UIEC Data Request 20.5

Class Cost of Service Allocation/Methodology & Procedures:

With respect to the Company's response to UIEC Data Request 19.5, wherein the Company advised that a sample was designed in April of 2008 for the Utah Residential Class and Utah Commercial Class 23; and in June 2008 for the Utah Commercial Industrial Class 06, please provide a copy of the study and reports validating the method for designing each of the samples. Please explain how the number of samples to be taken was determined, how the location of those samples was determined, and how all other information necessary to support a conclusion that the study will produce results that are statistically reliable were determined.

Response to UIEC Data Request 20.5

Please refer to Attachments UIEC 20.5 -1 through UIEC 20.5 -3 for sample design documents.

UTAH

07-035-93

GENERAL RATE CASE

ROCKY MOUNTAIN POWER

UIEC 20TH SET DATA REQUEST (1-11)

ATTACHMENT UIEC 20.5 –(1-3)

ON THE ENCLOSED CD

Attach UIEC 20.5 -1.pdf

Utah Residential Class (2008)
Load Recorder Study
Sampling Procedures

This paper describes the procedures used to develop the 2008 Utah Residential Class Study. This study will provide load data for use in support of cost studies and price filings before the Utah Public Service Commission, and for use in other studies of residential customer demand characteristics. The goal of this sample design is to provide relative precision of ± 5% at the 90% confidence level for an estimate of the average of the twelve monthly system peak hours, during twelve consecutive months.

Recorders will be placed in service effective no later than October 1st, 2008, and will be monitored on a continuous basis to insure no significant deviation from billing records.

Sampling Plan for Utah

This sampling plans includes several steps:

1. Formalization of the sample parameters;
2. Specification of the target variable;
3. Choice of the stratification variable;
4. Choice of method for estimating kW;
5. Choice of the number of strata;
6. Construction of the strata boundaries
7. Allocation of sample points to each stratum;
8. Selection of primary sample sites;
9. Selection of alternate sample sites.

Formalization of the sample parameters

This sample replaces the old Utah residential class sample, which was originally installed in 1991, and later refreshed in 1999. There is no secondary/primary voltage breakdown in the tariff and, accordingly, only one load sample is required to provide load estimates for this group.

Specification of the target variable

Load studies in the state of Utah are used primarily to support cost allocation studies. Current cost study methods use the average demand at the hours of the PacifiCorp system peak for twelve consecutive months (12SYSPK), as well as estimates of distribution and individual customer maximum demands, each averaged over twelve consecutive months.

These study designs treat 12SYSPK as the target variable because it is, by far, the most important peak measure for allocation of demand related costs.

The current Utah residential class study was used to provide estimates of means and residual variances required in these sample designs. The range of sample data employed encompassed the twelve month period from January 2007 through December 2007. Billing data for the twelve months ending February 2008 were used to determine appropriate stratification.

Choice of the Stratification Variable

A potential stratifying variable, according to Cochran, should meet three criteria[1]:

1. *The population is composed of institutions varying widely in size.*
2. *The principle variables to be measured are closely related to the sizes of the institutions.*
3. *A good measure of size is available for setting up the strata.*

Average monthly billing kWh (KWH_MNTH), which is the average monthly energy registered over a twelve consecutive month period, was selected as the best available variable for this purpose. It is readily available for all customers in this class, with a range from 0 to 191,500 kWh for any given customer in this group.

Choice of Method for Estimating kW

To estimate a peak demand for a population using MPU, the mean peak demand value from the sample is multiplied by the number of elements in the entire population. Use of the MPU method provides an unbiased estimate.

For ratio estimation, the ratio of the target variable (12SYSPK) over the auxiliary variable (KWH_ANN) is calculated for the sample. This ratio is then multiplied by the total annual billed kWh for the population to get the estimated total group peak demand. Because energy usage and peak demand are correlated, a ratio estimate will have a smaller variance than a MPU estimate. However, a ratio estimate may be slightly biased.

With stratified sample designs, ratio estimators can be computed in two ways: separately for each stratum, or a combined ratio can be computed over all strata. Separate ratio estimation tends to result in smaller variance. However, the combined ratio method is more appropriate when stratum sample sizes are small, because the risk of bias is reduced.

Tables C.1 shows sample size needed for the Utah Residential Class study using a mean-per-unit method, assuming a three strata design, with optimal allocation utilizing the Tschprow/Neyman method. Table C.2 details the same information in a four strata schema. The design as presented in Table C.1 was selected for this sample.

[1] William G. Cochran, "Sampling Techniques", Third Edition, Wiley, pg.101

Choice of the Number of Strata

As the number of strata increases, precision of the estimate of the total contribution to demand (kW) at system peak also increases. However, the increase in precision per additional stratum diminishes after a relatively small number of strata[2]. Desire for simplicity, and for a reasonable number of sites in each stratum lead to a preference for a small number of strata. If a minimum number of sites policy is followed (eg. 10 sites minimum per stratum), then the addition of strata can actually lead to more, rather than fewer, total sites. If such a policy is not followed, the result can be strata with so few recorders that confidence in sample estimates is at risk from unexpected data problems, variance estimates may not be sufficiently precise for future sample design purposes, and the sample may not be robust enough to be useful when analysis needs change.

A final decision on the number of strata requires actual cost comparison of potential stratification schemes to evaluate effectiveness versus cost. For this study, a three strata scheme was employed. The method described below was used to compare stratification approaches.

Construction of Strata Boundaries

Various methods might be used for definition of strata boundaries. Cochran found the "cumulative square root of f"[3] rule, as defined by Dalenius and Hodges (1959), to be superior in a comparative study of such methods applied to actual distributions exhibiting a range of skewness.

Steps in calculating strata boundaries under the "cumulative square root of f" rule are as follows. First, tabulate frequencies of the stratifying variable. For these studies, average monthly energy (KWH_MNTH) from customer billing records for the twelve months ending February 2008 were used. All Utah residential customers, whose end of year status was active, and whose total annual kWh consumption was greater than 250 kWh were included in this procedure, and in population figures for the sample design. Second, multiply the number of customers in each interval by the interval factor. Third, take the square root of these frequencies. Fourth, cumulatively sum the square roots. The resulting distribution of adjusted cumulative square roots of frequency is then partitioned into equal intervals by dividing by the number of strata. The final stratification scheme of three strata is presented in Table B.1, and shows the optimal boundaries resulting from

[2] William G. Cochran, "Sampling Techniques", Third Edition, Wiley, Pg. 132
[3] William G. Cochran, "Sampling Techniques", Third Edition, Wiley, Pgs. 129-130

the above procedure, after adjustments made to accommodate prior cost analysis requirements (if any).

Allocation of Sample Points to Each Stratum

Once the stratum boundaries have been determined, sample points (i.e., load recorders) must be assigned to the strata. The Tschprow-Neyman allocation procedure[4] allocates an optimal sampling rate to each stratum. Optimal allocation techniques minimize the variance of the population estimates by increasing the sample proportion in the strata having larger variances. This produces a sampling rate for each stratum which is proportional to the standard deviation within the stratum. The analogous procedure for a ratio sampling plan is allocation in proportion to the square root of the residual variance.

Data for estimating the variance of the 12SYSPK measure for each stratum were available for customers included in the current Utah residential class load study. These data were used to provide estimates for the new Utah residential class sample design. For the mean-per-unit method, the variance within each stratum was the ordinary variance of the mean.

Minimum recorder allocations and data loss adjustments are required for each stratum to maintain adequate data in case of recorder failure and to provide data for analysis of load characteristics other than the primary target variable, should such analysis be necessary. Minimums ranging from 5 to 15 sites per stratum have been used in past studies. In the present studies, a minimum of 10 sites was used. A minimum on the high side was selected, despite improvements in data quality due to solid state recording equipment, because changing requirements for load research and other areas using this data may require unanticipated applications, and because overall sample efficiencies are bringing these studies in well below the budgeted number of sites, even with the 10 site minimum. The final allocation of recorders reflected an additional ten percent data loss adjustment per stratum over the optimal or minimum allocation.

Because of an existing, ready supply of the types of meters required for a load study such as this, the decision was made to substantially increase the number of sites to be installed vs. the sample design. The three strata design selected class for the installation of 158 recorders to meet design standards. This design was supplemented with an additional 12 recorders, which translates to ± 4.64% precision at the 90% confidence level.

[4] William G. Cochran, "Sampling Techniques", Third Edition, Wiley, pgs. 96-99

Sample Selection

Systematic sample selections were used for each stratum to ensure a representative distribution. For practical reasons, inactive customers, customers with no kWh meter installed (usually certain types of lighting customers with very predictable demand and consumption, indicated by absence of a kWh meter number), and customers with very low consumption (<250 kWh total in the past 12 billing periods) were eliminated from the sampling frame. Eligible customers were then sorted by stratum and by average monthly billed energy (KWH_MNTH) within stratum. The number of customers available in the sampling frame for each stratum was then divided by the number of recorders allocated to that stratum (N_h/n_h), yielding the sampling interval size. A five digit random number between 0 and 1 was chosen for each stratum, and multiplied by the stratum interval size to obtain the starting selection point for each stratum (Table A). Beginning with this site, additional sites were selected at the given sampling intervals to obtain the desired number of sample sites. This procedure was repeated four times to provide a list of alternate selection sites.

The list of primary and alternate selection sites for this sample are contained in Appendix 1. This list was compared against current Utah profile metering installations to check for duplicates. Duplicates between the design and production systems were noted and updated in the Appendix.

Utah Residential Class Sample Parameters

Active Customers with kWh Meters
For the 12 Months Ending February 2008

Stratum	1	2	3	4	5	6
Sampling Frame	351,800	254,648	53,961			
Sample	68	70	32			
Interval	5,173.53	3,637.83	1,686.28			
Random Starts						
Primary						
Random No.[1]	0.69548	0.18893	0.86783			
Start	3598	687	1463			
Alternate 1						
Random No.[1]	0.22927	0.83647	0.60988			
Start	1186	3043	1028			
Alternate 2						
Random No.[1]	0.37149	0.71481	0.21123			
Start	1922	2600	356			
Alternate 3						
Random No.[1]	0.19601	0.58823	0.98344			
Start	1014	2140	1658			
Alternate 4						
Random No.[1]	0.10190	0.69198	0.17559			
Start	527	2517	296			

[1] Random numbers from Excel's random function.

Utah Residential Class DH Worksheet
Three Strata

Range			Customer Count f	Interval Factor μ	μf	$\sqrt{\mu f}$	cum $\sqrt{\mu f}$	
0	to	250	45840	1	45840	214.1	214.1	
251	to	500	139998	1	139998	374.2	588.3	
501	to	750	165962	1	165962	407.4	995.7	351,800
751	to	1000	129682	1	129682	360.1	1,355.8	
1001	to	1250	81025	1	81025	284.6	1,640.4	
1251	to	1500	43941	1	43941	209.6	1,850.0	254,648
1501	to	1750	22773	1	22773	150.9	2,000.9	
1751	to	2000	12264	1	12264	110.7	2,111.7	
2001	to	2250	6856	1	6856	82.8	2,194.5	
2251	to	2500	3998	1	3998	63.2	2,257.7	
2501	to	2750	2343	1	2343	48.4	2,306.1	
2751	to	3000	1564	1	1564	39.5	2,345.7	
3001	to	3250	1026	1	1026	32.0	2,377.7	
3251	to	3500	678	1	678	26.0	2,403.7	
3501	to	3750	508	1	508	22.5	2,426.3	
3751	to	4000	337	1	337	18.4	2,444.6	
4001	to	4250	280	1	280	16.7	2,461.4	
4251	to	4500	213	1	213	14.6	2,476.0	
4501	to	4750	145	1	145	12.0	2,488.0	
4751	to	5000	138	1	138	11.7	2,499.7	
5001	to	5250	97	1	97	9.8	2,509.6	
5251	to	5500	74	1	74	8.6	2,518.2	
5501	to	5750	85	1	85	9.2	2,527.4	
5751	to	6000	54	1	54	7.3	2,534.8	
6001	to	6250	46	1	46	6.8	2,541.6	
6251	to	6500	48	1	48	6.9	2,548.5	
6501	to	6750	38	1	38	6.2	2,554.6	
6751	to	7000	33	1	33	5.7	2,560.4	
7001	to	7250	34	1	34	5.8	2,566.2	
7251	to	7500	23	1	23	4.8	2,571.0	
7501	to	7750	24	1	24	4.9	2,575.9	
7751	to	8000	25	1	25	5.0	2,580.9	
8001	to	8250	25	1	25	5.0	2,585.9	
8251	to	8500	11	1	11	3.3	2,589.2	
8501	to	8750	17	1	17	4.1	2,593.4	
8751	to	9000	11	1	11	3.3	2,596.7	
9001	to	9250	15	1	15	3.9	2,600.5	
9251	to	9500	11	1	11	3.3	2,603.9	
9501	to	9750	6	1	6	2.4	2,606.3	
9751	to	10000	12	1	12	3.5	2,609.8	
10001	to	12500	59	10	590	24.3	2,634.1	
12501	to	15000	33	10	330	18.2	2,652.2	
15001	to	17500	25	10	250	15.8	2,668.0	
17501	to	20000	6	10	60	7.7	2,675.8	
20001	to	22500	9	10	90	9.5	2,685.3	
22501	to	191500	17	676	11492	107.2	2,792.5	53,961
Total N			660,409					660,409

BOUNDARIES INDICATED FOR STRATA:				
	3	4	5	6
1	930.8	698.1	558.5	465.4
2	1,861.6	1,396.2	1,117.0	930.8
3		2,094.4	1,675.5	1,396.2
4			2,234.0	1,861.6
5				2,327.1

SAMPLING ST	Avg. kWh[1]	Mean kW[2]	St. Dev [2]
1	468.827	0.740	0.426
2	1,030.830	1.964	0.585
3	2,100.870	4.150	1.096
4			
5			
6			

[1] Billing records for March 2007 through February 2008

[2] Load Research data for January 2007 through December 2007

Utah Residential Class DH Worksheet
Four Strata

Range			Customer Count f	Interval Factor μ	μf	$\sqrt{\mu f}$	cum $\sqrt{\mu f}$	
0	to	250	45840	1	45840	214.1	214.1	
251	to	500	139998	1	139998	374.2	588.3	185,838
501	to	750	165962	1	165962	407.4	995.7	
751	to	1000	129682	1	129682	360.1	1,355.8	295,644
1001	to	1250	81025	1	81025	284.6	1,640.4	
1251	to	1500	43941	1	43941	209.6	1,850.0	
1501	to	1750	22773	1	22773	150.9	2,000.9	
1751	to	2000	12264	1	12264	110.7	2,111.7	160,003
2001	to	2250	6856	1	6856	82.8	2,194.5	
2251	to	2500	3998	1	3998	63.2	2,257.7	
2501	to	2750	2343	1	2343	48.4	2,306.1	
2751	to	3000	1564	1	1564	39.5	2,345.7	
3001	to	3250	1026	1	1026	32.0	2,377.7	
3251	to	3500	678	1	678	26.0	2,403.7	
3501	to	3750	508	1	508	22.5	2,426.3	
3751	to	4000	337	1	337	18.4	2,444.6	
4001	to	4250	280	1	280	16.7	2,461.4	
4251	to	4500	213	1	213	14.6	2,476.0	
4501	to	4750	145	1	145	12.0	2,488.0	
4751	to	5000	138	1	138	11.7	2,499.7	
5001	to	5250	97	1	97	9.8	2,509.6	
5251	to	5500	74	1	74	8.6	2,518.2	
5501	to	5750	85	1	85	9.2	2,527.4	
5751	to	6000	54	1	54	7.3	2,534.8	
6001	to	6250	46	1	46	6.8	2,541.6	
6251	to	6500	48	1	48	6.9	2,548.5	
6501	to	6750	38	1	38	6.2	2,554.6	
6751	to	7000	33	1	33	5.7	2,560.4	
7001	to	7250	34	1	34	5.8	2,566.2	
7251	to	7500	23	1	23	4.8	2,571.0	
7501	to	7750	24	1	24	4.9	2,575.9	
7751	to	8000	25	1	25	5.0	2,580.9	
8001	to	8250	25	1	25	5.0	2,585.9	
8251	to	8500	11	1	11	3.3	2,589.2	
8501	to	8750	17	1	17	4.1	2,593.4	
8751	to	9000	11	1	11	3.3	2,596.7	
9001	to	9250	15	1	15	3.9	2,600.5	
9251	to	9500	11	1	11	3.3	2,603.9	
9501	to	9750	6	1	6	2.4	2,606.3	
9751	to	10000	12	1	12	3.5	2,609.8	
10001	to	12500	59	10	590	24.3	2,634.1	
12501	to	15000	33	10	330	18.2	2,652.2	
15001	to	17500	25	10	250	15.8	2,668.0	
17501	to	20000	6	10	60	7.7	2,675.8	
20001	to	22500	9	10	90	9.5	2,685.3	
22501	to	191500	17	676	11492	107.2	2,792.5	18,924
Total N			660,409					660,409

BOUNDARIES INDICATED FOR STRATA:

	3	4	5	6
1	930.8	698.1	558.5	465.4
2	1,861.6	1,396.2	1,117.0	930.8
3		2,094.4	1,675.5	1,396.2
4			2,234.0	1,861.6
5				2,327.1

SAMPLING ST	Avg. kWh[1]	Mean kW[2]	St. Dev [2]
1	330.909	0.531	0.296
2	730.251	1.221	0.448
3	1,309.720	2.751	0.861
4	2,845.460	4.856	0.850
5			
6			

1 Billing records for March 2007 through February 2008

2 Load Research data for January 2007 through December 2007

Utah Residential Class DH Worksheet
Five Strata

Range			Customer Count f	Interval Factor μ	μf	$\sqrt{\mu f}$	cum $\sqrt{\mu f}$	
0	to	250	45840	1	45840	214.1	214.1	
251	to	500	139998	1	139998	374.2	588.3	185,838
501	to	750	165962	1	165962	407.4	995.7	165,962
751	to	1000	129682	1	129682	360.1	1,355.8	
1001	to	1250	81025	1	81025	284.6	1,640.4	210,707
1251	to	1500	43941	1	43941	209.6	1,850.0	
1501	to	1750	22773	1	22773	150.9	2,000.9	
1751	to	2000	12264	1	12264	110.7	2,111.7	
2001	to	2250	6856	1	6856	82.8	2,194.5	
2251	to	2500	3998	1	3998	63.2	2,257.7	89,832
2501	to	2750	2343	1	2343	48.4	2,306.1	
2751	to	3000	1564	1	1564	39.5	2,345.7	
3001	to	3250	1026	1	1026	32.0	2,377.7	
3251	to	3500	678	1	678	26.0	2,403.7	
3501	to	3750	508	1	508	22.5	2,426.3	
3751	to	4000	337	1	337	18.4	2,444.6	
4001	to	4250	280	1	280	16.7	2,461.4	
4251	to	4500	213	1	213	14.6	2,476.0	
4501	to	4750	145	1	145	12.0	2,488.0	
4751	to	5000	138	1	138	11.7	2,499.7	
5001	to	5250	97	1	97	9.8	2,509.6	
5251	to	5500	74	1	74	8.6	2,518.2	
5501	to	5750	85	1	85	9.2	2,527.4	
5751	to	6000	54	1	54	7.3	2,534.8	
6001	to	6250	46	1	46	6.8	2,541.6	
6251	to	6500	48	1	48	6.9	2,548.5	
6501	to	6750	38	1	38	6.2	2,554.6	
6751	to	7000	33	1	33	5.7	2,560.4	
7001	to	7250	34	1	34	5.8	2,566.2	
7251	to	7500	23	1	23	4.8	2,571.0	
7501	to	7750	24	1	24	4.9	2,575.9	
7751	to	8000	25	1	25	5.0	2,580.9	
8001	to	8250	25	1	25	5.0	2,585.9	
8251	to	8500	11	1	11	3.3	2,589.2	
8501	to	8750	17	1	17	4.1	2,593.4	
8751	to	9000	11	1	11	3.3	2,596.7	
9001	to	9250	15	1	15	3.9	2,600.5	
9251	to	9500	11	1	11	3.3	2,603.9	
9501	to	9750	6	1	6	2.4	2,606.3	
9751	to	10000	12	1	12	3.5	2,609.8	
10001	to	12500	59	10	590	24.3	2,634.1	
12501	to	15000	33	10	330	18.2	2,652.2	
15001	to	17500	25	10	250	15.8	2,668.0	
17501	to	20000	6	10	60	7.7	2,675.8	
20001	to	22500	9	10	90	9.5	2,685.3	
22501	to	191500	17	676	11492	107.2	2,792.5	8,070
Total N			660,409					660,409

BOUNDARIES INDICATED FOR STRATA:

	3	4	5	6
1	930.8	698.1	558.5	465.4
2	1,861.6	1,396.2	1,117.0	930.8
3		2,094.4	1,675.5	1,396.2
4			2,234.0	1,861.6
5				2,327.1

SAMPLING STA	Avg. kWh[1]	Mean kW[2]	St. Dev [2]
1	330.909	0.531	0.296
2	623.263	1.037	0.407
3	961.824	1.816	0.511
4	1,595.290	3.082	0.936
5	3,704.130	4.856	0.850
6			

1 Billing records for March 2007 through February 2008

2 Load Research data for January 2007 through December 2007

Utah Residential Class DH Worksheet
Six Strata

Range			Customer Count f	Interval Factor μ	μf	$\sqrt{\mu f}$	cum $\sqrt{\mu f}$	
0	to	250	45840	1	45840	214.1	214.1	
251	to	500	139998	1	139998	374.2	588.3	185,838
501	to	750	165962	1	165962	407.4	995.7	165,962
751	to	1000	129682	1	129682	360.1	1,355.8	129,682
1001	to	1250	81025	1	81025	284.6	1,640.4	
1251	to	1500	43941	1	43941	209.6	1,850.0	124,966
1501	to	1750	22773	1	22773	150.9	2,000.9	
1751	to	2000	12264	1	12264	110.7	2,111.7	
2001	to	2250	6856	1	6856	82.8	2,194.5	
2251	to	2500	3998	1	3998	63.2	2,257.7	
2501	to	2750	2343	1	2343	48.4	2,306.1	
2751	to	3000	1564	1	1564	39.5	2,345.7	49,798
3001	to	3250	1026	1	1026	32.0	2,377.7	
3251	to	3500	678	1	678	26.0	2,403.7	
3501	to	3750	508	1	508	22.5	2,426.3	
3751	to	4000	337	1	337	18.4	2,444.6	
4001	to	4250	280	1	280	16.7	2,461.4	
4251	to	4500	213	1	213	14.6	2,476.0	
4501	to	4750	145	1	145	12.0	2,488.0	
4751	to	5000	138	1	138	11.7	2,499.7	
5001	to	5250	97	1	97	9.8	2,509.6	
5251	to	5500	74	1	74	8.6	2,518.2	
5501	to	5750	85	1	85	9.2	2,527.4	
5751	to	6000	54	1	54	7.3	2,534.8	
6001	to	6250	46	1	46	6.8	2,541.6	
6251	to	6500	48	1	48	6.9	2,548.5	
6501	to	6750	38	1	38	6.2	2,554.6	
6751	to	7000	33	1	33	5.7	2,560.4	
7001	to	7250	34	1	34	5.8	2,566.2	
7251	to	7500	23	1	23	4.8	2,571.0	
7501	to	7750	24	1	24	4.9	2,575.9	
7751	to	8000	25	1	25	5.0	2,580.9	
8001	to	8250	25	1	25	5.0	2,585.9	
8251	to	8500	11	1	11	3.3	2,589.2	
8501	to	8750	17	1	17	4.1	2,593.4	
8751	to	9000	11	1	11	3.3	2,596.7	
9001	to	9250	15	1	15	3.9	2,600.5	
9251	to	9500	11	1	11	3.3	2,603.9	
9501	to	9750	6	1	6	2.4	2,606.3	
9751	to	10000	12	1	12	3.5	2,609.8	
10001	to	12500	59	10	590	24.3	2,634.1	
12501	to	15000	33	10	330	18.2	2,652.2	
15001	to	17500	25	10	250	15.8	2,668.0	
17501	to	20000	6	10	60	7.7	2,675.8	
20001	to	22500	9	10	90	9.5	2,685.3	
22501	to	191500	17	676	11492	107.2	2,792.5	4,163
Total N			660,409					660,409

BOUNDARIES INDICATED FOR STRATA:

	3	4	5	6
1	930.8	698.1	558.5	465.4
2	1,861.6	1,396.2	1,117.0	930.8
3		2,094.4	1,675.5	1,396.2
4			2,234.0	1,861.6
5				2,327.1

SAMPLING STA	Avg. kWh[1]	Mean kW[2]	St. Dev [2]
1	330.909	0.531	0.296
2	623.263	1.037	0.407
3	867.171	1.536	0.330
4	1,200.660	2.372	0.473
5	1,889.330	3.885	0.959
6	4,631.280	5.475	0.769

1 Billing records for March 2007 through February 2008

2 Load Research data for January 2007 through December 2007

UTAH RESIDENTIAL CLASS LOAD STUDY DESIGN OPTION (2008)
THREE STRATA, MEAN-PER-UNIT DESIGN

		a Sample Mean kW	b Sample Mean kWh	c 2008 Pop N	d Variance of Mean	e Standard Deviation	f Wtd. Devtns. c*e	g Proprtn. row f/ sum f	h Optimal Allocation g*h total	i Optimal with Attrition	j Final with Attrition
STRATUM 1	0 - 750 kWh	0.740	468.827	351,800	0.1815	0.426	149867	0.4186	60	60	68
STRATUM 2	751 - 1,500 kWh	1.964	1,030.830	254,648	0.3422	0.585	148969	0.4161	60	60	70
STRATUM 3	GT 1,500 kWh	4.150	2,100.870	53,961	1.2012	1.096	59141	0.1652	24	24	32
EST POP MEAN (wtd by N)		1.491	818.882	660,409			357977	1.0000	144	144	170

Sample Estimate	Adj Sample Estimate
144	170

RELATIVE PRECISION OF SAMPLE KW ESTIMATE

		TOTAL KW Optimal n (col. h)	TOTAL KW Adjusted n (cc	TOTAL KW Final (col. J	MEAN KW Adj. n
Variance contributed by strata:	1	380,614,019	380,614,019	335,159,946	0.000873
	2	376,043,356	376,043,356	321,531,689	0.000862
	3	152,005,761	152,005,761	112,761,741	0.000349
	4				
Total Variance		908,663,136	908,663,136	769,453,375	0.002083
Standard Error		30144.03981	30144.03981	27739.02261	0.045644502
Desired Conf. Level		90%	90%	90%	90%
(z two tailed)		1.645	1.645	1.645	1.645
Conf. Interval		49586.94549	49586.94549	45630.6922	0.075085206
MPU Est of kW		984398.822	984398.822	984398.822	1.4906
Relative Conf. Int.		5.04%	5.04%	4.64%	5.04%

UTAH RESIDENTIAL CLASS LOAD STUDY DESIGN OPTION (2008)
FOUR STRATA, MEAN-PER-UNIT DESIGN

		a Sample Mean kW	b Sample Mean kWh	c 2008 Pop N	d Variance of Mean	e Standard Deviation	f Wtd. Devtns. c*e	g Proprtn. row f/ sum f	h Optimal Allocation g*h total	i Optimal with Attrition	j Final with Attrition
STRATUM 1	0 - 500 kWh	0.531	330.909	185,838	0.0876	0.296	55008	0.1612	21	21	23
STRATUM 2	501 - 1,000 kWh	1.221	730.251	295,644	0.2007	0.448	132449	0.3881	50	50	55
STRATUM 3	1,001 - 2,000 kWh	2.751	1,309.720	160,003	0.7413	0.861	137763	0.4036	52	52	57
STRATUM 4	GT 2,000 kWh	4.856	2,845.460	18,924	0.7225	0.850	16085	0.0471	6	10	11
EST POP MEAN (wtd by N)		1.502	818.881	660,409			341305	1.0000	129	133	146

Sample Estimate	Adj Sample Estimate
129	146

RELATIVE PRECISION OF SAMPLE KW ESTIMATE

		TOTAL KW Optimal n (col. h)	TOTAL KW Adjusted n (cc	TOTAL KW Final (col. J	MEAN KW Adj. n
Variance contributed by strata:	1	151,277,171	151,277,171	137,523,220	0.000347
	2	357,951,867	357,951,867	324,802,681	0.000821
	3	372,007,086	372,007,086	338,781,577	0.000853
	4	51,731,612	28,733,707	25,858,969	0.000066
Total Variance		932,967,735	909,969,831	826,966,448	0.002086
Standard Error		30544.52054	30165.70621	28757.0243	0.045677309
Desired Conf. Level		90%	90%	90%	90%
(z two tailed)		1.645	1.645	1.645	1.645
Conf. Interval		50245.73629	49622.58671	47305.305	0.075139174
MPU Est of kW		991724.499	991724.499	991724.499	1.5017
Relative Conf. Int.		5.07%	5.00%	4.77%	5.00%

UTAH RESIDENTIAL CLASS LOAD STUDY DESIGN OPTION (2008)
FIVE STRATA, MEAN-PER-UNIT DESIGN

		a Sample Mean kW	b Sample Mean kWh	c 2008 Pop N	d Variance of Mean	e Standard Deviation	f Wtd. Devtns. c*e	g Proprtn. row f/ sum f	h Optimal Allocation g*h total	i Optimal with Attrition	j Final with Attrition
STRATUM 1	0 - 500 kWh	0.531	330.909	185,838	0.0876	0.296	55008	0.1713	20	20	22
STRATUM 2	501 - 750 kWh	1.037	623.263	165,962	0.1656	0.407	67547	0.2103	24	24	26
STRATUM 3	751 - 1,250 kWh	1.816	961.824	210,707	0.2611	0.511	107671	0.3352	38	38	42
STRATUM 4	1,251 - 2,500 kWh	3.082	1,595.290	89,832	0.8761	0.936	84083	0.2618	30	30	33
STRATUM 5	GT 2,500 kWh	4.856	3,704.130	8,070	0.7225	0.850	6860	0.0214	2	10	11
EST POP MEAN (wtd by N)		1.468	818.882	660,409			321168	1.0000	114	122	134

Sample Estimate	Adj Sample Estimate
114	134

RELATIVE PRECISION OF SAMPLE KW ESTIMATE

		TOTAL KW Optimal n (col. h)	TOTAL KW Adjusted n (cc	TOTAL KW Final (col. J	MEAN KW Adj. n
Variance contributed by strata:	1	159,239,984	159,239,984	144,072,721	0.000365
	2	198,342,368	198,342,368	182,472,779	0.000455
	3	313,270,625	313,270,625	282,702,270	0.000718
	4	243,708,557	243,708,557	220,853,501	0.000559
	5	47,041,079	5,221,604	4,698,860	0.000012
Total Variance		961,602,613	919,783,137	834,800,131	0.002109
Standard Error		31009.71804	30327.92669	28892.90797	0.045922946
Desired Conf. Level		90%	90%	90%	90%
(z two tailed)		1.645	1.645	1.645	1.645
Conf. Interval		51010.98617	49889.43941	47528.8336	0.075543246
MPU Est of kW		969476.628	969476.628	969476.628	1.4680
Relative Conf. Int.		5.26%	5.15%	4.90%	5.15%

UTAH RESIDENTIAL CLASS LOAD STUDY DESIGN OPTION (2008)
SIX STRATA, MEAN-PER-UNIT DESIGN

		a Sample Mean kW	b Sample Mean kWh	c 2008 Pop N	d Variance of Mean	e Standard Deviation	f Wtd. Devtns. c*e	g Proprtn. row f/ sum f	h Optimal Allocation g*h total	i Optimal with Attrition	j Final with Attrition
STRATUM 1	0 - 500 kWh	0.531	330.909	185,838	0.0876	0.296	55008	0.1997	11	11	12
STRATUM 2	501 - 750 kWh	1.037	623.263	165,962	0.1656	0.407	67547	0.2453	14	14	15
STRATUM 3	751 - 1,000 kWh	1.536	867.171	129,682	0.1089	0.330	42795	0.1554	9	10	11
STRATUM 4	1,001 - 1,500 kWh	2.372	1,200.660	124,966	0.2237	0.473	59109	0.2146	12	12	13
STRATUM 5	1,501 - 3,000 kWh	3.885	1,889.330	49,798	0.9197	0.959	47756	0.1734	10	10	11
STRATUM 6	GT 3,000 kWh	5.475	4,631.280	4,163	0.5914	0.769	3201	0.0116	1	10	11
EST POP MEAN (wtd by N)		1.488	818.881	660,409			275416	1.0000	57	67	73

Sample Estimate	Adj Sample Estimate
57	73

RELATIVE PRECISION OF SAMPLE KW ESTIMATE

		TOTAL KW Optimal n (col. h)	TOTAL KW Adjusted n (col.	TOTAL KW Final (col. J	MEAN KW Adj. n
Variance	1	302,570,624	302,570,624	275,062,723	0.000694
contributed	2	350,934,567	350,934,567	325,865,849	0.000805
by strata:	3	228,911,257	203,475,104	183,126,181	0.000467
	4	317,593,517	317,593,517	291,125,061	0.000728
	5	253,356,054	253,356,054	228,015,869	0.000581
	6	#DIV/0!	1,136,000	1,022,154	0.000003
Total Variance		#DIV/0!	1,429,065,867	1,304,217,837	0.003277
Standard Error		#DIV/0!	37802.98754	36113.95627	0.057241781
Desired Conf. Level		90%	90%	90%	90%
(z two tailed)		1.645	1.645	1.645	1.645
Conf. Interval		#DIV/0!	62185.9145	59407.45806	0.09416273
MPU Est of kW		982651.131	982651.131	982651.131	1.4879
Relative Conf. Int.		#DIV/0!	6.33%	6.05%	6.33%

Utah Residential Class kWh Summary
For the Twelve months Ended December2007

N	MIN	MEAN	MAX	SUM
660409	20.9167	818.882	191500	540796854.04

Utah Residential Class Bill Frequency Worksheet
Average Monthly kWh

STRATUM		n	KWH
0 -	250 kWh	45840	7509948.49
251 -	500 kWh	139998	53985586.66
501 -	750 kWh	165962	103437896.36
751 -	1000 kWh	129682	112456520.23
1001 -	1250 kWh	81025	90206547.53
1251 -	1500 kWh	43941	59835563.13
1501 -	1750 kWh	22773	36686977.15
1751 -	2000 kWh	12264	22830329.69
2001 -	2250 kWh	6856	14492072.30
2251 -	2500 kWh	3998	9463095.36
2501 -	2750 kWh	2343	6125608.02
2751 -	3000 kWh	1564	4486683.57
3001 -	3250 kWh	1026	3202038.35
3251 -	3500 kWh	678	2281935.09
3501 -	3750 kWh	508	1836899.27
3751 -	4000 kWh	337	1303927.13
4001 -	4250 kWh	280	1155249.81
4251 -	4500 kWh	213	932379.14
4501 -	4750 kWh	145	669736.20
4751 -	5000 kWh	138	673522.79
5001 -	5250 kWh	97	495987.23
5251 -	5500 kWh	74	397539.55
5501 -	5750 kWh	85	477757.11
5751 -	6000 kWh	54	317909.17
6001 -	6250 kWh	46	281581.05
6251 -	6500 kWh	48	305877.22
6501 -	6750 kWh	38	251518.36
6751 -	7000 kWh	33	227053.26
7001 -	7250 kWh	34	242173.67
7251 -	7500 kWh	23	169887.46
7501 -	7750 kWh	24	183252.58
7751 -	8000 kWh	25	196815.58
8001 -	8250 kWh	25	202818.18
8251 -	8500 kWh	11	92142.44
8501 -	8750 kWh	17	146845.17
8751 -	9000 kWh	11	97612.48
9001 -	9250 kWh	15	136756.35
9251 -	9500 kWh	11	103161.21
9501 -	9750 kWh	6	57812.95
9751 -	10000 kWh	12	119141.10
10001 -	12500 kWh	59	662486.64
12501 -	15000 kWh	33	450447.31
15001 -	17500 kWh	25	402011.56
17501 -	20000 kWh	6	112065.00
20001 -	22500 kWh	9	194625.69
GT	22501 kWh	17	899059.42

Utah Residential Class Billing Statistics
Mean kWh - Three Strata

---------- STRATUM=1 ----------

N	KWH_MEAN
351800	468.827

---------- STRATUM=2 ----------

N	KWH_MEAN
254648	1030.83

---------- STRATUM=3 ----------

N	KWH_MEAN
53961	2100.87

Utah Residential Class Billing Statistics
Mean kWh - Four Strata

---------- STRATUM=1 ----------

N	KWH_MEAN
185838	330.909

---------- STRATUM=2 ----------

N	KWH_MEAN
295644	730.251

---------- STRATUM=3 ----------

N	KWH_MEAN
160003	1309.72

---------- STRATUM=4 ----------

N	KWH_MEAN
18924	2845.46

Utah Residential Class Billing Statistics
Mean kWh - Five Strata

---------- STRATUM=1 ----------

N	KWH_MEAN
185838	330.909

---------- STRATUM=2 ----------

N	KWH_MEAN
165962	623.263

---------- STRATUM=3 ----------

N	KWH_MEAN
210707	961.824

---------- STRATUM=4 ----------

N	KWH_MEAN
89832	1595.29

---------- STRATUM=5 ----------

N	KWH_MEAN
8070	3704.13

Utah Residential Class Billing Statistics
Mean kWh - Six Strata

STRATUM=1

N	KWH_MEAN
185838	330.909

STRATUM=2

N	KWH_MEAN
165962	623.263

STRATUM=3

N	KWH_MEAN
129682	867.171

STRATUM=4

N	KWH_MEAN
124966	1200.66

STRATUM=5

N	KWH_MEAN
49798	1889.33

STRATUM=6

N	KWH_MEAN
4163	4631.28

Utah Residential Class Eligible Sample Point Summary
Annual kWh GT 250, Agreement Status=ACT

---------- STRATUM=0 - 750 kWh ----------

The MEANS Procedure

Analysis Variable : KWH_MNTH Billed Usage

N	Mean
351800	468.8272641

---------- STRATUM=751 - 1,500 kWh ----------

Analysis Variable : KWH_MNTH Billed Usage

N	Mean
254648	1030.83

---------- STRATUM=GT 1,500 kWh ----------

Analysis Variable : KWH_MNTH Billed Usage

N	Mean
53961	2100.87

Attach UIEC 20.5 -2.pdf

Utah Schedule 006 (2008)
Load Recorder Study
Sampling Procedures

This paper describes the procedures used to develop the 2008 Utah Schedule 006 sample. This study will provide load data for use in support of cost studies and price filings before the Utah Public Service Commission, and for use in other studies of schedule 006 customer demand characteristics. The goal of the sample design is to provide relative precision of ± 10% at the 90% confidence level for an estimate of the average of the system peak hours, during twelve consecutive months.

Recorders will be placed in service effective no later than December 31st 2008, and will be monitored on a continuous basis to insure no significant deviation from billing records.

Sampling Plan for Utah

The sampling plan includes several steps:

1. Formalization of the sample parameters;
2. Specification of the target variable;
3. Choice of the stratification variable;
4. Choice of method for estimating kW;
5. Choice of the number of strata;
6. Construction of the strata boundaries
7. Allocation of sample points to each stratum;
8. Selection of primary sample sites;
9. Selection of alternate sample sites.

Formalization of the sample parameters

This sample replaces the old Utah Schedule 006 sample, which has been in the field since 1991. There is no secondary/primary voltage breakdown in the tariff and, accordingly, only one load sample is required to provide load estimates for this group.

Specification of the target variable

Load studies in the state of Utah are used primarily to support cost allocation studies. Current cost study methods use the average demand at the hours of the PacifiCorp system peak for twelve consecutive months (12SYSPK), as well as estimates of distribution and individual customer maximum demands, each averaged over twelve consecutive months.

These study designs treat 12SYSPK as the target variable because it is, by far, the most important peak measure for allocation of demand related costs.

The current Utah Schedule 006 study was used to provide estimates of means and residual variances required in these sample designs. Billing data for the 12 months ending April 2008 was used to determine appropriate stratification.

Choice of the Stratification Variable

A potential stratifying variable, according to Cochran, should meet three criteria[1]:

1. *The population is composed of institutions varying widely in size.*
2. *The principle variables to be measured are closely related to the sizes of the institutions.*
3. *A good measure of size is available for setting up the strata.*

Peak monthly billing kW (KW_MNTH), which is the maximum demand registered for a given year, was selected as the best available variable for this purpose. This is a fairly stable variable within the schedule 006, and will result in a minimum amount of strata migration among the sample customers. It is accessible for all schedule 006 customers and can range from 0 to 999 kW for this customer group.

Choice of Method for Estimating kW

To estimate a peak demand for a population using MPU, the mean peak demand value from the sample is multiplied by the number of elements in the entire population. Use of the MPU method provides an unbiased estimate.

For ratio estimation, the ratio of the target variable (12SYSPK) over the auxiliary variable (KWH_ANN) is calculated for the sample. This ratio is then multiplied by the total annual billed kWh for the population to get the estimated total group peak demand. Because energy usage and peak demand are correlated, a ratio estimate will have a smaller variance than a MPU estimate. However, a ratio estimate may be slightly biased.

With stratified sample designs, ratio estimators can be computed in two ways: separately for each stratum, or a combined ratio can be computed over all strata. Separate ratio estimation tends to result in smaller variance. However, the combined ratio method is more appropriate when stratum sample sizes are small, because the risk of bias is reduced.

Table C shows sample size needed for the Utah Schedule 006 study using a mean-per-unit method, assuming a three strata design. All sample designs assume optimal allocation utilizing the Tschprow/Neyman method. The design as presented in Table B was selected for this sample.

[1] William G. Cochran, "Sampling Techniques", Third Edition, Wiley, pg.101

Choice of the Number of Strata

As the number of strata increases, precision of the estimate of the total contribution to demand (kW) at system peak also increases. However, the increase in precision per additional stratum diminishes after a relatively small number of strata[2]. Desire for simplicity and for a reasonable number of sites in each stratum lead to a preference for a small number of strata. If a minimum number of sites policy is followed (eg. 10 sites minimum per stratum), then the addition of strata can actually lead to more, rather than fewer, total sites. If such a policy is not followed, the result can be strata with so few recorders that confidence in sample estimates is at risk from unexpected data problems, variance estimates may not be sufficiently precise for future sample design purposes, and the sample may not be robust enough to be useful when analysis needs change.

A final decision on the number of strata requires actual cost comparison of potential stratification schemes to evaluate effectiveness versus cost. For this study, a three strata scheme was employed (Table B). The method described below was used to compare stratification approaches.

Construction of Strata Boundaries

Various methods might be used for definition of strata boundaries. Cochran found the "cumulative square root of f"[3] rule, as defined by Dalenius and Hodges (1959), to be superior in a comparative study of such methods applied to actual distributions exhibiting a range of skewness.

Steps in calculating strata boundaries under the "cumulative square root of f" rule are as follows. First, tabulate frequencies of the stratifying variable. For these studies, peak monthly demand (KW_MNTH) from customer billing records 12 months ending April 2008 were used. All Utah Schedule 006 customers, regardless of end of year status (active/inactive) or annual consumption were included in this procedure, and in population figures for the sample design. Second, multiply the number of customers in each interval by the interval factor. Third, take the square root of these frequencies. Fourth, cumulatively sum the square roots. The resulting distribution of adjusted cumulative square roots of frequency is then partitioned into equal intervals by dividing by the number of strata. The final stratification scheme of three strata is presented in Table B, and shows the optimal boundaries resulting from the above procedure, after adjustments made to accommodate prior cost analysis requirements.

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[2] William G. Cochran, "Sampling Techniques", Third Edition, Wiley, Pg. 132

[3] William G. Cochran, "Sampling Techniques", Third Edition, Wiley, Pgs. 129-130

Allocation of Sample Points to Each Stratum

Once the stratum boundaries have been determined, sample points (i.e., load recorders) must be assigned to the strata. The Tschprow-Neyman allocation procedure[4] allocates an optimal sampling rate to each stratum. Optimal allocation techniques minimize the variance of the population estimates by increasing the sample proportion in the strata having larger variances. This produces a sampling rate for each stratum which is proportional to the standard deviation within the stratum. The analogous procedure for a ratio sampling plan is allocation in proportion to the square root of the residual variance.

Data for estimating the variance of the 12SYSPK measure for each stratum were available for customers included in the current Utah Schedule 006 load study. These data were used to provide estimates for the new Utah Schedule 006 sample design. For the mean-per-unit method, the variance within each stratum was the ordinary variance of the mean.

Minimum recorder allocations and data loss adjustments are required for each stratum to maintain adequate data in case of recorder failure and to provide data for analysis of load characteristics other than the primary target variable, should such analysis be necessary. Minimums ranging from 5 to 15 sites per stratum have been used in past studies. In the present studies, a minimum of 10 sites was used. A minimum on the high side was selected, despite improvements in data quality due to solid state recording equipment, because changing requirements for load research and other areas using this data may require unanticipated applications, and because overall sample efficiencies are bringing these studies in well below the budgeted number of sites, even with the 10 site minimum. The final allocation of recorders reflected an additional twelve percent data loss adjustment per stratum over the optimal or minimum allocation.

The three strata design selected the installation of 83 recorders to meet PURPA design standards. This design was supplemented with an additional 25 recorders, which translates to ± 8.83% precision at the 90% confidence level.

Sample Selection

Systematic sample selections were used for each stratum to ensure a representative distribution. For practical reasons, inactive customers, customers with no kWh meter installed (usually certain types of lighting customers with very predictable demand and consumption, indicated by absence of a kWh meter number), and customers with very

[4] William G. Cochran, "Sampling Techniques", Third Edition, Wiley, pgs. 96-99

low consumption (<250 kWh in the past 12 billing periods) were eliminated from the sampling frame. Eligible customers were then sorted by stratum and by peak monthly billed demand (KW_MNTH) within stratum. The number of customers available in the sampling frame for each stratum was then divided by the number of recorders allocated to that stratum, yielding the sampling interval size. A five digit random number between 0 and 1 was chosen for each stratum, and multiplied by the stratum interval size to obtain the starting selection point for each stratum (Table A). Beginning with this site, additional sites were selected at the given intervals to obtain the desired number of sample sites. This procedure was repeated four times to provide a list of alternate selection sites.

The list of primary and alternate selection sites for this sample are contained in Appendix 1. This list was compared against current Utah profile metering installations to check for duplicates. Duplicates between the design and production systems were noted and updated in the Appendix.

Utah Schedule 006 Sample Parameters

Active Customers with kW Meters
12 Months Ending April 2008 History

Stratum	1	2	3	4	5
Sampling Frame	9,349	4,140	1,232		
Sample	29	36	43		
Interval	322.38	115.00	28.65		
Random Starts					
Primary					
Random No.[1]	0.973457	0.190079	0.935239		
Start	314	22	27		
Alternate 1					
Random No.[1]	0.599504	0.937419	0.388758		
Start	193	108	11		
Alternate 2					
Random No.[1]	0.665786	0.251345	0.769783		
Start	215	29	22		
Alternate 3					
Random No.[1]	0.869928	0.226317	0.661234		
Start	280	26	19		
Alternate 4					
Random No.[1]	0.394018	0.896363	0.174696		
Start	127	103	5		

[1] Random numbers from Excel's random function.

Utah Schedule 006
Three Strata

Range			Customer Count f	Interval Factor μ	μf	$\sqrt{\mu f}$	cum $\sqrt{\mu f}$	
0	to	5	238	1	238	15.4	15.4	
6	to	10	183	1	183	13.5	29.0	
11	to	15	247	1	247	15.7	44.7	
16	to	20	318	1	318	17.8	62.5	
21	to	25	428	1	428	20.7	83.2	
26	to	30	890	1	890	29.8	113.0	
31	to	35	1416	1	1416	37.6	150.7	
36	to	40	1217	1	1217	34.9	185.5	
41	to	45	1143	1	1143	33.8	219.3	
46	to	50	987	1	987	31.4	250.8	
51	to	55	800	1	800	28.3	279.0	
56	to	60	591	1	591	24.3	303.4	
61	to	65	468	1	468	21.6	325.0	
66	to	70	423	1	423	20.6	345.6	9,349
71	to	75	328	1	328	18.1	363.7	
76	to	80	315	1	315	17.7	381.4	
81	to	85	273	1	273	16.5	397.9	
86	to	90	252	1	252	15.9	413.8	
91	to	95	225	1	225	15.0	428.8	
96	to	100	222	1	222	14.9	443.7	
101	to	110	378	2	756	27.5	471.2	
111	to	120	273	2	546	23.4	494.6	
121	to	130	238	2	476	21.8	516.4	
131	to	140	237	2	474	21.8	538.2	
141	to	150	178	2	356	18.9	557.0	
151	to	160	178	2	356	18.9	575.9	
161	to	170	156	2	312	17.7	593.6	
171	to	180	148	2	296	17.2	610.8	
181	to	190	120	2	240	15.5	626.3	
191	to	200	119	2	238	15.4	641.7	
201	to	225	277	5	1385	37.2	678.9	
226	to	250	223	5	1115	33.4	712.3	4,140
251	to	275	176	5	880	29.7	742.0	
276	to	300	150	5	750	27.4	769.3	
301	to	325	115	5	575	24.0	793.3	
326	to	350	105	5	525	22.9	816.2	
351	to	375	101	5	505	22.5	838.7	
376	to	400	67	5	335	18.3	857.0	
401	to	450	107	10	1070	32.7	889.7	
451	to	500	98	10	980	31.3	921.0	
501	to	550	76	10	760	27.6	948.6	
551	to	600	57	10	570	23.9	972.5	
601	to	650	45	10	450	21.2	993.7	
651	to	700	45	10	450	21.2	1,014.9	
701	to	750	29	10	290	17.0	1,031.9	
751	to	800	34	10	340	18.4	1,050.4	
801	to	850	14	10	140	11.8	1,062.2	
851	to	900	10	10	100	10.0	1,072.2	
901	to	950	3	10	30	5.5	1,077.7	
951	to	1000	0	10	0	0.0	1,077.7	1,232
Total N			14,721					14,721

BOUNDARIES INDICATED FOR STRATA:

	3	4	5	6
1	359.2	269.4	215.5	179.6
2	718.5	538.8	431.1	359.2
3		808.3	646.6	538.8
4			862.1	718.5
5				898.1

SAMPLING ST	Avg. kWh[1]	Mean kW[2]	St. Dev [2]
1	7,963.3	19.9	16.6
2	45,274.7	75.8	47.4
3	162,858.9	402.4	180.5
4			
5			
6			

[1] Billing records for 12 months ending April 2008.

[2] Load Research data for 12 months ending December 2007.

UTAH SCHEDULE 006 LOAD STUDY DESIGN OPTION (2008)
THREE STRATA, MEAN-PER-UNIT DESIGN

		a Sample Mean kW	b Sample Mean kWh	c 2008 Pop N	d Variance of Mean	e Standard Deviation	f Wtd. Devtns. c*e	g Proprtn. row f/ sum f	h Optimal Allocation g*h total	i Optimal with Attrition	j Final with Attrition
STRATUM 1	0 - 70 kW	19.2746	11,017	9,349	203.7063	14.2726	133434	0.2538	21	21	29
STRATUM 2	71 - 250 kW	86.8943	42,464	4,140	1825.8427	42.7299	176902	0.3365	28	28	36
STRATUM 3	GT 250 kW	330.8006	161,865	1,232	30575.8649	174.8596	215427	0.4097	34	34	43
EST POP MEAN (wtd by N)		64.3630	32,485	14,721			525763	1.0000	83	83	108

Sample Estimate	Adj Sample Estimate
83	108

RELATIVE PRECISION OF SAMPLE KW ESTIMATE

		TOTAL KW Optimal n (col. h)	TOTAL KW Adjusted n (col. i	TOTAL KW Final (col. J	MEAN KW Adj. n
Variance contributed by strata:	1	888,235,672	888,235,672	633,909,923	4.098770
	2	1,151,206,014	1,151,206,014	886,345,442	5.312249
	3	1,367,515,749	1,367,515,749	1,066,404,632	6.310412
	4				
Total Variance		3,406,957,435	3,406,957,435	2,586,659,996	15.721431
Standard Error		58369.14797	58369.14797	50859.21741	3.965026015
Desired Conf. Level		90%	90%	90%	90%
(z two tailed)		1.645	1.645	1.645	1.645
Conf. Interval		96017.24841	96017.24841	83663.41265	6.522467795
MPU Est of kW		947487.0757	947487.0757	947487.0757	64.3630
Relative Conf. Int.		10.13%	10.13%	8.83%	10.13%

Table C

UTAH SCHEDULE 006 LOAD STUDY DESIGN OPTION (2008)
FOUR STRATA, MEAN-PER-UNIT DESIGN

		a Sample Mean kW	b Sample Mean kWh	c 2008 Pop N	d Variance of Mean	e Standard Deviation	f Wtd. Devtns. c*e	g Proprtn. row f/ sum f	h Optimal Allocation g*h total	i Optimal with Attrition	j Final with Attrition
STRATUM 1	0 - 50 kW	15.2094	8,986	7,067	133.0257	11.5337	81508	0.1798	11	11	12
STRATUM 2	51 - 140 kW	53.3991	25,098	5,023	460.2787	21.4541	107764	0.2377	15	15	17
STRATUM 3	141 - 325 kW	145.5156	74,109	1,840	4908.6817	70.0620	128914	0.2843	18	18	20
STRATUM 4	GT 325 kW	379.9563	192,577	791	29239.2990	170.9950	135257	0.2983	19	19	21
EST POP MEAN (wtd by N)		64.1263	32,488	14,721			453444	1.0000	62	63	70

Sample Estimate	Adj Sample Estimate
62	70

RELATIVE PRECISION OF SAMPLE KW ESTIMATE

		TOTAL KW Optimal n (col. h)	TOTAL KW Adjusted n (col.	TOTAL KW Final (col. J	MEAN KW Adj. n
Variance contributed by strata:	1	663,329,182	663,329,182	602,941,066	3.060938
	2	827,028,314	827,028,314	723,360,777	3.816329
	3	968,015,128	968,015,128	865,168,064	4.466913
	4	991,946,469	991,946,469	890,438,993	4.577345
Total Variance		3,450,319,092	3,450,319,092	3,081,908,901	15.921524
Standard Error		58739.41685	58739.41685	55514.94304	3.990178443
Desired Conf. Level		90%	90%	90%	90%
(z two tailed)		1.645	1.645	1.645	1.645
Conf. Interval		96626.34072	96626.34072	91322.0813	6.563843538
MPU Est of kW		944002.7944	944002.7944	944002.7944	64.1263
Relative Conf. Int.		10.24%	10.24%	9.67%	10.24%

Table C.2

Attach UIEC 20.5 -3.pdf

Utah Schedule 023 (2008)
Load Recorder Study
Sampling Procedures

This paper describes the procedures used to develop the 2008 Utah Schedule 023 Load Study. This study will provide load data for use in support of cost studies and price filings before the Utah Public Service Commission, and for use in other studies of commercial customer demand characteristics. The goal of this sample design is to provide relative precision of ± 10% at the 90% confidence level for an estimate of the average of the twelve monthly system peak hours, during twelve consecutive months.

Recorders will be placed in service effective no later than October 1st, 2008, and will be monitored on a continuous basis to insure no significant deviation from billing records.

Sampling Plan for Utah

This sampling plan includes several steps:

1. Formalization of the sample parameters;
2. Specification of the target variable;
3. Choice of the stratification variable;
4. Choice of method for estimating kW;
5. Choice of the number of strata;
6. Construction of the strata boundaries
7. Allocation of sample points to each stratum;
8. Selection of primary sample sites;
9. Selection of alternate sample sites.

Formalization of the sample parameters

This sample replaces the old Utah Commercial schedule 023 sample, which was originally installed in 1991, and later refreshed in 2003. There is no secondary/primary voltage breakdown in the tariff and, accordingly, only one load sample is required to provide load estimates for this group.

Specification of the target variable

Load studies in the state of Utah are used primarily to support cost allocation studies. Current cost study methods use the average demand at the hours of the PacifiCorp system peak for twelve consecutive months (12SYSPK), as well as estimates of distribution and individual customer maximum demands, each averaged over twelve consecutive months.

These study designs treat 12SYSPK as the target variable because it is, by far, the most important peak measure for allocation of demand related costs.

The current Utah schedule 023 study was used to provide estimates of means and residual variances required in these sample designs. The range of sample data employed encompassed the twelve month period from January 2007 through December 2007. Billing data for the twelve months ending February 2008 were used to determine appropriate stratification.

Choice of the Stratification Variable

A potential stratifying variable, according to Cochran, should meet three criteria[1]:

1. *The population is composed of institutions varying widely in size.*
2. *The principle variables to be measured are closely related to the sizes of the institutions.*
3. *A good measure of size is available for setting up the strata.*

Average monthly billing kWh (KWH_MNTH), which is the average monthly energy registered over a twelve consecutive month period, was selected as the best available variable for this purpose. It is readily available for all customers in this class, with a range from 0 to 46,040 kWh for any given customer in this group.

Choice of Method for Estimating kW

To estimate a peak demand for a population using MPU, the mean peak demand value from the sample is multiplied by the number of elements in the entire population. Use of the MPU method provides an unbiased estimate.

For ratio estimation, the ratio of the target variable (12SYSPK) over the auxiliary variable (KWH_ANN) is calculated for the sample. This ratio is then multiplied by the total annual billed kWh for the population to get the estimated total group peak demand. Because energy usage and peak demand are correlated, a ratio estimate will have a smaller variance than a MPU estimate. However, a ratio estimate may be slightly biased.

With stratified sample designs, ratio estimators can be computed in two ways: separately for each stratum, or a combined ratio can be computed over all strata. Separate ratio estimation tends to result in smaller variance. However, the combined ratio method is more appropriate when stratum sample sizes are small, because the risk of bias is reduced.

Tables C.1 shows sample size needed for the Utah Schedule 023 study using a mean-per-unit method, assuming a three strata design, with optimal allocation utilizing the Tschprow/Neyman method. Table C.2 details the same information in a four strata schema. The design as presented in Table C.1 was selected for this sample.

[1] William G. Cochran, "Sampling Techniques", Third Edition, Wiley, pg.101

Choice of the Number of Strata

As the number of strata increases, precision of the estimate of the total contribution to demand (kW) at system peak also increases. However, the increase in precision per additional stratum diminishes after a relatively small number of strata[2]. Desire for simplicity, and for a reasonable number of sites in each stratum lead to a preference for a small number of strata. If a minimum number of sites policy is followed (eg. 10 sites minimum per stratum), then the addition of strata can actually lead to more, rather than fewer, total sites. If such a policy is not followed, the result can be strata with so few recorders that confidence in sample estimates is at risk from unexpected data problems, variance estimates may not be sufficiently precise for future sample design purposes, and the sample may not be robust enough to be useful when analysis needs change.

A final decision on the number of strata requires actual cost comparison of potential stratification schemes to evaluate effectiveness versus cost. For this study, a three strata scheme was employed. The method described below was used to compare stratification approaches.

Construction of Strata Boundaries

Various methods might be used for definition of strata boundaries. Cochran found the "cumulative square root of f"[3] rule, as defined by Dalenius and Hodges (1959), to be superior in a comparative study of such methods applied to actual distributions exhibiting a range of skewness.

Steps in calculating strata boundaries under the "cumulative square root of f" rule are as follows. First, tabulate frequencies of the stratifying variable. For these studies, average monthly energy (KWH_MNTH) from customer billing records for the twelve months ending February 2008 were used. All Utah schedule 023 customers, whose end of year status was active, and whose total annual kWh consumption was greater than 250 kWh were included in this procedure, and in population figures for the sample design. Second, multiply the number of customers in each interval by the interval factor. Third, take the square root of these frequencies. Fourth, cumulatively sum the square roots. The resulting distribution of adjusted cumulative square roots of frequency is then partitioned into equal intervals by dividing by the number of strata. The final stratification scheme of three strata is presented in Table B.1, and shows the optimal boundaries resulting from

[2] William G. Cochran, "Sampling Techniques", Third Edition, Wiley, Pg. 132
[3] William G. Cochran, "Sampling Techniques", Third Edition, Wiley, Pgs. 129-130

the above procedure, after adjustments made to accommodate prior cost analysis requirements (if any).

Allocation of Sample Points to Each Stratum

Once the stratum boundaries have been determined, sample points (i.e., load recorders) must be assigned to the strata. The Tschprow-Neyman allocation procedure[4] allocates an optimal sampling rate to each stratum. Optimal allocation techniques minimize the variance of the population estimates by increasing the sample proportion in the strata having larger variances. This produces a sampling rate for each stratum which is proportional to the standard deviation within the stratum. The analogous procedure for a ratio sampling plan is allocation in proportion to the square root of the residual variance.

Data for estimating the variance of the 12SYSPK measure for each stratum were available for customers included in the current Utah schedule 023 load study. These data were used to provide estimates for the new Utah schedule 023 sample design. For the mean-per-unit method, the variance within each stratum was the ordinary variance of the mean.

Minimum recorder allocations and data loss adjustments are required for each stratum to maintain adequate data in case of recorder failure and to provide data for analysis of load characteristics other than the primary target variable, should such analysis be necessary. Minimums ranging from 5 to 15 sites per stratum have been used in past studies. In the present studies, a minimum of 10 sites was used. A minimum on the high side was selected, despite improvements in data quality due to solid state recording equipment, because changing requirements for load research and other areas using this data may require unanticipated applications, and because overall sample efficiencies are bringing these studies in well below the budgeted number of sites, even with the 10 site minimum. The final allocation of recorders reflected an additional ten percent data loss adjustment per stratum over the optimal or minimum allocation.

Because of a desire to materially reduce the desired precision target level, the decision was made to substantially increase the number of sites to be installed vs. the sample design. The three strata design requires the installation of 68 recorders to meet design standards. This design was supplemented with an additional 7 recorders, which translates to ± 9.67% precision at the 90% confidence level.

[4] William G. Cochran, "Sampling Techniques", Third Edition, Wiley, pgs. 96-99

Sample Selection

Systematic sample selections were used for each stratum to ensure a representative distribution. For practical reasons, inactive customers, customers with no kWh meter installed (usually certain types of lighting customers with very predictable demand and consumption, indicated by absence of a kWh meter number), and customers with very low consumption (<250 kWh total in the past 12 billing periods) were eliminated from the sampling frame. Eligible customers were then sorted by stratum and by average monthly billed energy (KWH_MNTH) within stratum. The number of customers available in the sampling frame for each stratum was then divided by the number of recorders allocated to that stratum (N_h/n_h), yielding the sampling interval size. A five digit random number between 0 and 1 was chosen for each stratum, and multiplied by the stratum interval size to obtain the starting selection point for each stratum (Table A). Beginning with this site, additional sites were selected at the given sampling intervals to obtain the desired number of sample sites. This procedure was repeated four times to provide a list of alternate selection sites.

The list of primary and alternate selection sites for this sample are contained in Appendix 1. This list was compared against current Utah profile metering installations to check for duplicates. Duplicates between the design and production systems if any, were noted and updated in the Appendix.

Utah Commercial 023 Sample Parameters

Active Customers with kWh Meters
For the 12 Months Ending February 2008

Stratum	1	2	3	4	5	6
Sampling Frame	38,769	17,360	4,792			
Sample	29	33	13			
Interval	1,336.86	526.06	368.62			
Random Starts						
Primary						
Random No.[1]	0.77058	0.74693	0.87889			
Start	1030	393	324			
Alternate 1						
Random No.[1]	0.73299	0.42598	0.99982			
Start	980	224	369			
Alternate 2						
Random No.[1]	0.66732	0.29197	0.35048			
Start	892	154	129			
Alternate 3						
Random No.[1]	0.24683	0.49639	0.16335			
Start	330	261	60			
Alternate 4						
Random No.[1]	0.92241	0.86882	0.06259			
Start	1233	457	23			

[1] Random numbers from Excel's random function.

Utah 023 DH Worksheet
Three Strata

Range			Customer Count f	Interval Factor μ	μf	$\sqrt{\mu f}$	cum $\sqrt{\mu f}$	
0	to	250	12176	1	12176	110.3	110.3	
251	to	500	8590	1	8590	92.7	203.0	
501	to	750	6295	1	6295	79.3	282.4	
751	to	1000	4660	1	4660	68.3	350.6	
1001	to	1250	3895	1	3895	62.4	413.0	
1251	to	1500	3153	1	3153	56.2	469.2	38,769
1501	to	1750	2625	1	2625	51.2	520.4	
1751	to	2000	2283	1	2283	47.8	568.2	
2001	to	2250	1938	1	1938	44.0	612.2	
2251	to	2500	1648	1	1648	40.6	652.8	
2501	to	2750	1397	1	1397	37.4	690.2	
2751	to	3000	1253	1	1253	35.4	725.6	
3001	to	3250	1151	1	1151	33.9	759.5	
3251	to	3500	946	1	946	30.8	790.3	
3501	to	3750	839	1	839	29.0	819.3	
3751	to	4000	808	1	808	28.4	847.7	
4001	to	4250	714	1	714	26.7	874.4	
4251	to	4500	641	1	641	25.3	899.7	
4501	to	4750	619	1	619	24.9	924.6	
4751	to	5000	498	1	498	22.3	946.9	17,360
5001	to	5250	477	1	477	21.8	968.8	
5251	to	5500	414	1	414	20.3	989.1	
5501	to	5750	404	1	404	20.1	1,009.2	
5751	to	6000	373	1	373	19.3	1,028.5	
6001	to	6250	353	1	353	18.8	1,047.3	
6251	to	6500	301	1	301	17.3	1,064.6	
6501	to	6750	253	1	253	15.9	1,080.6	
6751	to	7000	237	1	237	15.4	1,095.9	
7001	to	7250	202	1	202	14.2	1,110.2	
7251	to	7500	217	1	217	14.7	1,124.9	
7501	to	7750	151	1	151	12.3	1,137.2	
7751	to	8000	175	1	175	13.2	1,150.4	
8001	to	8250	144	1	144	12.0	1,162.4	
8251	to	8500	155	1	155	12.4	1,174.9	
8501	to	8750	123	1	123	11.1	1,186.0	
8751	to	9000	103	1	103	10.1	1,196.1	
9001	to	9250	80	1	80	8.9	1,205.0	
9251	to	9500	82	1	82	9.1	1,214.1	
9501	to	9750	63	1	63	7.9	1,222.0	
9751	to	10000	52	1	52	7.2	1,229.2	
10001	to	11000	203	4	812	28.5	1,257.7	
11001	to	12000	97	4	388	19.7	1,277.4	
12001	to	13000	62	4	248	15.7	1,293.2	
13001	to	14000	29	4	116	10.8	1,304.0	
14001	to	15000	15	4	60	7.7	1,311.7	
15001	to	143600	27	514.4	13888.8	117.9	1,429.6	4,792
Total N			60,921					60,921

BOUNDARIES INDICATED FOR STRATA:				
	3	4	5	6
1	476.5	357.4	285.9	238.3
2	953.0	714.8	571.8	476.5
3		1,072.2	857.7	714.8
4			1,143.6	953.0
5				1,191.3

SAMPLING ST	Avg. kWh[1]	Mean kW[2]	St. Dev [2]
1	549.051	1.365	1.205
2	2,753.970	6.753	3.065
3	7,153.640	14.814	4.271
4			
5			
6			

[1] Billing records for March 2007 through February 2008
[2] Load Research data for January 2007 through December 2007

Utah 023 DH Worksheet
Four Strata

Range			Customer Count f	Interval Factor μ	μf	$\sqrt{\mu f}$	cum $\sqrt{\mu f}$	
0	to	250	12176	1	12176	110.3	110.3	
251	to	500	8590	1	8590	92.7	203.0	
501	to	750	6295	1	6295	79.3	282.4	
751	to	1000	4660	1	4660	68.3	350.6	31,721
1001	to	1250	3895	1	3895	62.4	413.0	
1251	to	1500	3153	1	3153	56.2	469.2	
1501	to	1750	2625	1	2625	51.2	520.4	
1751	to	2000	2283	1	2283	47.8	568.2	
2001	to	2250	1938	1	1938	44.0	612.2	
2251	to	2500	1648	1	1648	40.6	652.8	
2501	to	2750	1397	1	1397	37.4	690.2	16,939
2751	to	3000	1253	1	1253	35.4	725.6	
3001	to	3250	1151	1	1151	33.9	759.5	
3251	to	3500	946	1	946	30.8	790.3	
3501	to	3750	839	1	839	29.0	819.3	
3751	to	4000	808	1	808	28.4	847.7	
4001	to	4250	714	1	714	26.7	874.4	
4251	to	4500	641	1	641	25.3	899.7	
4501	to	4750	619	1	619	24.9	924.6	
4751	to	5000	498	1	498	22.3	946.9	
5001	to	5250	477	1	477	21.8	968.8	
5251	to	5500	414	1	414	20.3	989.1	
5501	to	5750	404	1	404	20.1	1,009.2	
5751	to	6000	373	1	373	19.3	1,028.5	
6001	to	6250	353	1	353	18.8	1,047.3	
6251	to	6500	301	1	301	17.3	1,064.6	9,791
6501	to	6750	253	1	253	15.9	1,080.6	
6751	to	7000	237	1	237	15.4	1,095.9	
7001	to	7250	202	1	202	14.2	1,110.2	
7251	to	7500	217	1	217	14.7	1,124.9	
7501	to	7750	151	1	151	12.3	1,137.2	
7751	to	8000	175	1	175	13.2	1,150.4	
8001	to	8250	144	1	144	12.0	1,162.4	
8251	to	8500	155	1	155	12.4	1,174.9	
8501	to	8750	123	1	123	11.1	1,186.0	
8751	to	9000	103	1	103	10.1	1,196.1	
9001	to	9250	80	1	80	8.9	1,205.0	
9251	to	9500	82	1	82	9.1	1,214.1	
9501	to	9750	63	1	63	7.9	1,222.0	
9751	to	10000	52	1	52	7.2	1,229.2	
10001	to	11000	203	4	812	28.5	1,257.7	
11001	to	12000	97	4	388	19.7	1,277.4	
12001	to	13000	62	4	248	15.7	1,293.2	
13001	to	14000	29	4	116	10.8	1,304.0	
14001	to	15000	15	4	60	7.7	1,311.7	
15001	to	143600	27	514.4	13888.8	117.9	1,429.6	2,470
Total N			60,921					60,921

BOUNDARIES INDICATED FOR STRATA:

	3	4	5	6
1	476.5	357.4	285.9	238.3
2	953.0	714.8	571.8	476.5
3		1,072.2	857.7	714.8
4			1,143.6	953.0
5				1,191.3

SAMPLING ST/	Avg. kWh[1]	Mean kW[2]	St. Dev [2]
1	396.862	0.662	0.788
2	1,707.240	2.913	0.796
3	4,167.170	9.330	3.202
4	8,529.070	16.309	3.705
5			
6			

1 Billing records for March 2007 through February 2008

2 Load Research data for January 2007 through December 2007

Utah 023 DH Worksheet
Five Strata

Range			Customer Count f	Interval Factor μ	μf	$\sqrt{\mu f}$	cum $\sqrt{\mu f}$	
0	to	250	12176	1	12176	110.3	110.3	
251	to	500	8590	1	8590	92.7	203.0	
501	to	750	6295	1	6295	79.3	282.4	27,061
751	to	1000	4660	1	4660	68.3	350.6	
1001	to	1250	3895	1	3895	62.4	413.0	
1251	to	1500	3153	1	3153	56.2	469.2	
1501	to	1750	2625	1	2625	51.2	520.4	
1751	to	2000	2283	1	2283	47.8	568.2	16,616
2001	to	2250	1938	1	1938	44.0	612.2	
2251	to	2500	1648	1	1648	40.6	652.8	
2501	to	2750	1397	1	1397	37.4	690.2	
2751	to	3000	1253	1	1253	35.4	725.6	
3001	to	3250	1151	1	1151	33.9	759.5	
3251	to	3500	946	1	946	30.8	790.3	
3501	to	3750	839	1	839	29.0	819.3	
3751	to	4000	808	1	808	28.4	847.7	9,980
4001	to	4250	714	1	714	26.7	874.4	
4251	to	4500	641	1	641	25.3	899.7	
4501	to	4750	619	1	619	24.9	924.6	
4751	to	5000	498	1	498	22.3	946.9	
5001	to	5250	477	1	477	21.8	968.8	
5251	to	5500	414	1	414	20.3	989.1	
5501	to	5750	404	1	404	20.1	1,009.2	
5751	to	6000	373	1	373	19.3	1,028.5	
6001	to	6250	353	1	353	18.8	1,047.3	
6251	to	6500	301	1	301	17.3	1,064.6	
6501	to	6750	253	1	253	15.9	1,080.6	
6751	to	7000	237	1	237	15.4	1,095.9	
7001	to	7250	202	1	202	14.2	1,110.2	
7251	to	7500	217	1	217	14.7	1,124.9	
7501	to	7750	151	1	151	12.3	1,137.2	5,854
7751	to	8000	175	1	175	13.2	1,150.4	
8001	to	8250	144	1	144	12.0	1,162.4	
8251	to	8500	155	1	155	12.4	1,174.9	
8501	to	8750	123	1	123	11.1	1,186.0	
8751	to	9000	103	1	103	10.1	1,196.1	
9001	to	9250	80	1	80	8.9	1,205.0	
9251	to	9500	82	1	82	9.1	1,214.1	
9501	to	9750	63	1	63	7.9	1,222.0	
9751	to	10000	52	1	52	7.2	1,229.2	
10001	to	11000	203	4	812	28.5	1,257.7	
11001	to	12000	97	4	388	19.7	1,277.4	
12001	to	13000	62	4	248	15.7	1,293.2	
13001	to	14000	29	4	116	10.8	1,304.0	
14001	to	15000	15	4	60	7.7	1,311.7	
15001	to	143600	27	514.4	13888.8	117.9	1,429.6	1,410
Total N			60,921					60,921

BOUNDARIES INDICATED FOR STRATA:

	3	4	5	6
1	476.5	357.4	285.9	238.3
2	953.0	714.8	571.8	476.5
3		1,072.2	857.7	714.8
4			1,143.6	953.0
5				1,191.3

SAMPLING ST	Avg. kWh[1]	Mean kW[2]	St. Dev [2]
1	315.437	0.385	0.334
2	1,280.920	2.699	0.816
3	2,829.430	6.270	1.932
4	5,422.430	11.775	3.423
5	9,627.600	13.821	5.747
6			

1 Billing records for March 2007 through February 2008

2 Load Research data for January 2007 through December 2007

Utah 023 DH Worksheet
Six Strata

Range			Customer Count f	Interval Factor μ	μf	$\sqrt{\mu f}$	cum $\sqrt{\mu f}$	
0	to	250	12176	1	12176	110.3	110.3	
251	to	500	8590	1	8590	92.7	203.0	20,766
501	to	750	6295	1	6295	79.3	282.4	
751	to	1000	4660	1	4660	68.3	350.6	
1001	to	1250	3895	1	3895	62.4	413.0	
1251	to	1500	3153	1	3153	56.2	469.2	18,003
1501	to	1750	2625	1	2625	51.2	520.4	
1751	to	2000	2283	1	2283	47.8	568.2	
2001	to	2250	1938	1	1938	44.0	612.2	
2251	to	2500	1648	1	1648	40.6	652.8	
2501	to	2750	1397	1	1397	37.4	690.2	9,891
2751	to	3000	1253	1	1253	35.4	725.6	
3001	to	3250	1151	1	1151	33.9	759.5	
3251	to	3500	946	1	946	30.8	790.3	
3501	to	3750	839	1	839	29.0	819.3	
3751	to	4000	808	1	808	28.4	847.7	
4001	to	4250	714	1	714	26.7	874.4	
4251	to	4500	641	1	641	25.3	899.7	
4501	to	4750	619	1	619	24.9	924.6	
4751	to	5000	498	1	498	22.3	946.9	7,469
5001	to	5250	477	1	477	21.8	968.8	
5251	to	5500	414	1	414	20.3	989.1	
5501	to	5750	404	1	404	20.1	1,009.2	
5751	to	6000	373	1	373	19.3	1,028.5	
6001	to	6250	353	1	353	18.8	1,047.3	
6251	to	6500	301	1	301	17.3	1,064.6	
6501	to	6750	253	1	253	15.9	1,080.6	
6751	to	7000	237	1	237	15.4	1,095.9	
7001	to	7250	202	1	202	14.2	1,110.2	
7251	to	7500	217	1	217	14.7	1,124.9	
7501	to	7750	151	1	151	12.3	1,137.2	
7751	to	8000	175	1	175	13.2	1,150.4	
8001	to	8250	144	1	144	12.0	1,162.4	
8251	to	8500	155	1	155	12.4	1,174.9	
8501	to	8750	123	1	123	11.1	1,186.0	3,979
8751	to	9000	103	1	103	10.1	1,196.1	
9001	to	9250	80	1	80	8.9	1,205.0	
9251	to	9500	82	1	82	9.1	1,214.1	
9501	to	9750	63	1	63	7.9	1,222.0	
9751	to	10000	52	1	52	7.2	1,229.2	
10001	to	11000	203	4	812	28.5	1,257.7	
11001	to	12000	97	4	388	19.7	1,277.4	
12001	to	13000	62	4	248	15.7	1,293.2	
13001	to	14000	29	4	116	10.8	1,304.0	
14001	to	15000	15	4	60	7.7	1,311.7	
15001	to	143600	27	514.4	13888.8	117.9	1,429.6	813
Total N			60,921					60,921

BOUNDARIES INDICATED FOR STRATA:				
	3	4	5	6
1	476.5	357.4	285.9	238.3
2	953.0	714.8	571.8	476.5
3		1,072.2	857.7	714.8
4			1,143.6	953.0
5				1,191.3

SAMPLING ST/	Avg. kWh[1]	Mean kW[2]	St. Dev[2]
1	223.916	0.385	0.334
2	924.085	2.453	0.781
3	2,044.450	3.394	0.663
4	3,693.570	8.433	2.240
5	6,436.950	13.734	3.224
6	10,661.300	14.072	5.740

1 Billing records for March 2007 through February 2008

2 Load Research data for January 2007 through December 2007

UTAH COMMERCIAL 023 LOAD STUDY DESIGN OPTION (2008)
THREE STRATA, MEAN-PER-UNIT DESIGN

		a Sample Mean kW	b Sample Mean kWh	c 2008 Pop N	d Variance of Mean	e Standard Deviation	f Wtd. Devtns. c*e	g Proprtn. row f/ sum f	h Optimal Allocation g*h total	i Optimal with Attrition	j Final with Attrition
STRATUM 1	0- 1500 kwh	1.365	549.051	38,769	1.4530	1.205	46733	0.3881	26	26	29
STRATUM 2	1501- 5000 kwh	6.753	2,753.970	17,360	9.3952	3.065	53211	0.4419	30	30	33
STRATUM 3	GT -5000 kwh	14.814	7,153.640	4,792	18.2436	4.271	20468	0.1700	12	12	13
EST POP MEAN (wtd by N)		3.958	1,696.875	60,921			120412	1.0000	68	68	75

Sample Estimate	Adj Sample Estimate
68	75

RELATIVE PRECISION OF SAMPLE KW ESTIMATE

		TOTAL KW Optimal n (col. h)	TOTAL KW Adjusted n (cc	TOTAL KW Final (col. J	MEAN KW Adj. n
Variance contributed by strata:	1	87,300,517	87,300,517	77,940,854	0.023522
	2	97,466,709	97,466,709	88,313,914	0.026262
	3	37,989,398	37,989,398	34,816,330	0.010236
Total Variance		222,756,624	222,756,624	201,071,098	0.060020
Standard Error		14925.03346	14925.03346	14179.95409	0.244989962
Desired Conf. Level		90%	90%	90%	90%
(z two tailed)		1.645	1.645	1.645	1.645
Conf. Interval		24551.68004	24551.68004	23326.02449	0.403008487
MPU Est of kW		241123.6339	241123.6339	241123.6339	3.9580
Relative Conf. Int.		10.18%	10.18%	9.67%	10.18%

Table C.1

UTAH COMMERCIAL 023 LOAD STUDY DESIGN OPTION (2008)
FOUR STRATA, MEAN-PER-UNIT DESIGN

		a Sample Mean kW	b Sample Mean kWh	c 2008 Pop N	d Variance of Mean	e Standard Deviation	f Wtd. Devtns. c*e	g Proprtn. row f/ sum f	h Optimal Allocation g*h total	i Optimal with Attrition	j Final with Attrition
STRATUM 1	0 - 1000 kWh	0.662	396.862	31,721	0.6214	0.788	25005	0.3165	9	10	11
STRATUM 2	1001 - 2750 kWh	2.913	1,707.240	16,939	0.6340	0.796	13488	0.1707	5	10	11
STRATUM 3	2751 - 6500 kWh	9.330	4,167.170	9,791	10.2541	3.202	31353	0.3969	12	12	13
STRATUM 4	GT 6501 kWh	16.309	8,529.070	2,470	13.7234	3.705	9150	0.1158	3	10	11
EST POP MEAN (wtd by N)		3.315	1,696.876	60,921			78996	1.0000	30	42	46

Sample Estimate	Adj Sample Estimate
30	46

RELATIVE PRECISION OF SAMPLE KW ESTIMATE

		TOTAL KW Optimal n (col. h)	TOTAL KW Adjusted n (cc	TOTAL KW Final (col. J	MEAN KW Adj. n
Variance contributed by strata:	1	78,133,862	69,450,132	62,503,147	0.018713
	2	45,465,467	20,200,908	18,179,743	0.005443
	3	89,254,096	89,254,096	81,807,888	0.024049
	4	41,811,804	9,265,148	8,335,243	0.002496
Total Variance		254,665,229	188,170,283	170,826,022	0.050701
Standard Error		15958.2339	13717.5174	13070.0429	0.225168947
Desired Conf. Level		90%	90%	90%	90%
(z two tailed)		1.645	1.645	1.645	1.645
Conf. Interval		26251.29476	22565.31612	21500.2206	0.370402917
MPU Est of kW		201968.0661	201968.0661	201968.066	3.3152
Relative Conf. Int.		13.00%	11.17%	10.65%	11.17%

Table C.2

UTAH COMMERCIAL 023 LOAD STUDY DESIGN OPTION (2008)
FIVE STRATA, MEAN-PER-UNIT DESIGN

		a	b	c	d	e	f	g	h	i	j
		Sample Mean kW	Sample Mean kWh	2008 Pop N	Variance of Mean	Standard Deviation	Wtd. Devtns. c*e	Proprtn. row f/ sum f	Optimal Allocation g*h total	Optimal with Attrition	Final with Attrition
STRATUM 1	0 - 750 kWh	0.385	315.437	27,061	0.1117	0.334	9046	0.1292	2	10	11
STRATUM 2	751 - 2000 kWh	2.699	1,280.920	16,616	0.6662	0.816	13562	0.1937	4	10	11
STRATUM 3	2001 - 4000 kWh	6.270	2,829.430	9,980	3.7309	1.932	19277	0.2753	5	10	11
STRATUM 4	4001 - 7750 kWh	11.775	5,422.430	5,854	11.7201	3.423	20041	0.2862	5	10	11
STRATUM 5	GT 7750 kWh	13.821	9,627.600	1,410	33.0241	5.747	8103	0.1157	2	10	11
EST POP MEAN (wtd by N)		3.385	1,696.875	60,921			70029	1.0000	18	50	55

Sample Estimate	Adj Sample Estimate
18	55

RELATIVE PRECISION OF SAMPLE KW ESTIMATE

		TOTAL KW Optimal n (col. h)	TOTAL KW Adjusted n (cc	TOTAL KW Final (col. J	MEAN KW Adj. n
Variance contributed by strata:	1	81,825,209	9,089,002	8,179,799	0.002449
	2	61,298,538	20,425,466	18,381,812	0.005503
	3	92,853,323	41,247,458	37,118,989	0.011114
	4	100,324,280	44,550,453	40,088,546	0.012004
	5	65,561,998	7,243,276	6,514,292	0.001952
Total Variance		401,863,349	122,555,655	110,283,439	0.033022
Standard Error		20046.5296	11070.48575	10501.59222	0.181718714
Desired Conf. Level		90%	90%	90%	90%
(z two tailed)		1.645	1.645	1.645	1.645
Conf. Interval		32976.54119	18210.94906	17275.1192	0.298927284
MPU Est of kW		206247.7077	206247.7077	206247.7077	3.3855
Relative Conf. Int.		15.99%	8.83%	8.38%	8.83%

Table C.3

UTAH COMMERCIAL 023 LOAD STUDY DESIGN OPTION (2008)
SIX STRATA, MEAN-PER-UNIT DESIGN

		a Sample Mean kW	b Sample Mean kWh	c 2008 Pop N	d Variance of Mean	e Standard Deviation	f Wtd. Devtns. c*e	g Proprtn. row f/ sum f	h Optimal Allocation g*h total	i Optimal with Attrition	j Final with Attrition
STRATUM 1	0 - 500 kWh	0.385	223.916	20,766	0.1117	0.334	6942	0.1124	1	10	11
STRATUM 2	501 - 1500 kWh	2.453	924.085	18,003	0.6098	0.781	14058	0.2275	3	10	11
STRATUM 3	1501 - 2750 kWh	3.394	2,044.450	9,891	0.4401	0.663	6562	0.1062	1	10	11
STRATUM 4	2751 - 5000 kWh	8.433	3,693.570	7,469	5.0155	2.240	16727	0.2707	3	10	11
STRATUM 5	5001 - 8750 kWh	13.734	6,436.950	3,979	10.3934	3.224	12828	0.2076	2	10	11
STRATUM 6	GT 8751 kWh	14.072	10,661.300	813	32.9526	5.740	4667	0.0755	1	10	11
EST POP MEAN (wtd by N)		3.526	1,696.875	60,921			61783	1.0000	12	60	66

Sample Estimate	Adj Sample Estimate
12	66

RELATIVE PRECISION OF SAMPLE KW ESTIMATE

		TOTAL KW Optimal n (col. h)	TOTAL KW Adjusted n (col.	TOTAL KW Final (col. J	MEAN KW Adj. n
Variance contributed by strata:	1	#DIV/0!	5,351,623	4,816,229	0.001442
	2	98,796,155	21,946,163	19,750,449	0.005913
	3	#DIV/0!	4,779,021	4,300,683	0.001288
	4	139,842,437	31,046,961	27,938,518	0.008365
	5	164,470,890	18,237,783	16,409,869	0.004914
	6	#DIV/0!	2,390,302	2,148,593	0.000644
Total Variance		#DIV/0!	83,751,853	75,364,342	0.022566
Standard Error		#DIV/0!	9151.603832	8681.263827	0.150220841
Desired Conf. Level		90%	90%	90%	90%
(z two tailed)		1.645	1.645	1.645	1.645
Conf. Interval		#DIV/0!	15054.3883	14280.679	0.247113283
MPU Est of kW		214793.8354	214793.8354	214793.8354	3.5258
Relative Conf. Int.		#DIV/0!	7.01%	6.65%	7.01%

Utah Schedule 023 kWh Summary
For the Twelve months Ended December 2007

N	MIN	MEAN	MAX	SUM
60921	20.9167	1696.88	46040	103375338.88

Utah Schedule 023 Bill Frequency Worksheet

STRATUM		n	KWH
0 -	250 kWh	12176	1479353.46
251 -	500 kWh	8590	3170489.41
501 -	750 kWh	6295	3886196.34
751 -	1000 kWh	4660	4052828.97
1001 -	1250 kWh	3895	4370999.22
1251 -	1500 kWh	3153	4326279.09
1501 -	1750 kWh	2625	4259747.28
1751 -	2000 kWh	2283	4273871.73
2001 -	2250 kWh	1938	4115525.01
2251 -	2500 kWh	1648	3910701.29
2501 -	2750 kWh	1397	3661782.09
2751 -	3000 kWh	1253	3596897.75
3001 -	3250 kWh	1151	3593109.81
3251 -	3500 kWh	946	3194257.27
3501 -	3750 kWh	839	3036260.46
3751 -	4000 kWh	808	3129214.85
4001 -	4250 kWh	714	2945360.59
4251 -	4500 kWh	641	2803785.01
4501 -	4750 kWh	619	2862282.09
4751 -	5000 kWh	498	2426138.25
5001 -	5250 kWh	477	2444556.14
5251 -	5500 kWh	414	2225808.51
5501 -	5750 kWh	404	2269200.04
5751 -	6000 kWh	373	2192661.42
6001 -	6250 kWh	353	2162867.26
6251 -	6500 kWh	301	1918363.82
6501 -	6750 kWh	253	1675808.86
6751 -	7000 kWh	237	1627743.02
7001 -	7250 kWh	202	1438834.15
7251 -	7500 kWh	217	1598485.46
7501 -	7750 kWh	151	1151014.55
7751 -	8000 kWh	175	1377131.82
8001 -	8250 kWh	144	1169241.34
8251 -	8500 kWh	155	1299826.07
8501 -	8750 kWh	123	1061078.63
8751 -	9000 kWh	103	913453.75
9001 -	9250 kWh	80	730909.44
9251 -	9500 kWh	82	767551.45
9501 -	9750 kWh	63	606506.15
9751 -	10000 kWh	52	514000.70
10001 -	11000 kWh	203	2121667.36
11001 -	12000 kWh	97	1106727.59
12001 -	13000 kWh	62	773889.25
13001 -	14000 kWh	29	387809.08
14001 -	15000 kWh	15	216264.62
GT	15001 kWh	27	528858.43

Utah 023 Billing Statistics
Mean kWh - Three Strata

STRATUM=1

N	KWH_MEAN
38769	549.051

STRATUM=2

N	KWH_MEAN
17360	2753.97

STRATUM=3

N	KWH_MEAN
4792	7153.64

Utah 023 Billing Statistics
Mean kWh - Four Strata

STRATUM=1

N	KWH_MEAN
31721	396.862

STRATUM=2

N	KWH_MEAN
16939	1707.24

STRATUM=3

N	KWH_MEAN
9791	4167.17

STRATUM=4

N	KWH_MEAN
2470	8529.07

Utah 023 Billing Statistics
Mean kWh - Five Strata

---------- STRATUM=1 ----------

N	KWH_MEAN
27061	315.437

---------- STRATUM=2 ----------

N	KWH_MEAN
16616	1280.92

---------- STRATUM=3 ----------

N	KWH_MEAN
9980	2829.43

---------- STRATUM=4 ----------

N	KWH_MEAN
5854	5422.43

---------- STRATUM=5 ----------

N	KWH_MEAN
1410	9627.60

Utah 023 Billing Statistics
Mean kWh - Six Strata

STRATUM=1

N	KWH_MEAN
20766	223.916

STRATUM=2

N	KWH_MEAN
18003	924.085

STRATUM=3

N	KWH_MEAN
9891	2044.45

STRATUM=4

N	KWH_MEAN
7469	3693.57

STRATUM=5

N	KWH_MEAN
3979	6436.95

STRATUM=6

N	KWH_MEAN
813	10661.30

STRATUM=0 - 1,500 kWh

The MEANS Procedure

Analysis Variable : KWH_MNTH Billed Usage

N	Mean
38146	548.6611961

STRATUM=1,501 - 5,000 kWh

Analysis Variable : KWH_MNTH Billed Usage

N	Mean
17138	2756.40

STRATUM=GT 5,000 kWh

Analysis Variable : KWH_MNTH Billed Usage

N	Mean
4748	7157.49

---------- STRATUM=0 - 1,500 kWh ----------

The MEANS Procedure

Analysis Variable : KWH_MNTH Billed Usage

N	Mean
38146	548.6611961

---------- STRATUM=1,501 - 5,000 kWh ----------

Analysis Variable : KWH_MNTH Billed Usage

N	Mean
17138	2756.40

---------- STRATUM=GT 5,000 kWh ----------

Analysis Variable : KWH_MNTH Billed Usage

N	Mean
4748	7157.49

---------- STRATUM=0 - 1,500 kWh ----------

The MEANS Procedure

Analysis Variable : KWH_MNTH Billed Usage

N	Mean
38769	549.0506975

---------- STRATUM=1,501 - 5,000 kWh ----------

Analysis Variable : KWH_MNTH Billed Usage

N	Mean
17360	2753.97

---------- STRATUM=GT 5,000 kWh ----------

Analysis Variable : KWH_MNTH Billed Usage

N	Mean
4792	7153.64