BENEFITS TO CUSTOMERS FROM IMPROVED SYSTEM PERFORMANCE

Introduction

There are significant customer benefits from the improvements in system performance proposed by ScottishPower. These benefits result primarily from improved customer service. While these improvements can be expected to result in higher levels of overall customer satisfaction, it is not easy to quantify the benefits associated with most of the planned service quality and system performance improvements prior to their implementation. As described in the testimony, this exhibit sets forth an approach which produces an estimate of the value to customers from improvements in reliability. The results of this analysis are presented in the following discussion.

Overview

This analysis estimates the value to PacifiCorp's customers from reductions in SAIDI and MAIFI.

SAIDI

The economic value of improvements in SAIDI can be estimated by multiplying the expected net reduction in SAIDI proposed to be achieved by ScottishPower times the estimated average interruption cost per unserved customer minute for the different types of customers served by PacifiCorp. For example, the five year weighted average SAIDI for the composite system served by PacifiCorp was 78 minutes per year.[1] A 10% reduction in the average SAIDI of the system would be about 7.8 minutes per year. The economic value of this reliability improvement can be obtained by multiplying the average reduction in SAIDI (i.e., 7.8) times the average cost per minute of interrupted service to PacifiCorp customers. The estimated average customer interruption cost per outage minute was obtained from a 1990 survey of

[1] This average excludes Montana and assumes that the historical reliability levels experienced in California are equal to the average reliability in Oregon, Idaho, Utah, Washington, and Wyoming.

residential, commercial and industrial customers performed for utility customers in the Pacific Northwest by the Bonneville Power Administration ("BPA") in cooperation with the Electric Power Research Institute ("EPRI").

MAIFI

The estimated economic value of improvements in MAIFI can be estimated by multiplying the expected net reduction in MAIFI proposed to be achieved by ScottishPower times the estimated average cost per customer interruption for momentary outages. The estimated average customer interruption cost per momentary outage was also estimated from the data in the BPA/EPRI customer survey referenced above.

Development of Measures of Interruption Costs

Interruption or outage costs are the economic costs customers experience as a result of electric supply interruptions. They are estimated using statistical surveys employing different cost measurement protocols for residential and non-residential customers. Normally, the parameters obtained from the statistical surveys are the average interruption costs given by customers for outages occurring at different times of the day, week and season and lasting different amounts of time.

To estimate interruption costs for non-residential customers, a two-stage survey design is usually employed. In the first stage, a representative sample of non-residential customers is contacted by telephone to identify the person within the business who is most familiar with production cost impacts of outages. In the second stage of the survey, after the appropriate party has been located at the sampled business, interruption cost information is collected for the sampled business either in-person or by mail.

In surveys of non-residential customers, the measurement effort is normally focused on obtaining measurements of the direct worth of costs that will result from service interruptions. This is done by describing different sets of outage circumstances called *scenarios* to respondents and asking them to describe the consequences for their business and any resulting costs. The scenarios involve variations in onset time, season, day of week and duration. In this way it is possible to

observe differences in interruption costs arising from the range of outage circumstances that will occur. The survey form and procedures are designed to assist the customer in estimating the costs that will result from the different kinds of outages that are described.

Interruption costs for residential customers are not usually measured using direct worth measurement protocols because it is very difficult for residential customers to assess accurately the losses they experience as a result of outages. Instead, interruption costs for these customers are measured indirectly using what are called "willingness to pay" or "willingness to accept" compensation techniques. In general, these techniques involve contacting a representative sample of residential customers and asking them to indicate the amount they would be willing to pay to purchase a backup power system capable of avoiding the circumstances described in an outage scenario (varying onset time, duration, etc.). They are also asked in these surveys how much they think it would be fair to compensate them in the event they experience an outage of the kind described in the survey.

Estimates of Interruption Costs for PacifiCorp's Customers

Table 1 below summarizes the interruption costs that were used to develop a rough estimate of the economic value of reliability improvements for PacifiCorp's customers. Both the 1990 and 1999 tables are included to show the development of the requisite information.

TABLE 1

1990 AVERAGE INTERRUPTION COSTS PER EVENT

	CUSTOMER TYPE		
OUTAGE DURATION	RESIDENTIAL	COMMERCIAL	INDUSTRIAL
Momentary Interruption *	$ 2.71	$ 100.19	$ 3,348.89
Fifteen Minute Outage	n/a	$ 630.06	$ 8,060.53
One Hour Outage	$ 3.16	$ 910.84	$ 10,465.27
Four Hour Outage	$ 4.93	n/a	n/a
Eight Hour Outage	$ 6.83	$ 3,150.46	$ 16,465.92

1999 AVERAGE INTERRUPTION COSTS PER EVENT

		CUSTOMER TYPE	
OUTAGE DURATION	RESIDENTIAL	COMMERCIAL	INDUSTRIAL
Momentary Interruption *	$ 3.41	$ 126.15	$ 4,216.64
Fifteen Minute Outage	n/a	$ 793.32	$ 10,149.14
One Hour Outage	$ 3.98	$ 1,146.85	$ 13,176.98
Four Hour Outage	$ 6.21	n/a	n/a
Eight Hour Outage	$ 8.60	$ 3,966.79	$ 20,732.50

* The residential momentary interruption cost figures were estimated by doing a regression analysis of the survey data. The commercial and industrial momentary interruption cost figures were estimated by applying the factors described below of 11% and 32%, respectively, to the cost of a one hour outage.

The interruption costs for PacifiCorp's customers shown in Table 1 were derived from an analysis of several data sources. As stated earlier, the average costs for a one hour outage for residential, commercial and industrial customers were obtained from the 1990 BPA/EPRI survey of interruption costs experienced by electricity customers in the Pacific Northwest.[2] The residential interruption costs included in Table 1 were obtained from Table 3-2 on page 3-10 of the study report. The commercial and industrial interruption costs were obtained from Table 5-18 on page 5-28 of the study report. The cost estimates from this table were adjusted for inflation using the U.S. city average for all items of the Consumer Price Index (CPI-U) for all urban consumers to develop the 1999 results.

The Cost of Momentary Interruptions – Estimation Approach

The BPA/EPRI study did not, however, directly measure the economic costs resulting from momentary outages. The shortest duration outage measured in that study was 15 minutes. To estimate the momentary interruption costs experienced by residential customers, a linear regression was calculated on the relationship between outage duration and interruption cost for these customers. The intercept from the regression model is the average value of the interruption cost as the duration of the outage approaches zero hours. The imputed outage cost for an outage of slightly more than zero hours duration (i.e., a momentary outage) is $2.71. Escalation for inflation between April 1990 and January 1999 brings the cost of the momentary outage to $3.41.

Momentary interruption costs for industrial and commercial customers were obtained by multiplying the interruption cost for the one hour interruption costs reported in the BPA/EPRI survey by a constant proportion observed in prior studies which measured both the cost of a one hour interruption and the momentary interruption. For industrial customers the constant fraction was 32%. That is, momentary interruption costs for industrial customers were estimated to be 32% of the

[2] The methods, procedures and results of the survey are summarized in Cost Benefit Analysis of Power System Reliability: Determination of Interruption Costs – Volume 2: Measurement of Interruption Costs for the Bonneville Power Administration.

cost of a one hour outage.[3] For commercial customers, the constant fraction was estimated to be 11%.[4] This approach was used instead of the regression model for commercial and industrial customers because the relationship between duration and magnitude of interruption costs for these customers is non-linear and the number of observations for industrial customers in the BPA/EPRI survey was relatively small.

Interruption Costs - Results

The interruption costs shown in Table 1 are a reasonable approximation of the value customers place on avoiding outages of varying durations. In the case of commercial and industrial customers, the above described interruption cost estimates are reasonable measures of the tangible economic losses businesses experience as a result of service interruptions.[5] For residential customers, they represent the economic value customers say they would be willing to pay to avoid service interruptions. These cost estimates were obtained using the methods and procedures that are generally accepted today for estimating the economic value of electric service interruptions.[6] They have been shown to produce consistent results for a number of different utilities including, but not limited to, Bonneville Power Administration, Pacific Gas and Electric, Southern California Edison, Southern Company, Duke Energy, Cinergy and Niagara Mohawk.

For example, a value of service study for Southern California Edison found that residential customers' willingness to pay to avoid a one-hour outage ranged from

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[3] This approach was taken with a view to generating a conservative result on this point. For particular industrial customers, especially in process industries, there may be no difference between the impact on the production process between a momentary and a longer duration outage. For a discussion of the 32% result, see Michael J. Sullivan, Terry Vardell and Mark Johnson, "Power Interruption Costs to Industrial and Commercial Customers of Electricity", IEEE Transactions on Industry Applications, Vol. 33, No. 6, November/December 1997.

[4] Discussions with Michael J. Sullivan (identified in note 2 above).

[5] There is a large range in interruption costs depending on the type and size of the industrial or commercial customer. The statistics presented in this exhibit are averages for each customer class and do not reflect the unique size differences of PacifiCorp's customer base.

[6] See Electric Power Research Institute, Outage Cost Estimation Guidebook, EPRI TR-106082, December 1995.

$2.84 to $3.06, compared to the BPA/EPRI survey result of $3.16[7] In addition, ScottishPower's own customer research in the U.K. supports the approximations of interruption costs shown in Table 1.

Estimates of the Benefits to PacifiCorp's Customers of Improved System Performance

MAIFI

The economic worth of a 5 percent improvement in MAIFI is obtained by estimating the reduction that will occur in the number of momentary interruptions and multiplying this reduction by the estimated total system cost per momentary interruption obtained from the outage cost surveys. For example, the composite weighted average number of system momentary interruptions is 6.35 per year. That is, on average customers on the PacifiCorp system experience about 6.35 momentary interruptions per year. A 5% reduction in the number of momentary interruptions is equivalent to about .31 momentary interruptions per year. According to Table 1 above, the average cost per momentary interruption for each of PacifiCorp's 1,226,502 residential customers is $3.41. The economic value of a 5% reduction in the number of momentary interruptions experienced by residential customers is thus equal to (.32 x 1,226,502 x $3.41) or $1.3 million per year. To obtain the economic worth of a 5% reduction in momentary interruptions for all customers on the system, equivalent calculations are made for commercial and industrial customers and summed.

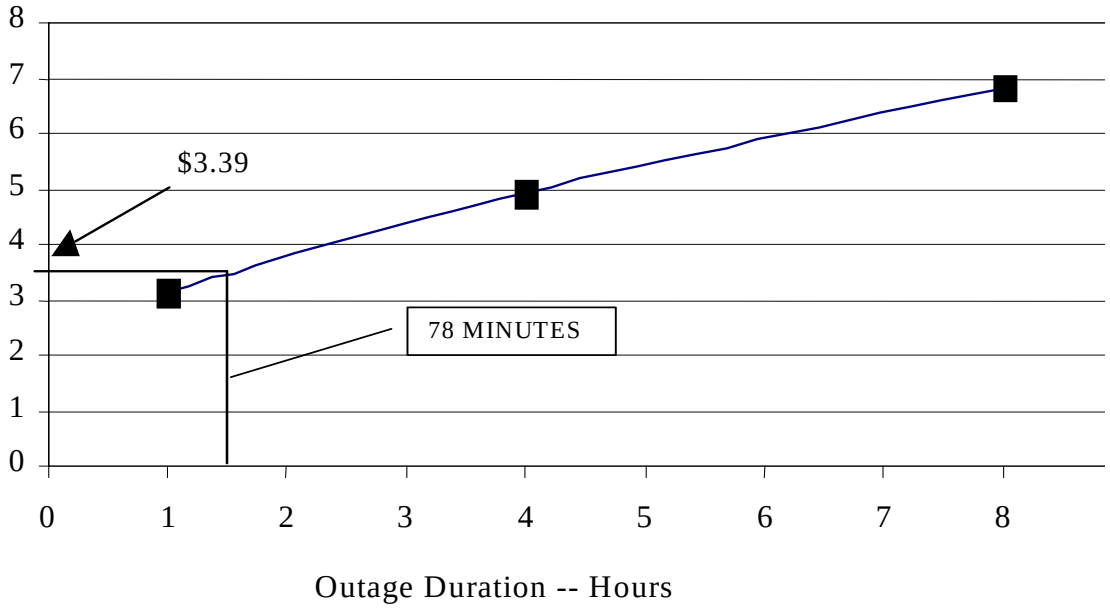
[7] RCG/Hagler, Bailly, Inc., Customer Value of Service Reliability Volume Two: Residential Customers at 2-6, 2-8 (1989) (report submitted to Southern California Edison, October 1989). SCE recently published updated estimates of residential customers' willingness to pay (WTP) to avoid outages of various durations. SCE's 1998 WTP estimates for residential customers ranges from $4.38 to $4.72 for a one-hour outage, $5.36 to $$5.65 for a hour-hour outage and $8.22 to $8.27 for an eight-hour outage. These estimates are comparable to the 1999 estimates used in this exhibit and shown in Table 1. See Southern California Edison Company's Distribution PBR Interim Report, filed with the California Public Utilities Commission on March 1, 1999.

SAIDI

The economic worth of an improvement in SAIDI is calculated in a slightly different way. The first step in calculating the economic worth of a 10% improvement in SAIDI is to calculate the economic worth of the service interruptions experienced on the average by customers. This is done by scaling the interruption costs per hour reported in Table 1 so that they correspond with the average extended outage duration and frequency (i.e., SAIDI and SAIFI) for the system. The composite system SAIDI for the PacifiCorp system is approximately 78 minutes. This means that, on average, PacifiCorp customers receive a total of about 78 minutes of interruptions each year. The SAIFI for the composite system is approximately 1. Thus on average, customers on the PacifiCorp system receive one outage of approximately 78 minutes duration each year. At issue is the economic value of an outage lasting 78 minutes.

The economic value of an outage of 78 minutes duration can be obtained for each type of customer on the PacifiCorp system from the information in Table 1 by interpolating between the point estimates for the 15 minute, 1 hour, 4 hour and 8 hour outage costs. Figure 1 below displays the relationship between outage duration and interruption cost for residential customers.

Figure 1



It is apparent in the figure that the relationship between interruption cost and duration is approximately linear between 1 and 8 hours duration. Taking account of the linear relationship between duration and interruption cost, it is possible to estimate the average cost of a 78 minute outage. The estimated average interruption cost (1990) for an outage of this duration is $3.39 ($2.71 + $.52 x the total number of hours out, or 1.3).

The same procedure is used to scale the average interruption costs for commercial and industrial customers to the average duration of outage experienced by customers on the PacifiCorp system. For commercial customers, the cost (1990) of a 78 minute interruption is approximately $988 ($567 + $323 x the number of hours out, or 1.3). For industrial customers, the average cost (1990) of a 78 minute interruption is approximately $10,722 ($10,465 + $857 x the number of hours in excess of one, or .3). The next step in calculating the economic worth of a 10% reduction in SAIDI is to calculate the economic cost of the composite system level SAIDI. This is obtained by multiplying the costs of the 78 minute outage identified above, times the number of customers experiencing those costs. For example, in 1999 dollars, the cost of a 78 minute outage for residential customers is approximately $4.27 (3.39 x 162.3/128.9 for inflation). The total cost of extended outages experienced by PacifiCorp's residential customers is thus ($4.27 x 1,226,502) or about $5 million. If SAIDI is reduced by 10% -- from 78 minutes to 70 minutes – the cost of outages to residential customers will be reduced by about $500,000. Equivalent calculations are made for commercial and industrial customers and summed with the values for residential customers to obtain composite system level costs of SAIDI and the value of reductions in SAIDI. (Please refer to the attached workpaper labeled "Regression Analysis Results for Residential and Commercial Customers & the Straightline Analysis Results for Industrial Customers.")

Conclusion

Table 2 below summarizes the results of this analysis. It indicates that customers will receive benefits of about $60 million per year from the improvements to SAIDI and MAIFI proposed by ScottishPower. This represents a significant benefit to customers in the form of reduced outages and improved service quality.

It should be emphasized that this $60 million in benefits associated with

improved system performance is not a one-time event. Rather, these benefits will continue into the future for a period long after ScottishPower takes the steps to improve system performance.

[BA991060.031]

Table 2

	Average Cost					
	A	B	C	D	(CxAxD/1,000,000)	(CxB/1,000,000)
	Momentary Interruption (1999)	Seventy-Eight Minute Outage (1999)	Number of Customers[1]	Number of Momentaries	Cost of System Momentaries ($ millions)	Cost of System Extended Outages ($ millions)
Residential	$ 3.41	$ 4.27	1,226,502	6.35	27	5
Commercial	$ 126.15	$ 1,243.47	168,145	6.35	135	209
Industrial	$ 4,216.64	$ 13,500.79	11,784	6.35	316	159
Total Economic Worth of 5% and 10% Reductions					**477** 24	**373** 37
Total					**61**	

1. Excludes customers in Montana

ATTACHMENT

Regression Analysis Results for Residential and Commercial Customers & the Straightline Analysis Results for Industrial Customers

REGRESSION SUMMARY OUTPUT - Residential

Regression Statistics	
Multiple R	0.99809
R Square	0.99618
Adjusted R Square	0.99236
Standard Error	0.16042
Observations	3.00000

Input Data

Hour (s)	Residential 1990	Residential 1999[3]
1	3.160	3.979
4	4.930	6.207
8	6.830	8.600

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1.00000	6.71153	6.71153	260.79	0.03937
Residual	1.00000	0.02574	0.02574		
Total	2.00000	6.73727			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95%*	*Upper 95%*
Intercept	2.713- **A**	0.168	16.164	0.04	0.580	4.846	0.580	4.846
X Variable 1	0.522 - **B**	0.032	16.149	0.04	0.111	0.932	0.111	0.932

REGRESSION SUMMARY OUTPUT - Commercial

Regression Statistics	
Multiple R	0.99990
R Square	0.99980
Adjusted R Square	0.99961
Standard Error	27.29128
Observations	3.00000

Input Data

Hour (s)	Commercial 1990	Commercial 1999[3]
0.25	630.06	793.32
1	910.84	1146.85
8	3150.46	3966.79

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1.00	3,814,972.29	3,814,972.29	5122.05	0.00889
Residual	1.00	744.81	744.81		
Total	2.00	3,815,717.10			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95%*	*Upper 95%*
Intercept	567.528 - **C**	21.025	26.993	0.024	300.38	834.67	300.38	834.67
X Variable 1	323.110 - **D**	4.515	71.568	0.009	265.75	380.48	265.75	380.48

STRAIGHTLINE ANALYSIS - Industrial

Hour (s)	Industrial 1990
0.25 hours	8,006.530
1 hour - **E**	10,465.27 - **G**
8 hours - **F**	16,465.92 - **H**

[(H - G) / (F - E)] =	857.235 - **I**

RESULTS — **g = 1.30**

	1990	Formula	1999[3]
Residential[1]	3.390	>> (A + (B x g)	4.270
Commercial[1]	987.570	>> (C + (D x g)	1,243.468
Industrial[2]	10,722.440	>> (G + I x (18/60))	13,500.792

1. A regression analysis, using 1990 dollars, was used to determine the value of a 78 minute interruption

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