Business Customer Outage Costs

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ABSTRACT

Previous studies of the costs of power outages for business customers have indicated that several factors, including type of business, season, length of outage and time of day, contributed significantly to cost estimates in studies involving hypothetical scenarios. More recent efforts to assess these factors at BC Hydro, reported in the present study, extended this work to examine the costs of actual outages by follow-up, structured interviews with a sample of businesses experiencing outages of at least 20 minutes duration, undertaken within one week of the outage occurrence. Early analysis of this ongoing research indicates that several, somewhat different, factors contribute to customer estimates of both costs of outages and costs per lost hour, including size of establishment, whether a production slowdown was involved, satisfaction with the accuracy of notification of anticipated length of outage, and the length of the outage. In addition, customers who called to report the outage and obtain information about its anticipated length showed a small seasonal effect. Some possible explanations for the differences between the present and earlier, hypothetical studies are discussed.

Introduction

Cost of outages for business customers is a key issue in the cost-effective management of electric utilities and more recently, a key issue in customer attraction and retention as electricity markets are deregulated and retail competition unfolds.

Costs of power outages for business customers have been examined in several papers (Caves, Herriges & Windle 1990; EPRI 2000), although the literature is not as extensive as that dealing with residential costs of outages. Usually business customers are provided several different scenarios that vary by outage duration, season and/or time of day, and are asked to assign a dollar value to the costs they would incur for specific interruption scenarios (direct cost method). Or, customers are asked how much they would pay to avoid a specific interruption scenario (contingent valuation).

Market research at BC Hydro has shown that one of the key drivers of customer satisfaction, corporate image and customer loyalty is the level of reliability (Tiedemann 1999). Together with Transmission and Distribution, Market Research is undertaking a project to understand the value of reliability to BC Hydro commercial and industrial (C&I) customers and develop a comprehensive set of new outage cost estimates for use in considering alternative investment portfolios.

Major challenges in determining the costs business customers experience during a power interruption include the variation in costs reported by different business sectors, for different outage durations, different seasons, and different times-of-day (e.g., early or late in the daily operating schedule).

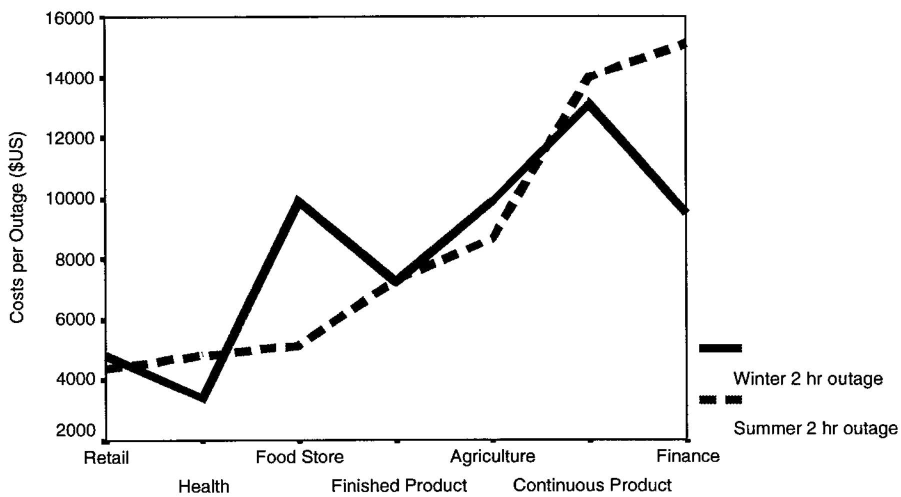
The first phase of the work involved participation in a large study managed by E source (E source, Inc. 1999) and including customers from the United States, Quebec and British Columbia. The second phase focussed on small and medium BC Hydro C&I customers, primarily from retail, service, accommodation, food and beverage sectors (Tiedemann 2000). The third phase, summarized in this paper, asked customers about recently experienced outages, and addressed all sizes and classes of BC Hydro C&I customers.

Phase 1 E source, Inc. C&I Study

This study included mid-sized establishments in the health, finance, retail, finished product manufacturing, continuous product manufacturing and food store segments. The first stage involved in-depth interviews with representatives of each sector, and the second stage involved a telephone recruitment and mail-back survey with 750 completions.

Customers were provided with a set of five power outage scenarios that varied in terms of length of outage and season. For each scenario customers were asked to estimate the costs including labor, revenue, damage, materials lost, start-up and other (miscellaneous) costs. Costs varied considerably by business segment, the season and the length of outage. For example, Figure 1 indicates the cost per outage ($US, range $ 3,400 - $ 14,000) for a two hour outage in the summer or winter, for the seven business sectors.

Figure 1. E-source Costs per Outage By Business Sector



E-source 1999 (n=750)

While the first phase of the research provided general information regarding the factors affecting outage costs, the British Columbia sample was insufficient to provide reliable new outage cost estimates for use in considering alternative investment portfolios. Consequently, a second phase of the research was initiated, as described below.

Phase 2 BC Hydro Small/Medium C&I Study

The second study included small and medium sized establishments primarily from retail, service, accommodation, food and beverage sectors (Tiedemann 2000). A telephone survey was conducted with 199 business customers to collect basic information about customers and to solicit participation in the detailed fax-back survey. Some 95 customers completed the survey providing estimates of the direct costs of outages.

A set of 16 scenarios was used, including outages of four different lengths (20 minutes, 2 hours, 4 hours, 12 hours) at four different seasons and time-of-day (8 am winter weekday, 8 am summer weekday, 4pm winter weekday, 4pm summer weekday). Each customer was asked about four outage length scenarios for just one time bin. Customers were asked to estimate the costs for lost production that could not be made up; labor costs including salaries, wages and overtime; damage to equipment or materials; overhead, depreciation and related costs; losses of future business due to poor customer satisfaction; and potential savings for costs not undertaken.

Once again, costs varied by business sector, season, length of outage and time-of-day. For example, cost per outage for a two hour outage ranged from \$ 523 - \$ 4,629 (\$US) depending upon the season (summer/winter) and the time-of-day (8 am/4 pm). In accordance with previous work involving hypothetical scenarios, outage costs increased with the length of outage, but not proportionately to outage length (1,2,4).

Modeling of the determinants of costs per outage indicated positive effects for length of outage, summer and morning outages (see Table 2 and equation 1). Coefficients on all the driving variables are statistically significant and the regression has fairly good explanatory power with an adjusted R^2 of 0.64.

Table 2. Definition of Variable

Term	Definition	Phase 2 Mean
CO	Costs per outage (\$US)	\$ 1,780
CkWh	Costs per kWh lost (\$US)	\$ 101
CHr	Costs per lost hour (\$US)	\$ 802
Hrs	Outage length (hours)	4.58
In_hrs	Inverse outage length (hours)	0.96
Sum	Summer (1)/Winter (0)	0.5
Morn	Morning (1)/Afternoon (0)	0.5

1. CO = -753 + 191 (Hrs) + 2,283 (Sum) + 1,028 (Morn)
   t-values 1.37 2.81 4.70 2.12
   $R^2 = 0.64$, $F(3,12) = 9.75$ ($p < .001$)

When costs were normalized on a lost kWh basis (cost per lost kWh), modeling of the determinants indicated positive and statistically significant effects for the inverse of outage length and summer outages. The regression has adequate explanatory power with an adjusted R^2 of 0.51 (equation 2).

2. CkWh = -55 + 59 (In_hrs) + 130 (Sum) + 71 (Morn)
   t-values 1.29 2.21 3.21 1.75
   $R^2 = 0.51$, $F(3,12) = 6.27$ ($p < .001$)

Costs were normalized on an hourly basis (cost per lost hour). These costs fall consistently with increased length consistent with the presence of substantial fixed costs but relatively small variable costs per outage. The coefficients for the inverse of the length of the outage and summer are statistically significant, and the adjusted R^2 of 0.51 is adequate (equation 3).

3. CHr = -401 + 463 (In_hrs) + 975 (Sum) + 542 (Morn)
   t-values 1.21 2.27 3.12 1.74
   $R^2 = 0.51$, $F(3.12) = 6.30$ ($p < .01$)

The second phase of the research provided more specific information regarding the contribution of outage length, season and time-of-day to outage costs. However, compared to the Phase 1 results, the Phase 2 results appeared to over-represent business segments which experience higher economic activity in the summer and find power interruptions in the late afternoon more disruptive than morning interruptions (retail, service, accommodation, food and beverage). Consequently, a third phase of the research was initiated, as described below.

Phase 3 BC Hydro Costs Of Actual Outages

Initiated in August 2000, this study involves ongoing surveying of customers for a twelve month period, shortly after they experience an outage. C&I customers are surveyed by telephone on a rolling basis, approximately one-week following an outage of a minimum of 20 minutes. This approach provides cost estimates based on the customers' recent experience with an actual outage, rather than the hypothetical scenarios and costs used in previous research at BC Hydro (E source, Inc. 1999; Tiedemann 2000). This report summarizes data for August 2000 – February 2001.

The project was designed to include approximately 40 large and 40 small/medium C&I responses every two weeks. Fortunately for large customers, but unfortunately for the research, insufficient numbers of large customers in the BC Hydro service territory experience outages of any kind. Large C&I customer accounts are those with annual consumption greater than 1 million kWh per year, including a number who generate electricity. As a consequence, the small/medium sample is growing at a much faster rate than the large customer sample. This report summarizes the data for small and medium sized customers with annual consumption less than 1 million kWh per year.

For the small/medium business sector successive random samples of 100 outages from the population of all outages in the previous two weeks are drawn and exhausted, until 40 interviews are complete. For the seven months the survey has been in field, BC Hydro business customers have experienced some 15,349 outages of 20 minutes or more. Sampling is without replacement, therefore once a business has completed a survey, that business is excluded from subsequent samples. As a result, the sample represents the first outage of more than 20 minutes that a business experiences between August 2000 and February 2001, and excludes businesses experiencing multiple outages.

Customers were asked to estimate labor costs (wages, salaries, overtime), costs due to equipment damage, extra costs such as material spoilage, and the value of lost production (industrial and manufacturing) or sales (commercial). Total costs, and those used in the following analyses, are direct costs minus savings due to wages or salaries not paid, material not used, and lost production made-up.

Other issues addressed in the questionnaire include satisfaction with reliability and restoration of power, and information regarding notice of the duration of outages, experience with momentary outages, and other characteristics of business activity.

Phase 3 Results - Cost of Actual Outages

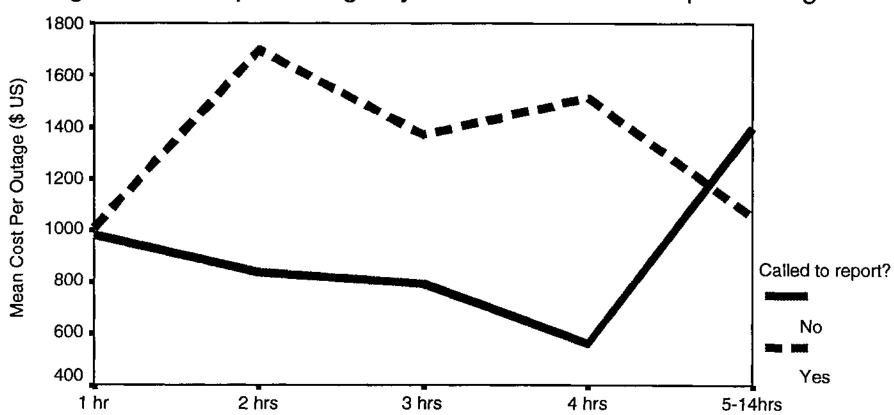
The starting sample of 370 surveys was reduced to 356 by removing cases more than six standard errors beyond the mean of the distributions for direct costs, savings, costs per outage, costs per kWh lost, and costs per lost hour. Average costs per lost kWh and lost hour are reasonably consistent with Phase 2 results. Average costs per outage in Phase 3 are somewhat lower than Phase 2, potentially related to the wider range of time-of-day of naturally occurring outages (Table 3), and lower or no costs associated with outages outside of normal operating hours.

Table 3. Comparison of Phase 2 & 3 Results

Term	Definition	Phase 2 Mean	Phase 3 Mean	Phase 3 Standard Error
CO	Costs per outage ($US)	$ 1,780	$ 1,081	91.73
CkWh	Costs per kWh lost ($US)	$ 101	$ 219	36.42
CHr	Costs per lost hour ($US)	$ 802	$ 641	63.56

Overall, costs per outage failed to increase with the duration of the outage, although smaller establishments (less than 5,000 square feet, annual consumption less than 100,000 kWh per year) with no production facilities showed a non-significant tendency to report higher outage costs with increasing duration. One potential reason customers may not experience increasing costs with increasing outage duration is the Power-On service provided by BC Hydro. Customers who call to report an outage are provided an estimate of how long it will take to restore power. As noted in Figure 4, customers who call to report an outage tend to report higher costs per outage, $F(1,354) = 6.82$, and $p < .01$. It is not surprising that those who experience higher costs are most likely to call to inquire about the duration of the outage.

Figure 4. Cost per Outage By Whether Called to Report Outage



Category - Length of Outage

BC Hydro Customer Cost of Outage Survey

May 2001 (n=356)

In addition, unlike the Phase 2 results, the costs per outage for winter were significantly higher than for summer and fall outages, $F(1,354) = 15.08$, and $p < .001$ (note, spring data is still being collected). This difference in results may be related to the wider range of business sectors represented in the Phase 3 results (resource-based; construction and manufacturing; communications; transportation; retail; institutional; food stores; accommodation, food and beverage).

Modeling the determinants of costs per outage resulted in positive effects for the square footage of the business establishment and for production slow downs; and negative effects for the respondent's satisfaction with the accuracy of the notification of the length of the outage and the inverse of the length of the outage (see Table 5 and equation 4). Coefficients on all the driving variables are statistically significant, while the regression has barely adequate explanatory power with an adjusted R^2

of 0.45. Unlike the Phase 2 results, the season and time-of-day of the outage failed to explain costs per outage.

Table 5. Phase 3 Definition of Variables

Term	Definition	Phase 3 Mean
CO	Costs per outage ($US)	$ 1,081
CkWh	Costs per kWh lost ($US)	$ 219
CHr	Costs per lost hour ($US)	$ 641
Hrs	Outage length (hours)	2.38
In_hrs	Inverse outage length (hours)	0.60
SqFt	Square Footage for e-account (1= > 5,000 Feet^2)	0.38
Pslow	Production slow down or stop? (1=yes)	0.81
Snotify	Satisfied with accuracy of notification of length of outage? (1=satisfied)	0.53
Size	Annual Consumption (1= > 100,000 kWh/year)	0.21
Winter	Winter (=1, 0= not winter)	0.31

4. CO = 255 + 1,223 (SqFt) + 1,165 (Pslow) – 509 (Snotify) – 517 (In_hrs)
t-values 0.99 6.68 5.14 -2.88 -2.11
$R^2 = 0.45$, $F(4, 307) = 19.71$ ($p < .001$)

It is interesting that those who are satisfied with the accuracy of the notification of the length of the outage consistently report lower costs per outage, particularly as satisfaction with the speed at which power is restored failed to explain costs per outage. This suggests electric utilities can minimize customers' perception of or actual outage costs by providing accurate notification of the duration of outages.

The sample was split into two groups: those who called to report the outage and obtain information about the length of the outage, and those that did not. The modeling results for these two samples reveal that costs increase with the length of the outage for those who do not know how long the outage will last. However, the length of the outage fails to explain costs per outage for customers who do know how long the outage will last (see equations 4.1 and 4.2).

Did not call to report an outage.

4.1 CO = -442 + 541 (SqFt) + 1,044 (Pslow) – 519 (Snotify) + 517 (Hrs) + 608 (Winter)
t-values –1.50 2.38 4.36 -2.57 3.28 2.14
$R^2 = 0.48$, $F(5, 159) = 9.61$ ($p < .001$)

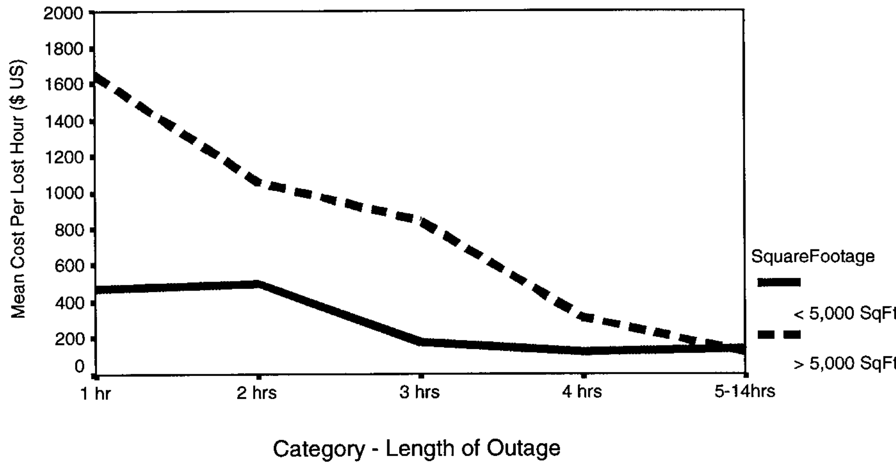
Did call to report an outage.

4.2 CO = 74 + 1,452 (SqFt) + 1,011 (Pslow) – 641 (Snotify)
t-values 0.18 4.84 2.72 -2.14
$R^2 = 0.45$, $F(3, 143) = 12.03$ ($p < .001$)

Modeling of the costs per lost kWh was unsuccessful with coefficients taking opposite signs and inadequate explanatory power.

As in Phase 2, costs per lost hour consistently fall with increasing length of outage, particularly for larger businesses (see Figure 6) and businesses that experienced a slow down or stop in production.

Figure 6. Cost per Lost Hour By Length of Outage



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Costs per lost hour are positively effected by inverse hours, by the square footage of the business establishment, whether production slowed down, and the size of the electric account. Once again, satisfaction with accuracy of the notification of the duration of the outage was negatively related to costs (see Table 5 and equation 5). Explanatory power is accounting for 53% of variance in costs per lost hour. Unlike the Phase 2 results, season and time of day of the outage failed to account for significant portions of the cost per lost hour.

5. CHr = -428 + 801 (In_hrs) + 583 (SqFt) + 581 (Pslow) – 336 (Snotify) + 372 (Size)
t-values -2.50 4.81 4.50 3.92 -2.91 2.34
$R^2 = 0.53$, $F(5, 306) = 23.95$ ($p < .001$)

Overall, while the modeling results are weak in terms of explanatory power they reflect expected relationships, including:

- higher costs per outage for outages of longer length, larger business establishments, and businesses experiencing production slow downs or stops; and
- higher costs per lost hour for short duration outages consistent with the presence of substantial fixed costs but relatively small variable costs per outage, , larger business establishments, and businesses experiencing production slow downs or stops.

Perhaps more unexpectedly, the modeling results also suggest that customers who are satisfied with the accuracy of the notification of the length of the outage report lower costs per outage and costs per lost hour.

Discussion

When customers were presented with hypothetical scenarios describing power interruptions in fax-back or mail-back surveys and asked to estimate the costs incurred, the duration of the outage, season and time-of-day adequately explain variations in costs per outage, costs per lost kWh and costs per lost hour. However, when customers complete a telephone survey after a recent outage, the size of the business in terms of square footage and/or energy consumption, whether production slowed down or stopped, and the duration of the outage contribute only weakly to the explanation of variations in costs per outage and cost per lost hour. In addition, perceptions about the accuracy of the notification of the duration of the outage affected costs per outage and costs per lost hour.

These differences may be related to the data collection methods, particularly in the business sector where the information required to answer questions regarding the costs of labor, lost materials and the like may reside in more than one individual or place in the organization. Fax-back and mail-back surveys provide the respondent additional reflection time and the opportunity to seek input from others in the organization, which could well effect the accuracy and validity of the cost estimates. Finally, the respondent bias to hypothetical surveys and to a telephone survey requesting information about an event the people in the business are not even aware of (e.g., short interruptions outside of operating hours) may be affecting the results.

A major and remaining challenge in estimating outage costs for business customers is the variability across business sectors and seasons (see Figures 1 and 7), compounded by significant variation in costs associated with the size of the business, length of outage, and the accuracy of the notification of duration of outages.

Figure 7. Costs per Outage By Business Sector

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Given the variability and weak relationships in the current data, it will interesting to see if the final sample based on twelve months replicates current results based on seven months (August 2000 – February 2001). Nevertheless, the research project has provided unanticipated benefits by opening a channel of information between BC Hydro Marketing and Sales division and the Distribution Trouble Reporting System. Marketing and sales personal are now able to identify those customers who experience significant outage costs or multiple outages, and who are most likely to benefit from BC Hydro power quality services. As a consequence, power quality service sales are increasing, customers are less vulnerable to power interruptions, and customers are experiencing reduced costs due to unreliability in their power supply.

References

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