Electric Power Distribution Reliability

SECOND EDITION

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Investor owned utilities attempt to maximize profits rather than maximize social welfare, which is presumably accomplished by satisfying all regulatory expectations for the least possible cost. Customer cost information becomes less important because a customer dollar is no longer equal to a utility dollar. Regardless, a good feel for customer costs can help investor owed utilities to better understand their customers and offer value added reliability services that can increase profits and increase customer satisfaction.

2.3.1 Customer Cost Surveys

The customer cost of reliability is typically estimated based on surveys. These surveys capture information about tangible costs, opportunity costs, and intangible costs. Tangible costs include items such as computer crashes, ruined processes, scrapped product, spoiled food, overtime pay, and the cost of going out to eat. Opportunity costs includes lost production and lost sales. Intangible costs include inconveniences such as water pump failures, difficulties in getting ready for work, impact on leisure time, and needing to reset digital clocks.

The cost of an interruption varies widely from customer to customer and from country to country. Other important factors include duration, time of year, day of the week, time of day, and whether advanced warning is provided. Customers will also be impacted less if they have back-up generators, uninterruptible power supplies and other on-site interruption mitigation equipment. Good customer surveys attempt to capture as much of this information as possible, but the quantity and interaction of parameters makes complete models difficult to achieve.

Estimates of customer cost are well documented by a host of surveys.[35-46] An interesting observation is the widely varying costs associated with different industries. Results from a University of Saskatchewan survey are shown in Table 2.8.[47] Costs of a typical one-hour interruption, normalized to peak load, are provided for a variety of commercial and industrial customers and shown to vary from virtually zero cost to more than $276 per kW. On average, industrial customers incur about $8.40/kW for a 1-hr interruption and commercial customers incur about $19.38/kW for a 1-hr interruption. Based on these results, large customers with high costs can easily incur millions of dollars per interruption hour.

The cost of an interruption is highly dependent on its duration. Short interruptions can result in computer crashes, ruined processes, and broken equipment. Longer interruptions result in lost production and ruined inventory. For specific customers, curves tend to be highly nonlinear. A semiconductor factory may incur a high initial cost due to a ruined process and a small time-dependent cost due to lost production. A plastic extrusion facility may incur small costs for short

Table 2.8. One-hour interruption costs for industrial and commercial customers. Results are based on a University of Saskatchewan survey and are presented in 2001 dollars.

Industrial	$/kW_{peak}$	Commercial	$/kW_{peak}$
Logging	2.11	Food and Drug	18.52
Forestry	0.00	Clothing Stores	18.92
Mining	3.00	Household Furniture	39.88
Crude Petroleum	276.01	Automotive	42.39
Quarry and Sand	5.33	General Merchandise	30.10
Services to Mining	2.13	Other Retail	5.95
Food Industries	20.46	Vending and Direct	0.00
Beverage Industries	1.55	Accommodations	1.32
Rubber Products	1.80	Food Service	19.90
Plastic Products	2.91	Entertainment	23.81
Leather Products	1.37	Personal Services	0.39
Primary Textiles	17.29	Other Services	3.51
Textile Products	8.93		
Clothing	8.68		
Wood Industries	2.93		
Furniture	23.20		
Paper Products	7.52		
Printing and Publishing	6.01		
Primary Metal	3.54		
Fabricated Metal	8.41		
Machinery	7.70		
Transportation	42.96		
Electrical Products	8.78		
Nonmetal Minerals	9.59		
Refined Petroleum	0.00		
Chemical Products	4.65		
Other Manufacturing	15.31		
Total Industrial	**8.40**	**Total Commercial**	**19.38**

interruptions, but incur an extremely high cost if the interruption is long enough for plastic to solidify within the extrusion equipment. A refrigeration warehouse may not incur any cost for short interruptions. At a certain point, food will begin to spoil and severe economic losses will occur. After all of the food is spoiled, additional interruption time will not harm this particular customer much more. Cost functions reflecting these three cases are shown in Figure 2.13.

Average customer cost curves tend to be linear and can be modeled as an initial cost plus a first-order time dependent cost. For planning purposes, it is useful to group results into a few basic customer classes: commercial, industrial, and residential. Since larger customers will have a higher cost of reliability, results are normalized to the peak kW load of each customer. Reliability cost curves for typical US customers are shown in Figure 2.14.[48]
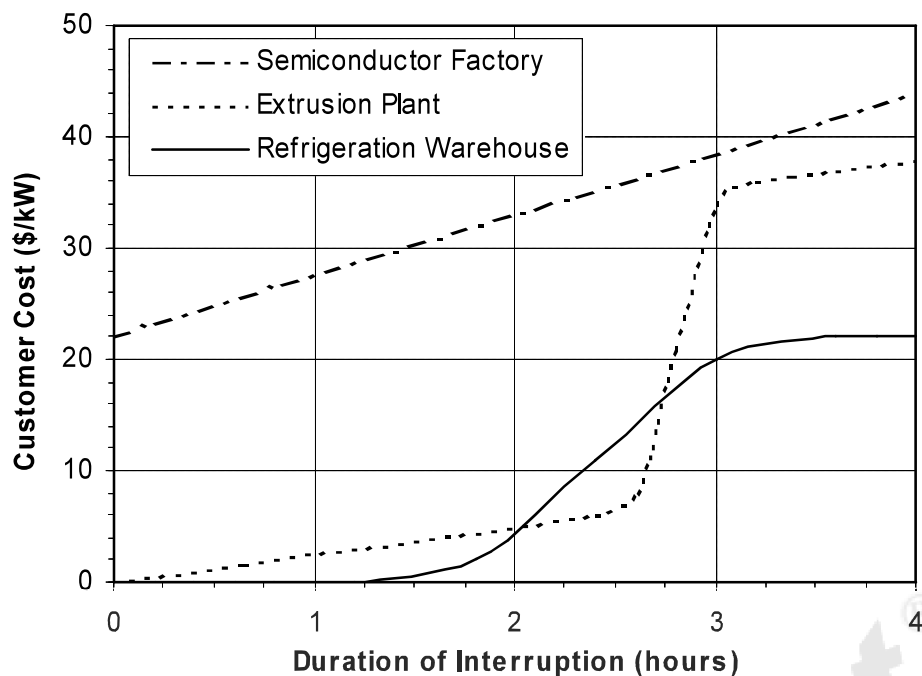
Figure 2.13. Interruption cost curves for several customer types. The semiconductor factory has high initial costs and linear time dependent costs. The extrusion plant and refrigeration warehouse have low initial costs and highly nonlinear time related costs.
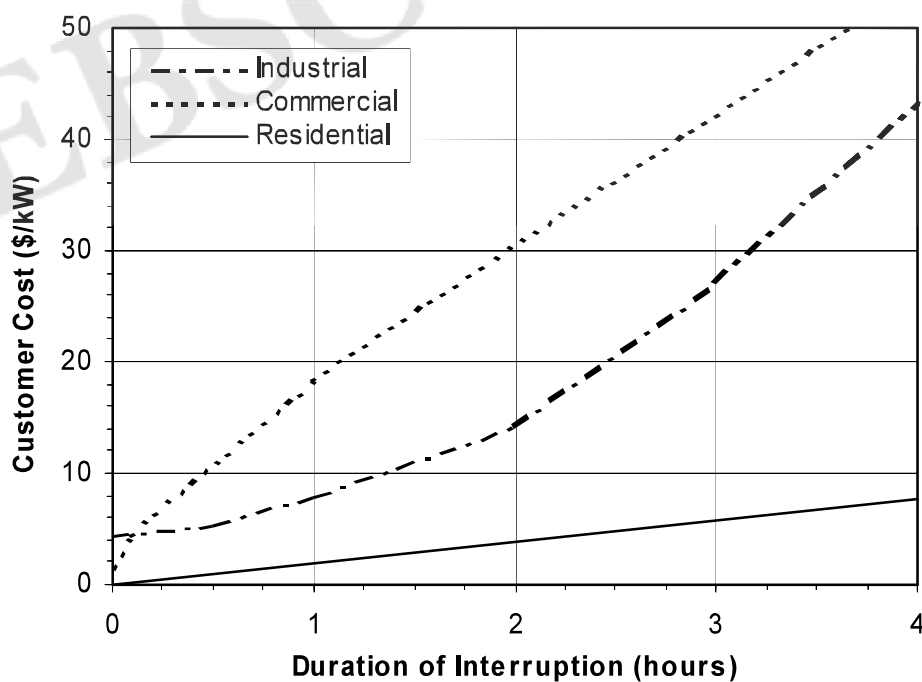
Figure 2.14. Average interruption costs for industrial, commercial, and residential customers. Average costs can be approximated with an initial cost and a first-order time related cost. Results are based on several North American surveys and are presented in 2001 dollars.

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