



# LOAD RESEARCH

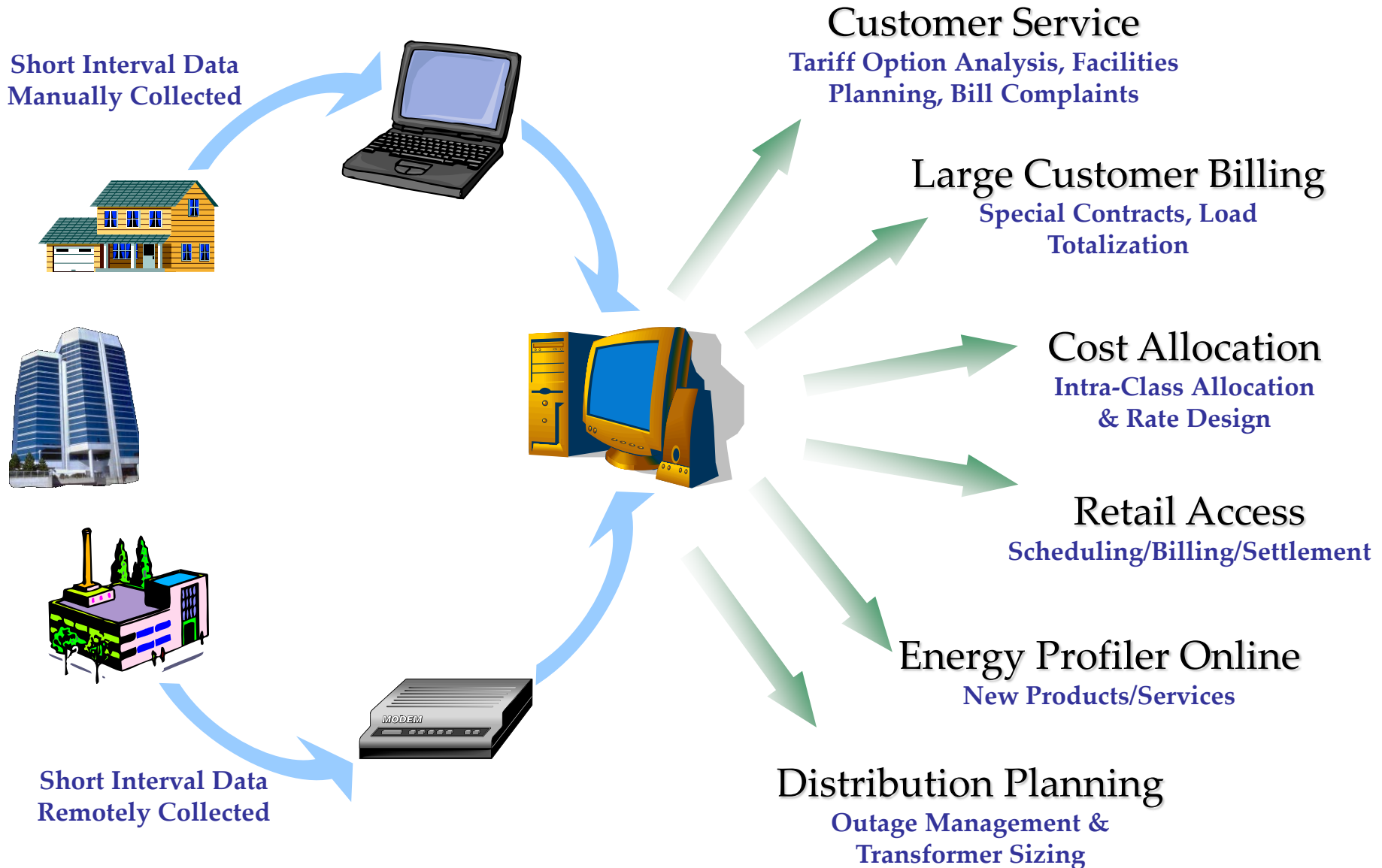
## Irrigation Load Study

Utah Cost of Service Task Force  
August 25, 2005

# What is Load Research?

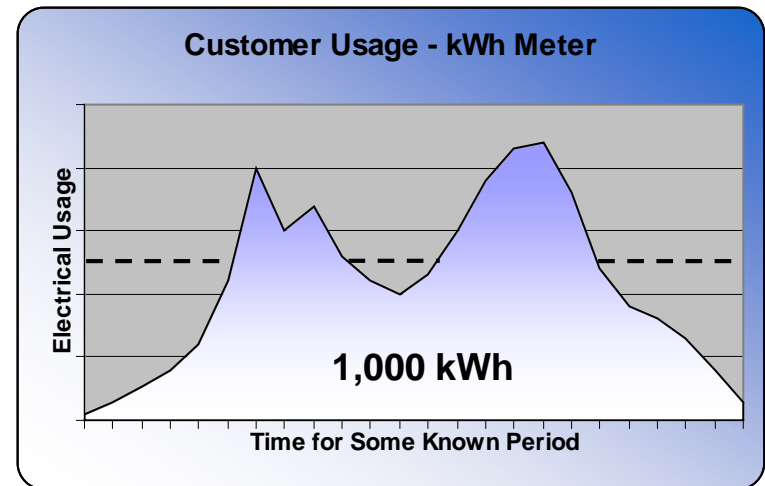
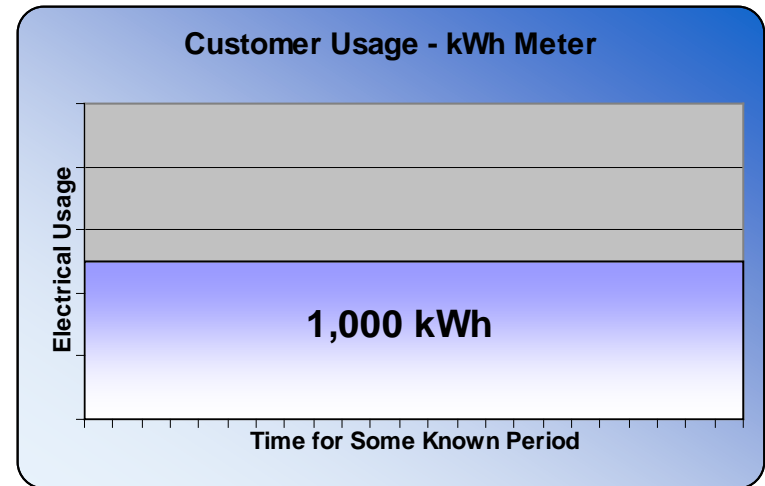
- The study of how and when our customers use energy so that PacifiCorp can most effectively:
  - Allocate Fixed Costs per Regulatory Mandates
  - Design or Maximize Customer Rates
  - Forecast Loads
  - Service Customer Data Requests
  - Size Distribution Circuits
  - Provide Customer Service

# Load Research Data Process

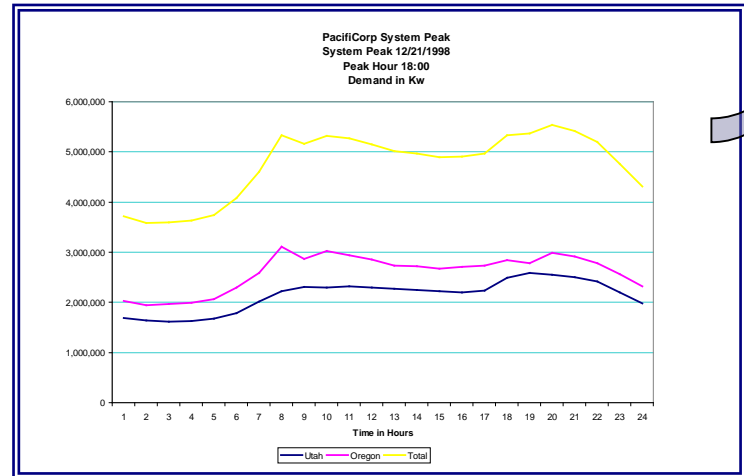
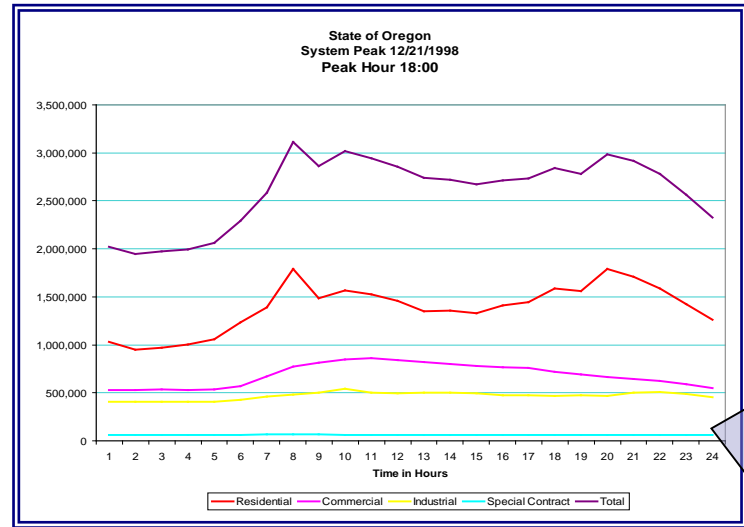
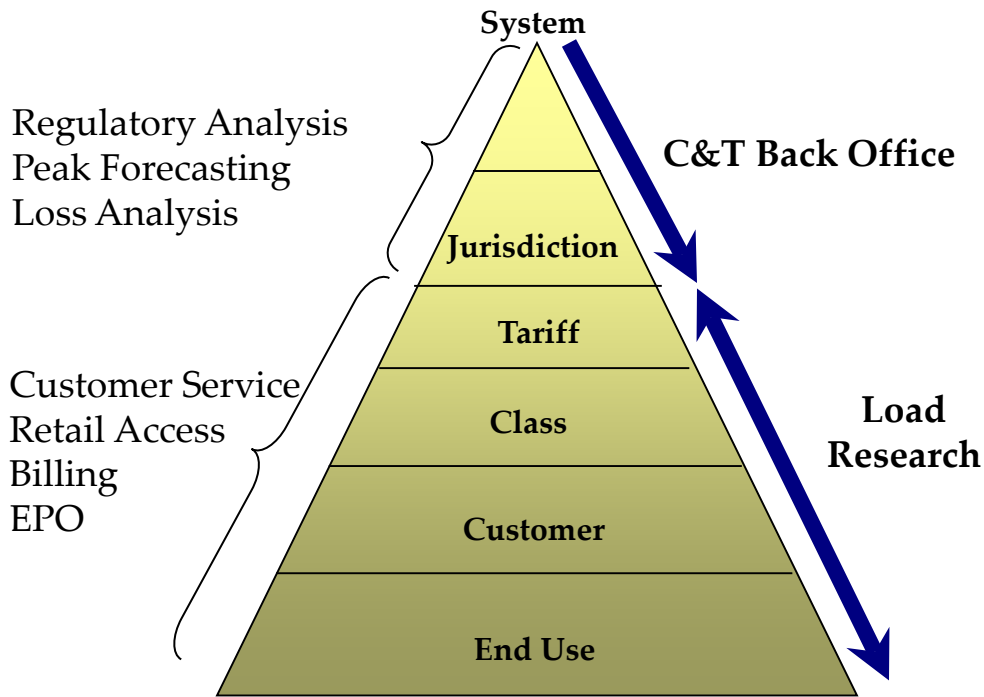


# Load Shape Analysis

- Electric usage varies over time and by customer type
- PacifiCorp is obligated to provide electricity (load) when the customer demands (kW) and for the length of time that the customer needs it (kWh).
- Load research (interval) data provides an important data input into planning, regulatory and financial decision making processes... \$\$\$\$\$\$



# Regulatory Support

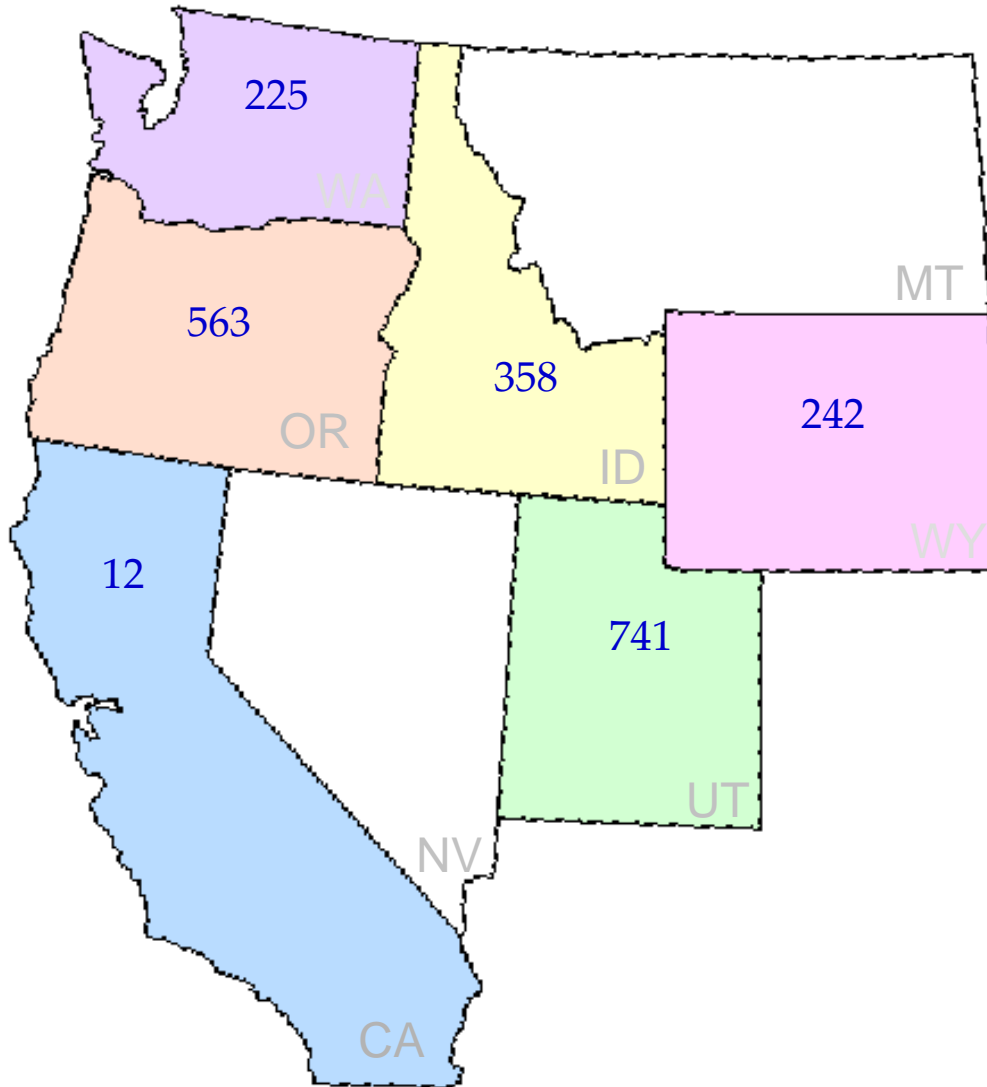


# Load Research Meters

State	Class	# Recorders
Utah	Residential	169
	Rate 023	63
	Rate 006	142
	Rate 008	190
	Rate 009	20
	Large Load	157
		<hr/> 741
Idaho	Rate 001	52
	Rate 036	45
	Rate 006	89
	Rate 008	4
	Rate 009	12
	Rate 023	56
	Irrigation	88
	Large Load	12
		<hr/> 358

State	Class	# Recorders
Oregon	Residential	91
	Rate 025	85
	Large Load	387
		<hr/> 563
Washington	Residential	53
	General Service	61
	Large Load	111
		<hr/> 225
Wyoming	Residential	44
	General Service	96
	Large Load	102
		<hr/> 242
Other (DSM, FinAnswer, etc.)		75
Total		<hr/> 2,204

# Load Research Meters



■ Load Research Meters

# Irrigation Load Study - Issues

- 1991-1993 3-year average for current reporting.
- Issues
  - Crop rotation
  - Weather impacts
    - Growing season
    - Access to water
  - Smaller family owned farms (vs. Corporations in Idaho)
- Options
  - Conduct new load studies
  - Use Idaho Data
  - Use system average costing/pricing



# Sample Design

## Bill Frequency Analysis Summary

Utah Irrigation Schedule 010  
Five Strata

Range	Customer Count	Interval	Factor (1K)	$f$	$\mu$	$\mu f$	$\sqrt{\mu f}$	cum $\sqrt{\mu f}$	
0 to	25	1066	1.0	1,066.0	32.6	32.6	1,066		
26 to	50	423	1.0	406.1	20.2	52.8	423		
51 to	75	204	1.0	195.8	14.0	66.8			
76 to	100	140	1.0	134.4	11.6	78.4	344		
101 to	125	99	1.0	95.0	9.7	88.1	99		
126 to	150	57	1.0	54.7	7.4	95.5			
151 to	175	49	1.0	47.0	6.9	102.4			
176 to	200	27	1.0	25.9	5.1	107.5			
201 to	225	25	1.0	24.0	4.9	112.4			
226 to	250	11	1.0	10.6	3.2	115.6			
251 to	275	3	1.0	2.9	1.7	117.3			
276 to	300	1	1.0	1.0	1.0	118.3			
301 to	325	4	1.0	3.8	2.0	120.3			
326 to	350	5	1.0	4.8	2.2	122.5			
351 to	375	1	1.0	1.0	1.0	123.4			
376 to	400	2	1.0	1.9	1.4	124.8			
401 to	450	1	2.0	2.0	1.4	126.2			
451 to	475	1	1.0	1.0	1.0	127.2			
476 to	550	1	3.0	3.0	1.7	128.9			
551 to	600	1	2.0	2.0	1.4	130.3			
601 to	800	2	8.0	15.9	4.0	134.3			
801 to	1,000	1	8.0	8.0	2.8	137.1			
1,001 to	2,000	1	40.0	40.0	6.3	143.5			
2,001 to	2,750	1	30.0	30.0	5.5	148.9	194		
Total N									
				2,126					2,126

BOUNDARIES INDICATED FOR STRATA:

	3	4	5	6
1	49.6	37.2	29.8	24.8
2	99.3	74.5	59.6	49.6
3		111.7	89.4	74.5
4			119.1	99.3
5				124.1

SAMPLING STATISTI	Avg. kWh <sup>2</sup>	Mean kW <sup>2</sup>	Res. Variance <sup>2</sup>
1	0	3.503	5.571
2	0	23.371	14.814
3	0	39.910	25.513
4	0	35.208	40.642
5	0	189.051	187.652

<sup>1</sup> Billing records for the twelve months ended June 2005

<sup>2</sup> Load Research estimates based on Idaho Schedule 010 sample data



# Utah Irrigation Sample Designs

3 Strata – 235 recorders

4 Strata – 203 recorders

5 Strata – 175 recorders

6 Strata – 169 recorders

# Sample Design - Stratification

UTAH SCHEDULE 010 LOAD STUDY DESIGN OPTION FOR 2005  
THREE STRATA, MEAN-PER-UNIT DESIGN

	a	b	c	d	e	f	g	h	i	j
	Sample Mean kW	Sample Mean kWh	2004 Pop N	Variance of Mean	Standard Deviation	Wtd. Devtns. c*e	Proptrn. row f/ sum f	Optimal Allocation g*h total	Optimal with Attrition	Final with Attrition
STRATUM 1	0- 50 kW 7.4760	0	1,489	125.6417	11.2090	16690	0.2130	45	45	50
STRATUM 2	51- 100 kW 39.9100	0	344	650.9132	25.5130	8776	0.1120	23	23	26
STRATUM 3	GT- 100 kW 162.2950	0	293	32590.7198	180.5290	52895	0.6750	142	142	159

EST POP MEAN (wtd by N)	34.0608	0	2,126			78362	1.0000	210	210	235
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Sample Estimate	210	Adj Sample Estimate	235
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## RELATIVE PRECISION OF SAMPLE KW ESTIMATE

	TOTAL KW Optimal n (col. h)	TOTAL KW Adjusted n (col. i)	MEAN KW Adj. n
Variance 1 contributor 2 by strata: 3	6,139,641	6,139,641	1.358365
	3,267,111	3,267,111	0.722832
	10,226,321	10,226,321	2.262522
Total Variance	19,633,072	19,633,072	4.343719
Standard Error	4430.922259	4430.922259	2.0841591
Desired Conf. Level (z two tailed)	90% 1.645	90% 1.645	90% 1.645
Conf. Interval	7288.867115	7288.867115	3.4284417
MPU Est of kW	72413.239	72413.239	34.0608
Relative Conf. Int.	10.07%	10.07%	10.07%

# Sample Design - Stratification

UTAH SCHEDULE 010 LOAD STUDY DESIGN OPTION FOR 2005  
FOUR STRATA, MEAN-PER-UNIT DESIGN

	a	b	c	d	e	f	g	h	i	j
	Sample Mean kW	Sample Mean kWh	2004 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 - 50 kW 7.4760	0	1,489	125.6417	11.2090	16690	0.2593	47	47	53
STRATUM 2	51 - 75 kW 25.5910	0	204	327.8634	18.1070	3694	0.0574	10	10	11
STRATUM 3	76 - 125 kW 48.9570	0	239	1008.1260	31.7510	7588	0.1179	21	21	24
STRATUM 4	GT- 125 kW 189.0510	0	194	35213.2731	187.6520	36404	0.5655	103	103	115
EST POP MEAN (wtd by N)	30.4464	0	2,126			64377	1.0000	182	181	203

## RELATIVE PRECISION OF SAMPLE KW ESTIMATE

	TOTAL KW Optimal n (col. h)	TOTAL KW Adjusted n (col. i)	MEAN KW Adj. n
Variance 1	5,864,566	5,864,566	1.297506
contribute 2	1,441,725	1,441,725	0.318974
by strata: 3	2,626,269	2,626,269	0.581049
4	6,094,658	6,094,658	1.348413
Total Variance	16,027,218	16,027,218	3.545942
Standard Error	4003.40078	4003.40078	1.88306716
Desired Conf. Level (z two tailed)	90% 1.645	90% 1.645	90% 1.645
Conf. Interval	6585.594284	6585.594284	3.09764548
MPU Est of kW	64728.945	64728.945	30.4464
Relative Conf. Int.	10.17%	10.17%	10.17%

Sample Estimate	182
Adj Sample Estimate	203

# Sample Design - Stratification

UTAH SCHEDULE 010 LOAD STUDY DESIGN OPTION FOR 2005  
FIVE STRATA, MEAN-PER-UNIT DESIGN

	a	b	c	d	e	f	g	h	i	j
	Sample Mean kW	Sample Mean kWh	2004 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 - 25 kW 3.5030	0	1,066	31.0360	5.5710	5939	0.0967	15	15	17
STRATUM 2	26 - 50 kW 23.3710	0	423	219.4546	14.8140	6266	0.1020	16	16	18
STRATUM 3	51 - 100 kW 39.9100	0	344	650.9132	25.5130	8776	0.1429	22	22	25
STRATUM 4	101 - 125 kW 35.2080	0	99	1651.7722	40.6420	4024	0.0655	10	10	11
STRATUM 5	GT- 125 kW 189.0510	0	194	35213.2731	187.6520	36404	0.5928	93	93	104

EST POP MEAN (wtd by N)	31.7548	0	2,126			61410	1.0000	156	156	175
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Sample Estimate	156	Adj Sample Estimate	175
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## RELATIVE PRECISION OF SAMPLE KW ESTIMATE

	TOTAL KW Optimal n (col. h)	TOTAL KW Adjusted n (col. i)	MEAN KW Adj. n
Variance 1	2,483,695	2,483,695	0.549505
contributer 2	2,518,768	2,518,768	0.557265
by strata: 3	3,433,350	3,433,350	0.759612
4	1,617,085	1,617,085	0.357772
5	7,499,662	7,499,662	1.659263
Total Variance	17,552,559	17,552,559	3.883416
Standard Error	4189.577478	4189.577478	1.970638512
Desired Conf. Level (z two tailed)	90% 1.645	90% 1.645	90% 1.645
Conf. Interval	6891.854951	6891.854951	3.241700353
MPU Est of kW	67510.657	67510.657	31.7548
Relative Conf. Int.	10.21%	10.21%	10.21%

# Sample Design - Stratification

UTAH SCHEDULE 010 LOAD STUDY DESIGN OPTION FOR 2005  
SIX STRATA, MEAN-PER-UNIT DESIGN

	a	b	c	d	e	f	g	h	i	j	
	Sample Mean kW	Sample Mean kWh	2004 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 - 25 kW	3.5030	0	1,066	31.0360	5.5710	5939	0.1003	15	15	17
STRATUM 2	26 - 50 kW	23.3710	0	423	219.4546	14.8140	6266	0.1058	16	16	18
STRATUM 3	51 - 75 kW	25.5910	0	204	327.8634	18.1070	3694	0.0624	9	10	11
STRATUM 4	76 - 100 kW	59.9560	0	140	437.1026	20.9070	2927	0.0494	7	10	11
STRATUM 5	101 - 125 kW	35.2080	0	99	1651.772164	40.6420	4024	0.0680	10	10	11
STRATUM 6	GT- 125 kW	189.0510	0	194	35118.76	187.4000	36356	0.6141	90	90	101
EST POP MEAN (wtd by N)	31.7009	0	2,126				59205	1.0000	146	151	169

Sample Estimate	146
Adj Sample Estimate	169

## RELATIVE PRECISION OF SAMPLE KW ESTIMATE

	TOTAL KW Optimal n (col. h)	TOTAL KW Adjusted n (col. i)	MEAN KW Adj. n
Variance 1	2,483,695	2,483,695	0.549505
contributer 2	2,518,768	2,518,768	0.557265
by strata: 3	1,630,301	1,441,725	0.318974
4	1,356,475	883,919	0.195563
5	1,617,085	1,617,085	0.357772
6	7,961,305	7,961,305	1.761399
Total Variance	17,567,629	16,906,496	3.740478
Standard Error	4191.375492	4111.750948	1.9340315
Desired Conf. Level (z two tailed)	90% 1.645	90% 1.645	90% 1.645
Conf. Interval	6894.812684	6763.830309	3.1814818
MPU Est of kW	67396.021	67396.021	31.7009
Relative Conf. Int.	10.23%	10.04%	10.04%

# Sample Design

## Bill Frequency Analysis Summary

Utah Irrigation Schedule 010  
Six Strata

Range	Customer Count	Interval Factor (1K)	$\mu$	$\mu f$	$\sqrt{\mu f}$	cum $\sqrt{\mu f}$	
0 to	25	1066	1.0	1,066.0	32.6	32.6	1,066
26 to	50	423	1.0	406.1	20.2	52.8	423
51 to	75	204	1.0	195.8	14.0	66.8	204
76 to	100	140	1.0	134.4	11.6	78.4	140
101 to	125	99	1.0	95.0	9.7	88.1	
126 to	150	57	1.0	54.7	7.4	95.5	
151 to	175	49	1.0	47.0	6.9	102.4	
176 to	200	27	1.0	25.9	5.1	107.5	
201 to	225	25	1.0	24.0	4.9	112.4	
226 to	250	11	1.0	10.6	3.2	115.6	268
251 to	275	3	1.0	2.9	1.7	117.3	
276 to	300	1	1.0	1.0	1.0	118.3	
301 to	325	4	1.0	3.8	2.0	120.3	
326 to	350	5	1.0	4.8	2.2	122.5	
351 to	375	1	1.0	1.0	1.0	123.4	
376 to	400	2	1.0	1.9	1.4	124.8	
401 to	450	1	2.0	2.0	1.4	126.2	
451 to	475	1	1.0	1.0	1.0	127.2	
476 to	550	1	3.0	3.0	1.7	128.9	
551 to	600	1	2.0	2.0	1.4	130.3	
601 to	800	2	8.0	15.9	4.0	134.3	
801 to	1,000	1	8.0	8.0	2.8	137.1	
1,001 to	2,000	1	40.0	40.0	6.3	143.5	
2,001 to	2,750	1	30.0	30.0	5.5	148.9	25
Total N	2,126						2,126

BOUNDARIES INDICATED FOR STRATA:

	3	4	5	6
1	49.6	37.2	29.8	24.8
2	99.3	74.5	59.6	49.6
3		111.7	89.4	74.5
4			119.1	99.3
5				124.1

SAMPLING STATISTICS

	Avg. kWh <sup>2</sup>	Mean kW <sup>2</sup>	Res. Variance <sup>2</sup>
1	0	3.503	5.571
2	0	23.371	14.814
3	0	25.591	18.107
4	0	59.956	20.907
5	0	95.052	67.321
6	0	404.370	257.663

<sup>1</sup> Billing records for the twelve months ended June 2005

<sup>2</sup> Load Research estimates based on Idaho Schedule 010 sample data

# Sample Design - Stratification

UTAH SCHEDULE 010 LOAD STUDY DESIGN OPTION FOR 2005  
SIX STRATA, MEAN-PER-UNIT DESIGN

	a	b	c	d	e	f	g	h	i	j	
	Sample Mean kW	Sample Mean kWh	2004 Pop N	Variance of Mean	Standard Deviation	Wtd. Devtns. c*e	Proptrn. row f/ sum f	Optimal Allocation g*h total	Optimal with Attrition	Final with Attrition	
STRATUM 1	0 - 25 kW	3.5030	0	1,066	31.0360	5.5710	5939	0.1371	15	15	17
STRATUM 2	26 - 50 kW	23.3710	0	423	219.4546	14.8140	6266	0.1447	15	15	17
STRATUM 3	51 - 75 kW	25.5910	0	204	327.8634	18.1070	3694	0.0853	9	10	11
STRATUM 4	76 - 100 kW	59.9560	0	140	437.1026	20.9070	2927	0.0676	7	10	11
STRATUM 5	101 - 250 kW	95.0520	0	268	4532.117041	67.3210	18042	0.4166	44	44	49
STRATUM 6	GT- 250 kW	404.3700	0	25	66390.22157	257.6630	6442	0.1487	16	16	18
EST POP MEAN (wtd by N)	29.5474	0	2,126				43309	1.0000	106	110	123

Sample Estimate	106
Adj Sample Estimate	123

## RELATIVE PRECISION OF SAMPLE KW ESTIMATE

	TOTAL KW Optimal n (col. h)	TOTAL KW Adjusted n (col. i)	MEAN KW Adj. n	Weighted St.Dev	Variance
Variance 1 contributor	2,483,695	2,483,695	0.549505	2.793361	15.56182
2	2,705,311	2,705,311	0.598537	2.94747	43.66383
by strata: 3	1,630,301	1,441,725	0.318974	1.737454	31.46009
4	1,356,475	883,919	0.195563	1.376754	28.78381
5	6,327,257	6,327,257	1.399874	8.486373	571.3111
6	995,853	995,853	0.220328	3.029904	780.694
Total Variance	15,498,892	14,837,759	3.282780	20.37132	1471.475
Standard Error	3936.863223	3851.981227	1.8118444	V =	3.22631

Desired Conf. Level (z two tailed)	90%	90%	90%
	1.645	1.645	1.645

Conf. Interval	6476.140001	6336.509119	2.9804841
MPU Est of kW	62817.721	62817.721	29.5474

Relative Conf. Int.	10.31%	10.09%	10.09%
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# Utah Irrigation Sample Designs

3 Strata – 235 recorders + 24 (10%) = \$78,218

4 Strata – 203 recorders + 20 = \$67,346

5 Strata – 175 recorders + 18 = \$58,286

6 Strata – 169 recorders + 17 = \$56,172

6 Strata (adjusted) – 123 + 20 = \$43,186



Data acquisition merged with FieldNet Pro operations for summer months only.

# Sample Expansion

The expansion of sample data using mean-per-unit procedures are simple and straight forward. The estimate of the population mean ( $\hat{Y}$ ) is derived by multiplying the sample mean ( $\bar{y}$ ) against the total number of customers in the target group (N), as indicated below:

$$\hat{Y} = N\bar{y} = N \sum y_i / n$$

If the sample mean ( $\bar{y}$ ) is derived from a stratified sample, the population mean ( $\hat{Y}$ ) is derived by performing the above outlined procedure on the individual strata basis (h) and summing the strata totals to derive the estimate for the total population, as outlined below:

$$\hat{Y} = \sum N_h \bar{y}_h = N \sum y_{hi} / n_h$$

# Sample Design

## Random Sample Selection

### Wyoming Small General Service Sample Parameters Secondary Voltage Level

#### Active Customers with kWh Meters March 2004 History

Stratum	1	2	3	4	5
Sampling Frame	9,239	6,933	1,537	450	137
Sample	10	16	15	10	10
Interval	923.90	433.31	102.47	45.00	13.70
Random Starts					
Primary					
Random No. <sup>(1)</sup>	0.58586	0.09998	0.14346	0.74103	0.24200
Start	541	43	15	33	3
Alternate 1					
Random No. <sup>(1)</sup>	0.87308	0.07351	0.96423	0.26432	0.66432
Start	807	32	99	12	9
Alternate 2					
Random No. <sup>(1)</sup>	0.26422	0.94305	0.77341	0.56170	0.55293
Start	244	409	79	25	8
Alternate 3					
Random No. <sup>(1)</sup>	0.88640	0.12908	0.30134	0.49127	0.49618
Start	819	56	31	22	7
Alternate 4					
Random No. <sup>(1)</sup>	0.78171	0.81263	0.64270	0.82765	0.46473
Start	722	352	66	37	6

<sup>(1)</sup> Random numbers from Probability and Statistics in Engineering and Management Science, Hines & Montgomery, 2nd Ed, Pg. 628, beginning at row 19, col 4.