linear Estimations.

OBS	MXTYR	RANKYR	PRMXTYR	ALPHA	YEAR
1	-50.3421	1	0.00958	0.375	1980
2	-49.8028	2	0.02490	0.375	1995
3	-49.3286	3	0.04023	0.375	1981
4	-48.9896	4	0.05556	0.375	1999
5	-48.7706	5	0.07088	0.375	2000
6	-48.6837	6	0.08621	0.375	1991
7	-48.6608	7	0.10153	0.375	1983
8	-48.5674	8	0.11686	0.375	1986
9	-48.3957	9	0.13218	0.375	1997
10	-48.2869	10	0.14751	0.375	1977
11	-48.2384	11	0.16284	0.375	1959
12	-48.1798	12	0.17816	0.375	2004
13	-48.0273	13	0.19349	0.375	2014
14	-47.3049	14	0.20881	0.375	1992
15	-47.2514	15	0.22414	0.375	2005
16	-47.1619	16	0.23946	0.375	1961
17	-47.1614	17	0.25479	0.375	2001
18	-47.1397	18	0.27011	0.375	1994
19	-47.0515	19	0.28544	0.375	2003
20	-46.9065	20	0.30077	0.375	1984
21	-46.8110	21	0.31609	0.375	1970
22	-46.7442	22	0.33142	0.375	2011
23	-46.7366	23	0.34674	0.375	2012
24	-46.6790	24	0.36207	0.375	1966
25	-46.2139	25	0.37739	0.375	1958
26	-46.0713	26	0.39272	0.375	1993
27	-45.8387	27	0.40805	0.375	1955
28	-45.8154	28	0.42337	0.375	2002
29	-45.7981	29	0.43870	0.375	2006
30	-45.7917	30	0.45402	0.375	2008

31	-45.6604	31	0.46935	0.375	1954
32	-45.6564	32	0.48467	0.375	1953
33	-45.3299	33	0.50000	0.375	1982
34	-45.2534	34	0.51533	0.375	2009
35	-45.1940	35	0.53065	0.375	1964
36	-45.0880	36	0.54598	0.375	1985
37	-45.0304	37	0.56130	0.375	1973
38	-44.9435	38	0.57663	0.375	1996
39	-44.8782	39	0.59195	0.375	1956
40	-44.8150	40	0.60728	0.375	1969
41	-44.8080	41	0.62261	0.375	1976
42	-44.7682	42	0.63793	0.375	1965
43	-44.6744	43	0.65326	0.375	2010
44	-44.6228	44	0.66858	0.375	1975
45	-44.5430	45	0.68391	0.375	1951
46	-43.8579	46	0.69923	0.375	2013
47	-43.5946	47	0.71456	0.375	1998
48	-43.4247	48	0.72989	0.375	1987
49	-43.3861	49	0.74521	0.375	1962
50	-43.2531	50	0.76054	0.375	1988
51	-43.0339	51	0.77586	0.375	1952
52	-42.9710	52	0.79119	0.375	1971
53	-42.9402	53	0.80651	0.375	1974
54	-42.5588	54	0.82184	0.375	1963
55	-42.2775	55	0.83716	0.375	1960
56	-41.6116	56	0.85249	0.375	1978
57	-41.4814	57	0.86782	0.375	2007
58	-41.4058	58	0.88314	0.375	1972
59	-41.3705	59	0.89847	0.375	1979
60	-40.8072	60	0.91379	0.375	1950
61	-40.7181	61	0.92912	0.375	1967
62	-40.6115	62	0.94444	0.375	1968
63	-40.5753	63	0.95977	0.375	1989

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Calc. Means and Standard Deviantions to use as Starting Values in Non-Linear Estimations.

OBS	MXTYR	RANKYR	PRMXTYR	ALPHA	YEAR
64	-39.4936	64	0.97510	0.375	1957
65	-38.9860	65	0.99042	0.375	1990

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

MODEL Procedure

Model Summary

Model Variables	1
Parameters	3
RANGE Variable	YEAR
Equations	1
Number of Statements	4

Model Variables: PRMXTYR

Parameters: GAMMA: -45.24 THETA: 2.704 MXTNL1

Equations: PRMXTYR

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

MODEL Procedure

NOTE: A finite difference approximation is used for the derivative of the PROBT function at line 385 column 101.

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

MODEL Procedure

The Equation to Estimate is:

PRMXTYR = F(GAMMA, THETA)

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

MODEL Procedure

OLS Estimation

OLS Estimation Summary

Dataset Option	Dataset
DATA=	MXTDATA
OUT=	FIT1
OUTEST=	EST1

Parameters Estimated	2

RANGE Processed	YEAR
First	1950
Last	2014

Minimization Summary

Method	GAUSS
Iterations	3

Final Convergence	Criteria
R	0.00010653
PPC(THETA)	0.000016
RPC(THETA)	0.000124
Object	3.57066E-6
Trace(S)	0.00076579
Objective Value	0.00074222

Observations Processed

Read	65
Solved	65

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

MODEL Procedure

OLS Estimation

Nonlinear OLS Summary of Residual Errors

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq	Durbin Watson
PRMXTYR	2	63	0.04824	0.0007658	0.02767	0.9910	0.9909	1.565

Nonlinear OLS Parameter Estimates

Parameter	Estimate	Approx. Std Err	'T' Ratio	Approx. Prob>|T|
GAMMA	-45.393847	0.03194	-1421.05	0.0001
THETA	2.792537	0.05539	50.42	0.0001

Number of Observations		Statistics for System	
Used	65	Objective	0.000742
Missing	0	Objective*N	0.0482

RANGE of Fit: YEAR = 1950 TO 2014

Correlations of Estimates

CorrB GAMMA THETA

GAMMA	1.0000	0.0940
THETA	0.0940	1.0000

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

MODEL Procedure

Model Summary

Model Variables	1
Parameters	3
RANGE Variable	YEAR
Equations	1
Number of Statements	5

Model Variables: PRMXTYR

Parameters: MXTNL1 GAMMA: -45.39(-1421) THETA: 2.793(50)

Equations: PRMXTYR

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

OBS	YEAR	_ESTYPE_	_TYPE_	_WEIGHT_	PRMXTYR	MXTYR
1	1950	OLS	ACTUAL	1	0.91379	-40.8072
2	1950	OLS	PREDICT	1	0.94726	-40.8072
3	1950	OLS	RESIDUAL	1	-0.03347	-40.8072
4	1951	OLS	ACTUAL	1	0.68391	-44.5430
5	1951	OLS	PREDICT	1	0.61920	-44.5430
6	1951	OLS	RESIDUAL	1	0.06471	-44.5430
7	1952	OLS	ACTUAL	1	0.77586	-43.0339
8	1952	OLS	PREDICT	1	0.79937	-43.0339
9	1952	OLS	RESIDUAL	1	-0.02351	-43.0339
10	1953	OLS	ACTUAL	1	0.48467	-45.6564
11	1953	OLS	PREDICT	1	0.46269	-45.6564
12	1953	OLS	RESIDUAL	1	0.02198	-45.6564
13	1954	OLS	ACTUAL	1	0.46935	-45.6604
14	1954	OLS	PREDICT	1	0.46214	-45.6604
15	1954	OLS	RESIDUAL	1	0.00721	-45.6604
16	1955	OLS	ACTUAL	1	0.40805	-45.8387
17	1955	OLS	PREDICT	1	0.43698	-45.8387
18	1955	OLS	RESIDUAL	1	-0.02893	-45.8387
19	1956	OLS	ACTUAL	1	0.59195	-44.8782
20	1956	OLS	PREDICT	1	0.57295	-44.8782
21	1956	OLS	RESIDUAL	1	0.01900	-44.8782
22	1957	OLS	ACTUAL	1	0.97510	-39.4936
23	1957	OLS	PREDICT	1	0.98071	-39.4936
24	1957	OLS	RESIDUAL	1	-0.00561	-39.4936
25	1958	OLS	ACTUAL	1	0.37739	-46.2139
26	1958	OLS	PREDICT	1	0.38499	-46.2139
27	1958	OLS	RESIDUAL	1	-0.00760	-46.2139
28	1959	OLS	ACTUAL	1	0.16284	-48.2384
29	1959	OLS	PREDICT	1	0.15614	-48.2384
30	1959	OLS	RESIDUAL	1	0.00669	-48.2384

31	1960	OLS	ACTUAL	1	0.83716	-42.2775
32	1960	OLS	PREDICT	1	0.86566	-42.2775
33	1960	OLS	RESIDUAL	1	-0.02849	-42.2775
34	1961	OLS	ACTUAL	1	0.23946	-47.1619
35	1961	OLS	PREDICT	1	0.26447	-47.1619
36	1961	OLS	RESIDUAL	1	-0.02500	-47.1619
37	1962	OLS	ACTUAL	1	0.74521	-43.3861
38	1962	OLS	PREDICT	1	0.76259	-43.3861
39	1962	OLS	RESIDUAL	1	-0.01738	-43.3861
40	1963	OLS	ACTUAL	1	0.82184	-42.5588
41	1963	OLS	PREDICT	1	0.84306	-42.5588
42	1963	OLS	RESIDUAL	1	-0.02122	-42.5588
43	1964	OLS	ACTUAL	1	0.53065	-45.1940
44	1964	OLS	PREDICT	1	0.52842	-45.1940
45	1964	OLS	RESIDUAL	1	0.00223	-45.1940
46	1965	OLS	ACTUAL	1	0.63793	-44.7682
47	1965	OLS	PREDICT	1	0.58828	-44.7682
48	1965	OLS	RESIDUAL	1	0.04966	-44.7682
49	1966	OLS	ACTUAL	1	0.36207	-46.6790
50	1966	OLS	PREDICT	1	0.32347	-46.6790
51	1966	OLS	RESIDUAL	1	0.03860	-46.6790
52	1967	OLS	ACTUAL	1	0.92912	-40.7181
53	1967	OLS	PREDICT	1	0.95049	-40.7181
54	1967	OLS	RESIDUAL	1	-0.02137	-40.7181
55	1968	OLS	ACTUAL	1	0.94444	-40.6115
56	1968	OLS	PREDICT	1	0.95414	-40.6115
57	1968	OLS	RESIDUAL	1	-0.00970	-40.6115
58	1969	OLS	ACTUAL	1	0.60728	-44.8150
59	1969	OLS	PREDICT	1	0.58178	-44.8150
60	1969	OLS	RESIDUAL	1	0.02550	-44.8150
61	1970	OLS	ACTUAL	1	0.31609	-46.8110
62	1970	OLS	PREDICT	1	0.30680	-46.8110
63	1970	OLS	RESIDUAL	1	0.00930	-46.8110

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

OBS	YEAR	_ESTYPE_	_TYPE_	_WEIGHT_	PRMXTYR	MXTYR
64	1971	OLS	ACTUAL	1	0.79119	-42.9710
65	1971	OLS	PREDICT	1	0.80555	-42.9710
66	1971	OLS	RESIDUAL	1	-0.01436	-42.9710
67	1972	OLS	ACTUAL	1	0.88314	-41.4058
68	1972	OLS	PREDICT	1	0.92090	-41.4058
69	1972	OLS	RESIDUAL	1	-0.03776	-41.4058
70	1973	OLS	ACTUAL	1	0.56130	-45.0304
71	1973	OLS	PREDICT	1	0.55158	-45.0304
72	1973	OLS	RESIDUAL	1	0.00973	-45.0304
73	1974	OLS	ACTUAL	1	0.80651	-42.9402
74	1974	OLS	PREDICT	1	0.80853	-42.9402
75	1974	OLS	RESIDUAL	1	-0.00202	-42.9402
76	1975	OLS	ACTUAL	1	0.66858	-44.6228
77	1975	OLS	PREDICT	1	0.60832	-44.6228
78	1975	OLS	RESIDUAL	1	0.06026	-44.6228
79	1976	OLS	ACTUAL	1	0.62261	-44.8080
80	1976	OLS	PREDICT	1	0.58275	-44.8080
81	1976	OLS	RESIDUAL	1	0.03986	-44.8080
82	1977	OLS	ACTUAL	1	0.14751	-48.2869
83	1977	OLS	PREDICT	1	0.15208	-48.2869
84	1977	OLS	RESIDUAL	1	-0.00457	-48.2869
85	1978	OLS	ACTUAL	1	0.85249	-41.6116
86	1978	OLS	PREDICT	1	0.90978	-41.6116
87	1978	OLS	RESIDUAL	1	-0.05729	-41.6116
88	1979	OLS	ACTUAL	1	0.89847	-41.3705
89	1979	OLS	PREDICT	1	0.92270	-41.3705
90	1979	OLS	RESIDUAL	1	-0.02423	-41.3705
91	1980	OLS	ACTUAL	1	0.00958	-50.3421
92	1980	OLS	PREDICT	1	0.04062	-50.3421
93	1980	OLS	RESIDUAL	1	-0.03104	-50.3421

94	1981	OLS	ACTUAL	1	0.04023	-49.3286
95	1981	OLS	PREDICT	1	0.08187	-49.3286
96	1981	OLS	RESIDUAL	1	-0.04164	-49.3286
97	1982	OLS	ACTUAL	1	0.50000	-45.3299
98	1982	OLS	PREDICT	1	0.50910	-45.3299
99	1982	OLS	RESIDUAL	1	-0.00910	-45.3299
100	1983	OLS	ACTUAL	1	0.10153	-48.6608
101	1983	OLS	PREDICT	1	0.12323	-48.6608
102	1983	OLS	RESIDUAL	1	-0.02170	-48.6608
103	1984	OLS	ACTUAL	1	0.30077	-46.9065
104	1984	OLS	PREDICT	1	0.29498	-46.9065
105	1984	OLS	RESIDUAL	1	0.00578	-46.9065
106	1985	OLS	ACTUAL	1	0.54598	-45.0880
107	1985	OLS	PREDICT	1	0.54344	-45.0880
108	1985	OLS	RESIDUAL	1	0.00254	-45.0880
109	1986	OLS	ACTUAL	1	0.11686	-48.5674
110	1986	OLS	PREDICT	1	0.13004	-48.5674
111	1986	OLS	RESIDUAL	1	-0.01318	-48.5674
112	1987	OLS	ACTUAL	1	0.72989	-43.4247
113	1987	OLS	PREDICT	1	0.75834	-43.4247
114	1987	OLS	RESIDUAL	1	-0.02846	-43.4247
115	1988	OLS	ACTUAL	1	0.76054	-43.2531
116	1988	OLS	PREDICT	1	0.77690	-43.2531
117	1988	OLS	RESIDUAL	1	-0.01637	-43.2531
118	1989	OLS	ACTUAL	1	0.95977	-40.5753
119	1989	OLS	PREDICT	1	0.95533	-40.5753
120	1989	OLS	RESIDUAL	1	0.00444	-40.5753
121	1990	OLS	ACTUAL	1	0.99042	-38.9860
122	1990	OLS	PREDICT	1	0.98745	-38.9860
123	1990	OLS	RESIDUAL	1	0.00297	-38.9860
124	1991	OLS	ACTUAL	1	0.08621	-48.6837
125	1991	OLS	PREDICT	1	0.12160	-48.6837
126	1991	OLS	RESIDUAL	1	-0.03539	-48.6837

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

OBS	YEAR	_ESTYPE_	_TYPE_	_WEIGHT_	PRMXTYR	MXTYR
127	1992	OLS	ACTUAL	1	0.20881	-47.3049
128	1992	OLS	PREDICT	1	0.24814	-47.3049
129	1992	OLS	RESIDUAL	1	-0.03933	-47.3049
130	1993	OLS	ACTUAL	1	0.39272	-46.0713
131	1993	OLS	PREDICT	1	0.40455	-46.0713
132	1993	OLS	RESIDUAL	1	-0.01183	-46.0713
133	1994	OLS	ACTUAL	1	0.27011	-47.1397
134	1994	OLS	PREDICT	1	0.26706	-47.1397
135	1994	OLS	RESIDUAL	1	0.00306	-47.1397
136	1995	OLS	ACTUAL	1	0.02490	-49.8028
137	1995	OLS	PREDICT	1	0.05969	-49.8028
138	1995	OLS	RESIDUAL	1	-0.03479	-49.8028
139	1996	OLS	ACTUAL	1	0.57663	-44.9435
140	1996	OLS	PREDICT	1	0.56381	-44.9435
141	1996	OLS	RESIDUAL	1	0.01282	-44.9435
142	1997	OLS	ACTUAL	1	0.13218	-48.3957
143	1997	OLS	PREDICT	1	0.14325	-48.3957
144	1997	OLS	RESIDUAL	1	-0.01106	-48.3957
145	1998	OLS	ACTUAL	1	0.71456	-43.5946
146	1998	OLS	PREDICT	1	0.73914	-43.5946
147	1998	OLS	RESIDUAL	1	-0.02458	-43.5946
148	1999	OLS	ACTUAL	1	0.05556	-48.9896
149	1999	OLS	PREDICT	1	0.10130	-48.9896
150	1999	OLS	RESIDUAL	1	-0.04574	-48.9896
151	2000	OLS	ACTUAL	1	0.07088	-48.7706
152	2000	OLS	PREDICT	1	0.11555	-48.7706
153	2000	OLS	RESIDUAL	1	-0.04467	-48.7706
154	2001	OLS	ACTUAL	1	0.25479	-47.1614
155	2001	OLS	PREDICT	1	0.26453	-47.1614
156	2001	OLS	RESIDUAL	1	-0.00974	-47.1614

157	2002	OLS	ACTUAL	1	0.42337	-45.8154
158	2002	OLS	PREDICT	1	0.44025	-45.8154
159	2002	OLS	RESIDUAL	1	-0.01688	-45.8154
160	2003	OLS	ACTUAL	1	0.28544	-47.0515
161	2003	OLS	PREDICT	1	0.27745	-47.0515
162	2003	OLS	RESIDUAL	1	0.00799	-47.0515
163	2004	OLS	ACTUAL	1	0.17816	-48.1798
164	2004	OLS	PREDICT	1	0.16113	-48.1798
165	2004	OLS	RESIDUAL	1	0.01703	-48.1798
166	2005	OLS	ACTUAL	1	0.22414	-47.2514
167	2005	OLS	PREDICT	1	0.25418	-47.2514
168	2005	OLS	RESIDUAL	1	-0.03004	-47.2514
169	2006	OLS	ACTUAL	1	0.43870	-45.7981
170	2006	OLS	PREDICT	1	0.44268	-45.7981
171	2006	OLS	RESIDUAL	1	-0.00398	-45.7981
172	2007	OLS	ACTUAL	1	0.86782	-41.4814
173	2007	OLS	PREDICT	1	0.91695	-41.4814
174	2007	OLS	RESIDUAL	1	-0.04913	-41.4814
175	2008	OLS	ACTUAL	1	0.45402	-45.7917
176	2008	OLS	PREDICT	1	0.44359	-45.7917
177	2008	OLS	RESIDUAL	1	0.01044	-45.7917
178	2009	OLS	ACTUAL	1	0.51533	-45.2534
179	2009	OLS	PREDICT	1	0.51997	-45.2534
180	2009	OLS	RESIDUAL	1	-0.00465	-45.2534
181	2010	OLS	ACTUAL	1	0.65326	-44.6744
182	2010	OLS	PREDICT	1	0.60124	-44.6744
183	2010	OLS	RESIDUAL	1	0.05202	-44.6744
184	2011	OLS	ACTUAL	1	0.33142	-46.7442
185	2011	OLS	PREDICT	1	0.31519	-46.7442
186	2011	OLS	RESIDUAL	1	0.01623	-46.7442
187	2012	OLS	ACTUAL	1	0.34674	-46.7366
188	2012	OLS	PREDICT	1	0.31616	-46.7366
189	2012	OLS	RESIDUAL	1	0.03059	-46.7366

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

OBS	YEAR	_ESTYPE_	_TYPE_	_WEIGHT_	PRMXTYR	MXTYR
190	2013	OLS	ACTUAL	1	0.69923	-43.8579
191	2013	OLS	PREDICT	1	0.70787	-43.8579
192	2013	OLS	RESIDUAL	1	-0.00864	-43.8579
193	2014	OLS	ACTUAL	1	0.19349	-48.0273
194	2014	OLS	PREDICT	1	0.17464	-48.0273
195	2014	OLS	RESIDUAL	1	0.01885	-48.0273

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

OBS	YEAR	MXTYR	PRMXTYR	PROBP
1	1950	-40.8072	0.91379	0.94726
2	1951	-44.5430	0.68391	0.61920
3	1952	-43.0339	0.77586	0.79937
4	1953	-45.6564	0.48467	0.46269
5	1954	-45.6604	0.46935	0.46214
6	1955	-45.8387	0.40805	0.43698
7	1956	-44.8782	0.59195	0.57295
8	1957	-39.4936	0.97510	0.98071
9	1958	-46.2139	0.37739	0.38499
10	1959	-48.2384	0.16284	0.15614
11	1960	-42.2775	0.83716	0.86566
12	1961	-47.1619	0.23946	0.26447
13	1962	-43.3861	0.74521	0.76259
14	1963	-42.5588	0.82184	0.84306
15	1964	-45.1940	0.53065	0.52842
16	1965	-44.7682	0.63793	0.58828
17	1966	-46.6790	0.36207	0.32347
18	1967	-40.7181	0.92912	0.95049
19	1968	-40.6115	0.94444	0.95414
20	1969	-44.8150	0.60728	0.58178
21	1970	-46.8110	0.31609	0.30680
22	1971	-42.9710	0.79119	0.80555
23	1972	-41.4058	0.88314	0.92090
24	1973	-45.0304	0.56130	0.55158
25	1974	-42.9402	0.80651	0.80853
26	1975	-44.6228	0.66858	0.60832
27	1976	-44.8080	0.62261	0.58275
28	1977	-48.2869	0.14751	0.15208
29	1978	-41.6116	0.85249	0.90978
30	1979	-41.3705	0.89847	0.92270

31	1980	-50.3421	0.00958	0.04062
32	1981	-49.3286	0.04023	0.08187
33	1982	-45.3299	0.50000	0.50910
34	1983	-48.6608	0.10153	0.12323
35	1984	-46.9065	0.30077	0.29498
36	1985	-45.0880	0.54598	0.54344
37	1986	-48.5674	0.11686	0.13004
38	1987	-43.4247	0.72989	0.75834
39	1988	-43.2531	0.76054	0.77690
40	1989	-40.5753	0.95977	0.95533
41	1990	-38.9860	0.99042	0.98745
42	1991	-48.6837	0.08621	0.12160
43	1992	-47.3049	0.20881	0.24814
44	1993	-46.0713	0.39272	0.40455
45	1994	-47.1397	0.27011	0.26706
46	1995	-49.8028	0.02490	0.05969
47	1996	-44.9435	0.57663	0.56381
48	1997	-48.3957	0.13218	0.14325
49	1998	-43.5946	0.71456	0.73914
50	1999	-48.9896	0.05556	0.10130
51	2000	-48.7706	0.07088	0.11555
52	2001	-47.1614	0.25479	0.26453
53	2002	-45.8154	0.42337	0.44025
54	2003	-47.0515	0.28544	0.27745
55	2004	-48.1798	0.17816	0.16113
56	2005	-47.2514	0.22414	0.25418
57	2006	-45.7981	0.43870	0.44268
58	2007	-41.4814	0.86782	0.91695
59	2008	-45.7917	0.45402	0.44359
60	2009	-45.2534	0.51533	0.51997
61	2010	-44.6744	0.65326	0.60124
62	2011	-46.7442	0.33142	0.31519
63	2012	-46.7366	0.34674	0.31616

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

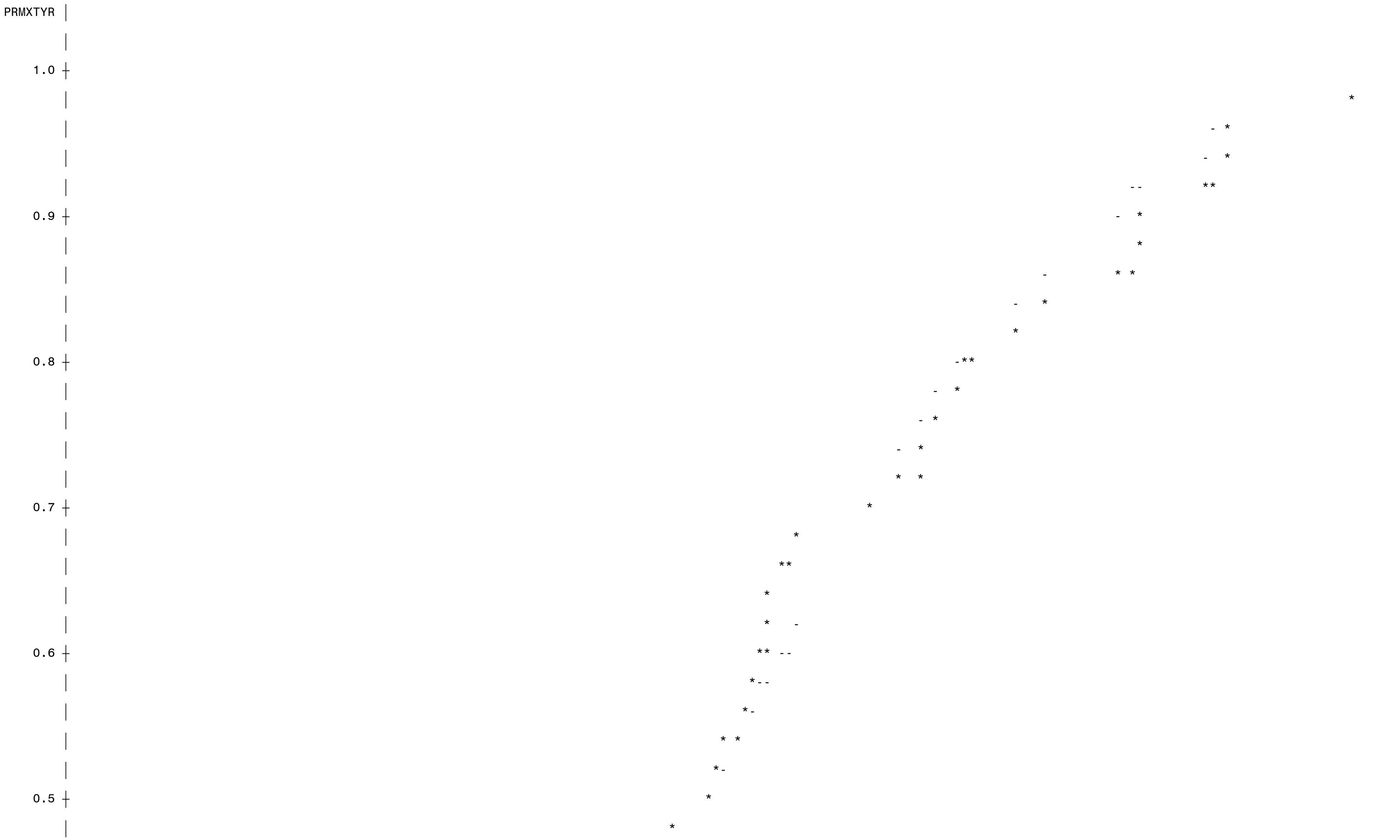
OBS	YEAR	MXTYR	PRMXTYR	PROBP
64	2013	-43.8579	0.69923	0.70787
65	2014	-48.0273	0.19349	0.17464

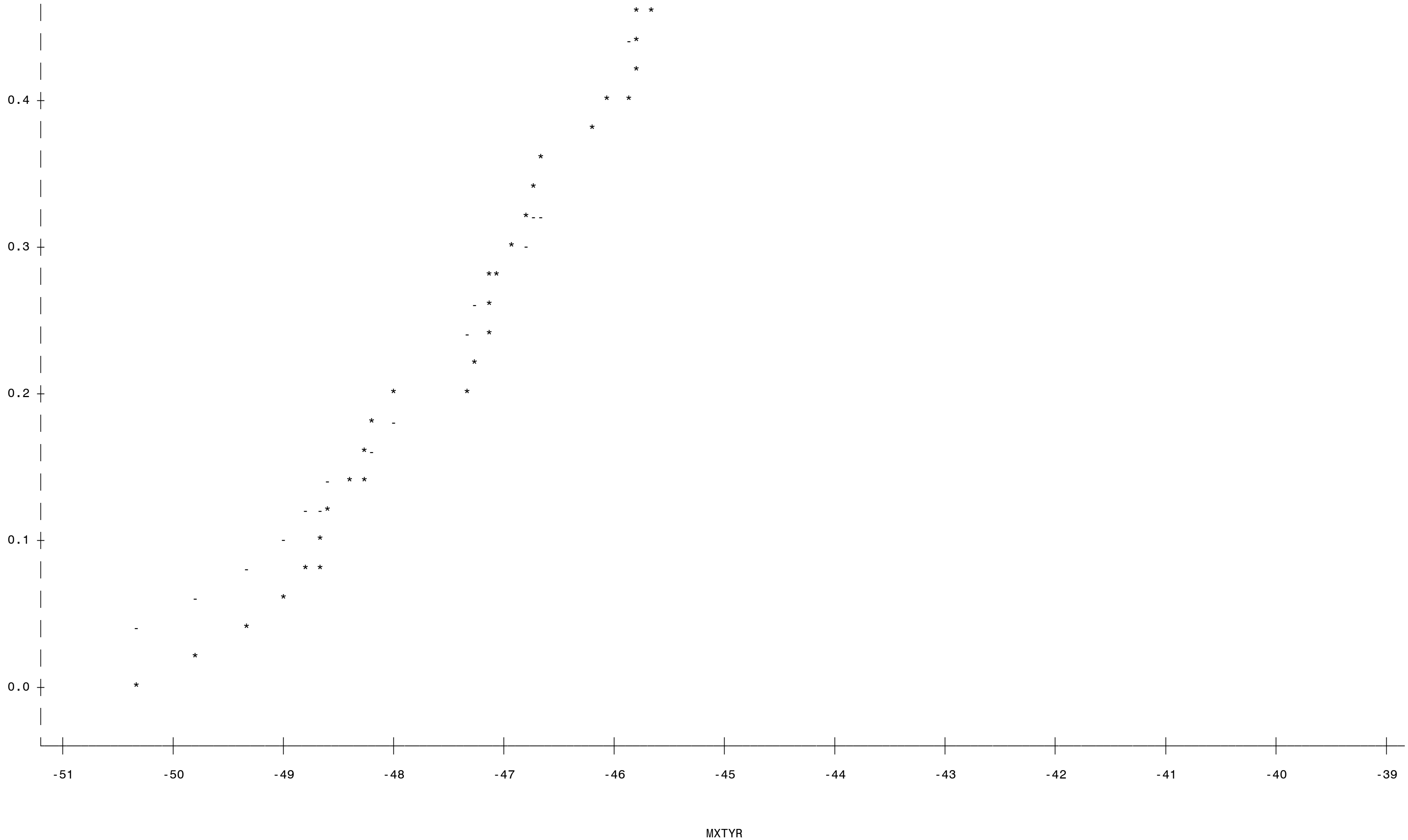
Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

Plot of PRMXTYR*MXTYR. Symbol used is '*'.

Plot of PROBP*MXTYR. Symbol used is '-'.





NOTE: 32 obs hidden.

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

OBS	_NAME_	_TYPE_	_NUSED_	GAMMA	THETA
1		OLS	65	-45.3938	2.79254
2	GAMMA	OLS	65	0.0010	0.00017
3	THETA	OLS	65	0.0002	0.00307

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Est'd CDFs and Logarithms of 'Empirical CDF rel. to Fitted CDF' values by Models.

OBS	YEAR	MXTYR	QUANTILE	PRMXTYR	PROBP1	LGPRRAT1
1	1950	-40.8072	3	0.91379	0.94726	-0.03597
2	1951	-44.5430	3	0.68391	0.61920	0.09940
3	1952	-43.0339	3	0.77586	0.79937	-0.02985
4	1953	-45.6564	2	0.48467	0.46269	0.04642
5	1954	-45.6604	2	0.46935	0.46214	0.01549
6	1955	-45.8387	2	0.40805	0.43698	-0.06850
7	1956	-44.8782	2	0.59195	0.57295	0.03263
8	1957	-39.4936	3	0.97510	0.98071	-0.00574
9	1958	-46.2139	2	0.37739	0.38499	-0.01993
10	1959	-48.2384	1	0.16284	0.15614	0.04198
11	1960	-42.2775	3	0.83716	0.86566	-0.03347
12	1961	-47.1619	1	0.23946	0.26447	-0.09931
13	1962	-43.3861	3	0.74521	0.76259	-0.02305
14	1963	-42.5588	3	0.82184	0.84306	-0.02550
15	1964	-45.1940	2	0.53065	0.52842	0.00422
16	1965	-44.7682	2	0.63793	0.58828	0.08103
17	1966	-46.6790	2	0.36207	0.32347	0.11273
18	1967	-40.7181	3	0.92912	0.95049	-0.02274
19	1968	-40.6115	3	0.94444	0.95414	-0.01022
20	1969	-44.8150	2	0.60728	0.58178	0.04290
21	1970	-46.8110	1	0.31609	0.30680	0.02985
22	1971	-42.9710	3	0.79119	0.80555	-0.01799
23	1972	-41.4058	3	0.88314	0.92090	-0.04187
24	1973	-45.0304	2	0.56130	0.55158	0.01748
25	1974	-42.9402	3	0.80651	0.80853	-0.00250
26	1975	-44.6228	3	0.66858	0.60832	0.09446
27	1976	-44.8080	2	0.62261	0.58275	0.06616
28	1977	-48.2869	1	0.14751	0.15208	-0.03051
29	1978	-41.6116	3	0.85249	0.90978	-0.06504
30	1979	-41.3705	3	0.89847	0.92270	-0.02661

31	1980	-50.3421	1	0.00958	0.04062	-1.44474
32	1981	-49.3286	1	0.04023	0.08187	-0.71053
33	1982	-45.3299	2	0.50000	0.50910	-0.01804
34	1983	-48.6608	1	0.10153	0.12323	-0.19367
35	1984	-46.9065	1	0.30077	0.29498	0.01942
36	1985	-45.0880	2	0.54598	0.54344	0.00466
37	1986	-48.5674	1	0.11686	0.13004	-0.10689
38	1987	-43.4247	3	0.72989	0.75834	-0.03825
39	1988	-43.2531	3	0.76054	0.77690	-0.02129
40	1989	-40.5753	3	0.95977	0.95533	0.00463
41	1990	-38.9860	3	0.99042	0.98745	0.00300
42	1991	-48.6837	1	0.08621	0.12160	-0.34395
43	1992	-47.3049	1	0.20881	0.24814	-0.17256
44	1993	-46.0713	2	0.39272	0.40455	-0.02968
45	1994	-47.1397	1	0.27011	0.26706	0.01138
46	1995	-49.8028	1	0.02490	0.05969	-0.87413
47	1996	-44.9435	2	0.57663	0.56381	0.02248
48	1997	-48.3957	1	0.13218	0.14325	-0.08039
49	1998	-43.5946	3	0.71456	0.73914	-0.03382
50	1999	-48.9896	1	0.05556	0.10130	-0.60066
51	2000	-48.7706	1	0.07088	0.11555	-0.48872
52	2001	-47.1614	1	0.25479	0.26453	-0.03752
53	2002	-45.8154	2	0.42337	0.44025	-0.03909
54	2003	-47.0515	1	0.28544	0.27745	0.02840
55	2004	-48.1798	1	0.17816	0.16113	0.10046
56	2005	-47.2514	1	0.22414	0.25418	-0.12577
57	2006	-45.7981	2	0.43870	0.44268	-0.00903
58	2007	-41.4814	3	0.86782	0.91695	-0.05507
59	2008	-45.7917	2	0.45402	0.44359	0.02326
60	2009	-45.2534	2	0.51533	0.51997	-0.00897
61	2010	-44.6744	2	0.65326	0.60124	0.08297
62	2011	-46.7442	1	0.33142	0.31519	0.05021
63	2012	-46.7366	2	0.34674	0.31616	0.09235

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Est'd CDFs and Logarithms of 'Empirical CDF rel. to Fitted CDF' values by Models.

OBS	YEAR	MXTYR	QUANTILE	PRMXTYR	PROBP1	LGPRRAT1
64	2013	-43.8579	3	0.69923	0.70787	-0.01228
65	2014	-48.0273	1	0.19349	0.17464	0.10249

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Stats for Logarithms of 'Empirical CDF rel. to Fitted CDF' values by Models to calc. RMSE of Prop. Model Spec

Analysis Variable : LGPRRAT1 Log(PrMxTYr/ProbP1)- T-Dist

N	Mean	Std Dev	Minimum	Maximum	Variance	USS
65	-0.0734366	0.2485858	-1.4447407	0.1127258	0.0617949	4.3054143

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Stats By Quantile for Logarithms of 'Empirical CDF rel. to Fitted CDF' values by Models to calc. RMSE of Prop. Model Spec

Analysis Variable : LGPRRAT1 Log(PrMxTYr/ProbP1)- T-Dist

QUANTILE=1

N	Mean	Std Dev	Minimum	Maximum	Variance	USS
22	-0.2238703	0.3849453	-1.4447407	0.1024932	0.1481829	4.2144349

QUANTILE=2

N	Mean	Std Dev	Minimum	Maximum	Variance	USS
21	0.0215011	0.0469216	-0.0685026	0.1127258	0.0022016	0.0537411

QUANTILE=3

N	Mean	Std Dev	Minimum	Maximum	Variance	USS
22	-0.0136253	0.0397337	-0.0650372	0.0993992	0.0015788	0.0372383

Southern California Gas Residential End-Use Model

I. Residential End-Use Model Description

Introduction:

SoCalGas used the End Use Forecaster model to generate annual gas demand forecasts for the residential market. The software's market segmentation and end-use modeling framework analyzes the impacts of competitive strategies (gas vs. electricity) and market scenarios on gas demand and market shares. The model separates the residential market into five building types (B-level).

These groups are identified by the premise code classification found in the company billing files. The five residential groups are:

- Single-Family(SF);
- Multi-Family <= 4 units (MF2);
- Multi-Family > 4 units (MF3);
- Master Metered (MM); and
- Sub-Metered (SM).

The residential model identifies eight end-uses (N-level) that are the primary drivers of natural gas demand:

- Space heating;
- Water heating;
- Cooking;
- Drying;
- Pool heating;
- Spa heating;
- Fireplace; and
- Barbeque.

The model assumes two fuel choices (F-level) for end-uses:

- Natural gas; and
- Electricity.

The model assumes up to four efficiency levels (E-level) for the various enduses. In general, the efficiency levels are:

- Stock;
- Standard;
- High efficiency; and
- Premium efficiency.

See Figure 1 for a classification of the number of efficiency levels for each end use by customer segment type.

A set of post-model adjustments were applied to the model's annual demand forecast. The first adjustment calibrates to the recorded 2014 weather-adjusted demand. Next, the annual forecast was parceled out to a series of monthly forecasts by a process which involves two steps. These two steps consist of (1) using the fitted equation for customer demand to generate a forecast of use per customer that varies with the number of calendar days and heating degree days in a given month and (2) calculating a series of weights based on the customer's predicted monthly usage share in total annual consumption. The shares obtained from the latter step were then applied to annual totals to derive the stream of monthly forecasts which are conditional on the particular weather design specification for the entire year. An adjustment to the forecast offsets the throughput by the energy efficiency savings. Annual conservation benefits associated with AMI are estimated by SoCalGas to represent 1% of the core gas throughput in the post deployment period which starts after 2016. During the deployment period of 2011-2016, 1/5 of 1% of the load will have been conserved due to AMI. After 2016, 1% of the load will have been conserved due to AMI energy savings. The residential load was reduced by the AMI expected energy savings.

Figures 2-5 illustrate the monthly forecasts for each weather scenario.

Data Sources:

The information used to perform the modeling and to generate the forecast includes historical 2014 consumption and customer counts; meter counts, growth, and decay; use per customer by vintage and unit energy consumption (UEC) values; fuel costs and price elasticity; equipment capital costs and availability; building and equipment lives and decay. The historical 2014 data is in Figure 6.

Meter Counts, Growth and Decay:

Regression equations were developed for each of the 5 building types. The meter count forecast is a company-specific forecast based on actual meter counts within the SoCalGas service territory. Data on meter decay rates were obtained from the Energy Information Administration (EIA). See Figure 7 for the meter forecast.

Use Per Customer by Vintage and UEC:

Use per customer and Unit Energy Consumption (UEC) data were based on company marketing data and the California Measurement Advisory Council. See Figure 8 for the appliance UEC's.

Fuel Costs and Price Elasticity:

Average and marginal gas prices ($/therm) were calculated from forecasts of the residential rate components. Residential rates have two consumption tiers. We used the simple average of the second tiers' projected monthly prices for each forecast year as the marginal rate. The marginal rate was used for each housing segment type.

For a given housing segment type, the average gas commodity rate was calculated using a pair of weights for the two consumption tiers applied to the simple average of each tier's monthly rate. The average commodity rate in each forecast year was developed using the same consumption tier weights, but with the forecasts of rates for each residential rate tier. The average gas price each year was then calculated by including the non-volumetric customer charges with the year's average gas commodity price. Figure 9 illustrates the gas price forecasts.

Electric Price Data:

The electricity price inputs consist of average prices (cents/kWh) and marginal prices (cents/kWh). The forecasts for the residential customer class were developed by SDG&E's electricity rate analysis group.

Figure 10 illustrates the electricity price forecasts.

Price elasticities for each building type were based on the SoCalGas Residential Econometric Demand Forecasting Model. See Figure 6 for price elasticities.

Equipment Capital Costs and Availability:

Data on equipment capital costs and availability were from EIA, the Residential Appliance Saturation Survey (RASS), Energy Star (EPA & DOE), and SoCalGas company data. See Figures 11 and 12 for gas and electric appliance equipment cost.

Building and Equipment Lives and Decay:

Building decay rates are based on the building shell lifetimes, where the lifetime is defined as the length of time it takes for either a demolition or a major renovation to occur. For single-family residential buildings, an exponential rate of decay of 0.3% per year was assumed. See Figure 13 for the building decay rates.
Data on equipment lives and decay rates are based on EIA, RASS, Energy Star, and SoCalGas company data. See Figure 14 for the average lifetimes of gas appliances.

Saturations, Fuel and Efficiency Shares:

Saturation values, fuel shares, and efficiency shares were extracted from SoCalGas company data files and the most recent the RASS survey. Please see Figures 15-18 for saturations, fuel, and efficiency shares.

AMI:
Mass deployment of AMI gas modules will began in 2011. The conservation benefits estimated by SoCalGas represent approximately 1% of core gas throughput in 2016 (post deployment year). The conservation benefits were incorporated in the forecast as a post-model adjustment.

II. Residential End-Use Model Data

Southern California Gas Company

Figure 1: Number of Efficiency Levels by End Use by Customer Segment

	Space Heating		Water Heating		Cooking		Drying		Pool		Spa		Fireplace		BBQ	
	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric
Single Family	4	1	4	4	2	2	2	4	2	0	2	0	1	1	1	1
Multi-Family 2-4 Units	4	1	4	4	2	2	2	4	0	0	0	0	0	0	1	1
Multi-Family > 4 Units	4	1	4	4	2	2	2	4	0	0	0	0	0	0	1	1
Master Meter	4	1	4	4	2	2	2	4	0	0	0	0	0	0	1	1
Sub-Meter	4	1	4	4	2	2	2	4	0	0	0	0	0	0	1	1

Southern California Gas Company
Figure 2: Average Temperature Year Demand Forecast

YEAR	MDTH1	MDTH2	MDTH3	MDTH4	MDTH5	MDTH6	MDTH7	MDTH8	MDTH9	MDTH10	MDTH11	MDTH12	TOTAL
2014	34,275	30,077	26,641	21,965	15,570	12,382	11,851	11,830	11,652	14,745	22,728	35,793	249,509
2015	34,064	29,891	26,477	21,829	15,474	12,306	11,778	11,757	11,580	14,654	22,588	35,572	247,971
2016	33,730	29,969	26,218	21,615	15,322	12,185	11,662	11,642	11,467	14,510	22,366	35,224	245,911
2017	33,632	29,512	26,141	21,552	15,278	12,150	11,628	11,608	11,434	14,468	22,301	35,121	244,825
2018	33,465	29,365	26,011	21,445	15,202	12,089	11,570	11,550	11,377	14,396	22,190	34,946	243,608
2019	33,260	29,186	25,852	21,314	15,109	12,015	11,499	11,479	11,307	14,308	22,054	34,732	242,115
2020	32,900	29,232	25,573	21,084	14,946	11,885	11,375	11,355	11,185	14,153	21,816	34,357	239,861

Southern California Gas Company
Figure 3: Cold Temperature Year Demand Forecast

YEAR	MDTH1	MDTH2	MDTH3	MDTH4	MDTH5	MDTH6	MDTH7	MDTH8	MDTH9	MDTH10	MDTH11	MDTH12	TOTAL
2014	39,177	34,313	29,887	24,278	16,415	12,617	11,888	11,863	11,729	15,410	25,206	41,023	273,807
2015	38,973	34,134	29,732	24,152	16,329	12,551	11,827	11,802	11,668	15,330	25,075	40,810	272,383
2016	38,655	34,227	29,489	23,955	16,196	12,449	11,730	11,705	11,573	15,205	24,871	40,477	270,532
2017	38,588	33,797	29,438	23,913	16,168	12,427	11,710	11,685	11,552	15,179	24,827	40,407	269,689
2018	38,451	33,677	29,334	23,828	16,111	12,383	11,668	11,644	11,512	15,125	24,740	40,264	268,736
2019	38,276	33,524	29,200	23,720	16,037	12,327	11,615	11,591	11,459	15,056	24,627	40,081	267,515
2020	37,940	33,595	28,944	23,512	15,897	12,219	11,513	11,489	11,359	14,924	24,411	39,729	265,531

Southern California Gas Company
Figure 4: Hot Temperature Year Demand Forecast

YEAR	MDTH1	MDTH2	MDTH3	MDTH4	MDTH5	MDTH6	MDTH7	MDTH8	MDTH9	MDTH10	MDTH11	MDTH12	TOTAL
2014	29,374	25,841	23,396	19,652	14,726	12,147	11,813	11,797	11,576	14,079	20,249	30,562	225,212
2015	29,158	25,651	23,224	19,507	14,617	12,058	11,726	11,710	11,491	13,976	20,101	30,338	223,558
2016	28,814	25,718	22,950	19,277	14,445	11,916	11,588	11,572	11,355	13,811	19,863	29,980	221,290
2017	28,689	25,239	22,850	19,194	14,382	11,864	11,537	11,522	11,306	13,751	19,777	29,850	219,961
2018	28,496	25,069	22,696	19,064	14,285	11,784	11,460	11,444	11,230	13,658	19,644	29,649	218,479
2019	28,266	24,866	22,513	18,910	14,170	11,689	11,367	11,352	11,139	13,548	19,485	29,410	216,716
2020	27,890	24,893	22,214	18,659	13,982	11,534	11,216	11,201	10,991	13,368	19,226	29,018	214,191

Southern California Gas Company
Figure 5: Base Temperature Year Demand Forecast

YEAR	MDTH1	MDTH2	MDTH3	MDTH4	MDTH5	MDTH6	MDTH7	MDTH8	MDTH9	MDTH10	MDTH11	MDTH12	TOTAL
2014	11,676	10,546	11,676	11,299	11,676	11,299	11,676	11,676	11,299	11,676	11,299	11,676	137,476
2015	11,500	10,387	11,500	11,129	11,500	11,129	11,500	11,500	11,129	11,500	11,129	11,500	135,407
2016	11,213	10,490	11,213	10,851	11,213	10,851	11,213	11,213	10,851	11,213	10,851	11,213	132,387
2017	11,056	9,986	11,056	10,700	11,056	10,700	11,056	11,056	10,700	11,056	10,700	11,056	130,179
2018	10,849	9,799	10,849	10,499	10,849	10,499	10,849	10,849	10,499	10,849	10,499	10,849	127,742
2019	10,616	9,589	10,616	10,274	10,616	10,274	10,616	10,616	10,274	10,616	10,274	10,616	125,000
2020	10,291	9,627	10,291	9,959	10,291	9,959	10,291	10,291	9,959	10,291	9,959	10,291	121,498

Southern California Gas Company
Figure 6: 2014 Historical Data

Segment	Total Therm Sales	Meter Count Pre-1979 customers	Meter Count 1979-2004 customers	Meter Count 2005-2014 customers
Single Family	1,393,249,598	2,408,225	1,251,653	13,959
Multi-Family 2-4 Units	153,296,957	406,595	136,609	2,215
Multi-Family > 4 Units	305,047,534	701,383	461,307	7,527
Master Meter	122,675,890	33,170	3,718	55
Sub-Meter	40,348,326	1,711	105	0

Segment	Use Per Customer (UPC, Therms) Pre-79 Customers	Use Per Customer (UPC, Therms) 1979-2004	Use Per Customer (UPC, Therms) 2005-2014
Single Family	381	377	301
Multi-Family 2-4 Units	286	267	235
Multi-Family > 4 Units	267	252	219
Master Meter	3,000	6,090	9,431
Sub-Meter	22,079	24,487	0

Segment	Price Elasticity
Single Family	-0.1053
Multi-Family 2-4 Units	-0.11171
Multi-Family > 4 Units	-0.07145
Master Meter	-0.0688
Sub-Meter	-0.1053

Southern California Gas Company
Figure 7: Meter Count Forecast

Year	Single Family	Multi-Family 2-4 Units	Multi-Family > 4 Units	Master Meter	Sub-Meter
2015	3,632,536	559,244	1,199,880	38,790	1,907
2016	3,645,823	563,189	1,208,344	38,790	1,907
2017	3,667,357	571,156	1,225,437	38,790	1,907
2018	3,689,926	581,281	1,247,160	38,790	1,907
2019	3,713,212	592,674	1,271,605	38,790	1,907
2020	3,737,197	604,302	1,296,553	38,790	1,907

* Note: Master meter and sub-meter groups are expected to decline.
A decay rate was built into the model specification.

Southern California Gas Company
Figure 8: Appliance Unit Energy Consumption (Gas in therms, Electric in Kwh)

		Single Family		Multi-Family 2 - 4 Units		Multi-Family > 4 Units		Master Meter		Sub Meter	
End-Use	**Vintage**	**Gas**	**Electric**	**Gas**	**Electric**	**Gas**	**Electric**	**Gas**	**Electric**	**Gas**	**Electric**
Space Heat	Stock	370	4,110	200	730	200	730	200	730	330	1,340
	Standard	330	3,730	180	670	180	-	180	-	300	-
	High	310	3,450	170	620	170	-	170	-	280	-
	Premium	280	3,170	150	570	150	-	150	-	260	-
Water Heat	Stock	260	2,440	230	2,440	230	2,440	230	2,440	210	2,010
	Standard	240	2,220	210	2,220	210	2,220	210	2,220	190	1,830
	High	230	2,110	200	2,110	200	2,110	200	2,110	180	1,740
	Premium	220	2,050	190	2,050	190	2,050	190	2,050	180	1,690
Cooking	Stock	50	574	34	465	34	465	34	465	45	514
	Standard	43	488	29	395	29	395	29	395	38	437
Drying	Stock	45	1,442	24	1,442	24	1,442	24	1,442	26	873
	Standard	43	1,370	23	1,370	23	1,370	23	1,370	25	830
Pool	Stock	177	3,431	177	3,431	177	3,431	177	3,431	177	3,431
Spa	Stock	146	430	146	430	146	430	146	430	146	430
Fireplace	Stock	21	-	21	-	21	-	21	-	21	-
BBQ	Stock	28	-	28	-	28	-	28	-	28	-

Southern California Gas Company
Figure 9: Average and Marginal Gas Prices ($/therm)

Year	Res Price Deflator	R SF Average Price	R SF Marginal Price	R MF2 Average Price	R MF2 Marginal Price	R MF3 Average Price	R MF3 Marginal Price	R MM Average Price	R MM Marginal Price	R SM Average Price	R SM Marginal Price
2014	100.0	1.1177	1.1494	1.1088	1.1494	1.0875	1.1494	1.0901	1.1494	1.1182	1.1494
2015	99.5	1.0176	1.0493	1.0087	1.0493	0.9874	1.0493	0.9900	1.0493	1.0181	1.0493
2016	101.8	1.0456	1.0774	1.0368	1.0774	1.0155	1.0774	1.0181	1.0774	1.0462	1.0774
2017	104.5	1.0456	1.0773	1.0368	1.0773	1.0155	1.0773	1.0181	1.0773	1.0461	1.0773
2018	107.2	1.0788	1.1105	1.0700	1.1105	1.0486	1.1105	1.0512	1.1105	1.0793	1.1105
2019	109.8	1.1337	1.1655	1.1249	1.1655	1.1036	1.1655	1.1062	1.1655	1.1343	1.1655
2020	112.6	1.2340	1.2658	1.2252	1.2658	1.2039	1.2658	1.2065	1.2658	1.2346	1.2658

Southern California Gas Company
Figure 10: Average and Marginal Electricity Prices ($/therm)

Year	R SF Average Price	R SF Marginal Price	R MF2 Average Price	R MF2 Marginal Price	R MF3 Average Price	R MF3 Marginal Price	R MM Average Price	R MM Marginal Price	R SM Average Price	R SM Marginal Price
2014	18.30	27.69	18.16	27.47	17.81	26.95	17.85	18.46	18.31	20.60
2015	18.43	27.88	18.27	27.64	17.88	27.06	17.93	18.54	18.43	20.75
2016	19.23	29.10	19.07	28.86	18.68	28.26	18.73	19.36	19.24	21.66
2017	19.92	30.15	19.76	29.89	19.35	29.28	19.40	20.06	19.93	22.43
2018	20.75	31.40	20.58	31.14	20.17	30.52	20.22	20.91	20.76	23.36
2019	21.53	32.59	21.37	32.33	20.96	31.72	21.01	21.73	21.54	24.25
2020	22.36	33.84	22.20	33.59	21.81	33.01	21.86	22.61	22.37	25.17

Southern California Gas Company
Figure 11: Gas Appliance Equipment Cost (Nominal $)

End-Use	Efficiency Level	Single Family	Multi-Family 2 - 4 Units	Multi-Family > 4 Units	Master Meter	Sub Meter
Space Heat	Stock	4,000	2,000	1,600	1,000	1,600
	Standard	4,600	2,300	1,840	1,150	1,840
	High	4,800	2,400	1,920	1,200	1,920
	Premium	5,000	2,500	1,980	1,250	1,980
Water Heat	Stock	550	330	330	330	330
	Standard	650	390	390	390	390
	High	700	420	420	420	420
	Premium	750	450	450	450	450
Cooking	Stock	500	300	250	250	250
	Standard	1,400	1,400	1,400	1,400	1,400
Drying	Stock	328	328	328	328	328
	Standard	482	482	482	482	482
Pool	Stock	1,200	1,200	1,200	1,200	1,200
Spa	Stock	2,000	2,000	2,000	2,000	2,000
Fireplace	Stock	150	150	150	150	150
BBQ	Stock	1,000	600	600	600	600

Southern California Gas Company
Figure 12: Electric Appliance Equipment Cost (Nominal $)

End-Use	Efficiency Level	Single Family	Multi-Family 2 - 4 Units	Multi-Family > 4 Units	Master Meter	Sub Meter
Space Heat	Stock	4,100	2,050	1,640	1,025	1,640
Water Heat	Stock	550	330	330	330	330
	Standard	650	390	390	390	390
	High	700	420	420	420	420
	Premium	750	450	450	450	450
Cooking	Stock	500	300	250	250	250
	Standard	1,400	1,400	1,400	1,400	1,400
Drying	Stock	328	328	328	328	328
	Standard	482	482	482	482	482
Pool	Stock	1,200	1,200	1,200	1,200	1,200
Spa	Stock	2,000	2,000	2,000	2,000	2,000
Fireplace	Stock	150	150	150	150	150
BBQ	Stock	1,000	600	600	600	600

Southern California Gas Company
Figure 13: Building Lives and Decay Rate

Building Type	Building decay Rate
Single Family	0.003
Multi-Family 2-4 Units	0.006
Multi-Family > 4 Units	0.006
Master Meter	0.008
Sub-Meter	0.008

Southern California Gas Company
Figure 14: Gas Appliance Age (Years)

		Single Family		Multi-Family 2 - 4 Units		Multi-Family > 4 Units		Master Meter		Sub Meter	
End-Use	Vintage	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max
Space Heat	Pre-1979	17	17	15	15	15	15	16	16	16	16
	1979-2004	10	17	12	15	11	15	11	16	11	16
	2005-2014	3	17	4	15	4	15	4	16	4	16
Water Heat	Pre-1979	7	7	7	8	6	8	6	8	6	8
	1979-2004	7	7	8	8	8	8	8	8	8	8
	2005-2014	3	7	2	8	4	8	4	8	4	8
Cooking	Pre-1979	10	12	10	10	10	11	14	14	14	14
	1979-2004	10	12	9	10	11	11	11	14	11	14
	2005-2014	2	12	2	10	4	11	3	14	3	14
Drying	Pre-1979	8	8	7	9	6	8	8	8	8	8
	1979-2004	8	8	9	9	8	8	8	8	8	8
	2005-2014	6	8	3	9	3	8	4	8	4	8
Pool	Pre-1979	13	13	13	13	13	13	13	13	13	13
	1979-2004	9	13	9	13	9	13	9	13	9	13
	2005-2014	3	13	3	13	3	13	3	13	3	13
Spa	Pre-1979	11	11	11	11	11	11	11	11	11	11
	1979-2004	8	11	8	11	8	11	8	11	8	11
	2005-2014	3	11	3	11	3	11	3	11	3	11
Fireplace	Pre-1979	15	15	15	15	15	15	15	15	15	15
	1979-2004	15	15	15	15	15	15	15	15	15	15
	2005-2014	15	15	15	15	15	15	15	15	15	15
BBQ	Pre-1979	7	7	5	6	5	5	5	9	5	9
	1979-2004	7	7	6	6	5	5	9	9	9	9
	2005-2014	5	7	3	6	5	5	2	9	2	9
Other	Pre-1979	15	15	15	15	15	15	15	15	15	15
	1979-2004	15	15	15	15	15	15	15	15	15	15
	2005-2014	15	15	15	15	15	15	15	15	15	15

Southern California Gas Company
Figure 15: End Use Saturations

End-Use	Vintage	Single Family	Multi-Family 2 - 4 Units	Multi-Family > 4 Units	Master Meter	Sub Meter
Space Heat	Pre-1979	0.9847	0.9672	0.9178	0.7296	0.8173
	1979-2004	0.9915	0.9668	0.9424	0.7803	0.8853
	2005-2014	0.9985	0.9691	0.8323	0.8271	N/A
Water Heat	Pre-1979	0.9753	0.9064	0.6048	0.9658	0.9835
	1979-2004	0.9831	0.8911	0.6488	0.9935	1.0000
	2005-2014	0.9612	0.8758	0.7649	0.9082	N/A
Cooking	Pre-1979	0.8089	0.7929	0.8623	0.5657	0.8728
	1979-2004	0.8606	0.8016	0.7910	0.4696	0.8660
	2005-2014	0.9465	0.8665	0.8996	0.3434	N/A
Drying	Pre-1979	0.6816	0.4894	0.1177	0.1616	0.4546
	1979-2004	0.7246	0.4940	0.2484	0.0726	0.4868
	2005-2014	0.7640	0.5434	0.4821	0.1922	N/A
Pool	Pre-1979	0.0664	0.0521	0.1045	0.1179	0.1179
	1979-2004	0.1090	0.1308	0.1941	0.0053	0.0053
	2005-2014	0.0911	0.1308	0.1941	0.0053	N/A
Spa	Pre-1979	0.0690	0.0526	0.0668	0.1329	0.1329
	1979-2004	0.1486	0.1923	0.2896	0.2012	0.2012
	2005-2014	0.1199	0.1923	0.2896	0.2012	N/A
Fireplace	Pre-1979	0.1193	0.2634	0.1519	0.1894	0.1894
	1979-2004	0.1663	0.6261	0.4775	0.4156	0.4156
	2005-2014	0.2179	0.6261	0.4775	0.4156	N/A
BBQ	Pre-1979	0.1286	0.2630	0.0760	0.1875	0.0554
	1979-2004	0.2416	0.4739	0.0797	0.0797	0.1532
	2005-2014	0.3044	0.4405	0.1759	0.1759	N/A

Southern California Gas Company
Figure 16: Gas Fuel Shares (average)

End-Use	Single Family	Multi-Family 2 - 4 Units	Multi-Family > 4 Units	Master Meter	Sub Meter
Space Heat	0.9573	0.9399	0.8249	0.9610	0.9610
Water Heat	0.9876	0.9803	0.9627	0.9614	0.9614
Cooking	0.8075	0.8183	0.8151	0.8744	0.8744
Drying	0.7924	0.7416	0.7445	0.7190	0.5657
Pool	0.8247	0.8247	0.8247	0.8247	0.8247
Spa	0.5819	0.5819	0.5819	0.5819	0.5819
Fireplace	0.5816	0.5816	0.5816	0.5816	0.5816
BBQ	0.2759	0.2663	0.2978	0.1251	0.0364

Southern California Gas Company
Figure 17: Gas Efficiency Shares

Gas End-Use	Efficiency Level	Single Family Existing	Single Family New	Multi-Family 2 - 4 Units Existing	Multi-Family 2 - 4 Units New	Multi-Family > 4 Units Existing	Multi-Family > 4 Units New	Master Meter Existing	Master Meter New	Sub Meter Existing	Sub Meter New
Space Heat	Stock	0.59	0.59	0.70	0.70	0.50	0.50	0.50	0.50	0.59	0.59
	Standard	0.34	0.34	0.28	0.28	0.48	0.48	0.48	0.48	0.34	0.34
	High	0.06	0.06	0.01	0.01	0.01	0.01	0.01	0.01	0.06	0.06
	Premium	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Water Heat	Stock	0.10	0.10	0.22	0.22	0.13	0.13	0.13	0.13	0.10	0.10
	Standard	0.68	0.68	0.61	0.61	0.76	0.76	0.76	0.76	0.68	0.68
	High	0.21	0.21	0.16	0.16	0.10	0.10	0.10	0.10	0.21	0.21
	Premium	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cooking	Stock	0.90	0.90	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	Standard	0.10	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Drying	Stock	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	Standard	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Pool	Stock	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Spa	Stock	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fireplace	Stock	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
BBQ	Stock	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Southern California Gas Company
Figure 18: Electric Efficiency Shares

Electric End-Use	Efficiency Level	Single Family Existing	Single Family New	Multi-Family 2 - 4 Units Existing	Multi-Family 2 - 4 Units New	Multi-Family > 4 Units Existing	Multi-Family > 4 Units New	Master Meter Existing	Master Meter New	Sub Meter Existing	Sub Meter New
Space Heat	Stock	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Water Heat	Stock	0.10	0.10	0.22	0.22	0.13	0.13	0.13	0.13	0.10	0.10
	Standard	0.68	0.68	0.61	0.61	0.76	0.76	0.76	0.76	0.68	0.68
	High	0.21	0.21	0.16	0.16	0.10	0.10	0.10	0.10	0.21	0.21
	Premium	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cooking	Stock	0.90	0.90	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	Standard	0.10	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Drying	Stock	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	Standard	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Pool	Stock	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Spa	Stock	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fireplace	Stock	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
BBQ	Stock	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

III. Energy Efficiency

Southern California Gas Company
Energy Efficiency

	Reported 2006 Therms	Reported 2007 Therms	Reported 2008 Therms	Reported 2009 Therms	Reported 2010 Therms	Reported 2011 Therms	Reported 2012 Therms	Reported 2013	Reported 2014	Forecast 2015	Forecast 2016	Forecast 2017	Forecast 2018	Forecast 2019	Forecast 2020
SoCalGas EE Program TOTAL (Recorded)	**11,062,485**	**29,194,539**	**27,113,756**	**24,591,452**	**27,413,193**	**37,233,416**	**32,077,678**	**25,817,960**	**28,856,008**						
PUC Goal	**14,700,000**	**19,300,000**	**23,300,000**	**27,200,000**	**28,000,000**	**30,000,000**	**32,000,000**	24,120,000	23,190,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000
Difference	**(3,637,515)**	**9,894,539**	**3,813,756**	**(2,608,548)**	**(586,807)**	**7,233,416**	**77,678**	**1,697,960**	**5,666,008**						
					98%	**124%**	**100%**	**107%**	**124%**						

SoCalGas	2006 therms	2007 therms	2008 therms	2009 therms	2010 therms	2011 therms	2012 therms	2013 therms	2014 therms	2015 therms
Core Residential	2,185,663	3,300,334	2,294,755	6,334,588	9,072,268	12,564,473	8,445,190	8,173,595	7,371,223	7,551,112
Core Commercial	3,609,253	10,528,400	10,091,230	7,423,112	7,457,290	10,030,218	9,608,803	2,380,370	4,093,890	4,789,493
Core Industrial	1,097,965	3,202,828	3,069,837	2,258,173	2,268,570	3,051,276	2,923,078	2,803,233	2,457,183	3,166,066
NonCore Commercial	515,069	1,502,486	1,440,098	1,059,337	1,064,214	1,431,391	1,371,252	293,874	2,168,951	1,578,427
NonCore Industrial retail	1,201,827	3,505,800	3,360,229	2,471,785	2,483,166	3,339,913	3,199,588	4,184,881	6,592,493	5,799,216
NonCore Industrial refinery	2,452,708	7,154,691	6,857,607	5,044,458	5,067,684	6,816,146	6,529,768	7,982,006	6,172,268	7,603,545
Total	**11,062,485**	**29,194,539**	**27,113,756**	**24,591,452**	**27,413,193**	**37,233,416**	**32,077,678**	**25,817,960**	**28,856,008**	**30,487,860**

Proportionally scale it down or up to match PUC Goals for 2010 - 2014

ANNUAL NET SAVINGS	2006 Mdth	2007 Mdth	2008 Mdth	2009 Mdth	2010 Mdth	2011 Mdth	2012 Mdth	2013 Mdth	2014 Mdth	2015 Mdth	2016 Mdth	2017 Mdth	2018 Mdth	2019 Mdth	2020 Mdth
Core Residential	219	330	229	633	927	1,012	842	764	592	755	755	755	755	755	755
Core Commercial	361	1,053	1,009	742	762	808	959	222	329	479	479	479	479	479	479
Core Industrial	110	320	307	226	232	246	292	262	197	317	317	317	317	317	317
NonCore Commercial	52	150	144	106	109	115	137	27	174	158	158	158	158	158	158
NonCore Industrial retail	120	351	336	247	254	269	319	391	530	580	580	580	580	580	580
NonCore Industrial refinery	245	715	686	504	518	549	651	746	496	760	760	760	760	760	760
Total	**1,106**	**2,919**	**2,711**	**2,459**	**2,800**	**3,000**	**3,200**	**2,412**	**2,319**	**3,049**	**3,049**	**3,049**	**3,049**	**3,049**	**3,049**

Cumulative Savings Mdth	2012 Mdth	2013 Mdth	2014 Mdth	2015 Mdth	2016 Mdth	2017 Mdth	2018 Mdth	2019 Mdth	2020 Mdth
Core Residential				755	1,510	2,265	3,020	3,776	4,531
Core Commercial				479	958	1,437	1,916	2,395	2,874
Core Industrial				317	633	950	1,266	1,583	1,900
NonCore Commercial				158	316	474	631	789	947
NonCore Industrial regular				580	1,160	1,740	2,320	2,900	3,480
NonCore Industrial refinery				760	1,521	2,281	3,041	3,802	4,562
Total Load Impacts				**3,049**	**6,098**	**9,146**	**12,195**	**15,244**	**18,293**

MMCF factor **1.0266**

Cumulative Savings MMCF	2012 mmcf	2013 mmcf	2014 mmcf	2015 mmcf	2016 mmcf	2017 mmcf	2018 mmcf	2019 mmcf	2020 mmcf
Core Residential	-		-	736	1,471	2,207	2,942	3,678	4,413
Core Commercial	-		-	467	933	1,400	1,866	2,333	2,799
Core Industrial	-		-	308	617	925	1,234	1,542	1,850
NonCore Commercial	-		-	154	308	461	615	769	923
NonCore Industrial regular	-		-	565	1,130	1,695	2,260	2,824	3,389
NonCore Industrial refinery	-		-	741	1,481	2,222	2,963	3,703	4,444
Total Cumulative Load	**-**		**-**	**2,970**	**5,940**	**8,909**	**11,879**	**14,849**	**17,819**
Forecast Year ====>				1	2	3	4	5	6

NOTES:

Weather for SDG&E: Heating Degree Days – Average and Cold Year Designs; and Winter Peak Day Design Temperatures

July 2015

I. Overview

San Diego Gas and Electric Company's service area for natural gas extends from southern Orange County throughout San Diego County to the Mexican border. To quantify the overall temperature experienced within this region, SDGandE aggregates daily temperature recordings from three U.S. Weather Bureau weather stations into one system average heating degree-day ("HDD") figure. The table below lists weather station locations along with its associated temperature zone(s).

Table 1

Representative Weather Stations with Temperature Zones

Station Location	**Weight**	**Temperature Zone**
1. El Cajon[1]	1/3	Coastal and Inland
2. San Diego's Lindberg Field	(1/3) x (#Coastal/(#Coastal + #Inland))	Coastal
3. Miramar Naval Air Station	1/3 x (#Inland/(#Coastal + #Inland))	Inland

SDGandE uses 65° Fahrenheit to calculate the number of HDDs. One heating degree-day is accumulated for each degree that the daily average is *below* 65° Fahrenheit. To arrive at the system average HDDs figure for its entire service area, SDGandE weights the HDD figure for each zone using the weights[2] shown in Table 1. These weights are used in calculating the data shown from January 1995 to December 2014.

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[1] It turns out that the location of the station for El Cajon is at the boundary of the Coastal and Inland zones. Therefore, El Cajon is use to represent the entire combined Coastal and Inland zones.

[2] As of December 2014, there were 469,087 gas customers associated with the Coastal temperature zone and 398,037 gas customers associated with the Inland temperature zone. The following URL shows a map of the SDG&E service area and temperature zones: http://www.sdge.com/tm2/pdf/ELEC_MAPS_Maps_-_Elec.pdf ; less than 0.04% of SDG&E's gas customers were in the mountain and desert zones.

Daily maximum and minimum temperatures, for each individual weather station in the table above, are compiled from National Weather Service data. The web-site:

http://www.wrh.noaa.gov/sgx/obs/rtp/rtpmap.php?wfo=sgx

provides easy access to temperature data for San Diego and parts of surrounding counties. For each station, the average temperature is computed as the (maximum + minimum)/2 and this value is used to compute the heating degrees (i.e., the *daily* HDD) for each station as well. System average values of HDD are then computed using the weights for each respective station. Annual and monthly HDDs for the entire SDGandE service area from 1995 to 2014 are listed in Table 2, below.

Table 2

Calendar Month Heating Degree-Days (Jan. 1995 through Dec. 2014)

	Month												Total
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**"Cal-Year"**
1995	264	117	163	127	107	23	0	0	0	7	44	221	1073
1996	235	189	175	73	18	3	0	0	1	73	142	243	1152
1997	255	249	145	102	2	2	0	0	0	16	94	287	1153
1998	252	256	205	195	94	22	1	0	5	31	172	338	1571
1999	276	266	279	223	115	51	3	0	4	4	146	243	1610
2000	247	216	224	94	28	3	0	0	0	50	237	227	1327
2001	352	298	199	198	30	5	0	0	0	9	127	325	1543
2002	315	225	247	158	91	13	0	0	2	54	81	294	1479
2003	141	201	179	184	95	32	0	0	0	7	157	275	1270
2004	273	269	98	65	14	4	1	0	0	52	200	265	1241
2005	244	197	159	118	33	5	0	0	4	38	95	231	1122
2006	275	204	305	144	33	0	0	0	1	35	88	287	1372
2007	365	225	155	139	64	20	0	0	4	28	112	340	1451
2008	331	278	187	131	89	16	0	0	0	13	59	287	1391
2009	177	247	202	141	30	11	0	0	0	41	124	291	1262
2010	240	212	195	178	88	24	10	1	2	31	181	238	1402
2011	220	277	196	96	75	20	0	0	0	25	172	340	1422
2012	232	239	230	129	37	13	0	0	0	16	102	268	1267
2013	323	269	150	104	23	6	0	0	0	40	104	241	1262
2014	158	140	80	78	20	1	0	0	0	0	44	170	691
20-Yr-Avg (Jan1995-Dec2014)													
Avg.	**258.7**	**228.8**	**188.6**	**133.9**	**54.2**	**13.7**	**0.8**	**0.1**	**1.1**	**28.4**	**124.0**	**270.6**	**1302.9**
St.Dev.[3]	**55.2**	**41.3**	**48.0**	**42.6**	**36.1**	**12.7**	**2.4**	**0.2**	**1.6**	**18.5**	**60.1**	**38.8**	**153.916**
Min.	**141.4**	**116.6**	**80.2**	**65.5**	**2.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**44.2**	**170.3**	**691.2**
Max.	**364.6**	**298.2**	**304.9**	**222.7**	**115.4**	**51.1**	**10.2**	**1.1**	**4.7**	**73.0**	**237.0**	**340.0**	**1610.2**

[3] **Standard Deviation calculated from data for Jan 1994 – Dec 2013.**

II. Calculations to Define Our Average-Temperature Year

The simple average of the 20-year period (January 1995 through December 2014) was used to represent the Average Year total and the individual monthly values for HDD. The standard deviation of these 20 years of annual HDDs was used to design the two Cold Years based on a "1-in-10" and "1-in-35" chance, ***c***, that the respective annual "Cold Year" $\boldsymbol{hdd_c}$ value would be exceeded.

Our model for the annual HDD data is essentially a regression model where the only "explanatory" variable is the constant term. For example, the annual HDDs are modeled by the equation below:

$HDD_y = \beta_0 + e_y$; where β_0 represents the mean and the e_y is an error term.

It turns out (e.g., see *Econometrics*, Wonnacott and Wonnacott, 1970, Wiley & Sons, Inc., 1970, p. 254) that the average of the annual HDD_y estimates β_0 and that the standard deviation of these HDDs about the mean, β_0, estimates the standard deviation, s_e, of the error term, e_y. Further, a probability model for the annual HDD is based on a T-Distribution with N-1 degrees of freedom, where, N is the number of years of HDD data we use:

$U = (HDD_y - \beta_0)/s_e$, has a T-Distribution with N-1 degrees of freedom.

III. Calculating the Cold-Temperature Year Weather Designs

<u>Cold Year HDD Weather Designs</u>

For SDGandE, cold-temperature-year HDD weather designs are developed with a 1-in-35 year chance of occurrence. In terms of probabilities this can be expressed as the following for a "1-in-35" cold-year HDD value in equation 1 and a "1-in-10" cold-year HDD value in equation 2, with Annual HDD as the random variable:

(1) Prob { Annual HDD > "1-in-35" Cold-Yr HDD } = 1/35 = 0.0286

(2) Prob { Annual HDD > "1-in-10" Cold-Yr HDD } = 1/10 = 0.1000

An area of 0.0286 under one tail of the T-Distribution translates to 2.025 standard deviations *above* an average-year based on a t-statistic with 19 degrees of freedom. Using the standard deviation of 153.916 HDD from the 20 years of data for 1994-2013, these equations yield values of about 1,615 HDD for a “1-in-35” cold year and 1,507 as the number of HDDs for a “1-in-10” cold year (an area of 0.1000 under one tail of the T-Distribution translates to 1.328 standard deviations *above* an average-year based on a t-statistic with 19 degrees of freedom). For example, the “1-in-35” cold-year HDD is calculated as follows:

(3) Cold-year HDD = 1,615 which equals approximately

1,303 average-year HDDs + 2.025 * 153.916

Table 3 shows monthly HDD figures for “1-in-35” cold year, “1-in-10” cold year and, average year temperature designs. The monthly average-temperature-year HDDs are calculated from weighted monthly HDDs from 1995 to 2014, as shown as the bottom of Table 2, above. For example, the average-year December value of 270.6 HDD equals the simple average of the 20 December HDD figures from 1995 to 2014, and represents 20.7 percent of the HDDs in an average-year. SDGandE calculates the cold--temperature-year monthly HDD values using the same shape of the average-year HDDs. For example, since 20.8 percent of average-temperature-year HDDs occurred in December, the estimated number of HDDs during December for a cold-year is equal to 1,615 HDDs multiplied by 20.8 percent, or 335.4 HDDs.

Table 3

Calendar Month Heating Degree-Day Designs

	Cold		Average	Hot	
	1-in-35 Design	1-in-10 Design		1-in-10 Design	1-in-35 Design
January	320.7	299.2	258.7	218.2	196.8
February	283.6	264.6	228.8	193.0	174.0
March	233.8	218.1	188.6	159.1	143.4
April	166.0	154.9	133.9	113.0	101.9
May	67.2	62.7	54.2	45.7	41.2
June	17.0	15.8	13.7	11.5	10.4
July	1.0	0.9	0.8	0.7	0.6
August	0.1	0.1	0.1	0.1	0.1
September	1.4	1.3	1.1	1.0	0.9
October	35.2	32.9	28.4	24.0	21.6
November	153.7	143.5	124.0	104.6	94.3
December	335.4	312.9	270.6	228.2	205.8
	1615	1507	1303	1099	991

IV. Calculating the Peak-Day Design Temperature

SDG&E's Peak-Day design temperature of 42.7 degrees Fahrenheit, denoted "Deg-F," is determined from a statistical analysis of observed annual minimum daily system average temperatures constructed from daily temperature recordings from the three U.S. Weather Bureau weather stations discussed above. Since we have a time series of daily data by year, the following notation will be used for the remainder of this discussion:

(1) $AVG_{y,d}$ = system average value of Temperature

for calendar year "y" and day "d".

The calendar year, y, can range from 1972 through 2014, while the day, d, can range from 1 to 365, for non leap years, or from 1 to 366 for leap years. The "upper" value for the day, d, thus depends on the calendar year, y, and will be denoted by n(y)=365, or 366, respectively, when y is a non-leap year or a leap year.

For each calendar year, we calculate the following statistic from our series of daily system average temperatures defined in equation (1) above:

(2) $MinAVG_y = \min_{d=1}^{n(y)}\{ AVG_{y,d} \}$, for y=1972, 1973, …, 2014.

(The notation used in equation 2 means "For a particular year, y, list all the daily values of system average temperature for that year, then pick the smallest one.")

The resulting minimum annual temperatures are shown in Table 4, below. Note that most of the minimum temperatures occur in the months of December or January; however, for some calendar years the minimums occurred in other months (the observed minimum for 1991 was in March, and for 2004 it was in November).

The statistical methods we use to analyze this data employ software developed to fit three generic probability models: the Generalized Extreme Value (GEV) model, the Double-Exponential or GUMBEL (EV1) model and a 2-Parameter Students' T-Distribution (T-Dist) model. [The GEV and EV1 models have the same mathematical specification as those implemented in a DOS-based executable-only computer code that was developed by Richard L. Lehman and described in a paper published in the Proceedings of the Eighth Conference on Applied Climatology, January 17-22, 1993, Anaheim, California, pp. 270-273, by the American Meteorological Society, Boston, MA., with the title "Two

Software Products for Extreme Value Analysis: System Overviews of ANYEX and DDEX." At the time he wrote the paper, Dr. Lehman was with the Climate Analysis Center, National Weather Service/NOAA in Washington, D.C., zip code 20233.] The Statistical Analysis Software (SAS) procedure for nonlinear statistical model estimation (PROC MODEL, from SAS V6.12) was used to do the calculations. Further, the calculation procedures were implemented to fit the probability models to observed *maximums* of data, like heating degrees. By recognizing that:

$$- MinAVG_y = - \min_{d=1}^{n(y)}\{AVG_{y,d}\} = \max_{d=1}^{n(y)}\{ -AVG_{y,d}\}, \text{ for } y=1972, \ldots, 2014;$$

this same software, when applied to the *negative* of the minimum temperature data, yields appropriate probability model estimation results.

The calculations done to fit any one of the three probability models chooses the parameter values that provide the "best fit" of the parametric probability model's calculated cumulative distribution function (CDF) to the empirical cumulative distribution function (ECDF). Note that the ECDF is constructed based on the variable "-$MinAVG_y$" (which is a *maximum* over a set of *negative* temperatures) with values of the variable $MinAVG_y$ that are the same as shown in Table 4, below.

In Table 5, the data for -$MinAVG_y$ are shown after they have been sorted from "lowest" to "highest" value. The ascending *ordinal* value is shown in the column labeled "RANK" and the empirical cumulative distribution function is calculated and shown in the next column. The formula used to calculate this function is:

$$ECDF = (RANK - \alpha)/[MaxRANK + (1 - 2\alpha)],$$

where the parameter "α" (shown as *alpha* in Table 5) is a "small" positive value (usually less than ½) that is used to bound the ECDF away from 0 and 1.

Of the three probability models considered (GEV, EV1, and T_Dist) the results obtained for the T_Dist model were selected since the fit to the ECDF was better than that of either the GEV model or the EV1 model. (Although convergence to stable parameter estimates is occasionally a problem with fitting a GEV model to the ECDF, the T_Dist model had no problems with convergence of the iterative procedure to estimate parameters.)

The T_Dist model used here is a three-parameter probability model where the varable $z = (-MinAVG_y - \gamma) / \theta$, for each year, y, is presumed to follow a T_Dist with location parameter, γ, and scale parameter, θ, and a third parameter, v, that represents the number of degrees of freedom. For a given number of years of data, N, then v=N-2.

The following mathematical expression specifies the T_Dist model we fit to the data for "-MinAVG$_y$ " shown in Table 5, below.

(3) ECDF(-MinAVG$_y$) = Prob { -T < -MinAVG$_y$ }= T_Dist{z; γ, θ, v=N-2},

where "T_Dist{ . }" is the cumulative probability distribution function for Student's T-Distribution[4], and

(4) z = (-MinAVG$_y$ - γ) / θ, for each year, y, and

the parameters "γ" and "θ" are estimated for this model for given degrees of freedom v=N-2. The estimated values for γ and θ are shown in Table 5 along with the fitted values of the model CDF (the column: "Fitted" Model CDF).

Now, to calculate a *peak-day design temperature*, TPDD$_\delta$, with a specified likelihood, δ, that a value less than TPDD$_\delta$ would be observed, we use the equation below:

(5) δ = Prob { T $\leq$ TPDD$_\delta$ }, which is equivalent to

(6) δ = Prob { [(-T - γ) / θ] $\geq$ [(-TPDD$_\delta$ - γ) / θ] }, = Prob { [(-T - γ) / θ] $\geq$ [z$_\delta$] },

where z$_\delta$ = [(-TPDD$_\delta$ - γ) / θ]. In terms of our probability model,

(7) δ = 1 – T_Dist{ z$_\delta$; γ, θ, v=N-2},

which yields the following equation for z$_\delta$,

(7') z$_\delta$ = { TINV_Dist{ (1-δ); γ, θ, v=N-2}, where "TINV_Dist{ . }" is the inverse function of the T_Dist{ . } function[5]. The implied equation for TPDD$_\delta$ is:

(8) TPDD$_\delta$ = - [γ + (z$_\delta$)(θ)].

To calculate the minimum daily (system average) temperature to define our extreme weather event, we specify that this COLDEST-Day be one where the temperature would be lower with a "1-in-35" likelihood. This criterion translates into two equations to be solved based on equations (7) and (8) above:

---

[4] A common mathematical expression for Student's T-Distribution is provided at http://en.wikipedia.org/wiki/Student%27s_t-distribution; with a probability density function

$$f(t) = \frac{\Gamma(\frac{\nu+1}{2})}{\sqrt{\nu\pi}\,\Gamma(\frac{\nu}{2})}\left(1+\frac{t^2}{\nu}\right)^{-\frac{\nu+1}{2}},$$

such that T_Dist{z; γ, θ, ν=N-2}=∫f(t) dt, from t=-∞ to t=z. Also, the notation Γ(.) is known in mathematics as the GAMMA function; see http://www.wikipedia.org/wiki/Gamma_function for a description. Also, see *Statistical Theory*, 3rd Ed., B.W. Lindgren, MacMillian Pub. Inc, 1976, pp. 336-337.

[5] Computer software packages such as SAS and EXCEL have implemented statistical and mathematical functions to readily calculate values for T_Dist{ . } and TINV_Dist{ . } as defined above.

(9) solve for “z_δ” from equation (7’) above with (1-δ) = (1 - 1/35) = 1 - 0.0286,

(10) solve for “$TPDD_\delta$” from $TPDD_\delta = -[\gamma + (z_\delta)(\theta)]$.

The value of $z_\delta = 1.959$ and $TPDD_\delta = -[\gamma + (z_\delta)(\theta)] = 42.7$ degrees Fahrenheit, with values for “v=N-2”; along with “γ” and “θ” in Table 5, below.

SDG&E’s peak-day design temperature of 44.3 degrees Fahrenheit, is calculated in a methodologically similar way as for the 42.7 degree peak day temperature. The criteria specified in equation (9) above for a “1-in-35” likelihood would be replaced by a “1-in-10” likelihood.

(9’) solve for “z_δ” from equation (7’) above with (1-δ) = (1 - 1/10) = 1 - 0.1000,

which yields a “z_δ” value of $z_\delta = 1.303$ and, $TPDD_\delta = -[\gamma + (z_\delta)(\theta)] = 44.3$ with values for “v=N-2”; along with “γ” and “θ” in Table 5, below.

A plot of the cumulative distribution function for $MinAVG_y$ based on “v=N-2”, the fitted model parameters, “γ” and “θ” with values in Table 5, below, is shown in Figure 1.

Table 4

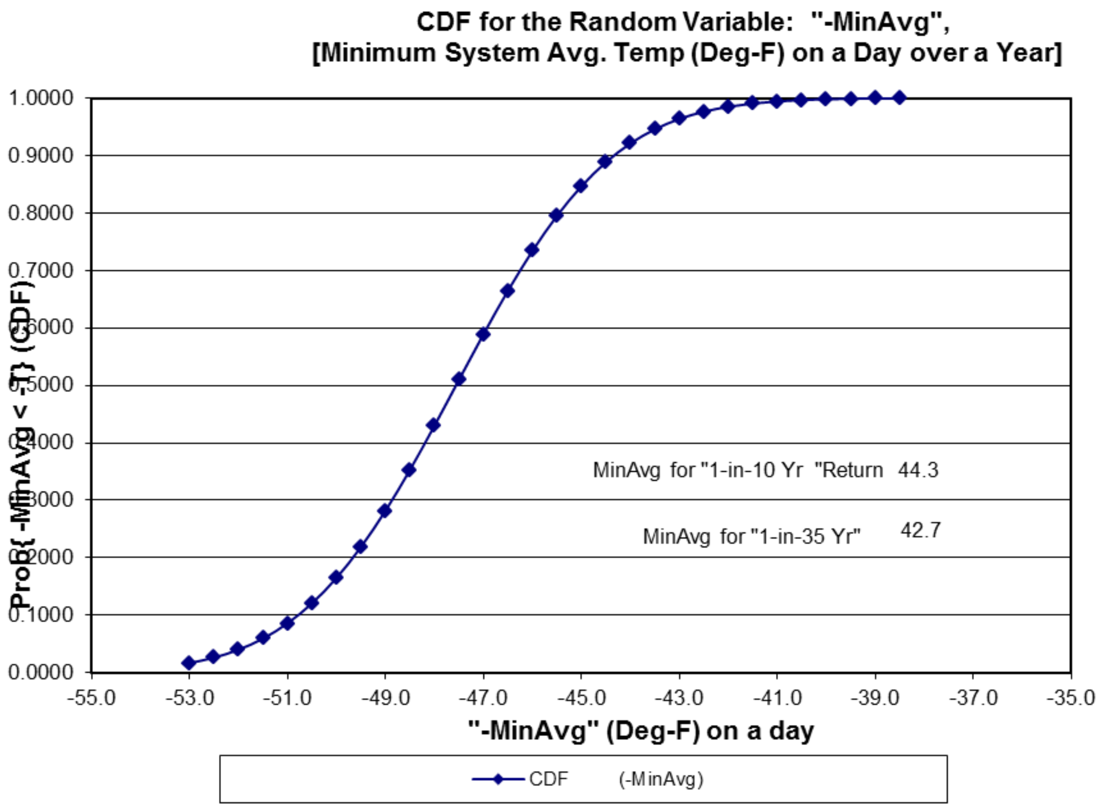
YEAR	MINAVG	Month(MinAvg)
1972	46.8593	Dec
1973	46.1101	Jan
1974	44.2202	Dec
1975	44.1101	Jan
1976	45.1651	Jan
1977	50.7492	Mar
1978	42.8043	Dec
1979	45.4985	Jan
1980	53.8043	Jan
1981	49.8593	Jan
1982	48.8318	Dec
1983	51.4985	Jan
1984	48.4709	Dec
1985	46.1101	Dec
1986	50.1101	Feb
1987	41.4985	Dec
1988	45.4434	Dec
1989	45.1651	Jan
1990	43.7768	Feb
1991	48.7768	Mar
1992	47.1651	Dec
1993	46.7768	Jan
1994	48.0550	Nov
1995	51.1651	Dec
1996	48.7768	Feb
1997	49.0826	Dec
1998	46.7768	Dec
1999	48.8043	Jan
2000	50.3609	Jan
2001	47.6942	Jan
2002	45.7492	Jan
2003	49.0550	Dec
2004	47.7492	Nov
2005	47.8043	Jan
2006	48.3609	Dec
2007	43.3609	Jan
2008	48.7217	Dec
2009	48.4159	Feb
2010	48.1927	Dec
2011	49.0826	Feb
2012	48.1376	Dec
2013	44.1376	Jan
2014	47.7759	Dec

Table 5

YEAR	Days/Yr	**-MinAvg**	Month (-MinAvg)	Rank	Emprical CDF	**Fitted Model CDF**
				alpha=	0.375	
1980	366	-53.8032	Jan	1	0.0145	-2.264
1983	365	-51.4972	Jan	2	0.0376	-1.826
1995	365	-51.1639	Dec	3	0.0607	-1.582
1977	365	-50.7486	Mar	4	0.0838	-1.405
2000	366	-50.3606	Jan	5	0.1069	-1.263
1986	365	-50.1093	Feb	6	0.1301	-1.142
1981	365	-49.8579	Jan	7	0.1532	-1.036
1997	365	-49.0819	Dec	8	0.1763	-0.940
2011	365	-49.0819	Feb	9	0.1994	-0.853
2003	365	-49.0546	Dec	10	0.2225	-0.771
1982	365	-48.8305	Dec	11	0.2457	-0.694
1999	365	-48.8032	Jan	12	0.2688	-0.622
1991	365	-48.7759	Mar	13	0.2919	-0.552
1996	366	-48.7759	Feb	14	0.3150	-0.485
2008	366	-48.7213	Dec	15	0.3382	-0.421
1984	366	-48.4699	Dec	16	0.3613	-0.358
2009	365	-48.4153	Feb	17	0.3844	-0.296
2006	365	-48.3606	Dec	18	0.4075	-0.235
2010	365	-48.1912	Dec	19	0.4306	-0.176
2012	366	-48.1366	Dec	20	0.4538	-0.117
1994	365	-48.0546	Nov	21	0.4769	-0.058
2005	365	-47.8032	Jan	22	0.5000	0.000
2014	365	-47.7759	Dec	23	0.5231	0.058
2004	366	-47.7486	Nov	24	0.5462	0.117
2001	365	-47.6940	Jan	25	0.5694	0.176
1992	366	-47.1639	Dec	26	0.5925	0.235
1972	366	-46.8579	Dec	27	0.6156	0.296
1993	365	-46.7759	Jan	28	0.6387	0.358
1998	365	-46.7759	Dec	29	0.6618	0.421
1973	365	-46.1093	Jan	30	0.6850	0.485
1985	365	-46.1093	Dec	31	0.7081	0.552
2002	365	-45.7486	Jan	32	0.7312	0.622
1979	365	-45.4972	Jan	33	0.7543	0.694
1988	366	-45.4426	Dec	34	0.7775	0.771
1976	366	-45.1639	Jan	35	0.8006	0.853
1989	365	-45.1639	Jan	36	0.8237	0.940
1974	365	-44.2185	Dec	37	0.8468	1.036
2013	365	-44.1366	Jan	38	0.8699	1.142
1975	365	-44.1093	Jan	39	0.8931	1.263
1990	365	-43.7759	Feb	40	0.9162	1.405
2007	365	-43.3606	Jan	41	0.9393	1.582
1978	365	-42.8032	Dec	42	0.9624	1.826
1987	365	-41.4972	Dec	43	0.9855	2.264

"Gamma" (Fitted) =	**-47.56**
"Theta" (Fitted) =	**2.48**
Deg. Freedom=	**41**

Figure 1


CDF for the Random Variable: "-MinAvg",
[Minimum System Avg. Temp (Deg-F) on a Day over a Year]
Prob{ -MinAvg < -T} (CDF)
1.0000
0.9000
0.8000
0.7000
0.6000
0.5000
0.4000
0.3000
0.2000
0.1000
0.0000
-55.0
-53.0
-51.0
-49.0
-47.0
-45.0
-43.0
-41.0
-39.0
-37.0
-35.0
"-MinAvg" (Deg-F) on a day
MinAvg for "1-in-10 Yr "Return 44.3
MinAvg for "1-in-35 Yr" 42.7
CDF (-MinAvg)

V. Estimating the Uncertainty in the Peak-Day Design Temperature

The calculated peak-day design temperatures in section IV above also have a statistical uncertainty associated with them. The estimated measures of uncertainty recommended for our use are calculated from the fitted model for the probability distribution and are believed to be reasonable, although rough, approximations.

The basic approach used the estimated parameters for the probability distribution (see the results provided in Table 5, above) to calculate the fitted temperatures as a function of the empirical CDF listed in Table 5. These fitted temperatures are then "compared" with the observed temperatures by calculating the difference = "observed" – "fitted" values. The full set of differences are then separated into the lower third (L), the middle third (M) and the upper third (U) of the distribution. Finally, calculate values of the root-mean-square error (RMSE) of the differences in each third of the distribution, along with the entire set of differences overall. The data in Table 6, below, show the temperature data and the resulting RMSE values.

The formula below is used to calculate the RMSE for a specified set of "N" data differences:

$$\text{RMSE} = \text{SQRT}\left\{ \left(\sum_{i=1, \ldots, N} e[\, i\,]^{2} \right) / (N\text{-}2) \right\},$$

where e[i] = *observed* less *fitted* value of temperature, T[i]. The number of estimated paramters (3 for the GEV model, 2 for the T-Dist and EV1 models) is subtracted from the respective number of data differences, N, in the denominator of the RMSE expression.

Since both the "1-in-35" and "1-in-10" peak-day temperature values are in the lower third quantile of the fitted distribution, the calculated standard error for these estimates is 0.4 Deg-F.

Table 6

Quantile: (Lower, Middle, Upper 3rd's)	Observed $T_{[i]}$ Temp. Ranked	Fitted Value of $T_{[i]}$	Residual $e_{[i]}$: Obs'd. less Fitted Value of $T_{[i]}$	Square of $e_{[i]}$:	
U	53.8032	53.1654	0.6378	0.406782	
U	51.4972	52.0802	-0.5830	0.339897	
U	51.1639	51.4758	-0.3119	0.097306	
U	50.7486	51.0377	-0.2891	0.083552	
U	50.3606	50.6858	-0.3252	0.105735	
U	50.1093	50.3871	-0.2779	0.077226	
U	49.8579	50.1246	-0.2667	0.071128	
U	49.0819	49.8880	-0.8061	0.649725	
U	49.0819	49.6710	-0.5891	0.347036	
U	49.0546	49.4693	-0.4147	0.171944	
U	48.8305	49.2796	-0.4491	0.201650	
U	48.8032	49.0996	-0.2964	0.087847	
U	48.7759	48.9275	-0.1516	0.022992	
U	48.7759	48.7619	0.0140	0.000195	
M	48.7213	48.6017	0.1196	0.014313	
M	48.4699	48.4457	0.0242	0.000585	
M	48.4153	48.2933	0.1220	0.014888	
M	48.3606	48.1436	0.2170	0.047108	
M	48.1912	47.9961	0.1951	0.038060	
M	48.1366	47.8502	0.2864	0.082026	
M	48.0546	47.7052	0.3494	0.122065	
M	47.8032	47.5608	0.2424	0.058753	
M	47.7759	47.4164	0.3595	0.129229	
M	47.7486	47.2715	0.4771	0.227610	
M	47.6940	47.1256	0.5684	0.323075	
M	47.1639	46.9781	0.1858	0.034521	
M	46.8579	46.8284	0.0294	0.000866	
M	46.7759	46.6760	0.0999	0.009988	
M	46.7759	46.5200	0.2559	0.065482	
L	46.1093	46.3597	-0.2505	0.062741	
L	46.1093	46.1941	-0.0849	0.007205	
L	45.7486	46.0221	-0.2735	0.074778	
L	45.4972	45.8421	-0.3449	0.118939	
L	45.4426	45.6524	-0.2098	0.044021	
L	45.1639	45.4506	-0.2868	0.082237	
L	45.1639	45.2337	-0.0698	0.004874	
L	44.2185	44.9971	-0.7786	0.606261	
L	44.1366	44.7345	-0.5980	0.357570	
L	44.1093	44.4359	-0.3266	0.106677	
L	43.7759	44.0840	-0.3081	0.094929	
L	43.3606	43.6459	-0.2852	0.081351	
L	42.8032	43.0415	-0.2382	0.056756	
L	41.4972	41.9562	-0.4590	0.210715	
			Overall RMSE ($e_{[i]}$):	0.4	°F
			Upper 3rd RMSE ($e_{[i]}$):	0.5	°F
			Middle 3rd RMSE ($e_{[i]}$):	0.3	°F
			Lower 3rd RMSE ($e_{[i]}$):	0.4	°F

VI. The Relationship between Annual Likelihoods for Peak-Day Temperatures and "Expected Return Time"

The event whose probability distribution we've modeled is the likelihood that the minimum daily temperature over a calendar year is less than a specified value. And, in particular, we've used this probability model to infer the value of a temperature, our *peak-day design temperature* ($TPDD_\delta$), that corresponds to a pre-defined likelihood, δ, that the observed minimum temperature is less than or equal to this design temperature.

(1) δ = Prob{ Minimum Daily Temperature over the Year < $TPDD_\delta$ }.

For some applications, it is useful to think of how this specified likelihood (or "risk level" δ) relates to the expected number of years until this Peak-Day event would first occur. This expected number of years is what is meant by the *return period*. The results stated below are found in the book: ***Statistics of Extremes***, E.J. Gumbel, Columbia University Press, 1958, on pages 21-25.

(2) E[#Yrs for Peak-Day Event to Occur] = $1 / \delta$,

1 / Prob{ Minimum Daily Temperature over the Year < $TPDD_\delta$ }.

For our peak-day design temperature (42.7°F) associated with a 1-in-35 annual likelihood, the return period is 35 years (δ=1/35). For the 44.3°F peak-day design temperature, the return period is 10 years (δ=1/10). Occasionally, a less precise terminology is used. For example, the 42.7°F peak-day design temperature may be referred to as a "1-in-35 year cold day"; and the 44.3°F peak-day design temperature may be referred to as a "1-in-10 year cold day."

The probability model for the *return period*, as a random variable, is a geometric (discrete) distribution with positive integer values for the *return period*. The parameter δ = Prob{ Minimum Daily Temperature over the Year < $TPDD_\delta$ }.

(3) Prob{ *return period* = r } = $(1 - \delta)^{(r-1)}\,\delta$, for r = 1, 2, 3, . . .

The expected value of the *return period* is already given in (2) above; the variance of the *return period* is:

(4) Var[*return period*] = (E[*return period*])^2 x (1- (1 / E [*return period*])),

(4') Var[*return period*] = (E[*return period*]) x (E [*return period*] - 1).

Equations (4) and (4') indicate that the standard deviation (square root of the variance) of the *return period* is nearly equal to its expected value. Thus, there is substantial variability about the expected value—a *return period* is not very precise.

VII. Attachment 1: SAS Program Execution Log

```
NOTE: Copyright (c) 1989-1996 by SAS Institute Inc., Cary, NC, USA.
NOTE: SAS (r) Proprietary Software Release 6.12  TS020
      Licensed to SAN DIEGO GAS & ELECTRIC CO, Site 0009311007.



WARNING: Your system is scheduled to expire on March 31, 2015, which is 1 days from now. Please contact your
installation representative to have your system
         renewed. The SAS system will no longer function on or after that date.
Title1 "Data Analysis for Maximum/Minimum Daily SysAvg Temperatures (Un-Rounded)." ;
Title2 "Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods." ;

/****************************************************************************************************/
/*                                                                                                  */
/*                                                                                                  */
/*                                                                                                  */
/* FILE SAVED: "S:\Weather\2014Cgr\SDGandE-Alt2Wgt\GEV4DlyTemp(NLReg2)_Sdge4WP.sas"                 */
/*                                                                                                  */
/*             Mar. 30th, 2015 for Annual Max of Negative of Min. Temp.                             */
/*             Also, separately for and each of twelve(12) calendar months Jan-Dec.                 */
/*             Fit GEV models (3-parameter and 2-parameter), plus a simple T-Dist. model.           */
/*                                                                                                  */
/*                                                                                                  */
/*                                                                                                  */
/*     2016 TCAP-Phase II Work Paper:  Model Estimation for the 2-Parameter T-Dist,                 */
/*             same generic model as used for the 2013 TCAP.                                        */
/*                                                                                                  */
/*                                                                                                  */
/*                                                                                                  */
/****************************************************************************************************/

options mprint ;
/* %cour8p
   %cour8l ; */
```

```
 options ls=211 ps=69 ; **<<LANDSCAPE:  SAS-Monospace w/Roman 6pt. Font >>**;
*options ls=160 ps=90 ; **<<PORTRAIT:   SAS-Monospace w/Roman 6pt. Font >>**;

options date number notes ;

libname out2 'S:\Weather\2016Tcap-Phase II\SDGandE-Alt2Wgt\' ;
NOTE: Libref OUT2 was successfully assigned as follows:
      Engine:        V612
      Physical Name: S:\Weather\2016Tcap-Phase II\SDGandE-Alt2Wgt
 **<< Change library reference to use applicable daily data. >>**

libname estout2 'S:\Weather\2016Tcap-Phase II\SDGandE-Alt2Wgt\MinTemp\' ;
 **<< Change library reference to use estimation results directory. >>**;

proc contents data=out2.SAvgSDGE ;
WARNING: The BASE Product product with which CONTENTS is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
run ;

NOTE: The PROCEDURE CONTENTS used 0.65 seconds.

data seriesD ;
WARNING: The BASE Product product with which DATASTEP is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
  set out2.SAvgSDGE ;
  year = year(date) ;
  month = month(date) ;
  posAvg = avg ;
  negAvg = -avg ;
run ;

NOTE: The data set WORK.SERIESD has 15737 observations and 10 variables.
NOTE: The DATA statement used 3.4 seconds.

proc means data=seriesD noprint nway ;
```

```
WARNING: The BASE Product product with which MEANS is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
  class year month ;
   var posAvg negAvg ;
  output out=mostat
                 mean=posAvg  negAvg
                  max=MxPosAvg MxNegAvg
                  min=MnPosAvg MnNegAvg    ;
run;

NOTE: The data set WORK.MOSTAT has 517 observations and 10 variables.
NOTE: The PROCEDURE MEANS used 0.23 seconds.

proc sort data=mostat ;
WARNING: The BASE Product product with which SORT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
   by year month ;
run ;

NOTE: The data set WORK.MOSTAT has 517 observations and 10 variables.
NOTE: The PROCEDURE SORT used 0.26 seconds.

data mostat ;
WARNING: The BASE Product product with which DATASTEP is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
   set mostat ;
   MxPRatio = MxPosAvg/ PosAvg  ;
   MnPRatio = MnPosAvg/ PosAvg  ;
   MxNRatio = MxNegAvg/ NegAvg  ;
   MnNRatio = MnNegAvg/ NegAvg  ;
run ;

NOTE: The data set WORK.MOSTAT has 517 observations and 14 variables.
NOTE: The DATA statement used 0.39 seconds.
```

```
/****************
***<< Print Summary Tables of Means/Minimums/Maximums of daily NEGATIVE-Temperatures (degrees-F). >>*** ;

proc transpose data=mostat out=AvTData prefix=AvT_ ;   **<< Update "year" value as necessary! >>** ;
   where (year < 2015) ;
   by year;
   id month ;
   var NegAvg  ;
run ;

data AvTData ;
   set AvTData ;

 if (mod(year,4)=0) then do ;
        AvTyr = (AvT_1 + AvT_3 + AvT_5 + AvT_7 + AvT_8 + AvT_10 + AvT_12)*31
               + (AvT_4 + AvT_6 + AvT_9 + AvT_11)*30
               + (AvT_2)*29 ;
        AvTyr = AvTyr / 366 ;
        end ;
 else do ;
        AvTyr = (AvT_1 + AvT_3 + AvT_5 + AvT_7 + AvT_8 + AvT_10 + AvT_12)*31
               + (AvT_4 + AvT_6 + AvT_9 + AvT_11)*30
               + (AvT_2)*28 ;
        AvTyr = AvTyr / 365 ;
        end ;

run ;

proc print data=AvTData ;
 id year ;
 var AvTyr AvT_1-AvT_12 ;
title3 'Monthly Mean NEGATIVE Temperature (Deg-F) from 1972 thru 2014.';
run ;





proc transpose data=mostat out=MnTData prefix=MnT_ ;
   where (year < 2015) ;    **<< Update "year" value as necessary! >>** ;
```

```
   by year;
   id month ;
   var MnNegAvg ;
run ;

data MnTData ;
   set MnTData ;
 MnTyr = min(of MnT_1-MnT_12) ;
run ;

proc print data=MnTData ;
 id year ;
 var MnTyr MnT_1-MnT_12 ;
title3 'Monthly MINIMUM NEGATIVE-Temperature (Deg-F) from 1972 thru 2014.';
run ;
****************/





proc transpose data=mostat out=MxTData prefix=MxT_ ;
WARNING: The BASE Product product with which TRANSPOSE is associated will expire within 30 days. Please contact your
SAS installation representative to have it renewed.
   where (year < 2015) ;    **<< Update "year" value as necessary! >>** ;
   by year;
   id month ;
   var MxNegAvg ;
run ;

NOTE: The data set WORK.MXTDATA has 43 observations and 14 variables.
NOTE: The PROCEDURE TRANSPOSE used 0.26 seconds.


data MxTData ;
WARNING: The BASE Product product with which DATASTEP is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
   set MxTData ;
 MxTyr = max(of MxT_1-MxT_12) ;
run ;

NOTE: The data set WORK.MXTDATA has 43 observations and 15 variables.
NOTE: The DATA statement used 0.32 seconds.
```

```
proc print data=MxTData ;
WARNING: The BASE Product product with which PRINT is associated will expire within 30 days. Please contact your SAS installation representative to have it renewed.
 id year ;
 var MxTyr MxT_1-MxT_12 ;
title3 'Monthly MAXIMUM NEGATIVE-Temperature (Deg-F) from 1972 thru 2014.';  **<< Update "year" value as necessary! >>** ;
run ;

NOTE: The PROCEDURE PRINT used 0.04 seconds.

/****************
***<< Descriptive Statistics: Maximums of daily NEGATIVE-Temperatures (Deg-F) for Year and each calendar month. >>*** ;

proc corr data=MxTData ;
  var MxTyr MxT_1 - MxT_12 ;
title3 'Correlation Matrix of Monthly Maximum NEGATIVE-Temperatures (Deg-F) within same year.';
run ;

proc arima data=MxTData ;
  identify var=MxTyr ;
  identify var=MxT_1 ;
  identify var=MxT_2 ;
  identify var=MxT_3 ;
  identify var=MxT_4 ;
  identify var=MxT_5 ;
  identify var=MxT_6 ;
  identify var=MxT_7 ;
  identify var=MxT_8 ;
  identify var=MxT_9 ;
```

```
  identify var=MxT_10 ;
  identify var=MxT_11 ;
  identify var=MxT_12 ;
title3 "Auto-correlation analysis of each calendar month's Maximum NEGATIVE-Temperatures (Deg-F) within same year.";
run ;

proc univariate normal data=MxTData plot ;
  id year ;
  var MxTyr MxT_1 - MxT_12 ;
title3 "Probability plots and tests for NORMALity by each calendar month's Maximun NEGATIVE-Temperatures (Deg-F) time series.";
run ;

proc means data=MxTData ;
  var MxT_1 - MxT_12  MxTYr ;
run ;
****************/

***<< Statistical Estimation of GEV Models: Maximums of daily heating degrees for Year and each calendar month. >>*** ;

%macro RankIt(file=MxTData,var=MxTYr,rank=RankYr,prob=PrMxTYr,Nobser=43,PltValue=0.375) ;

                 **<< Update "Nobser" value as necessary! >>** ;

proc sort data=&file ;
  by &var ;
run ;

data &file ;
   set &file ;
   retain &rank 0     alpha &pltvalue ;

  &rank = &rank + 1 ;
  &prob =  (&rank - alpha) / (&Nobser +(1 - 2*alpha)) ;
run ;
```

```
proc print data=&file ;
  var &var &rank &prob alpha year ;
run ;
%mend RankIt ;

%macro GEVfit(file=MxTData,ofile=MxTNL1,outfit=fit1,outest=est1,depvar=PrMxTYr,var=MxTYr,typeGEV=1,
              KappaI=0.25,GammaI=-47.05,ThetaI=2.77,YrLo=1972,YrHi=2014) ;

                 **<< Update "YrHi" value as necessary! >>** ;

proc sort data=&file ;
   by year ;
run ;

proc model data=&file converge=0.001
           maxit=500 dw ;  outmodel=&ofile ;
     range year = &YrLo to &YrHi ;   **<< Dropped monthly data beyond 2014 data. >>** ;

     y = (&var - Gamma) / Theta ;

    %if &typeGEV=1 %then %do ;  ***<< 3-parameter GEV Model. >>>*** ;
        &depvar = exp( -(1 - Kappa * (y))**(1/Kappa) ) ;
        %let typmod = 3-parameter GEV Model. ;
        %end ;

    %if &typeGEV=2 %then %do ;  **<< 2-parameter "Double Exponential" or  "Gumbel" Model. >>** ;
        &depvar = exp( -exp(-(y)) ) ;
        %let typmod = 2-parameter Double Exponential or Gumbel Model. ;
        %end ;

    %if (&typeGEV NE 1) AND (&typeGEV NE 2) %then  %do ; **<< 2-parameter "T-Dist" Model. >>** ;
        dft=(&YrHi - &YrLo) +1 -2 ;
        &depvar = probt(y,dft) ;
        %let typmod = 2-parameter T-Dist Model. ;
        %end ;
```

```
  %if &typeGEV = 1 %then %do ;
  parms
        Kappa  &KappaI
        Gamma  &GammaI
        Theta  &ThetaI ;
  %end ;

  %if (&typeGEV NE 1)  %then %do ;
  parms
        Gamma  &GammaI
        Theta  &ThetaI ;
  %end ;



  fit &depvar   /out=&outfit  outall
                 outest=&outest corrb corrs outcov ;

title3 "Non-linear Estimation of &&typmod: for Maximum NEGATIVE Temperature (Deg-F)." ;
run ;
%mend GEVfit ;







/****************
****************/

proc means data=MxTData ;
WARNING: The BASE Product product with which MEANS is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
  var MxT_1 - MxT_12  MxTYr ;
 output out=VarStat
        mean=mean1-mean12 meanYr
        std=stdev1-stdev12 stdevYr;
title3 "Calc. Means and Standard Deviantions to use as Starting Values in Non-Linear Estimations." ;
run ;

NOTE: The data set WORK.VARSTAT has 1 observations and 28 variables.
NOTE: The PROCEDURE MEANS used 0.31 seconds.
```

```
proc print data=VarStat ;
WARNING: The BASE Product product with which PRINT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
run ;


NOTE: The PROCEDURE PRINT used 0.03 seconds.




data _null_ ;
WARNING: The BASE Product product with which DATASTEP is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
   set VarStat ;

  call symput('gamma_Yr',meanYr) ;
  call symput('theta_Yr',stdevYr) ;

  call symput('gamma_12',mean12) ;
  call symput('theta_12',stdev12) ;

  call symput('gamma_11',mean11) ;
  call symput('theta_11',stdev11) ;

  call symput('gamma_10',mean10) ;
  call symput('theta_10',stdev10) ;

  call symput('gamma_9',mean9) ;
  call symput('theta_9',stdev9) ;

  call symput('gamma_8',mean8) ;
  call symput('theta_8',stdev8) ;

  call symput('gamma_7',mean7) ;
  call symput('theta_7',stdev7) ;

  call symput('gamma_6',mean6) ;
  call symput('theta_6',stdev6) ;

  call symput('gamma_5',mean5) ;
  call symput('theta_5',stdev5) ;

  call symput('gamma_4',mean4) ;
```

```
356    call symput('theta_4',stdev4) ;

357

358    call symput('gamma_3',mean3) ;

359    call symput('theta_3',stdev3) ;

360

361    call symput('gamma_2',mean2) ;

362    call symput('theta_2',stdev2) ;

363

364    call symput('gamma_1',mean1) ;

365    call symput('theta_1',stdev1) ;

366

367  run ;


NOTE: Numeric values have been converted to character values at the places given by: (Line):(Column).

      328:26   329:26   331:26   332:26   334:26   335:26   337:26   338:26   340:25   341:25   343:25   344:25
346:25   347:25   349:25   350:25   352:25   353:25   355:25   356:25   358:25   359:25

      361:25   362:25   364:25   365:25

NOTE: The DATA statement used 0.18 seconds.



368

369

370

371

372

373

374  *********<<< Analysis for "Annual" Data  (i.e., SUFIX "mm" = "_Yr"  >>>******************;

375

376

377

MPRINT(RANKIT):   **<< UPDATE "NOBSER" VALUE AS NECESSARY! >>** ;

378

379

380  %RankIt(file=MxTData,var=MxTYr,rank=RankYr,prob=PrMxTYr,Nobser=43,PltValue=0.375) ;

WARNING: The BASE Product product with which SORT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.

MPRINT(RANKIT):   PROC SORT DATA=MXTDATA ;

MPRINT(RANKIT):   BY MXTYR ;

MPRINT(RANKIT):   RUN ;


NOTE: The data set WORK.MXTDATA has 43 observations and 15 variables.

NOTE: The PROCEDURE SORT used 0.18 seconds.
```

```
WARNING: The BASE Product product with which DATASTEP is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.

MPRINT(RANKIT):   DATA MXTDATA ;

MPRINT(RANKIT):   SET MXTDATA ;

MPRINT(RANKIT):   RETAIN RANKYR 0 ALPHA 0.375 ;

MPRINT(RANKIT):   RANKYR = RANKYR + 1 ;

MPRINT(RANKIT):   PRMXTYR = (RANKYR - ALPHA) / (43 +(1 - 2*ALPHA)) ;

MPRINT(RANKIT):   RUN ;


NOTE: The data set WORK.MXTDATA has 43 observations and 18 variables.

NOTE: The DATA statement used 0.21 seconds.



WARNING: The BASE Product product with which PRINT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.

MPRINT(RANKIT):   PROC PRINT DATA=MXTDATA ;

MPRINT(RANKIT):   VAR MXTYR RANKYR PRMXTYR ALPHA YEAR ;

MPRINT(RANKIT):   RUN ;


NOTE: The PROCEDURE PRINT used 0.01 seconds.



381

382                   **<< Update "Nobser" value as necessary! >>** ;

383

384  *** << Do estimation for the 2-Parameter, T-Dist using "suffix" value of "0" for "typeGEV" macro variable. >> ***
;

385

386

387  %GEVfit(file=MxTData,ofile=MxTNL1,outfit=fit1,outest=est1,depvar=PrMxTYr,var=MxTYr,typeGEV=0,

MPRINT(GEVFIT):   **<< UPDATE "YRHI" VALUE AS NECESSARY! >>** ;

388          KappaI=0.25,GammaI=&gamma_Yr,ThetaI=&theta_Yr,YrLo=1972,YrHi=2014) ;

WARNING: The BASE Product product with which SORT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.

MPRINT(GEVFIT):   PROC SORT DATA=MXTDATA ;

MPRINT(GEVFIT):   BY YEAR ;

MPRINT(GEVFIT):   RUN ;


NOTE: The data set WORK.MXTDATA has 43 observations and 18 variables.

NOTE: The PROCEDURE SORT used 0.15 seconds.



WARNING: The SAS/ETS product with which MODEL is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.

MPRINT(GEVFIT):   PROC MODEL DATA=MXTDATA CONVERGE=0.001 MAXIT=500 DW ;

MPRINT(GEVFIT):   OUTMODEL%MXTNL1 ;
```

```
MPRINT(GEVFIT):   RANGE YEAR = 1972 TO 2014 ;
MPRINT(GEVFIT):   **<< DROPPED MONTHLY DATA BEYOND 2014 DATA. >>** ;
MPRINT(GEVFIT):   Y % (MXTYR - GAMMA) / THETA ;
MPRINT(GEVFIT):   **<< 2-PARAMETER "T-DIST" MODEL. >>** ;
MPRINT(GEVFIT):   DFT%(2014 - 1972) +1 -2 ;
MPRINT(GEVFIT):   PRMXTYR % PROBT(Y,DFT) ;
MPRINT(GEVFIT):   PARMS GAMMA -47.44245353 THETA 2.5357107211 ;

MPRINT(GEVFIT):   FIT PRMXTYR /OUT=FIT1 OUTALL OUTEST=EST1 CORRB CORRS OUTCOV ;
MPRINT(GEVFIT):   TITLE3 "Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-
F)." ;
MPRINT(GEVFIT):   RUN ;

NOTE: At OLS Iteration 3 CONVERGE=0.001 Criteria Met.
NOTE: The data set WORK.FIT1 has 129 observations and 6 variables.
NOTE: The data set WORK.EST1 has 3 observations and 5 variables.
389
390                   **<< Update "YrHi" value as necessary! >>** ;
391
392

NOTE: The PROCEDURE MODEL used 0.4 seconds.


393  proc print data=fit1 ;
WARNING: The BASE Product product with which PRINT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
394  run ;

NOTE: The PROCEDURE PRINT used 0.01 seconds.


395
396
397
398
399  proc transpose data=fit1 out=pred1 prefix=probP ;
WARNING: The BASE Product product with which TRANSPOSE is associated will expire within 30 days. Please contact your
SAS installation representative to have it renewed.
400     where (_type_ = "PREDICT" ) ;
401     by year;
402     var prmxtyr ;
403  run ;

NOTE: The data set WORK.PRED1 has 43 observations and 3 variables.
```

```
NOTE: The PROCEDURE TRANSPOSE used 0.17 seconds.


404
405  data comb1 ;
WARNING: The BASE Product product with which DATASTEP is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
406     merge MxTData pred1 ;
407    by year ;
408     ProbP = ProbP1 ;
409    keep year MxTYr PrMxTYr ProbP ;
410  run ;

NOTE: The data set WORK.COMB1 has 43 observations and 4 variables.
NOTE: The DATA statement used 0.18 seconds.


411
412
413  proc print data=comb1 ;
WARNING: The BASE Product product with which PRINT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
414  run ;

NOTE: The PROCEDURE PRINT used 0.01 seconds.


415
416
417  proc plot data=comb1 ;
WARNING: The BASE Product product with which PLOT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
418    plot prmxtyr*MxTYr='*'
419         probP*MxTYr='-' / overlay ;
420  run ;

421
422

NOTE: The PROCEDURE PLOT used 0.03 seconds.


423  proc print data=est1 ;
WARNING: The BASE Product product with which PRINT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
```

```
run ;

NOTE: The PROCEDURE PRINT used 0.01 seconds.

/**************
data estout2.est0_Yr ;   ***<<< Save a copy of the "2-parameter T-Dist Model" estimation results!  >>>*** ;
  set est1 ;
run ;
**************/

data comb  ;
WARNING: The BASE Product product with which DATASTEP is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
   merge MxTData pred1(rename=(ProbP1=ProbP1)) ;
  by year ;

 ***<< "Log(PrMxTYr) - Log(ProgP)" to calc. RMSE of Proportional Errors Models! >>** ;
   LgPrRat1 = Log(PrMxTYr/ProbP1) ;

 label   LgPrRat1 = "Log(PrMxTYr/ProbP1)- T-Dist" ;

   if (PrMxTYr <= (1/3)) then Quantile=1 ;  **<< "Lower Third" >>** ;
   if (PrMxTYr > (1/3)) AND (PrMxTYr <= (2/3)) then Quantile=2 ; **<< "Middle Third" >>** ;
   if (PrMxTYr > (2/3)) then Quantile=3 ;  **<< "Upper Third" >>** ;

  keep year MxTYr Quantile PrMxTYr ProbP1 LgPrRat1 ;
run ;

NOTE: The data set WORK.COMB has 43 observations and 6 variables.
NOTE: The DATA statement used 0.31 seconds.

proc print data=comb  ;
WARNING: The BASE Product product with which PRINT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
```

```
  var year MxTYr Quantile  PrMxTYr ProbP1  LgPrRat1 ;
title3 "Est'd CDFs and Logarithms of 'Empirical CDF rel. to Fitted CDF' values by Models." ;
run ;

NOTE: The PROCEDURE PRINT used 0.01 seconds.

proc means data=comb  n mean std min max var uss ;
WARNING: The BASE Product product with which MEANS is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
  var LgPrRat1 ;
title3 "Stats for Logarithms of 'Empirical CDF rel. to Fitted CDF' values by Models to calc. RMSE of Prop. Model
Spec" ;
run ;

NOTE: The PROCEDURE MEANS used 0.01 seconds.

proc sort data=comb ;
WARNING: The BASE Product product with which SORT is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
  by Quantile ;
run ;

NOTE: The data set WORK.COMB has 43 observations and 6 variables.
NOTE: The PROCEDURE SORT used 0.17 seconds.

proc means data=comb  n mean std min max var uss ;
WARNING: The BASE Product product with which MEANS is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
  by Quantile ;
  var LgPrRat1 ;
title3 "Stats By Quantile for Logarithms of 'Empirical CDF rel. to Fitted CDF' values by Models to calc. RMSE of
Prop. Model Spec" ;
run ;

NOTE: The PROCEDURE MEANS used 0.01 seconds.
```

```
proc means data=comb  n mean std min max var uss ;
WARNING: The BASE Product product with which MEANS is associated will expire within 30 days. Please contact your SAS
installation representative to have it renewed.
  by Quantile ;
  var LgPrRat1 ;
title3 "Stats By Quantile for Logarithms of 'Empirical CDF rel. to Fitted CDF' values by Models to calc. RMSE of
Prop. Model Spec" ;
run ;

NOTE: The PROCEDURE MEANS used 0.01 seconds.

quit ;
```

VIII. Attachment 2: SAS Program Output

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

CONTENTS PROCEDURE

Data Set Name:	OUT2.SAVGSDGE	Observations:	15737
Member Type:	DATA	Variables:	6
Engine:	V612	Indexes:	0
Created:	21:19 Monday, February 9, 2015	Observation Length:	48
Last Modified:	21:19 Monday, February 9, 2015	Deleted Observations:	0
Protection:		Compressed:	NO
Data Set Type:		Sorted:	NO
Label:			

-----Engine/Host Dependent Information-----

Data Set Page Size:	8192
Number of Data Set Pages:	94
File Format:	607
First Data Page:	1
Max Obs per Page:	169
Obs in First Data Page:	147

-----Alphabetic List of Variables and Attributes-----

#	Variable	Type	Len	Pos	Format	Informat	Label
2	AVG	Num	8	8			Syst-Avg. Avg
6	CDD	Num	8	40			Syst-Avg. Cdd
1	DATE	Num	8	0	DATE9.	MMDDYY10.	

5	HDD	Num	8	32	Syst-Avg. Hdd
3	MAX	Num	8	16	Syst-Avg. Max
4	MIN	Num	8	24	Syst-Avg. Min

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Monthly MAXIMUM NEGATIVE-Temperature (Deg-F) from 1972 thru 2014.

YEAR	MXTYR	MXT_1	MXT_2	MXT_3	MXT_4	MXT_5	MXT_6	MXT_7	MXT_8	MXT_9	MXT_10	MXT_11	MXT_12
1972	-46.8579	-47.1639	-50.5518	-54.7486	-56.8032	-59.3880	-63.6940	-69.5847	-67.6940	-66.0000	-55.7486	-54.1093	-46.8579
1973	-46.1093	-46.1093	-54.1093	-53.0546	-56.1093	-57.6940	-63.7486	-67.6940	-69.2787	-66.0000	-61.8032	-52.1093	-52.1093
1974	-44.2185	-48.2185	-51.3880	-52.7486	-57.8032	-60.0546	-64.3060	-67.2787	-69.2787	-66.9454	-57.8032	-54.8579	-44.2185
1975	-44.1093	-44.1093	-49.1639	-48.2185	-51.3880	-57.4426	-60.3606	-66.3060	-68.0000	-66.0000	-60.1093	-50.1093	-50.1639
1976	-45.1639	-45.1639	-54.1093	-49.8032	-55.3880	-60.0000	-63.0546	-69.5847	-68.7486	-68.1093	-61.8032	-49.8579	-52.5791
1977	-50.7486	-51.8579	-52.1093	-50.7486	-54.1093	-58.6394	-65.6394	-68.9454	-71.6940	-68.1093	-63.4426	-56.1639	-56.5518
1978	-42.8032	-52.2185	-53.4972	-55.8032	-55.1639	-60.1093	-66.3606	-68.0000	-68.7486	-66.4153	-65.3880	-54.5245	-42.8032
1979	-45.4972	-45.4972	-50.1093	-51.1639	-58.1093	-60.3606	-63.6940	-67.6940	-70.9454	-71.6394	-61.0546	-52.1093	-52.4699
1980	-53.8032	-53.8032	-56.1093	-54.1093	-55.7486	-58.8032	-64.0000	-69.5847	-69.9454	-67.7486	-60.1093	-55.8579	-54.9125
1981	-49.8579	-49.8579	-53.0819	-53.2787	-56.1639	-61.7213	-66.6394	-71.6394	-72.2514	-68.3880	-58.4972	-54.5245	-53.4426
1982	-48.8305	-49.4426	-54.3333	-53.7486	-53.1093	-60.4153	-62.0546	-67.0000	-70.9727	-64.0819	-61.4972	-55.4426	-48.8305
1983	-51.4972	-51.4972	-53.2185	-55.7759	-54.1366	-60.1639	-62.1912	-67.9454	-70.0546	-67.8579	-66.7486	-51.8852	-52.5518
1984	-48.4699	-51.5518	-51.8305	-58.7486	-57.6940	-59.4426	-65.3880	-72.6120	-73.6667	-72.1093	-61.0273	-53.1639	-48.4699
1985	-46.1093	-48.8305	-46.8305	-49.4426	-58.4153	-60.3606	-62.6667	-71.6940	-68.6120	-65.3880	-63.0546	-50.8305	-46.1093
1986	-50.1093	-56.3606	-50.1093	-53.4153	-57.3333	-58.7759	-65.9727	-67.5847	-70.2514	-60.1093	-60.7213	-58.1093	-53.1366
1987	-41.4972	-42.4153	-49.1366	-53.0819	-56.0546	-60.3606	-63.8907	-64.6120	-64.3333	-66.9727	-63.4972	-54.4426	-41.4972
1988	-45.4426	-49.1366	-52.4153	-55.1912	-55.6667	-57.0546	-59.6940	-68.5574	-68.5574	-63.3333	-62.3060	-53.3880	-45.4426
1989	-45.1639	-45.1639	-45.8032	-51.7213	-56.7213	-58.4153	-62.0000	-68.0000	-69.0273	-62.7213	-61.0273	-56.7759	-51.4972
1990	-43.7759	-48.1093	-43.7759	-50.1093	-58.7213	-58.1093	-63.0273	-68.8088	-68.9727	-68.0000	-65.0273	-55.1366	-43.7759
1991	-48.7759	-51.6940	-54.6667	-48.7759	-57.9454	-58.0000	-61.3060	-66.5028	-67.8907	-65.0000	-58.0000	-51.1366	-50.4972
1992	-47.1639	-52.0546	-56.3880	-56.0000	-63.0819	-64.2787	-65.3333	-68.1421	-68.3880	-69.9454	-64.4153	-55.1366	-47.1639
1993	-46.7759	-46.7759	-52.3880	-54.4153	-58.6667	-59.8032	-61.3606	-67.9454	-67.6940	-64.3880	-62.4153	-55.6940	-52.0546
1994	-48.0546	-51.7486	-52.1639	-53.7213	-55.3333	-59.2787	-64.6120	-67.8907	-70.2514	-66.6667	-61.3880	-48.0546	-50.4699
1995	-51.1639	-52.4153	-56.0819	-52.4426	-53.3880	-56.0819	-60.9727	-66.6120	-70.0000	-66.7213	-62.6120	-60.1093	-51.1639
1996	-48.7759	-50.3880	-48.7759	-54.9727	-58.3606	-61.6394	-64.6120	-68.1968	-69.2241	-67.0273	-55.0819	-53.3880	-52.1093
1997	-49.0819	-51.0000	-50.8852	-52.3606	-53.0819	-64.6667	-63.9454	-67.6120	-70.5574	-69.5847	-62.0546	-57.6940	-49.0819
1998	-46.7759	-51.4426	-52.7759	-50.0546	-51.0819	-57.4426	-62.0546	-66.5028	-71.2241	-64.0000	-61.2787	-56.3333	-46.7759

1999	-48.8032	-48.8032	-49.7486	-50.1093	-49.2458	-56.9727	-58.3606	-64.1968	-67.1695	-63.6120	-64.2514	-54.3880	-51.0546
2000	-50.3606	-50.3606	-52.6667	-50.3880	-57.7213	-62.3333	-64.3060	-66.9727	-67.6667	-67.2787	-59.0273	-50.8032	-52.3880
2001	-47.6940	-47.6940	-49.0819	-52.3880	-51.4426	-60.2241	-62.4153	-66.9727	-66.8634	-67.9454	-64.2514	-50.8852	-50.3880
2002	-45.7486	-45.7486	-47.7759	-52.7213	-57.2787	-57.6394	-61.6667	-66.5847	-67.2241	-64.4153	-59.6394	-57.3333	-50.1093
2003	-49.0546	-54.6940	-52.7759	-52.8305	-53.4699	-57.4426	-61.3333	-67.8907	-70.8907	-68.2241	-61.3880	-54.7759	-49.0546
2004	-47.7486	-51.0273	-53.0819	-54.8305	-58.3606	-63.3606	-64.9727	-67.3880	-69.5847	-66.0000	-57.3333	-47.7486	-49.4153
2005	-47.8032	-47.8032	-53.9398	-55.8032	-58.0000	-60.7213	-64.0000	-67.8907	-69.4482	-64.6667	-60.7486	-55.0819	-52.6667
2006	-48.3606	-51.0000	-49.1093	-48.8032	-55.6940	-61.0819	-66.2787	-73.6940	-70.3333	-66.8634	-59.8032	-51.9454	-48.3606
2007	-43.3606	-43.3606	-51.3333	-50.6667	-54.9727	-60.0000	-61.9454	-68.6120	-70.6120	-63.6940	-61.2241	-57.0273	-48.4426
2008	-48.7213	-49.6667	-49.7486	-50.7213	-53.6667	-57.0546	-60.9181	-68.5028	-69.2787	-67.3333	-59.6940	-59.0819	-48.7213
2009	-48.4153	-49.0819	-48.4153	-53.3880	-54.4699	-60.9727	-63.0273	-67.7815	-68.2787	-67.6394	-57.0819	-55.1366	-49.4972
2010	-48.1912	-51.3880	-51.1366	-50.8305	-53.0000	-57.6667	-62.0000	-63.2241	-65.3333	-64.9181	-59.1366	-51.1366	-48.1912
2011	-49.0819	-49.4699	-49.0819	-54.1639	-51.4426	-59.0819	-61.4153	-67.9727	-67.2241	-66.2241	-61.3333	-54.4699	-49.1366
2012	-48.1366	-50.0546	-50.4426	-50.4426	-54.4153	-60.7213	-62.3060	-65.9181	-69.8907	-70.6667	-62.3880	-55.3333	-48.1366
2013	-44.1366	-44.1366	-48.1639	-52.4426	-55.7486	-62.0546	-64.8088	-67.9181	-66.6667	-66.7213	-59.7213	-56.8305	-49.8032
2014	-47.7759	-54.7759	-53.0819	-58.4972	-55.1366	-60.3880	-66.6667	-69.3333	-71.2787	-69.0000	-66.0273	-60.4153	-47.7759

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Calc. Means and Standard Deviantions to use as Starting Values in Non-Linear Estimations.

Variable	N	Mean	Std Dev	Minimum	Maximum
MXT_1	43	-49.3742161	3.2022068	-56.3606458	-42.4152709
MXT_2	43	-51.2881798	2.7616322	-56.3879584	-43.7759167
MXT_3	43	-52.7135257	2.4893895	-58.7486042	-48.2185001
MXT_4	43	-55.5731100	2.6388054	-63.0819375	-49.2458126
MXT_5	43	-59.6794860	1.9579997	-64.6666667	-56.0819375
MXT_6	43	-63.2325581	1.9598426	-66.6666667	-58.3606458
MXT_7	43	-67.9856647	1.9603962	-73.6939792	-63.2240833
MXT_8	43	-69.1629346	1.8132688	-73.6666667	-64.3333333
MXT_9	43	-66.6154491	2.3805517	-72.1092500	-60.1092500
MXT_10	43	-61.1851376	2.6075649	-66.7486042	-55.0819375
MXT_11	43	-54.2636536	2.9521622	-60.4152709	-47.7486042
MXT_12	43	-49.5320412	3.1457961	-56.5518334	-41.4972084
MXTYR	43	-47.4424535	2.5357107	-53.8032292	-41.4972084

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Calc. Means and Standard Deviantions to use as Starting Values in Non-Linear Estimations.

OBS	_TYPE_	_FREQ_	MEAN1	MEAN2	MEAN3	MEAN4	MEAN5	MEAN6	MEAN7	MEAN8	MEAN9	MEAN10	MEAN11	MEAN12
1	0	43	-49.3742	-51.2882	-52.7135	-55.5731	-59.6795	-63.2326	-67.9857	-69.1629	-66.6154	-61.1851	-54.2637	-49.5320

OBS	MEANYR	STDEV1	STDEV2	STDEV3	STDEV4	STDEV5	STDEV6	STDEV7	STDEV8	STDEV9	STDEV10	STDEV11	STDEV12	STDEVYR
1	-47.4425	3.20221	2.76163	2.48939	2.63881	1.95800	1.95984	1.96040	1.81327	2.38055	2.60756	2.95216	3.14580	2.53571

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Calc. Means and Standard Deviantions to use as Starting Values in Non-Linear Estimations.

OBS	MXTYR	RANKYR	PRMXTYR	ALPHA	YEAR
1	-53.8032	1	0.01445	0.375	1980
2	-51.4972	2	0.03757	0.375	1983
3	-51.1639	3	0.06069	0.375	1995
4	-50.7486	4	0.08382	0.375	1977
5	-50.3606	5	0.10694	0.375	2000
6	-50.1093	6	0.13006	0.375	1986
7	-49.8579	7	0.15318	0.375	1981
8	-49.0819	8	0.17630	0.375	1997
9	-49.0819	9	0.19942	0.375	2011
10	-49.0546	10	0.22254	0.375	2003
11	-48.8305	11	0.24566	0.375	1982
12	-48.8032	12	0.26879	0.375	1999
13	-48.7759	13	0.29191	0.375	1991
14	-48.7759	14	0.31503	0.375	1996
15	-48.7213	15	0.33815	0.375	2008
16	-48.4699	16	0.36127	0.375	1984
17	-48.4153	17	0.38439	0.375	2009
18	-48.3606	18	0.40751	0.375	2006
19	-48.1912	19	0.43064	0.375	2010
20	-48.1366	20	0.45376	0.375	2012
21	-48.0546	21	0.47688	0.375	1994
22	-47.8032	22	0.50000	0.375	2005
23	-47.7759	23	0.52312	0.375	2014
24	-47.7486	24	0.54624	0.375	2004
25	-47.6940	25	0.56936	0.375	2001
26	-47.1639	26	0.59249	0.375	1992
27	-46.8579	27	0.61561	0.375	1972

28	-46.7759	28	0.63873	0.375	1993
29	-46.7759	29	0.66185	0.375	1998
30	-46.1093	30	0.68497	0.375	1973
31	-46.1093	31	0.70809	0.375	1985
32	-45.7486	32	0.73121	0.375	2002
33	-45.4972	33	0.75434	0.375	1979
34	-45.4426	34	0.77746	0.375	1988
35	-45.1639	35	0.80058	0.375	1976
36	-45.1639	36	0.82370	0.375	1989
37	-44.2185	37	0.84682	0.375	1974
38	-44.1366	38	0.86994	0.375	2013
39	-44.1093	39	0.89306	0.375	1975
40	-43.7759	40	0.91618	0.375	1990
41	-43.3606	41	0.93931	0.375	2007
42	-42.8032	42	0.96243	0.375	1978
43	-41.4972	43	0.98555	0.375	1987

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

MODEL Procedure

Model Summary

Model Variables	1
Parameters	3
RANGE Variable	YEAR
Equations	1
Number of Statements	4

Model Variables: PRMXTYR

Parameters: GAMMA: -47.44 THETA: 2.536 MXTNL1

Equations: PRMXTYR

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

MODEL Procedure

NOTE: A finite difference approximation is used for the derivative of the PROBT function at line 388 column 101.

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

MODEL Procedure

The Equation to Estimate is:

PRMXTYR = F(GAMMA, THETA)

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

MODEL Procedure

OLS Estimation

OLS Estimation Summary

Dataset Option	Dataset
DATA=	MXTDATA
OUT=	FIT1
OUTEST=	EST1

Parameters Estimated	2

RANGE Processed	YEAR
First	1972
Last	2014

Minimization Summary

Method	GAUSS
Iterations	3

Final Convergence	Criteria
R	0.00018188
PPC(THETA)	0.000039
RPC(THETA)	0.000261
Object	4.99927E-6
Trace(S)	0.00163677
Objective Value	0.00156064

Observations Processed

Read	43
Solved	43

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

MODEL Procedure

OLS Estimation

Nonlinear OLS Summary of Residual Errors

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq	Durbin Watson
PRMXTYR	2	41	0.06711	0.0016368	0.04046	0.9810	0.9806	2.222

Nonlinear OLS Parameter Estimates

Parameter	Estimate	Approx. Std Err	'T' Ratio	Approx. Prob>|T|
GAMMA	-47.560840	0.05108	-931.19	0.0001
THETA	2.475063	0.09055	27.33	0.0001

Number of Observations		Statistics for System	
Used	43	Objective	0.001561
Missing	0	Objective*N	0.0671

RANGE of Fit: YEAR = 1972 TO 2014

Correlations of Estimates

CorrB	GAMMA	THETA
GAMMA	1.0000	0.1369
THETA	0.1369	1.0000

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

MODEL Procedure

Model Summary

Model Variables	1
Parameters	3
RANGE Variable	YEAR
Equations	1
Number of Statements	5

Model Variables: PRMXTYR

Parameters: MXTNL1 GAMMA: -47.56(-931) THETA: 2.475(27)

Equations: PRMXTYR

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

OBS	YEAR	_ESTYPE_	_TYPE_	_WEIGHT_	PRMXTYR	MXTYR
1	1972	OLS	ACTUAL	1	0.61561	-46.8579
2	1972	OLS	PREDICT	1	0.61109	-46.8579
3	1972	OLS	RESIDUAL	1	0.00452	-46.8579
4	1973	OLS	ACTUAL	1	0.68497	-46.1093
5	1973	OLS	PREDICT	1	0.71962	-46.1093
6	1973	OLS	RESIDUAL	1	-0.03465	-46.1093
7	1974	OLS	ACTUAL	1	0.84682	-44.2185
8	1974	OLS	PREDICT	1	0.90785	-44.2185
9	1974	OLS	RESIDUAL	1	-0.06103	-44.2185
10	1975	OLS	ACTUAL	1	0.89306	-44.1093
11	1975	OLS	PREDICT	1	0.91467	-44.1093
12	1975	OLS	RESIDUAL	1	-0.02160	-44.1093
13	1976	OLS	ACTUAL	1	0.80058	-45.1639
14	1976	OLS	PREDICT	1	0.83075	-45.1639
15	1976	OLS	RESIDUAL	1	-0.03017	-45.1639
16	1977	OLS	ACTUAL	1	0.08382	-50.7486
17	1977	OLS	PREDICT	1	0.10249	-50.7486
18	1977	OLS	RESIDUAL	1	-0.01868	-50.7486
19	1978	OLS	ACTUAL	1	0.96243	-42.8032
20	1978	OLS	PREDICT	1	0.96923	-42.8032
21	1978	OLS	RESIDUAL	1	-0.00680	-42.8032
22	1979	OLS	ACTUAL	1	0.75434	-45.4972
23	1979	OLS	PREDICT	1	0.79538	-45.4972
24	1979	OLS	RESIDUAL	1	-0.04104	-45.4972
25	1980	OLS	ACTUAL	1	0.01445	-53.8032
26	1980	OLS	PREDICT	1	0.00782	-53.8032
27	1980	OLS	RESIDUAL	1	0.00663	-53.8032

28	1981	OLS	ACTUAL	1	0.15318	-49.8579
29	1981	OLS	PREDICT	1	0.17940	-49.8579
30	1981	OLS	RESIDUAL	1	-0.02622	-49.8579
31	1982	OLS	ACTUAL	1	0.24566	-48.8305
32	1982	OLS	PREDICT	1	0.30535	-48.8305
33	1982	OLS	RESIDUAL	1	-0.05969	-48.8305
34	1983	OLS	ACTUAL	1	0.03757	-51.4972
35	1983	OLS	PREDICT	1	0.05971	-51.4972
36	1983	OLS	RESIDUAL	1	-0.02214	-51.4972
37	1984	OLS	ACTUAL	1	0.36127	-48.4699
38	1984	OLS	PREDICT	1	0.35765	-48.4699
39	1984	OLS	RESIDUAL	1	0.00362	-48.4699
40	1985	OLS	ACTUAL	1	0.70809	-46.1093
41	1985	OLS	PREDICT	1	0.71962	-46.1093
42	1985	OLS	RESIDUAL	1	-0.01153	-46.1093
43	1986	OLS	ACTUAL	1	0.13006	-50.1093
44	1986	OLS	PREDICT	1	0.15461	-50.1093
45	1986	OLS	RESIDUAL	1	-0.02455	-50.1093
46	1987	OLS	ACTUAL	1	0.98555	-41.4972
47	1987	OLS	PREDICT	1	0.99068	-41.4972
48	1987	OLS	RESIDUAL	1	-0.00513	-41.4972
49	1988	OLS	ACTUAL	1	0.77746	-45.4426
50	1988	OLS	PREDICT	1	0.80147	-45.4426
51	1988	OLS	RESIDUAL	1	-0.02401	-45.4426
52	1989	OLS	ACTUAL	1	0.82370	-45.1639
53	1989	OLS	PREDICT	1	0.83075	-45.1639
54	1989	OLS	RESIDUAL	1	-0.00705	-45.1639
55	1990	OLS	ACTUAL	1	0.91618	-43.7759
56	1990	OLS	PREDICT	1	0.93306	-43.7759
57	1990	OLS	RESIDUAL	1	-0.01687	-43.7759
58	1991	OLS	ACTUAL	1	0.29191	-48.7759
59	1991	OLS	PREDICT	1	0.31305	-48.7759
60	1991	OLS	RESIDUAL	1	-0.02114	-48.7759
61	1992	OLS	ACTUAL	1	0.59249	-47.1639
62	1992	OLS	PREDICT	1	0.56332	-47.1639

63	1992	OLS	RESIDUAL	1	0.02917	-47.1639

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

OBS	YEAR	_ESTYPE_	_TYPE_	_WEIGHT_	PRMXTYR	MXTYR
64	1993	OLS	ACTUAL	1	0.63873	-46.7759
65	1993	OLS	PREDICT	1	0.62362	-46.7759
66	1993	OLS	RESIDUAL	1	0.01510	-46.7759
67	1994	OLS	ACTUAL	1	0.47688	-48.0546
68	1994	OLS	PREDICT	1	0.42143	-48.0546
69	1994	OLS	RESIDUAL	1	0.05545	-48.0546
70	1995	OLS	ACTUAL	1	0.06069	-51.1639
71	1995	OLS	PREDICT	1	0.07654	-51.1639
72	1995	OLS	RESIDUAL	1	-0.01585	-51.1639
73	1996	OLS	ACTUAL	1	0.31503	-48.7759
74	1996	OLS	PREDICT	1	0.31305	-48.7759
75	1996	OLS	RESIDUAL	1	0.00198	-48.7759
76	1997	OLS	ACTUAL	1	0.17630	-49.0819
77	1997	OLS	PREDICT	1	0.27112	-49.0819
78	1997	OLS	RESIDUAL	1	-0.09482	-49.0819
79	1998	OLS	ACTUAL	1	0.66185	-46.7759
80	1998	OLS	PREDICT	1	0.62362	-46.7759
81	1998	OLS	RESIDUAL	1	0.03823	-46.7759
82	1999	OLS	ACTUAL	1	0.26879	-48.8032
83	1999	OLS	PREDICT	1	0.30919	-48.8032
84	1999	OLS	RESIDUAL	1	-0.04040	-48.8032
85	2000	OLS	ACTUAL	1	0.10694	-50.3606
86	2000	OLS	PREDICT	1	0.13227	-50.3606
87	2000	OLS	RESIDUAL	1	-0.02533	-50.3606
88	2001	OLS	ACTUAL	1	0.56936	-47.6940
89	2001	OLS	PREDICT	1	0.47868	-47.6940
90	2001	OLS	RESIDUAL	1	0.09068	-47.6940

91	2002	OLS	ACTUAL	1	0.73121	-45.7486
92	2002	OLS	PREDICT	1	0.76589	-45.7486
93	2002	OLS	RESIDUAL	1	-0.03468	-45.7486
94	2003	OLS	ACTUAL	1	0.22254	-49.0546
95	2003	OLS	PREDICT	1	0.27474	-49.0546
96	2003	OLS	RESIDUAL	1	-0.05220	-49.0546
97	2004	OLS	ACTUAL	1	0.54624	-47.7486
98	2004	OLS	PREDICT	1	0.46995	-47.7486
99	2004	OLS	RESIDUAL	1	0.07629	-47.7486
100	2005	OLS	ACTUAL	1	0.50000	-47.8032
101	2005	OLS	PREDICT	1	0.46123	-47.8032
102	2005	OLS	RESIDUAL	1	0.03877	-47.8032
103	2006	OLS	ACTUAL	1	0.40751	-48.3606
104	2006	OLS	PREDICT	1	0.37411	-48.3606
105	2006	OLS	RESIDUAL	1	0.03340	-48.3606
106	2007	OLS	ACTUAL	1	0.93931	-43.3606
107	2007	OLS	PREDICT	1	0.95136	-43.3606
108	2007	OLS	RESIDUAL	1	-0.01206	-43.3606
109	2008	OLS	ACTUAL	1	0.33815	-48.7213
110	2008	OLS	PREDICT	1	0.32083	-48.7213
111	2008	OLS	RESIDUAL	1	0.01732	-48.7213
112	2009	OLS	ACTUAL	1	0.38439	-48.4153
113	2009	OLS	PREDICT	1	0.36585	-48.4153
114	2009	OLS	RESIDUAL	1	0.01854	-48.4153
115	2010	OLS	ACTUAL	1	0.43064	-48.1912
116	2010	OLS	PREDICT	1	0.40012	-48.1912
117	2010	OLS	RESIDUAL	1	0.03051	-48.1912
118	2011	OLS	ACTUAL	1	0.19942	-49.0819
119	2011	OLS	PREDICT	1	0.27112	-49.0819
120	2011	OLS	RESIDUAL	1	-0.07170	-49.0819
121	2012	OLS	ACTUAL	1	0.45376	-48.1366
122	2012	OLS	PREDICT	1	0.40861	-48.1366
123	2012	OLS	RESIDUAL	1	0.04515	-48.1366
124	2013	OLS	ACTUAL	1	0.86994	-44.1366
125	2013	OLS	PREDICT	1	0.91300	-44.1366

126	2013	OLS	RESIDUAL	1	-0.04306	-44.1366

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

OBS	YEAR	_ESTYPE_	_TYPE_	_WEIGHT_	PRMXTYR	MXTYR
127	2014	OLS	ACTUAL	1	0.52312	-47.7759
128	2014	OLS	PREDICT	1	0.46559	-47.7759
129	2014	OLS	RESIDUAL	1	0.05753	-47.7759

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

OBS	YEAR	MXTYR	PRMXTYR	PROBP
1	1972	-46.8579	0.61561	0.61109
2	1973	-46.1093	0.68497	0.71962
3	1974	-44.2185	0.84682	0.90785
4	1975	-44.1093	0.89306	0.91467
5	1976	-45.1639	0.80058	0.83075
6	1977	-50.7486	0.08382	0.10249
7	1978	-42.8032	0.96243	0.96923
8	1979	-45.4972	0.75434	0.79538
9	1980	-53.8032	0.01445	0.00782
10	1981	-49.8579	0.15318	0.17940
11	1982	-48.8305	0.24566	0.30535
12	1983	-51.4972	0.03757	0.05971
13	1984	-48.4699	0.36127	0.35765
14	1985	-46.1093	0.70809	0.71962
15	1986	-50.1093	0.13006	0.15461
16	1987	-41.4972	0.98555	0.99068
17	1988	-45.4426	0.77746	0.80147
18	1989	-45.1639	0.82370	0.83075
19	1990	-43.7759	0.91618	0.93306
20	1991	-48.7759	0.29191	0.31305
21	1992	-47.1639	0.59249	0.56332
22	1993	-46.7759	0.63873	0.62362
23	1994	-48.0546	0.47688	0.42143
24	1995	-51.1639	0.06069	0.07654
25	1996	-48.7759	0.31503	0.31305
26	1997	-49.0819	0.17630	0.27112
27	1998	-46.7759	0.66185	0.62362

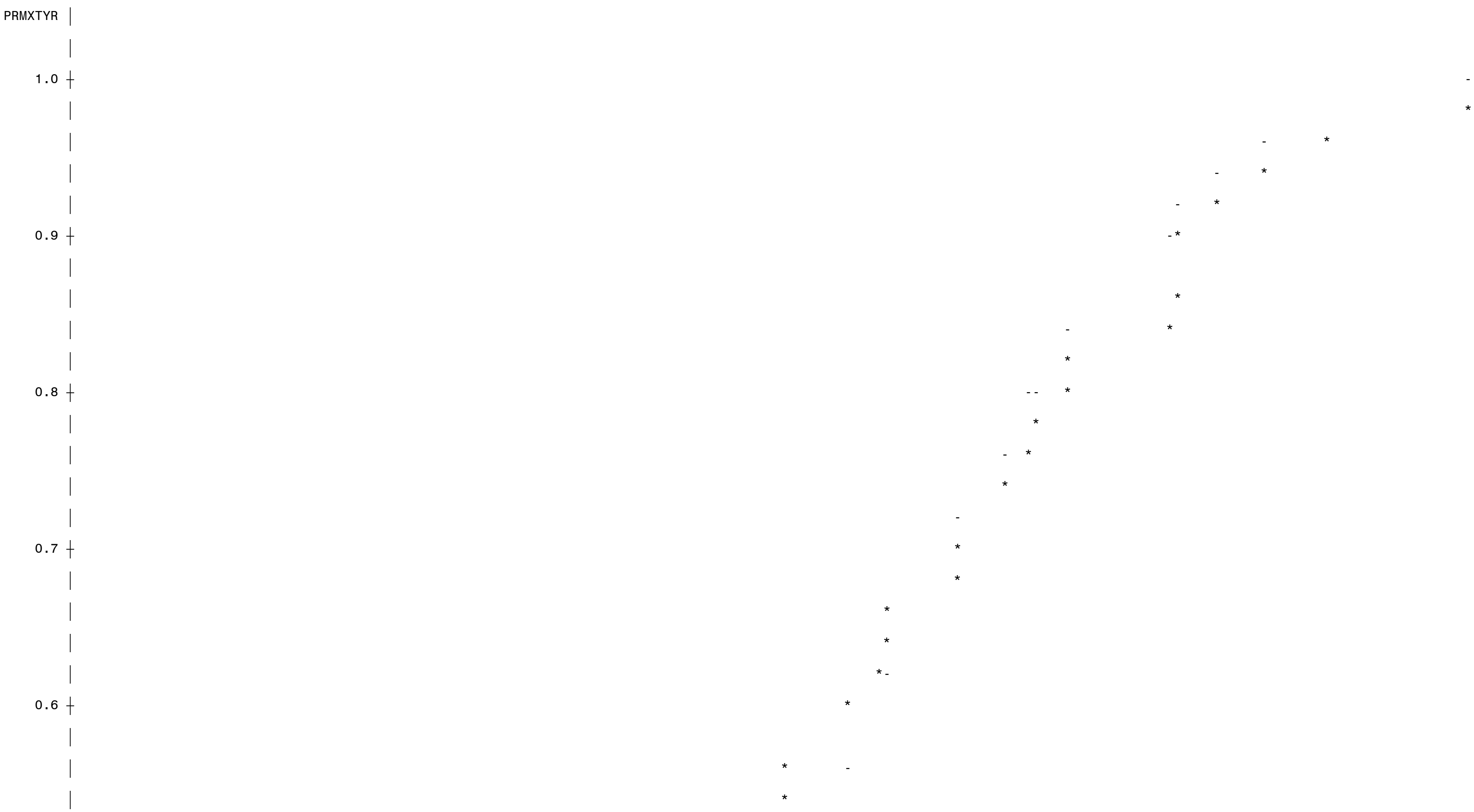
28	1999	-48.8032	0.26879	0.30919
29	2000	-50.3606	0.10694	0.13227
30	2001	-47.6940	0.56936	0.47868
31	2002	-45.7486	0.73121	0.76589
32	2003	-49.0546	0.22254	0.27474
33	2004	-47.7486	0.54624	0.46995
34	2005	-47.8032	0.50000	0.46123
35	2006	-48.3606	0.40751	0.37411
36	2007	-43.3606	0.93931	0.95136
37	2008	-48.7213	0.33815	0.32083
38	2009	-48.4153	0.38439	0.36585
39	2010	-48.1912	0.43064	0.40012
40	2011	-49.0819	0.19942	0.27112
41	2012	-48.1366	0.45376	0.40861
42	2013	-44.1366	0.86994	0.91300
43	2014	-47.7759	0.52312	0.46559

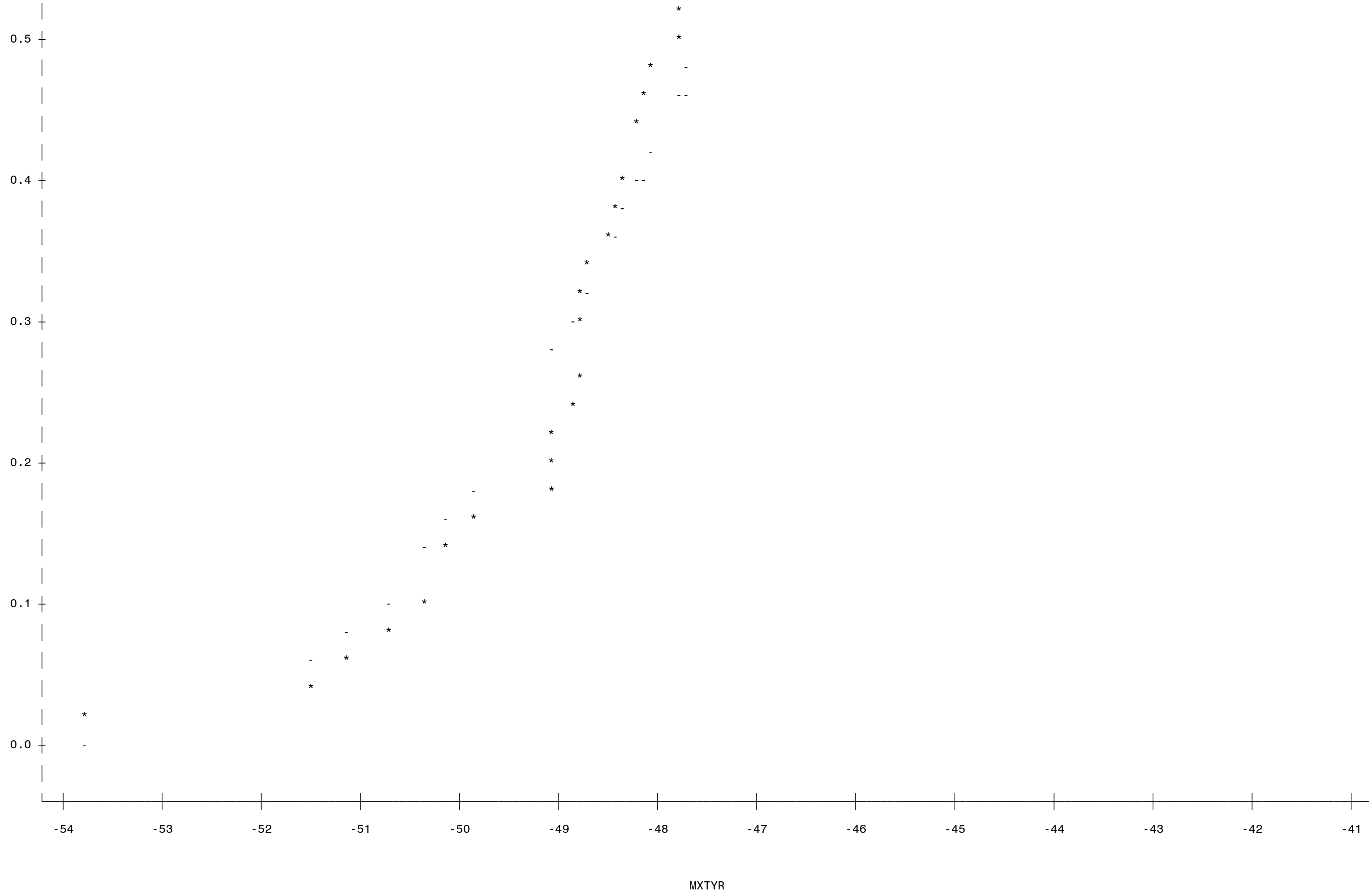
Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

Plot of PRMXTYR*MXTYR. Symbol used is '*'.

Plot of PROBP*MXTYR. Symbol used is '-'.





NOTE: 13 obs hidden.

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Non-linear Estimation of 2-parameter T-Dist Model.: for Maximum NEGATIVE Temperature (Deg-F).

OBS	_NAME_	_TYPE_	_NUSED_	GAMMA	THETA
1		OLS	43	-47.5608	2.47506
2	GAMMA	OLS	43	0.0026	0.00063
3	THETA	OLS	43	0.0006	0.00820

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Est'd CDFs and Logarithms of 'Empirical CDF rel. to Fitted CDF' values by Models.

OBS	YEAR	MXTYR	QUANTILE	PRMXTYR	PROBP1	LGPRRAT1
1	1972	-46.8579	2	0.61561	0.61109	0.00736
2	1973	-46.1093	3	0.68497	0.71962	-0.04934
3	1974	-44.2185	3	0.84682	0.90785	-0.06959
4	1975	-44.1093	3	0.89306	0.91467	-0.02390
5	1976	-45.1639	3	0.80058	0.83075	-0.03699
6	1977	-50.7486	1	0.08382	0.10249	-0.20117
7	1978	-42.8032	3	0.96243	0.96923	-0.00704
8	1979	-45.4972	3	0.75434	0.79538	-0.05298
9	1980	-53.8032	1	0.01445	0.00782	0.61387
10	1981	-49.8579	1	0.15318	0.17940	-0.15803
11	1982	-48.8305	1	0.24566	0.30535	-0.21750
12	1983	-51.4972	1	0.03757	0.05971	-0.46327
13	1984	-48.4699	2	0.36127	0.35765	0.01008
14	1985	-46.1093	3	0.70809	0.71962	-0.01615
15	1986	-50.1093	1	0.13006	0.15461	-0.17292
16	1987	-41.4972	3	0.98555	0.99068	-0.00519
17	1988	-45.4426	3	0.77746	0.80147	-0.03042
18	1989	-45.1639	3	0.82370	0.83075	-0.00852
19	1990	-43.7759	3	0.91618	0.93306	-0.01825
20	1991	-48.7759	1	0.29191	0.31305	-0.06992
21	1992	-47.1639	2	0.59249	0.56332	0.05048
22	1993	-46.7759	2	0.63873	0.62362	0.02393
23	1994	-48.0546	2	0.47688	0.42143	0.12361
24	1995	-51.1639	1	0.06069	0.07654	-0.23198
25	1996	-48.7759	1	0.31503	0.31305	0.00631
26	1997	-49.0819	1	0.17630	0.27112	-0.43036
27	1998	-46.7759	2	0.66185	0.62362	0.05949

28	1999	-48.8032	1	0.26879	0.30919	-0.14004
29	2000	-50.3606	1	0.10694	0.13227	-0.21262
30	2001	-47.6940	2	0.56936	0.47868	0.17349
31	2002	-45.7486	3	0.73121	0.76589	-0.04634
32	2003	-49.0546	1	0.22254	0.27474	-0.21070
33	2004	-47.7486	2	0.54624	0.46995	0.15044
34	2005	-47.8032	2	0.50000	0.46123	0.08071
35	2006	-48.3606	2	0.40751	0.37411	0.08552
36	2007	-43.3606	3	0.93931	0.95136	-0.01275
37	2008	-48.7213	2	0.33815	0.32083	0.05259
38	2009	-48.4153	2	0.38439	0.36585	0.04945
39	2010	-48.1912	2	0.43064	0.40012	0.07349
40	2011	-49.0819	1	0.19942	0.27112	-0.30713
41	2012	-48.1366	2	0.45376	0.40861	0.10480
42	2013	-44.1366	3	0.86994	0.91300	-0.04831
43	2014	-47.7759	2	0.52312	0.46559	0.11651

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Stats for Logarithms of 'Empirical CDF rel. to Fitted CDF' values by Models to calc. RMSE of Prop. Model Spec

Analysis Variable : LGPRRAT1 Log(PrMxTYr/ProbP1)- T-Dist

N	Mean	Std Dev	Minimum	Maximum	Variance	USS
43	-0.0339368	0.1741811	-0.4632695	0.6138723	0.0303390	1.3237633

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Stats By Quantile for Logarithms of 'Empirical CDF rel. to Fitted CDF' values by Models to calc. RMSE of Prop. Model Spec

Analysis Variable : LGPRRAT1 Log(PrMxTYr/ProbP1)- T-Dist

-- QUANTILE=1 ---

N	Mean	Std Dev	Minimum	Maximum	Variance	USS
14	-0.1568182	0.2537892	-0.4632695	0.6138723	0.0644089	1.1816034

-- QUANTILE=2 ---

N	Mean	Std Dev	Minimum	Maximum	Variance	USS
15	0.0774637	0.0491452	0.0073635	0.1734859	0.0024153	0.1238229

-- QUANTILE=3 ---

N	Mean	Std Dev	Minimum	Maximum	Variance	USS
14	-0.0304130	0.0203577	-0.0695939	-0.0051884	0.000414437	0.0183370

Fit GEV Probability Model to Empirical CDF using NL-OLS Regression Methods.

Stats By Quantile for Logarithms of 'Empirical CDF rel. to Fitted CDF' values by Models to calc. RMSE of Prop. Model Spec

Analysis Variable : LGPRRAT1 Log(PrMxTYr/ProbP1)- T-Dist

QUANTILE=1

N	Mean	Std Dev	Minimum	Maximum	Variance	USS
14	-0.1568182	0.2537892	-0.4632695	0.6138723	0.0644089	1.1816034

QUANTILE=2

N	Mean	Std Dev	Minimum	Maximum	Variance	USS
15	0.0774637	0.0491452	0.0073635	0.1734859	0.0024153	0.1238229

QUANTILE=3

N	Mean	Std Dev	Minimum	Maximum	Variance	USS
14	-0.0304130	0.0203577	-0.0695939	-0.0051884	0.000414437	0.0183370

San Diego Gas and Electric Residential End-Use Model

I. Residential End-Use Model Description

Introduction:

SDG&E used the End Use Forecaster model to generate annual gas demand forecasts for the residential market from 2017 through 2019. The software's market segmentation and end-use modeling framework analyzes the impacts of competitive strategies (gas vs. electricity) and market scenarios on gas demand and market shares.

The model separates the residential market into four building types (B-level). These groups are identified by the premise code classification found in the company billing files. The four residential groups are:

• Single-Family (SF);
• Multi-Family (MF);
• Master Metered (MM); and
• Sub-Metered (SM).

The residential model identifies eight end-uses (N-level) that are the primary drivers of natural gas demand:

• Space heating;
• Water heating;
• Cooking;
• Drying;
• Pool heating;
• Spa heating;
• Fireplace; and
• Barbeque.

The model assumes two fuel choices (F-level) for end-uses:

• Natural gas; and
• Electricity.

The model assumes up to four efficiency levels (E-level) for the various enduses. In general, the efficiency levels are:

• Stock;
• Standard;
• High efficiency; and
• Premium efficiency.

See Figure 1 for a classification of the number of efficiency levels for each end use by customer segment type.

A set of post-model adjustments were applied to the model's annual demand forecast. The first adjustment calibrates to the recorded 2014 weather-adjusted demand. Next, the annual forecast was parceled out to a series of monthly forecasts by a process which involves two steps. These two steps consist of (1) using the fitted equation for customer demand to generate a forecast of use per customer that varies with the number of calendar days and heating degree days in a given month and (2) calculating a series of weights based on the customer's predicted monthly usage share in total annual consumption. The shares obtained from the latter step were then applied to annual totals to derive the stream of monthly forecasts which are conditional on the particular weather design specification for the entire year. An adjustment to the forecast offsets the throughput by the energy efficiency savings. Annual conservation benefits associated with AMI are estimated by SDGE to represent 1% of the core gas throughput in the post deployment period. In each year of the deployment period, 1/3 of 1% of the load will have been conserved due to AMI. After 2011, 1% of the load will have been conserved due to AMI energy savings. The residential load was reduced by the AMI expected energy savings.

Figures 2-5 illustrate the monthly forecasts for each weather scenario.

Data Sources:

The information used to perform the modeling and to generate the forecast includes historical 2014 consumption and customer counts; meter counts, growth, and decay; use per customer by vintage and unit energy consumption (UEC) values; fuel costs and price elasticity; equipment capital costs and availability; building and equipment lives and decay. The historical 2014 data is in Figure 6.

Meter Counts, Growth and Decay:

Regression equations were developed for each building type. The meter count forecast is a company-specific forecast based on actual meter counts within the SDG&E service territory. Data on meter decay rates were obtained from the Energy Information Administration (EIA). See Figure 7 for the meter forecast.

Use Per Customer by Vintage and UEC:

Use per customer and Unit Energy Consumption (UEC) data were based on company marketing data and the California Measurement Advisory Council. See Figure 8 for the appliance UEC's.

Fuel Costs and Price Elasticity:

Average and marginal gas prices ($/therm) were calculated from forecasts of the residential rate components. Residential rates have two consumption tiers. We used the simple average of the second tiers' projected monthly prices for each forecast year as the marginal rate. The marginal rate was used for each housing segment type.

For a given housing segment type, the average gas commodity rate was calculated using a pair of weights for the two consumption tiers applied to the simple average of each tier's monthly rate. The average commodity rate in each forecast year was developed using the same consumption tier weights, but with the forecasts of rates for each residential rate tier. The average gas price each year was then calculated by including the non-volumetric customer charges with the year's average gas commodity price. Figure 9 illustrates the gas price forecasts.

Electric Price Data:

The electricity price inputs consist of average prices (cents/kWh) and marginal prices (cents/kWh). The forecasts for the residential customer class were developed by SDG&E's electricity rate analysis group.

A ratio of the housing type's average gas price to the overall residential gas price was constructed. The weight was then multiplied by the overall average electricity price to derive residential market-specific electricity prices.

The marginal prices for each residential housing type were calculated by multiplying each year's respective average price by a ratio
Copies of these rate schedules were obtained from the SCE web-site. Figure 10 illustrates the electricity price forecasts.

Price elasticities for each building type were based on the SoCalGas Residential Econometric Demand Forecasting Model. See Figure 7 for price elasticities.

Equipment Capital Costs and Availability:

Data on equipment capital costs and availability were from EIA, the Residential Appliance Saturation Survey (RASS), Energy Star (EPA & DOE), and SDGE company data. See Figures 11 and 12 for gas and electric appliance equipment cost.

Building and Equipment Lives and Decay:

Building decay rates are based on the building shell lifetimes, where the lifetime is defined as the length of time it takes for either a demolition or a major renovation to occur. For single-family residential buildings, an exponential rate of decay of 0.3% per year was assumed. See Figure 13 for the building decay rates.

Data on equipment lives and decay rates are based on EIA, RASS, Energy Star, and SoCalGas company data. See Figure 14 for the average lifetimes of gas appliances.

Saturations, Fuel and Efficiency Shares:

Saturation values, fuel shares, and efficiency shares were extracted from SoCalGas company data files and the RASS survey. Please see Figures 15-18 for saturations, fuel, and efficiency shares.

<u>AMI:</u>

The conservation benefits estimated by SDGE represent approximately 1% of core gas throughput in 2014 (post deployment year). The conservation benefits were incorporated in the forecast as a post-model adjustment.

II. Residential End-Use Model Data

San Diego Gas and Electric Company
Figure 1: Number of Efficiency Levels by End Use by Customer Segment

	Space Heating		Water Heating		Cooking		Drying		Pool		Spa		Fireplace		BBQ	
	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric
Single Family	4	1	4	4	2	2	2	4	2	0	2	0	1	0	1	1
Multi-Family	4	1	4	4	2	2	2	4	0	0	0	0	0	0	1	1
Master Meter	4	1	4	4	2	2	2	4	0	0	0	0	0	0	1	1
Sub-Meter	4	1	4	4	2	2	2	4	0	0	0	0	0	0	1	1

San Diego Gas and Electric Company
Figure 2: Average Temperature Year Demand Forecast

YEAR	MDTH1	MDTH2	MDTH3	MDTH4	MDTH5	MDTH6	MDTH7	MDTH8	MDTH9	MDTH10	MDTH11	MDTH12	TOTAL
2014	4,291	3,823	3,538	2,901	2,095	1,610	1,520	1,513	1,476	1,817	2,795	4,418	31,797
2015	4,235	3,773	3,492	2,864	2,068	1,590	1,501	1,493	1,457	1,794	2,759	4,361	31,387
2016	4,281	3,863	3,530	2,895	2,090	1,607	1,517	1,510	1,472	1,814	2,789	4,408	31,777
2017	4,306	3,836	3,550	2,912	2,102	1,616	1,526	1,518	1,481	1,824	2,806	4,434	31,912
2018	4,320	3,849	3,562	2,921	2,109	1,621	1,531	1,523	1,486	1,830	2,814	4,448	32,014
2019	4,327	3,855	3,568	2,926	2,112	1,624	1,533	1,526	1,488	1,833	2,819	4,456	32,069
2020	4,315	3,893	3,558	2,918	2,106	1,619	1,529	1,521	1,484	1,828	2,811	4,443	32,026

San Diego Gas and Electric Company
Figure 3: Cold Temperature Year Demand Forecast

YEAR	MDTH1	MDTH2	MDTH3	MDTH4	MDTH5	MDTH6	MDTH7	MDTH8	MDTH9	MDTH10	MDTH11	MDTH12	TOTAL
2014	4,939	4,396	4,009	3,235	2,227	1,640	1,517	1,508	1,474	1,884	3,104	5,097	35,029
2015	4,887	4,350	3,967	3,201	2,203	1,623	1,501	1,492	1,458	1,864	3,071	5,043	34,660
2016	4,942	4,447	4,011	3,237	2,228	1,641	1,518	1,509	1,474	1,885	3,106	5,099	35,097
2017	4,975	4,428	4,038	3,258	2,243	1,652	1,528	1,519	1,484	1,898	3,126	5,133	35,283
2018	4,996	4,447	4,055	3,272	2,252	1,659	1,535	1,525	1,491	1,906	3,140	5,155	35,435
2019	5,012	4,460	4,068	3,282	2,259	1,664	1,540	1,530	1,495	1,912	3,149	5,171	35,542
2020	5,006	4,505	4,063	3,279	2,257	1,662	1,538	1,528	1,493	1,910	3,146	5,165	35,551

San Diego Gas and Electric Company
Figure 4: Hot Temperature Year Demand Forecast

YEAR	MDTH1	MDTH2	MDTH3	MDTH4	MDTH5	MDTH6	MDTH7	MDTH8	MDTH9	MDTH10	MDTH11	MDTH12	TOTAL
2014	3,640	3,248	3,065	2,568	1,963	1,582	1,525	1,519	1,479	1,752	2,487	3,738	28,564
2015	3,583	3,197	3,017	2,527	1,932	1,557	1,501	1,495	1,456	1,724	2,448	3,679	28,115
2016	3,620	3,279	3,048	2,554	1,952	1,573	1,516	1,511	1,471	1,742	2,473	3,717	28,457
2017	3,637	3,245	3,063	2,566	1,962	1,580	1,524	1,518	1,478	1,750	2,485	3,735	28,542
2018	3,644	3,251	3,068	2,570	1,965	1,583	1,526	1,520	1,480	1,753	2,489	3,741	28,592
2019	3,644	3,251	3,069	2,571	1,965	1,583	1,526	1,521	1,480	1,754	2,489	3,742	28,596
2020	3,626	3,284	3,053	2,558	1,956	1,575	1,519	1,513	1,473	1,745	2,477	3,723	28,501

San Diego Gas and Electric Company
Figure 5: Base Temperature Year Demand Forecast

YEAR	MDTH1	MDTH2	MDTH3	MDTH4	MDTH5	MDTH6	MDTH7	MDTH8	MDTH9	MDTH10	MDTH11	MDTH12	TOTAL
2014	1,554	1,404	1,554	1,504	1,554	1,504	1,554	1,554	1,504	1,554	1,504	1,554	18,297
2015	1,505	1,359	1,505	1,457	1,505	1,457	1,505	1,505	1,457	1,505	1,457	1,505	17,721
2016	1,517	1,419	1,517	1,468	1,517	1,468	1,517	1,517	1,468	1,517	1,468	1,517	17,911
2017	1,515	1,368	1,515	1,466	1,515	1,466	1,515	1,515	1,466	1,515	1,466	1,515	17,837
2018	1,505	1,360	1,505	1,457	1,505	1,457	1,505	1,505	1,457	1,505	1,457	1,505	17,725
2019	1,492	1,347	1,492	1,444	1,492	1,444	1,492	1,492	1,444	1,492	1,444	1,492	17,564
2020	1,466	1,371	1,466	1,418	1,466	1,418	1,466	1,466	1,418	1,466	1,418	1,466	17,305

San Diego Gas and Electric Company
Figure 6: 2014 Historical Data

Segment	Total Therm Sales	Meter Count Pre-1979 customers	Meter Count 1979-2004 customers	Meter Count 2005-2014 customers
Single Family	181,284,609	547,077	91,428	1,814
Multi-Family	41,485,109	138,989	35,891	927
Master Meter	26,536,647	11,030	358	25
Sub-Meter	8,133,159	464	1	0

Segment	Use Per Customer (UPC, Therms) Pre-79 Customers	Use Per Customer (UPC, Therms) 1979-2004	Use Per Customer (UPC, Therms) 2005-2014
Single Family	337	406	327
Multi-Family	277	335	268
Master Meter	2,829	3,413	1,802
Sub-Meter	21,417	14,967	0

Segment	Price Elasticity
Single Family	-0.1053
Multi-Family	-0.07145
Master Meter	-0.0688
Sub-Meter	-0.1053

San Diego Gas and Electric Company
Figure 7: Meter Count Forecast

Year	Single Family	Multi-Family	Master Meter	Sub-Meter
2015	654,381	179,668	11,520	469
2016	664,046	182,322	11,520	469
2017	674,245	185,122	11,520	469
2018	684,597	187,964	11,520	469
2019	695,103	190,849	11,520	469
2020	705,588	193,727	11,520	469

* Note: Master meter and sub-meter groups are expected to decline.
A decay rate was built into the model specification.

San Diego Gas and Electric Company
Figure 8: Appliance Unit Energy Consumption (Gas in therms, Electric in Kwh)

		Single Family		Multi-Family		Master Meter		Sub Meter	
End-Use	**Vintage**	**Gas**	**Electric**	**Gas**	**Electric**	**Gas**	**Electric**	**Gas**	**Electric**
Space Heat	Stock	370	4,110	200	730	200	730	330	1,340
	Standard	330	3,730	180	-	180	-	300	-
	High	310	3,450	170	-	170	-	280	-
	Premium	280	3,170	150	-	150	-	260	-
Water Heat	Stock	260	2,440	230	2,440	230	2,440	210	2,010
	Standard	240	2,220	210	2,220	210	2,220	190	1,830
	High	230	2,110	200	2,110	200	2,110	180	1,740
	Premium	220	2,050	190	2,050	190	2,050	180	1,690
Cooking	Stock	50	574	34	465	34	465	45	514
	Standard	43	488	29	395	29	395	38	437
Drying	Stock	45	1,442	24	1,442	24	1,442	26	873
	Standard	43	1,370	23	1,370	23	1,370	25	830
Pool	Stock	177	3,431	177	3,431	177	3,431	177	3,431
Spa	Stock	146	430	146	430	146	430	146	430
Fireplace	Stock	21	-	21	-	21	-	21	-
BBQ	Stock	28	-	28	-	28	-	28	-

San Diego Gas and Electric Company

Figure 9: Average and Marginal Gas Prices ($/therm)

Year	Res Price Deflator	R SF Average Price	R SF Marginal Price	R MF Average Price	R MF Marginal Price	R MM Average Price	R MM Marginal Price	R SM Average Price	R SM Marginal Price
2014	100.0	1.3086	1.3282	1.2900	1.3282	1.2916	1.3282	1.3089	1.3282
2015	99.5	1.3238	1.3465	1.3022	1.3465	1.3041	1.3465	1.3242	1.3465
2016	101.8	1.1992	1.2182	1.1812	1.2182	1.1828	1.2182	1.1996	1.2182
2017	104.5	1.1951	1.2141	1.1771	1.2141	1.1786	1.2141	1.1954	1.2141
2018	107.2	1.2111	1.2303	1.1928	1.2303	1.1944	1.2303	1.2114	1.2303
2019	109.8	1.2520	1.2718	1.2331	1.2718	1.2347	1.2718	1.2523	1.2718
2020	112.6	1.3425	1.3639	1.3221	1.3639	1.3238	1.3639	1.3428	1.3639

San Diego Gas and Electric Company

Figure 10: Average and Marginal Electricity Prices ($/therm)

Year	R SF Average Price	R SF Marginal Price	R MF Average Price	R MF Marginal Price	R MM Average Price	R MM Marginal Price	R SM Average Price	R SM Marginal Price
2014	17.29	26.16	17.04	25.79	17.07	17.65	17.29	19.46
2015	17.36	26.27	17.08	25.84	17.10	17.68	17.36	19.54
2016	18.08	27.36	17.81	26.95	17.83	18.44	18.09	20.35
2017	18.62	28.18	18.34	27.76	18.37	18.99	18.63	20.96
2018	19.34	29.26	19.05	28.82	19.07	19.72	19.34	21.77
2019	20.00	30.26	19.70	29.80	19.72	20.39	20.00	22.51
2020	20.68	31.30	20.37	30.82	20.40	21.09	20.69	23.28

San Diego Gas and Electric Company
Figure 11: Gas Appliance Equipment Cost (Nominal $)

End-Use	Efficiency Level	Single Family	Multi-Family	Master Meter	Sub Meter
Space Heat	Stock	4,000	1,600	1,000	1,600
	Standard	4,600	1,840	1,150	1,840
	High	4,800	1,920	1,200	1,920
	Premium	5,000	1,980	1,250	1,980
Water Heat	Stock	550	330	330	330
	Standard	650	390	390	390
	High	700	420	420	420
	Premium	750	450	450	450
Cooking	Stock	500	250	250	250
	Standard	1,400	1,400	1,400	1,400
Drying	Stock	328	328	328	328
	Standard	482	482	482	482
Pool	Stock	1,200	1,200	1,200	1,200
Spa	Stock	2,000	2,000	2,000	2,000
Fireplace	Stock	150	150	150	150
BBQ	Stock	1,000	600	600	600

San Diego Gas and Electric Company
Figure 12: Electric Appliance Equipment Cost (Nominal $)

End-Use	Efficiency Level	Single Family	Multi-Family	Master Meter	Sub Meter
Space Heat	Stock	4,100	1,640	1,025	1,640
Water Heat	Stock	550	330	330	330
	Standard	650	390	390	390
	High	700	420	420	420
	Premium	750	450	450	450
Cooking	Stock	500	250	250	250
	Standard	1,400	1,400	1,400	1,400
Drying	Stock	328	328	328	328
	Standard	482	482	482	482
Pool	Stock	1,200	1,200	1,200	1,200
Spa	Stock	2,000	2,000	2,000	2,000
Fireplace	Stock	150	150	150	150
BBQ	Stock	1,000	600	600	600

San Diego Gas and Electric Company
Figure 13: Building Lives and Decay Rate

Building Type	Building decay Rate
Single Family	0.003
Multi-Family	0.006
Master Meter	0.008
Sub-Meter	0.008

San Diego Gas and Electric Company
Figure 14: Gas Appliance Age (Years)

		Single Family		Multi-Family		Master Meter		Sub Meter	
End-Use	**Vintage**	**Max**	**Average**	**Max**	**Average**	**Max**	**Average**	**Max**	**Average**
Space Heat	Pre-1979	17	17	15	15	16	16	16	16
	1979-2004	10	17	11	15	11	16	11	16
	2005-2014	3	17	4	15	4	16	4	16
Water Heat	Pre-1979	7	7	6	8	6	8	6	8
	1979-2004	7	7	8	8	8	8	8	8
	2005-2014	3	7	4	8	4	8	4	8
Cooking	Pre-1979	12	12	10	11	14	14	14	14
	1979-2004	10	12	11	11	11	14	11	14
	2005-2014	2	12	4	11	3	14	3	14
Drying	Pre-1979	8	8	6	8	8	8	8	8
	1979-2004	8	8	8	8	8	8	8	8
	2005-2014	6	8	3	8	4	8	4	8
Pool	Pre-1979	13	13	13	13	13	13	13	13
	1979-2004	9	13	9	13	9	13	9	13
	2005-2014	3	13	3	13	3	13	3	13
Spa	Pre-1979	11	11	11	11	11	11	11	11
	1979-2004	8	11	8	11	8	11	8	11
	2005-2014	3	11	3	11	3	11	3	11
Fireplace	Pre-1979	15	15	15	15	15	15	15	15
	1979-2004	15	15	15	15	15	15	15	15
	2005-2014	15	15	15	15	15	15	15	15
BBQ	Pre-1979	7	7	5	5	5	9	5	9
	1979-2004	7	7	5	5	9	9	9	9
	2005-2014	5	7	5	5	2	9	2	9
Other	Pre-1979	15	15	15	15	15	15	15	15
	1979-2004	15	15	15	15	15	15	15	15
	2005-2014	15	15	15	15	15	15	15	15

San Diego Gas and Electric Company
Figure 15: End Use Saturations

End-Use	Vintage	Single Family	Multi-Family	Master Meter	Sub Meter
Space Heat	Pre-1979	0.9692	0.9178	0.8875	0.9130
	1979-2004	0.9933	0.9424	0.8161	0.9355
	2005-2014	0.9753	0.8323	0.6471	N/A
Water Heat	Pre-1979	0.9754	0.6048	0.8125	0.9022
	1979-2004	0.9721	0.6488	0.7816	1.0000
	2005-2014	0.9899	0.7649	0.5294	N/A
Cooking	Pre-1979	0.7245	0.8623	0.6250	0.8696
	1979-2004	0.7402	0.7910	0.5057	0.9032
	2005-2014	0.9445	0.8996	0.8235	N/A
Drying	Pre-1979	0.6123	0.1177	0.3000	0.4130
	1979-2004	0.6605	0.2484	0.4713	0.7097
	2005-2014	0.7507	0.4821	0.2941	N/A
Pool	Pre-1979	0.0400	0.1045	0.1179	0.1179
	1979-2004	0.0626	0.1941	0.0053	0.0053
	2005-2014	0.0211	0.1941	0.0053	N/A
Spa	Pre-1979	0.0597	0.0668	0.1329	0.1329
	1979-2004	0.1145	0.2896	0.2012	0.2012
	2005-2014	0.0952	0.2896	0.2012	N/A
Fireplace	Pre-1979	0.0855	0.1519	0.1894	0.1894
	1979-2004	0.1881	0.4775	0.4156	0.4156
	2005-2014	0.2949	0.4775	0.4156	N/A
BBQ	Pre-1979	0.1117	0.0816	0.0875	0.0652
	1979-2004	0.2055	0.0721	0.1494	0.0967
	2005-2014	0.3637	0.1669	0.0588	N/A

San Diego Gas and Electric Company
Figure 16: Gas Fuel Shares (average)

End-Use	Single Family	Multi-Family	Master Meter	Sub Meter
Space Heat	0.9399	0.8168	0.7710	0.7304
Water Heat	0.9878	0.9673	0.9356	0.7403
Cooking	0.6621	0.7440	0.5861	0.6871
Drying	0.7592	0.6962	0.8156	0.5469
Pool	0.7263	0.7263	0.7263	0.7263
Spa	0.5462	0.5819	0.5819	0.5819
Fireplace	0.5815	0.5816	0.5816	0.5816
BBQ	0.2814	0.2344	0.3114	0.1364

Southern California Gas Company
Figure 17: Gas Efficiency Shares

Gas End-Use	Efficiency Level	Single Family Existing	Single Family New	Multi-Family 2 - 4 Units Existing	Multi-Family 2 - 4 Units New	Multi-Family > 4 Units Existing	Multi-Family > 4 Units New	Master Meter Existing	Master Meter New	Sub Meter Existing	Sub Meter New
Space Heat	Stock	0.59	0.59	0.70	0.70	0.50	0.50	0.50	0.50	0.59	0.59
	Standard	0.34	0.34	0.28	0.28	0.48	0.48	0.48	0.48	0.34	0.34
	High	0.06	0.06	0.01	0.01	0.01	0.01	0.01	0.01	0.06	0.06
	Premium	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Water Heat	Stock	0.10	0.10	0.22	0.22	0.13	0.13	0.13	0.13	0.10	0.10
	Standard	0.68	0.68	0.61	0.61	0.76	0.76	0.76	0.76	0.68	0.68
	High	0.21	0.21	0.16	0.16	0.10	0.10	0.10	0.10	0.21	0.21
	Premium	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cooking	Stock	0.90	0.90	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	Standard	0.10	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Drying	Stock	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	Standard	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Pool	Stock	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Spa	Stock	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fireplace	Stock	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
BBQ	Stock	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

San Diego Gas and Electric Company
Figure 18: Electric Efficiency Shares

Electric End-Use	Efficiency Level	Single Family Existing	Single Family New	Multi-Family Existing	Multi-Family New	Master Meter Existing	Master Meter New	Sub Meter Existing	Sub Meter New
Space Heat	Stock	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Water Heat	Stock	0.10	0.10	0.13	0.13	0.13	0.13	0.10	0.10
	Standard	0.68	0.68	0.76	0.76	0.76	0.76	0.68	0.68
	High	0.21	0.21	0.10	0.10	0.10	0.10	0.21	0.21
	Premium	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cooking	Stock	0.90	0.90	0.95	0.95	0.95	0.95	0.95	0.95
	Standard	0.10	0.10	0.05	0.05	0.05	0.05	0.05	0.05
Drying	Stock	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	Standard	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Pool	Stock	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Spa	Stock	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fireplace	Stock	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
BBQ	Stock	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

III. Energy Efficiency

San Diego Gas and Electric Company
Energy Efficiency

	Reported 2006 Therms	Reported 2007 Therms	Reported 2008 Therms	Reported 2009 Therms	Reported 2010 Therms	Reported 2011 Therms	Reported 2012 Therms	Reported 2013 Therms	Forecast 2014 Therms	Forecast 2015 Therms	Forecast 2016 Therms	Forecast 2017 Therms	Forecast 2018 Therms	Forecast 2019 Therms	Forecast 2020 Therms
SDG&E EE Programs TOTAL Recorded	**1,652,856**	**3,141,304**	**3,146,590**	**4,764,177**	**628,756**	**1,365,631**	**1,713,642**	**852,804**	**2,107,194**						
PUC Goal	**2,700,000**	**3,100,000**	**3,700,000**	**3,700,000**	**3,500,000**	**3,800,000**	**4,100,000**	**2,200,000**	**2,200,000**	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000
Difference	**(1,047,144)**	**41,304**	**(553,410)**	**1,064,177**	**(2,871,244)**	**(2,434,369)**	**(2,386,358)**	**(1,347,196)**	**(92,806)**						

SDGE	**2006 therms**	**2007 therms**	**2008 therms**	**2009 therms**	**2010 therms**	**2011 therms**	**2012 therms**	**2013 therms**	**2014 therms**
Core Residential	505,394	891,146	906,495	1,127,509	(793,637)	161,413	(698,947)	(107,097)	408,263
Core Commercial	1,011,317	1,983,180	1,974,310	3,205,182	1,253,628	1,061,339	2,126,338	846,010	1,497,355
Core Industrial	20,715	40,621	40,439	65,651	25,678	21,739	43,553	17,329	30,670
NonCore Commercial	11,543	22,636	22,535	36,584	14,309	12,114	24,270	9,656	17,091
NonCore Industrial retail	103,887	203,722	202,811	329,252	128,779	109,026	218,428	86,906	153,816
Total	**1,652,856**	**3,141,304**	**3,146,590**	**4,764,177**	**628,756**	**1,365,631**	**1,713,642**	**852,804**	**2,107,194**

Proportionally scale savings down or up to match PUC Goals for 2011 - 2014

ANNUALSAVINGS	**2006 mdth**	**2007 mdth**	**2008 mdth**	**2009 mdth**	**2010 mdth**	**2011 mdth**	**2012 mdth**	**2013 mdth**	**2014 mdth**	**2015 mdth**	**2016 mdth**	**2017 mdth**	**2018 mdth**	**2019 mdth**	**2020 mdth**
Residential	51	89	91	113	(442)	45	(167)	(28)	(28)	(31)	(31)	(31)	(31)	(31)	(31)
Core Commercial	101	198	197	321	698	295	509	218	218	248	248	248	248	248	248
Core Industrial	2	4	4	7	14	6	10	4	4	5	5	5	5	5	5
Noncore Commercial	1	2	2	4	8	3	6	2	2	3	3	3	3	3	3
Noncore Industrial	10	20	20	33	72	30	52	22	22	25	25	25	25	25	25
Total	**165**	**314**	**315**	**476**	**350**	**380**	**410**	**220**	**220**	**250**	**250**	**250**	**250**	**250**	**250**

Cumulative Savings mdth

SDGE	**2015 mdth**	**2016 mdth**	**2017 mdth**	**2018 mdth**	**2019 mdth**	**2020 mdth**
Residential	(31)	(63)	(94)	(126)	(157)	(188)
Core Commercial	248	496	744	992	1,240	1,488
Core Industrial	5	10	15	20	25	30
Noncore Commercial	3	6	8	11	14	17
Noncore Industrial	25	51	76	102	127	153
Total Load Impacts	**250**	**500**	**750**	**1,000**	**1,250**	**1,500**

MMCF factor **1.017**

Cumulative Savings MMCF

SDGE	**2012 mmcf**	**2013 mmcf**	**2014 mmcf**	**2015 mmcf**	**2016 mmcf**	**2017 mmcf**	**2018 mmcf**	**2019 mmcf**	**2020 mmcf**
Residential	-	-	-	(31)	(62)	(93)	(123)	(154)	(185)
Core Commercial	-	-	-	244	488	732	975	1,219	1,463
Core Industrial	-	-	-	5	10	15	20	25	30
Noncore Commercial	-	-	-	3	6	8	11	14	17
Noncore Industrial	-	-	-	25	50	75	100	125	150
Total Cumulative Load	**-**	**-**	**-**	**246**	**492**	**737**	**983**	**1,229**	**1,475**

Forecast Year ====>	1	2	3	4	5	6

NOTES:

2014 Reported data is preliminary. Final reported data will be filed in the EE Annual Report on May 1, 2015.

Median Life Cycle of 10 years is assumed.