07-035-93/Rocky Mountain Power July 8, 2008 UIEC 20th Set Data Request 20.5



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 \pm 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

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This sampling plans includes several steps:

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- 1. Formalization of the sample parameters;
- 2. Specification of the target variable;
- 3. Choice of the stratification variable;
- 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 criteria¹:

- 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.

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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. 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

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Various methods might be used for definition of strata boundaries. Cochran found the "cumulative square root of f" 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.

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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 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.

10

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 \pm 4.64% precision at the 90% confidence level.

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

Sample Selection

2000

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.

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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⁾ Start	0.69548 3598	0.18893 687	0.86783 1463			
Alternate 1 Random No. ⁽¹⁾ Start	0.22927 1186	0.83647 3043	0.60988 1 0 28			
Alternate 2 Random No. ⁽¹⁾ Start	0.37149 1922	0.71481 2600	0.21123 356			
Alternate 3 Random No. ⁽¹⁾ Start	0.19601 1014	0.58823 2140	0.98344 1658			
Alternate 4 Random No. ⁽¹⁾ Start	0.10190 527	0.69198 2517	0.17559 296			

27

ATTEN.

⁽¹⁾ Random numbers from Excel's random function.

Utah Residential Class DH Worksheet Three Strata Customer Interval

526

Total N	660,409	660,409
rotal iv	000,409	660,409

BOUNDARIES INI	DICATED FOR	STRATA:		
	3	4	5	6
1 —	930.8	698.1	558.5	465.4
2	1,861.6	396.2 1	117.0	930.8
3	2	,094.4 🚅 1	675.5 € 1	396.2
4		es 150 2	234 04 \$ 1	861.6
5			2	327.1

SAMPLING STA	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

Customer	Interval
Count	Factor

Range			Count	Factor				
0 to 250 45840 1 45840 214.1 214.1 214.1 251 to 500 139998 1 139998 374.2 568.3 185,838 501 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 1 1261 1 1,640.4 1 1261 1 1,640.4 1 1261 1 1,640.4 1 1,640.4 1 1,751 1 2,757.7 1 1,751 1 2,757.7 1 1,751 1 2,707.7 1 1,751 1 2,000.9 1 1,751 1 2,200.0 1 1,751 1 2,000.9 1 1,751 1 1,752 1,777 1 1,752 1,752 1 1,752 1,752 1 1,752 1,752<		ge	ſ		μf	√uf	cum õf	
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Test		750	165962	1	165962			100,000
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1751 10 2000 12264 1 12264 110.7 2,111.7 160,003	1501 to	1750						
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12501 to 15000 33 10 330 18.2 2,634.1 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					12	3.5	2,609.8	
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						24.3	2,634.1	
17501 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						18.2		
20001 to 22500 9 10 90 9.5 2,685.3							2,668.0	
22501 to 191500 47 27 14100							2,675.8	
2230, 10 191300 17 676 11492 107.2 2,792.5 18,924							2,685.3	
	 22301 10	191000	1/	6/6	11492	107.2	2,792.5	18,924

Total N

660,409

660,409

32

20

BOUNDARIES INDICATED FO	OR STRATA:	··	
3	4	5	6
1 930.8	698.1	6558.5 kg	465.4
2 20 1 861.6	1,396.2	1117/03/5	930.8
3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	2,094.4	675.5	396.2
4 70 3		234 0 5 1	8616
5		5-2	327 1

SAMPLING STA	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 Silling records for March 2007 through February 2008

² Load Research data for January 2007 through Docember 2007

Utah Residential Class DH Worksheet
Five Strata
Customer Interval
Count Factor

20

_657P

			Count	Factor				
	Rang	ge	ſ	д	μf	√μ∫	cum √µ∫	
) 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	81 025	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	
5251	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 9751	to to	9750	6 12	1	6	2.4 3.5	2,606.3	
10001		10000 12500	59	1 10	12 590	3.5 24.3	2,609.8	
12501	to						2,634.1	
15001	to to	15000 17500	33 25	10 10	330 250	18.2 15.8	2,652.2 2,668.0	
17501	to	20000	∠5 6	10	∠50 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	2,003.3	8,070
22001		131300		- 0,0	11452	107.2	2,132.3	0,070

Total N 660,409 660,409

BOUNDARIES INDICAT	ED FO	R STRATA	١;	
	3	4	5	6
1	30.8 _{3 7} .	£ 698.1	558.5	465.4
2 1,8	61.6	1,396.2	1,117.0	930.8
3		2,094.4	1,675.5	396.2
4			2,234.0	861.6
5			2	327.1

SAMPLING STA	Avg. kWh1	Mean kW2	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 Occember 2007

Utah Residential Class DH Worksheet Six Strata

SIX	Strata
Customer	Interval

			Count	Factor					
1	Range		Count	Factor		6	1. 1	cum √μf	
	to	250	45840	μ	_	μ <i>f</i>	√μ <i>f</i>		
251	to	500	139998		1 1	45840 139998	214.1	214.1	105 020
501	to	750	165962		'	165962	374.2 407.4	588.3 995.7	185,838
751	to	1000	129682		'- -				165,962
1001		1250				129682	360.1	1,355.8	129,682
1251	to to		81025		1	81025	284.6	1,640.4	101000
		1500	43941		1	43941	209,6	1,850.0	124,966
1501	to	1750	22773		1	22773	150.9	2,000.9	
1751 2001	to to	2000	12264 6856		1	12264	110.7	2,111.7	
2251	to	2250			1	6856	82.8	2,194.5	
2501	to	2500 2750	3998		1	3998	63.2	2,257.7	
2751	to	3000	2343 1564		1 1	2343 1564	48.4 39.5	2,306.1	40.700
3001	to	3250	1026	-	1			2,345.7	49,798
3251	to	3500	678		1	1026	32.0	2,377.7	
3501	tò	3750	508		1	678 508	26,0 22,5	2,403.7	
3751	to	4000	337		: 1	337	18.4	2,426.3 2,444.6	
4001	to	4250	280		1	280	16.7	2,444.6	
4251	to	4500	213		1	213	14.6	2,476.0	
4501	to	4750	145		1	145	12.0	2,478.0	
4 751	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		•	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		i	38	6.2	2,554.6	
6751	to	7000	33		ı	33	5.7	2,560.4	
7001	to	7250	34	1		34	5.8	2,566.2	
7251	to	7500	23	1	1	23	4.8	2,571.0	
	to	7750	24	1	l	24	4.9	2,575.9	
7751	to	8000	25	1	ŧ	25	5.0	2,580.9	
	to	8250	25	1		25	5.0	2,585.9	
	to	8500	11	1		11	3.3	2,589.2	
	to	8750	17	1		17	4.1	2,593.4	
	to	9000	11	1		11	3.3	2,596.7	
	to	9250	15	1		15	3.9	2,600.5	
	to	9500	11	1		11	3.3	2,603.9	
	to	9750	6	1		6	2.4	2,606.3	
		10000	12	1		12	3.5	2,609.8	
		12500	59	10		590	24.3	2,634.1	
		15000	33 25	10		330	18.2	2,652.2	
		17500 20000	25 6	10 10		250 60	15.8	2,668.0	
		20000 22500	9	10		90	7.7	2,675.8	
		22500 91500	9 17	676		11492	9.5 107.2	2,685.3 2,792.5	4,163
42001		31300		0/0		11452	107.2	2,192.3	4,103

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Total N 660,409 660,409

BOUNDARIES INDICA	TED FO	R STRATA:		
	3	4	5	6
1	30.8	698 1	558.5	465.4
2 18	616:	1,396.2 1, 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 kW2	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

STRATUM 1 STRATUM 2 STRATUM 3

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	J Final with Attrition	68 70 32	170	Adj Sample Estimate 170								
	Optimal with Attrition	60 60 77	144	Sample Estimate								
ء.	Optimal Allocation g*h total	0 0 7 7 8	144		MEAN KW Adj. n	0.000873 0.000862 0.000349	0.002083	0.045644502	90% 1.645	0.075085206	1,4906	5.04%
o	Propition from f	0.4186 0.4161 0.1652	1.0000	•	TOTAL KW Final (col. J	335,159,946 321,531,689 112,761,741	769,453,375	27739.02261	90% 1.645	45630.6922	984398.822	4.64%
•	Wtd. Devtns. c*e	149867 148969 59141	357977	'n	TOTAL KW TOTAL KV Adjusted n (cc Final (col, J	380,614,019 376,043,356 152,005,761	908,663,136	30144.03981	90% 1.645	49586.94549	984398.822	5.04%
Φ	Standard Deviation	0.426 0.585 1.096		V ESTIMAT								
ס	Variance of Mean	0.1815 0.3422 1.2012		RELATIVE PRECISION OF SAMPLE KW ESTIMATE	TOTAL KW Optimal n (col. h)	380,614,019 376,043,356 152,005,761	908,663,136	30144.03981	90% 1.645	49586.94549	984398.822	5.04%
O	2008 Pop N	351,800 254,648 53,961	660,409	RECISION	O	₩ 0.00 4	ø.	٦.	Level		>	Int.
٩	Sample Mean kWh	468.827 1,030.830 2,100.870	818.882	RELATIVE PI		Variance contributed by strata:	Total Variance	Standard Error	Desired Conf. Leve (z two tailed)	Conf. Interval	MPU Est of kW	Relative Conf. Int
- -	Sample Mean kW	0.740 1.964 4.150	1.491	_		7 0 11	_	0,			~	匠
		0 - 750 KWh 751 - 1,500 KWh GT 1,500 KWh	EST POP MEAN (wtd by N)									
5		7UM MUT 10M 20 2 8	EST P(

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

		Final with Attrition	23 55 57	5 E	146	Adj Sample Estimate 146
		Optimal with Attrition	21 50 52	0.0	133 [Sample Estimate 129
	£	Optimal Allocation g*h total	21 50 52	φ	129	
	m	Proprtn. row f/ sum f	0.1612 4 0.3881 0.4036	0.0471	1.0000	
	٠	Wtd. Devtns. c*e	55008 132449 137763	16085	341305	121
	ø	Standard Deviation	0.296 0.448 0.861			W ESTIMATI
	ס	Variance of Mean	0.0876 0.2007 0.7413	0.7225		RELATIVE PRECISION OF SAMPLE KW ESTIMATE
	O	2008 Pop N	185,838 295,644 160,003	18,824	660,409	RECISION
	Ω	Sample Mean kWh	330,909 730,251 1,309,720	2,045.400	818.881	RELATIVE P
N.S	w	Sample Mean kW	0.531 1.221 2.751 4 856		1,502	
FOUR STRATA, MEAN-PER-UNIT DESIGN			0 - 500 kWh 501 - 1,000 kWh 1,001 - 2,000 kWh	2001	EST POP MEAN (wtd by N)	
FOUR STRATA			STRATUM 1 STRATUM 2 STRATUM 3 STRATUM 4		EST P	

	TOTAL KW Optimal n (col. h)	TOTAL KW TOTAL KW Adjusted n (cc Final (col. J	TOTAL KW TOTAL KW djusted n (cc Final (col. J	MEAN KW Adj. n
Variance 1 contributed 2 by strata: 3	151,277,171 357,951,867 372,007,086 51,731,612	151,277,171 357,951,867 372,007,086 28,733,707	137,523,220 324,802,681 338,781,577 25,858,969	0.000347 0.000821 0.000853 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 (z two tailed)	90% 1.645	90% 1.645	90% 1.645	90% 1.645
Conf. Interval	50245.73629	49622.58671	47305.305	47305.305 0.075139174
MPU Est of kW	991724.499	991724.499	991724,499	1.5017

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

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		Final with Attrition	22 26 42 33	134
		Optimal with Attrition	20 24 38 30	122
	ج.	Optimal Allocation g*h total	24 24 30 38 20 20	114
	co.	Proprtn. row f/ sum f	0.1713 0.2103 0.3352 0.2618 0.0214	1,0000
	•••	Wtd. Devtns. c*e	55008 67547 107671 84083 6860	321168
	ø	Standard Deviation	0.296 0.407 0.511 0.936 0.850	
	ס	Variance of Mean	0.0876 0.1656 0.2611 0.8761 0.7225	
	O	2008 Pop N	185,838 165,962 210,707 89,832 8,070	660,409
	Д	Sample Mean kWh	330.909 623.263 961.824 1,595.290 3,704.130	818.882
-	œ	Sample Mean kW	0.531 . 1.037 . 1.816 . 3.082 . 4.856	1.468
			0 - 500 kWh 501 - 750 kWh 751 - 1,250 kWh 1,251 - 2,500 kWh GT 2,500 kWh	EST POP MEAN (wtd by N)
, , , , , , , , , , , , , , , , , , , ,			STRATUM 1 STRATUM 3 STRATUM 4 STRATUM 6	EST PC

RELATIVE PRECISION OF SAMPLE KW ESTIMATE

Sample Adj Sample Estimate 114 134

5.15%	4.90%	5.15%	5.26%	Relative Conf. Int.
1.4680	969476,628	969476.628	969476.628	MPU Est of kW
47528.8336 0.075543246	47528.8336	49889,43941	51010.98617	Conf. Interval
90% 1.645	90% 1.645	90% 1.645	90%	Desired Conf. Level (z two tailed)
0.045922946	28892.90797	30327,92669	31009.71804	Standard Error
0.002109	834,800,131	919,783,137	961,602,613	Total Variance
0.000039	4.698.860	5,221,604	47,041,079	က
0.000560	220.853.501	243,708,557	243,708,557	4
0.000718	282,702,270	313,270,625	313,270,625	by strata: 3
0.000363	182,472,779	198,342,368	198,342,368	contributed 2
0.000388	144.072.721	159,239,984	159,239,984	Variance 1
MEAN KW Adj. n	TOTAL KW Final (col. J	TOTAL KW TOTAL KV Adjusted n (cc Final (col. J	TOTAL KW Optimal n (col. h)	

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

	_	al Optimal Final on with with al Attrition	11 11 12 13 13 10 11 11 12 13 13 14 15 15 15 15 15 15 15 15 15 15 15 15 15	Samp Estima
		Proprin. Optimal row f/ Allocation sum f g*h total	0.1997 0.2453 0.1554 0.2146 0.0116	•
		VV(d. P.) Devtns. r. c*e s	55008 67547 42795 59109 47756 3201	
	æ	Standard Deviation	0.296 0.407 0.330 0.959 0.769	/ESTIMATE
	ס	Variance of Mean	0.0876 0.1656 0.1089 0.2237 0.9197 0.5914	ATIVE PRECISION OF SAMPLE KW ESTIMATE
	υ	2008 Pop N	185,838 165,962 129,682 124,966 49,798 4,163 660,409	ECISION OF
	۵	Sample Mean kWh	330.909 623.263 867.171 1,200.660 1,889.330 4,631.280 818.881	RELATIVE PR
	w	Sample Mean kW	0.531 1.037 1.536 2.372 3.885 5.475	ď
SIX SIKAIA, MEAN-PEK-UNIT DESIGN			IM 1 0 - 500 kWh IM 2 501 - 750 kWh IM 3 751 - 1,000 kWh IM 4 1,001 - 1,500 kWh IM 5 1,501 - 3,000 kWh IM 6 GT 3,000 kWh EST POP MEAN (wid by N)	
SIX SIRAIA, ME,			STRATUM 1 STRATUM 2 STRATUM 3 STRATUM 4 STRATUM 5 STRATUM 6	

ESTIMATE
⋛
F SAMPLE
P
PRECISION
Ä
RELATIN

6.33%	6.05%	6.33%	0//\lQ#	Relative Conf. Int.
1.4879	982651.131	982651.131	982651.131	MPU Est of kW
0.09416273	59407.45806	62185.9145	#DIV/0i	Conf. Interval
90% 1.645	90% 1.645	90% 1.645	90% 1.645	Desired Conf. Level (z two tailed)
36113.95627 0.057241781	36113.95627	37802.98754	#DIV/0i	Standard Error
0.003277	1,304,217,837	1,429,065,867	#DIV/0I	Total Variance
0.00003	1,022,154	1,136,000	0/\iO#	ဖ
0.000581	228,015,869	253,356,054	253,356,054	5
0.000728	291,125,061	317,593,517	317,593,517	. 4
0.000467	183,126,181	203,475,104	228,911,257	by strata: 3
0.000805	325,865,849	350,934,567	350,934,567	contributed 2
0.000694	275.062.723	302,570,624	302,570,624	Variance 1
MEAN KW Adj. n	TOTAL KW Final (col. J	TOTAL KW TOTAL K Adjusted n (col. Final (col. J	TOTAL KW Optimal n (col. h)	

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Utah Residential Class kWh Summary For the Twelve months Ended December2007

N	MIN	MEAN	MAX	SUM
660409	20.9167	818.882	191500	540796854.04

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<u>EX</u>

Utah Residential Class Bill Frequency Worksheet Average Monthly kWh

STI	RATUM	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 k W h	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 - 15001 -	15000 kWh	33	450447.31
17501 -	17500 kWh	25	402011.56
	20000 kWh	6	112065.00
	22500 kWh	9	194625.69
GT	22501 kWh	17	899059.42

Utah Residential Class Billing Statistics Mean kWh - Three Strata

	1	RATUM=1	ST	
N	H_MEAN	KWH	N	
7	68.827	46	351800	
	·	የ⊸ΜίΙሞ⊈ና	STI	
			N	
N	I_MEAN	KWH_	IN	
3	30.83	103	254648	
- 		ATUM=3	STR	·
	MEAN	KWH_M	N	
	0.87	2100	3961	

<u> 4344</u>

Utah Residential Class Billing Statistics Mean kWh - Four Strata

 STR	ATUM=1		
N	KWH_MEAN		
185838	330.909		
			E
 STR	ATUM=2	,	
И	KWH_MEAN		
295644	730.251	•	
 STRA	ATUM=3		
N	KWH_MEAN		
160003	1309.72		
			3
 STRA	ATUM=4		
N	KWH_MEAN	ديد. ديد	
18924	2845.46	<u> </u>	-

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Utah Residential Class Billing Statistics Mean kWh - Five Strata

 STR	ATUM=1		-
И	KWH_MEAN		
185838	330.909		
 STRA	ATUM=2		
N	KWH_MEAN		
165962	623.263	•	
 STRA	ATUM=3	·	
N	KWH_MEAN		
210707	961.824		
			20
 STRA	TUM=4		
N	KWH_MEAN		200
89832	1595.29		
 - - STRA	TUM=5		
N	KWH_MEAN		7
8070	3704.13		

:::::::\

Utah Residential Class Billing Statistics Mean kWh - Six Strata

	STR	ATUM=1	
	N	KWH_MEAN	
	185838	330.909	
			蛭
	STRA	ATUM=2	
	N	KWH_MEAN	2
	165962	623.263	
		mrina— 2	
···	51KA	110M=2	
	N	KWH_MEAN	
	129682	867.171	_
	STRA	TUM=4	
	N	KWH_MEAN	
	124966	1200.66	
	STRA	TUM=5	
		KWH_MEAN	
		1889.33	
			<u> </u>
	STRA	rum=6	
	N	KWH_MEAN	
	4163	4631.28	

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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 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 ------200 Analysis Variable : KWH_MNTH Billed Usage N 53961 2100.87

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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 \pm 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 criteria¹:

- 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-perunit 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. 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" 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.

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 procedure⁴ 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 \pm 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⁾ Start	0.973457 314	0.190079 22	0.935239 27		
Alternate 1 Random No. ⁽¹⁾ Start	0.599504 193	0.937419 108	0.388758 11		
Alternate 2 Random No. ⁽¹⁾ Start	0.665786 215	0.251345 29	0.769783 22		
Alternate 3 Random No. ⁽¹⁾ Start	0.869928 280	0.226317 26	0.661234 19		
Alternate 4 Random No. ⁽¹⁾	0.394018 127	0.896363 103	0.174696 5		

⁽¹⁾ Random numbers from Excel's random function.

Utah Schedule 006 Three Strata Customer Interval

			Count	Factor				
	Range		I	μ	pf	õ f	cum √µ∫	
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	4 4 4 0
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	769.3 793.3	
301	to	325	115	5 5		24,0 22,9	816.2	
326	to	350	105	5 5		22.5	838.7	
351	to	375 400	101 67	5 5		18.3	857.0	
376 401	to to	450	107	10		32.7	889.7	
451	to	500	98	10		31.3	921.0	
501	to	550	76	10		27.6	948.6	
551	to	600	57	10		23.9	972.5	
601	to	650	45	10		21.2	993.7	
651	to	700	45	10		21.2	1,014.9	
701	to	750	29	10		17.0	1,031.9	
751	to	800	34	10		18,4	1,050.4	
801	to	850	14	10		11.8	1,062.2	
851	to	900	10	10		10.0	1,072.2	
901	to	950	3	10		5,5	1,077.7	
951	to	1000	0	10		0.0	1,077.7	1,232

Total N 14,721 14,721

BOUNDARIES IND	ICATED 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	(A)	H. Swakili	862.1	718.5
5	540			898.1

SAMPLING STA	Avg. kWh¹	Mean kW²	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				

Billing records for 12 months ending April 2008.
 Load Research data for 12 months ending December 2007.

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

ER-UNIT DESIGN	N B	Ф	υ	ъ	ထ	, Mtd	Groontn	h Oofimal	i Optimal	— ст
	Sample Mean kW	Sample Mean kWh	2008 Pop N	Variance of Mean	Standard Deviation	Devtns.	row f/ sum f	Allocation g*h total	with	with
0 - 70 kW 19.2746 71 - 250 kW 86.8943 GT 250 kW 330.8006	19.2746 86.8943 330.8006	11,017 42,464 161,865	9,349 4,140 1,232	203.7063 1825.8427 30575.8649	14,2726 42.7299 174,8596	133434 176902 215427	0.2538 0.3365 0.4097	21 28 34	21 28 34	29 36 43
(wtd by N)	64.3630	32,485	14,721			525763	1.0000	83	88 3	108
		RELATIVE PRI	ECISION (RELATIVE PRECISION OF SAMPLE KW ESTIMATE	ESTIMATE					Estimate
			Ü	TOTAL KW Optimal n (col. h)		TOTAL KW TOTAL K' Adjusted n (col. i Final (col. J	TOTAL KW Final (col. J	MEAN KW Adj. n		
		Variance 1 contributed 2 by strata: 3		888,235,672 1,151,206,014 1,367,515,749		888,235,672 1,151,206,014 1,367,515,749	633,909,923 886,345,442 1,066,404,632	4.098770 5.312249 6.310412		
		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 (z two tailed)	Level	90% 1.645		90%	90% 1.645	90% 1.645		
		Conf. Interval		96017.24841		96017.24841	83663.41265	83663.41265 6.522467795		
		MPU Est of kW	>	947487.0757		947487.0757	947487.0757	64.3630		
	-	Relative Conf. Int	nt.	10.13%		10.13%	8.83%	10.13%		

EST POP MEAN (wtd by N)

STRATUM 1 STRATUM 2 STRATUM 3

·— [with With Attrition	12 17 20 21	70	Adj Sample Estimate 70				
. -	Optimal with Attrition	± € € €	63	Sample Estimate 62				
- د : (Optimal Allocation g*h total	L L L L L C & C C	62		MEAN KW Adj. n	3.060938 3.816329 4.466913 4.577345	15.921524	55514.94304 3.990178443
o.]	ropin. row fl	0.1798 0.2377 0.2843 0.2983	1.0000		TOTAL KW Final (col. J	602,941,066 723,360,777 865,168,064 890,438,993	3,450,319,092 3,081,908,901	
9- 1	vvta. Devtns. c*e	81508 107764 128914 135257	453444		TOTAL KW TOTAL KV Adjusted n (col. Final (col. J	663,329,182 827,028,314 968,015,128 991,946,469	3,450,319,092	58739.41685
w	Standard Deviation	11.5337 21.4541 70.0620 170.9950		ESTIMATE				
ס	Variance of Mean	133.0257 460.2787 4908.6817 29239.2990		ATIVE PRECISION OF SAMPLE KW ESTIMATE	TOTAL KW Optimal n (col. h)	663,329,182 827,028,314 968,015,128 991,946,469	3,450,319,092	58739.41685
υ	2008 Pop N	7,067 5,023 1,840 791	14,721	RECISION		- 0 m 4	o.	'n
ON (2008)	Sample Mean kWh	8,986 25,098 74,109 192,577	32,488	RELATIVE PI		Variance contributed by strata:	Total Variance	Standard Error
SIGN OPTIC N	Sample Mean kW	15.2094 53.3991 145.5156 379.9563	64.1263					
UTAH SCHEDULE 006 LOAD STUDY DESIGN OPTION (2 FOUR STRATA, MEAN-PER-UNIT DESIGN a		0 - 50 kW 15,2094 51 - 140 kW 53,3991 141 - 325 kW 145,5156 GT 325 kW 379,9563	EST POP MEAN (wid by N)					
UTAH SCHEDL FOUR STRATA		STRATUM 1 STRATUM 2 STRATUM 3 STRATUM 4	EST P(

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64.1263

944002.7944

944002.7944 96626.34072

91322.0813 6.563843538

90% 1.645

90% 1.645

90% 1.645

Desired Conf. Level (z two tailed)

96626.34072 944002.7944

Relative Conf. Int MPU Est of kW Conf. Interval

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 \pm 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

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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 criteria¹:

- 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.

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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-perunit 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.

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. 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

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Various methods might be used for definition of strata boundaries. Cochran found the "cumulative square root of f" 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.

202

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 procedure⁴ 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.

120

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 \pm 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.

翼 21. 22.

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⁾ Start	0.77058 1030	0.74693 393	0.87889 324			
Alternate 1 Random No. ⁽¹⁾ Start	0.73299 980	0.42598 224	0.99982 369			
Alternate 2 Random No. ⁽¹⁾ Start	0.66732 892	0.29197 154	0.35048 129		-	
Alternate 3 Random No. ⁽¹⁾ Start	0.24683 330	0.49639 261	0.16335 60			
Alternate 4 Random No. ⁽¹⁾ Start	0.92241 1233	0.86882 457	0.06259 23			

⁽¹⁾ Random numbers from Excel's random function.

Utah 023 DH Worksheet Three Strata Customer Interval

		Customer	interva				
Ran	ae	Count	Factor		, .		
0 to	250	f 12176	μ	μf	√µ∫	cum √μƒ	
251 to	500	8590		1 12176			
501 to	750	6295		1 8590	92.7	203.0	
751 to	1000	4660		1 6295	79.3	282.4	
1001 to	1250	3895		1 4660	68.3	350.6	
1251 to	1500			1 3895	62.4	413.0	
1501 to	1750	3153		1 3153	56.2	469.2	38,769
1751 to	2000	2625		1 2625	51.2	520.4	
2001 to	2250	2283		2283	47.8	568.2	
2251 to	2500	1938	1		44.0	612.2	
2501 to	2750 2750	1648	1		40.6	652.8	
2751 to	3000	1397	1		37.4	690.2	
3001 to	3250	1253	1		35.4	725.6	
3251 to	3500	1151	1		33.9	759.5	
3501 to	3750	946	1		30.8	790.3	
3751 to	4000	839	1		29.0	819.3	
4001 to	4250	808	1		28.4	847.7	
4251 to	4500	714	1	714	26.7	874.4	
4501 to	4750	641	1	641	25.3	899.7	
4751 to	5000	619 498	1	619	24.9	924.6	
5001 to	5250		1	498	22.3	946.9	17,360
5251 to	5500	477 414	1	477	21.8	968.8	
5501 to	57 50	414 404	1	414	20.3	989.1	
5751 to	6000	373	1	404	20.1	1,009.2	
6001 to	6250	353	1	373	19.3	1,028.5	
6251 to	6500	301	1	353	18,8	1,047.3	
6501 to	6750	253	1	301	17.3	1,064.6	
6751 to	7000	237	1	253	15.9	1,080.6	
7001 to	7250	202	1	237	15.4	1,095.9	
7251 to	7500	217	1 1	202	14.2	1,110.2	
7501 to	7750	151	1	217	14.7	1,124.9	
7751 to	8000	175	1	151	12.3	1,137.2	
8001 to	8250	144	1	175	13.2	1,150.4	
8251 to	8500	155	1	144 155	12.0	1,162.4	
8501 to	8750	123	1	123	12.4	1,174.9	
8751 to	9000	103	1	103	11.1	1,186.0	
9001 to	9250	80	1	80	10.1	1,196.1	
9251 to	9500	82	1	82	8.9 9.1	1,205.0	
9501 to	9750	63	i	63	9.1 7.9	1,214.1	
9751 to	10000	52	1	52		1,222.0	
10001 to	11000	203	4	812		1,229.2	
11001 to	12000	97	4	388		1,257.7	
12001 to	13000	62	4	248		1,277.4 1,293.2	
13001 to	14000	29	4	116		1,293.2 1,304.0	
14001 to	15000	15	4	60		1,304.0 1,311.7	
15001 to	143600	27	514.4	13888.8		1,429.6	4,792
			<u> </u>			-, 120.0	4,132

Total N	60,921	60,921
TOTAL IN	60,921	60,921

BOUNDARIES INC	ICATED FOR	STRATA:		
	3	4	5	6
1	476.5	357 4	285 9	238 3
2	953.0	714.8	5718	476.5
3		072.2	8577	714 R
4			1436	053 N
5			1	191.3

SAMPLING STA	Avg. kWh¹	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				

Billing records for March 2007 through February 2008
 Load Research data for January 2007 through December 2007

Utah 023 DH Worksheet Four Strata Customer Interval

				Count	Factor				
		Rang	je	f	μ	μf	√μƒ	cum õ <i>f</i>	
_	C	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	175 0	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	lo	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 8251	to	8250	144	1	144	12.0	1,162.4	
	8501	to to	8500 8750	155 123	1 1	155	12.4 11.1	1,174.9	
	8751	to	9000	103	1	123 103	10.1	1,186.0 1,196.1	
	9001	to	9250	80	1	80	8.9	1,196.1	
	9251	to	9500	82	1	82	9.1	1,203.0	
	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	1,225.2	
	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

鹽

BOUNDARIES INDICATED FO	OR STRATA:		
3	4	5	6
1 476.5	357.4	∕285.9	238.3
2 7 7 953.0	714.8	571.8	476.5
3	1,072.2	857.74	714.8
4		143 65-5	953.0
5		1	1913

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 Biffing records for March 2007 through February 2008

² Lood Research data for January 2007 through December 2007

Utah 023 DH Worksheet Five Strata Customer Interval

_	Count	Factor				
Range	J	μ	μf	õtf	cum õ f	
0 to	250 12176		12176	110.3		
251 to	500 8590			92.7	203.0	
501 to	750 6295	1		79.3	282.4	27,061
751 to	1000 4660	1	4660	68.3	350.6	27,001
1001 to	1250 3895	1		62.4	413.0	
1251 to	1500 3153	1		56.2	469.2	
1501 to	1750 2625	1	- 1.00	51.2	520.4	
	2000 2283	1	2283	47.8		40.040
	2250 1938	1	1938	44.0	568.2	16,616
	2500 1648	1	1648	40.6	612.2	
	2750 1397	1	1397	37.4	652.8	
	3000 1253	1	1253	35.4	690.2 725.6	
	3250 1151	1	1151	33.9		
	3500 946	1	946	30,8	759.5	
	3750 839	1	839	29.0	790.3	
3751 to 4	808 000	1	808	28.4	819.3	
	250 714	1	714	26.7	847.7	9,980
	500 641	1	641	25.3	874.4	
	750 619	1	619	24.9	899,7	
	000 498	1	498	24.9	924.6	
	250 477	1	477	21.8	946.9	
	500 414	1	414	20.3	968.8	
	750 404	1	404	20.3	989.1	
	000 373	1	373	19.3	1,009.2	
	250 353	1	353	18.8	1,028.5	
	500 301	1	301	17.3	1,047.3 1,064.6	
	750 253	1	253	15.9		
6751 to 70	000 237	1	237	15.4	1,080.6 1,095.9	
	250 202	1	202	14.2	1,110.2	
	500 217	1	217	14.7	1,110.2	
	^{'50} 151	1	151	12.3	1,124.9	5.054
	00 175	1	175	13.2	1,150.4	5,854
	50 144	1	144	12.0	1,162.4	
	00 155	1	155	12.4	1,174.9	
8501 to 87	50 123	1	123	11.1	1,186.0	
8751 to 90	00 103	1	103	10.1	1,196.1	
9001 to 92	50 80	1	80	8.9	1,205.0	
9251 to 950		1	82	9.1	1,214.1	
9501 to 975	50 63	1	63	7.9	1,222.0	
9751 to 1000	00 52	1	52	7.2	1,229.2	
10001 to 1100		4	812		1,257.7	
11001 to 1200		4	388		1,277.4	
12001 to 1300		4	248		1,293.2	
13001 to 1400		4	116		1,304.0	
14001 to 1500		4	60		1,311.7	
15001 to 14360	0 27	514.4	13888.8		1,429.6	1,410

<u></u>

lotal N	60,921	
	,	60.921

BOUNDARIES INDICA	TED FO	R STRATA	 	
*****	3	4	5	6
1 4	76.5	2357.4 1	285.9 湯藤	238.3
2 9	53 O	714.8	571.8	476.5
3 💮 📜		10722	857.7	7148
4			1,143.6	953.0
5				1913

==				
SAMPLING STA	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 Customer Interval

			Count	Factor				
ı	Rang	ge	ſ	μ	μ ƒ	√μ <i>f</i>	cum õf	
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	450 0	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	ło	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
JULANIA	00,321	CO, CE.

BOUNDARIES INDICA	ATED FOR	STRATA:		
	3	4	5	6
1 22 3	476.5	357.4	285.9	238.3
2	953,0 🐭	714.8	571.8	476.5
3	3,01	072.2	857.7	714.8
4			143.6	953.0
5				1,191.3

SAMPLING STA	Avg. kWh ¹	Mean kW²	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

427.

² Lead Research data for January 2007 through December 2007

						EST POP MEAN (wid by N)	STRATUM 2 STRATUM 3	STRATUM 1		UTA⊓ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐
						AN (wid by N)	1501- 5000 kwh GT -5000 kwh			NO23 LOAD STUDY DAN-PER-UNIT DESIG
7	လ္	7	₽ 0 <		771	3.958	6.753 14.814	Sample Mean kW	ខា	ESIGN OF
	Standard Error	Total Variance	Variance 1 contributed 2 by strata: 3		RELATIVE PR	1,696.875	2,753.970 7,153.640	Sample Sample Mean kW Mean kWh	ō-	TION (2008)
				<u>.o</u>	ECISION C	60,921	38,769 17,360 4,792	2008 Pop N	n	2
	14925,03346	222,756,624	87,300,517 97,466,709 37,989,398	TOTAL KW Optimal n (col. h)	RELATIVE PRECISION OF SAMPLE KW ESTIMATE		1.4530 9.3952 18.2436	Variance of Mean	Ω.	<u> </u>
		-		T	/ ESTIMATE		1.205 3.065 4.271	Standard Deviation	Ф	
	14925.03346	222,756,624	87,300,517 97,466,709 37,989,398	TOTAL KW TOTAL KV Adjusted n (cc Final (col. J	111	120412	46733 53211 20468	Wtd. Devtns. c*e	→	
	14179.95409 0.244989962	201,071,098	77,940,854 88,313,914 34,816,330	TOTAL KW inal (col. J		1.0000	0.3881 0.4419 0.1700	Proprin. row f/ sum f	മ	en e
	0.244989962	0.060020	0.023522 0.026262 0.010236	MEAN KW Adj. n		თ დ	26 30 12	Optimal Allocation g*h total	- -	•
				ł	Sample / Estimate 68	68 	26 30 12	Optimal with Attrition	- -	22
					Adj Sample Estimate 75	75	29 33 13	Final with Attrition		w to the contract of the contr

Table C.1

MPU Est of kW Conf. Interval

241123.6339 24551.68004

241123.6339 24551.68004

241123.6339

3.9580

23326.02449 0.403008487

Desired Conf. Level (z two tailed)

90% 1.645

90% 1.645

90% 1.645

90% 1.645

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		200
EST POP	UTAH COMMERC FOUR STRATA, N FOUR STRATUM 1 STRATUM 2 STRATUM 3 STRATUM 4	E
EST POP MEAN (wtd by N)	UTAH COMMERCIAL 023 LOAD STUDY DESIGN OPTION (2008) FOUR STRATA, MEAN-PER-UNIT DESIGN Sample Sample Mean kW Mean kWh 0 - 1000 kWh 0.662 396.862 STRATUM 1 0 - 1000 kWh 2.913 1,707.240 STRATUM 3 2751 - 6500 kWh 9.330 4,167.170 STRATUM 4 GT 6501 kWh 16.309 8,529.070	题
3.315	SM a Sample Sample Mean kW 0.662 2.913 9.330 16.309	2
1,696.876	Sample Sample Mean kW Mean kWh 0.662 396.862 2.913 1,707.240 9.330 4,167.170 16.309 8,529.070	
60,921	c 2008 Pop N 31,721 16,939 9,791 2,470	150
	d Variance of Mean 0.6214 0.6340 10.2541 13.7234	
	e Standard Deviation 0.788 0.796 3.202 3.705	
78996	f Wtd. Devtns. c*e 25005 13488 31353 9150	
1.0000	g Proprtn. row f/ sum f 0.3165 0.1707 0.3969 0.1158	<u>4</u>
30	h Optimal Allocation g*h total ,	

'RELATIVE PRECISION OF SAMPLE KW ESTIMATE

42

Sample Estimate 30

Adj Sample Estimate 46

ω 13 σ φ

1110 120 100

MPU Est of kW	Conf. Interval	Desired Conf. Level (z two tailed)	Standard Error	Total Variance	Variance 1 contributed 2 by strata: 3	0
201968.0661	26251.29476	90% 1.645	15958.2339	254,665,229	78,133,862 45,465,467 89,254,096 41,811,804	TOTAL KW Optimal n (col. h)
201968.0661 201968.066	22565.31612	90% 1.645	13717.5174	188,170,283 170,826,022	69,450,132 20,200,908 89,254,096 9,265,148	TOTAL KW TOTAL KW Adjusted n (cc Final (col. J
201968.066	22565.31612 21500.2206 0.370402917	90% 1.645	13717.5174 13070.0429 0.225168947	170,826,022	62,503,147 18,179,743 81,807,888 8,335,243	TOTAL KW Final (col. J
3.3152	0.370402917	90% 1.645	0.225168947	0.050701	0.018713 0.005443 0.024049 0.002496	MEAN KW Adj. n

Table C.2

Relative Conf. Int.

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- 104

j Final with Attrition

		ESTPOP	STRATUM 2 STRATUM 3 STRATUM 4 STRATUM 5	STRATUM 1		UTArı COMMERI FIVE STRATA, N	<u>22</u>
		EST POP MEAN (wtd by N)	751 - 2000 KWh 2001 - 4000 KWh 4001 - 7750 KWh GT 7750 KWh	0 750 555		UTArı COMMERCIAL 023 LOAD STUDY DESIGN OPTION (2008) FIVE STRATA, MEAN-PER-UNIT DESIGN	5
		3.385	0.385 2.699 6.270 11.775 13.821		w	DESIGN O	
	RELATIVE PF	1,696.875	315.437 1,280.920 2,829.430 5,422.430 9,627.600		ъ	PTION (2008)	
유	RECISION C	60,921	27,061 16,616 9,980 5,854 1,410	2008 Pop N	n		
Optimal n (col. h)	RELATIVE PRECISION OF SAMPLE KW ESTIMATE		0.1117 0.6662 3.7309 11.7201 33.0241	Variance of Mean	Q.	<u>دن دی</u>	<u>.</u>
	V ESTIMATE		0.334 0.816 1.932 3.423 5.747	Standard Deviation	Φ		
TOTAL KW TOTAL KW		70029	9046 13562 19277 20041 8103	Wtd. Devtns. c*e	- ,		policies Salativ
TOTAL KW		1.0000	0.1292 0.1937 0.2753 0.2862 0.1157	Proprtn. row f/ sum f	ω.		what/
MEAN KW		18	0.4 ED ED CO	Optimal Allocation g*h total	o r		
	Sample A Estimate	50	10 10 10 10	Optimal with Attrition	- .		
	Adj Sample Estimate 55	55		Final with Attrition			election of the second

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

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

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											ESTP	STRATUM 5 STRATUM 6	STRATUM 2 STRATUM 3 STRATUM 4		
											EST POP MEAN (wid by N)	5001 - 8750 kWh GT 8751 kWh	0 - 500 kWh 501 - 1500 kWh 1501 - 2750 kWh		AND THE PROPERTY OF THE PROPER
1=	1 -	0	5.5	ء ا							3.526	13.734 14.072			מ
Relative Conf. Int.	MPU Est of kW	Conf. Interval	Desired Conf. Level (z two tailed)	Standard Error	6 Total Variance	4.00		Variance 1 contributed 2		RELATIVE PR	1,696.875	3,693.570 6,436.950 10,661.300	223.916 924.085 2,044.450	Sample Mean kWh	o.
Int.	V		Level	7		. 01 +	- W ,	10 -	0	RECISION	60,921	7,469 3,979 813	20,766 18,003 9,891	2008 Pop N	O
#DIV/0!	214793.8354	#DIV/0I	90% 1.645	#DIV/0!	#DIV/0!	164,470,890	#DIV/0!	#DIV/0! 98 796 155	TOTAL KW Optimal n (col. h)	RELATIVE PRECISION OF SAMPLE KW ESTIMATE		5.0155 10.3934 32.9526	0.1117 0.6098 0.4401	Variance of Mean	Ω.
									<u> </u>	N ESTIMAT		2.240 3.224 5.740	0.334 0.781 0.663	Standard Deviation	Ø
7.01%	214793.8354	15054.3883	90% 1.645	9151.603832	2,390,302 83,751,853	31,046,961 18,237,783	4,779,021	5,351,623	TOTAL KW TOTAL Adjusted n (col. Final (col.	Ē	61783			vvia. Devins. c*e	<u></u>
6.65%	214793.8354	14280.679	90% 1.645	8681.263827	2,148,593 75,364,342	27,938,518 16,409,869	4,300,683	4,816,229	TOTAL KW Final (col. J		1.0000	0.2707 0.2076 0.0755	0.1124 0.2275 0.1062	row f/ sum f) . (O
7.01%	3,5258	0.679 0.247113283	90% 1.645	0.150220841		0.008365 0.004914		0.001442	MEAN KW Adj. n		12	•		Optimal Allocation g*h total) = ==
										Sample Estimate 12	60	1000	10 10	Optimal with Attrition	
										Adj Sample Estimate 66	66	=======================================		Final with Attrition	

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

И	MIN	MEAN	MAX	SUM
60921	20.9167	1696.88	46040	103375338.88

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S	TRATUM	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		550
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		臣
4751 -	5000 kWh	498	2426138.25		
5001 -	5250 kWh	477	2444556.14		
5251 -	5500 kWh	414	2225808.51		
5501 -	5750 kWh	404	2269200.04		豆
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		g=30
7001 - 7251 -	7250 kWh	202	1438834.15		巨
7501 -	7500 kWh	217	1598485.46		
7751 -	7750 kWh	151	1151014.55		
8001 -	8000 kWh	175	1377131.82		
8251 -	8250 kWh	144	1169241.34		E.D.
8501 -	8500 kWh	155	1299826.07		
8751 -	8750 kWh	123	1061078.63		
9001 -	9000 kWh	103	913453.75		
9251 -	9250 kWh	80	730909.44		
9501 -	9500 kWh	82	767551.45		
9751 -	9750 kWh	63	606506.15		
10001 -	10000 kWh	52	514000.70		
11001 -	11000 kWh	203	2121667.36		
12001 -	12000 kWh	97	1106727.59		
13001 -	13000 kWh	62	773889.25		
14001 -	14000 kWh	29	387809.08		
GT	15000 kWh	15	216264.62		
Gi	15001 kWh	27	528858.43		
					V = 1

Utah 023 Billing Statistics Mean kWh - Three Strata

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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

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Utah 023 Billing Statistics Mean kWh - Five Strata ______ STRATUM=1 ------KWH_MEAN N 27061 315.437 ______ STRATUM=2 ------KWH_MEAN N 1280.92 16616 ______ STRATUM=3 -----KWH_MEAN N 9980 2829.43 ----- STRATUM=4 -----N KWH_MEAN 100 5422.43 5854 ______ STRATUM=5 -----KWH_MEAN N

9627.60

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Utah 023 Billing Statistics Mean kWh - Six Strata KWH_MEAN 20766 223.916 N KWH MEAN 18003 924.085 ----- STRATUM=3 -----N KWH MEAN 9891 2044.45 N KWH_MEAN 7469 3693.57 N KWH MEAN 3979 6436.95 ------ STRATUM=6 -----. N KWH_MEAN

10661.30

Utah Schedule 023 Eliqible Sample Point Summary 1 Annual kWh GT 250, Agreement Status=ACT 13:55 Thursday, April 10, 2008 € ----- STRATUM=0 - 1,500 kWh ------The MEANS Procedure Analysis Variable : KWH MNTH Billed Usage 38146 548.6611961 ----- STRATUM=1,501 - 5,000 kWh ------Analysis Variable : KWH_MNTH Billed Usage Mean 17138 2756.40 ----- 5TRATUM=GT 5,000 kWh ------200 Analysis Variable : KWH MNTH Billed Usage N Mean 4748 7157.49

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Utah Schedule 023 Eligible Sample Point Summary Annual kWh GT 250, Agreement Status=ACT 13:55 Thursday, April 10, 2000 The MEANS Procedure Analysis Variable : KWH_MNTH Billed Usage Mean 38146 548.6611961 _____ 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 Mean _ 4748 7157.49

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ميد	Utah Schedule 023 Eligible Sample Point Summary 3 Annual kWh GT 250, Agreement Status=ACT 13:55 Thursday, April 10, 2008					
	STRATUM=0 - 1,500 kWh					
The MEANS Procedure Analysis Variable : KWH_MNTH Billed Usage						
	38769 549.0506975					
		3				
	STRATUM=1,501 - 5,000 kWh					
	Analysis Variable : KWH_MNTH Billed Usage					
	N Mean					
	17360 2753.97	•				
	STRATUM=GT 5,000 kWh					
.222	Analysis Variable : KWH_MNTH Billed Usage					
	N Mean					

4792 7153.64

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