The Cost of Power Disturbances to Industrial & Digital Economy Companies

Submitted to:

EPRI's Consortium for Electric Infrastructure for a Digital Society (CEIDS)

By

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The Cost of Power Disturbances to Industrial & Digital Economy Companies

Executive Summary

The importance of power reliability and power quality continues to increase for U.S. businesses, particularly industrial and digital economy companies

The importance of reliable, high-quality electrical power continues to grow as society becomes ever more reliant on digital circuitry for everything from e-commerce to industrial process controllers to the onboard circuitry in toasters and televisions. With this shift to a digital society, business activities have become increasingly sensitive to disturbances in the power supply. Such disturbances not only include *power outages* (the complete absence of voltage, whether for a fraction of a second or several hours), but also *power quality phenomena* (all other deviations from perfect power, including voltage sags, surges, transients, and harmonics).

Three sectors of the U.S. economy are particularly sensitive to power disturbances:

- **The digital economy (DE).** This sector includes firms that rely heavily on data storage and retrieval, data processing, or research and development operations. Specific industries include telecommunications, data storage and retrieval services (including collocation facilities or Internet hotels), biotechnology, electronics manufacturing, and the financial industry.

- **Continuous process manufacturing (CPM).** This sector includes manufacturing facilities that continuously feed raw materials, often at high temperatures, through an industrial process. Specific industries include paper; chemicals; petroleum; rubber and plastic; stone, clay, and glass; and primary metals.

- **Fabrication and essential services (F&ES).** This sector includes all other manufacturing industries, plus utilities and transportation facilities such as railroads and mass transit, water and wastewater treatment, and gas utilities and pipelines.

These three sectors account for roughly 2 million business establishments in the U.S. Although this is only 17 percent of all U.S. business establishments, these same three sectors account for approximately 40 percent of U.S. gross domestic product (GDP). Moreover, disruptions in each of these sectors – but especially DE and F&ES – have an almost immediate effect on other sectors that depend on the services they provide.

EPRI's Consortium for Electric Infrastructure for a Digital Society (CEIDS) contracted Primen to conduct a national survey of business establishments to quantify the cost of power disturbances to industrial and digital economy firms

The survey employed a statistically representative sample of 985 establishments to reflect costs of the roughly 2 million industrial and digital economy establishments in the U.S. An initial screening identified at each establishment sampled an individual who was knowledgeable about the facility's energy usage and how power disturbances affect their operations. These individuals were then invited to complete the survey online or by mail, depending on their preference. The survey presented respondents with a set of hypothetical outage scenarios and asked them to estimate the costs they would incur from each outage across different categories. This approach, called *direct costing*, has been widely used by utilities to develop estimates of outage costs. The survey also captured information on the number and duration of outages experienced (which allowed for estimating annual outage costs), the number and cost of power quality phenomena experienced, and descriptive information about the business.

Industrial and DE firms are collectively losing $45.7 billion a year to outages

Power outages cost each of the roughly 2 million establishments in these three sectors more than $23,000 a year. The bulk of this loss ($29.2 billion) is concentrated in the F&ES sector, which is particularly vulnerable to equipment damage. DE firms lose $13.5 billion to outages annually, primarily from lost productivity and idled labor. The greatest losses per establishment are among CPM firms, which suffer the loss of raw materials as well as the costs incurred by other sectors.

Costs vary with the length of the outage but even short outages are costly

Even a one-second outage can damage equipment and disrupt highly sensitive operations to the point where labor becomes idled as systems are reset and brought back online. The average

cost of a one-second outage among industrial and DE firms is $1,477, vs. an average cost of $2,107 for a three-minute outage and $7,795 for a one-hour outage. Brief outages are also more frequent than outages of an hour or more; industrial and DE establishments report that 49 percent of the outages they experience last less than 3 minutes.

Industrial and DE companies lose another $6.7 billion each year to PQ phenomena

DE firms have lower power quality (PQ)-related losses, per establishment, than either of the industrial sectors. The F&ES sector seems to be particularly sensitive to PQ phenomena, losing more than $9,600 annually per establishment and accounting for 85 percent of the aggregate losses across all three sectors. Once again, equipment damage seems to play a large role in the costs to industrial facilities.

These data suggest that across *all* business sectors, the U.S. economy is losing between $104 billion and $164 billion a year to outages and another $15 billion to $24 billion to PQ phenomena

California has the highest costs for both outages and PQ phenomena (between $13.2 billion and $20.4 billion), followed by Texas ($8.3 billion to $13.2 billion) and New York ($8.0 billion to $12.6 billion). California's costs are based on a typical year of power disturbances; costs are likely to increase dramatically if the state experiences the level of rolling blackouts predicted for summer 2001. Projections to all business sectors are extrapolations from the survey data based on the assumption that per-establishment costs from outages and PQ phenomena for firms outside the DE and industrial sectors are anywhere from 25 percent to 50 percent as high as the costs reported by these sectors, and are statistically valid as long as this assumption is correct.

Chapter 1 Introduction and Method

Background

As the U.S. economy becomes increasingly dependent on sophisticated information technologies, computer-controlled industrial processes, and digital circuits, the importance of reliable, high-quality electrical power has grown accordingly. The interconnection of communications systems, data networks, and supply and distribution chains gives local power outages national and global consequences.

Moreover, society's growing reliance on digital circuitry has made even brief disruptions of the power supply potentially costly. Many electronic components are seriously disrupted by power outages of less than a second, or by minor voltage fluctuations or other distortions of the electrical signal that in earlier years would have gone virtually unnoticed.

Such power disturbances pose problems not only for dotcoms or Internet hotels, but also for industrial facilities reliant on electrical motors and electronic controls for manufacturing processes. In fact, power disturbances affect everyone who uses digital equipment, including common household devices like televisions and microwaves.

Types of Power Disturbances

We usually associate power outages with power supply problems. But at least two types of power disturbances can create costs for businesses, power outages and power quality (PQ) phenomena.

- **Power outage.** An outage is a complete loss of power at the plug — that is, zero voltage. Outages can last anywhere from a fraction of a second (also known as momentary interruptions) to several hours. Although in the past, most outages were caused by problems in the local electric distribution system, recent events in California are a vivid reminder that outages (i.e., rolling blackouts) can also result from insufficient power supply to a region or transmission constraints.

- **Power quality (PQ) phenomena.** Broadly speaking, power quality is a measure of how well a source of electric power meets the energy-supply needs of connected loads – if the load experiences no operational problems then, by this measure, PQ is adequate. Less subjective measures of PQ note any deviation in amplitude, shape, etc. of voltage and current waveforms from the ideal, and include short duration events – such as voltage sags, surges, and transients – or long-term conditions such as harmonics and phase voltage imbalance.

Power outages can result from faults on the transmission or distribution system, equipment failures, or supply shortages. PQ phenomena can arise from any number of sources including remote faults, lightning, capacitor switching, harmonic resonance, starting of large loads, overloaded or unbalanced equipment, high-impedance connections, poorly designed power conditioning equipment, and poor grounding.

The Cost of Power Disturbance to U.S. Businesses

Power disturbances cause economic losses for businesses in a variety of ways. A power disturbance can disrupt business activities beyond the length of the outage or event because many operations cannot be restarted instantaneously. The resulting downtime means lost production or sales that the business can't always make up later.

Downtime also results in wages paid while workers are idled. And depending on the kind of business, downtime can result in spoiled or damaged materials or inventory. Even brief events can damage electric motors or other equipment, creating significant losses for a business.

The electric utility industry has long been aware that power disturbances can cause economic losses for business customers. Reliable, national data to back up this assertion and quantify the losses, however, have been surprisingly scarce. Various estimates have been published, but all of them either rely on very indirect cost measures or are confined to a particular region or outage event. Most also focus exclusively on longer outages. As a result, they supply no data on the cost of brief outages or PQ phenomena. The result is that a recent review of the outage cost literature,[1] found no studies from which one could reliably extrapolate the overall cost of power disturbances to U.S. business.

[1] Webber, Carrie and Eto, Joe. *Electricity Outage Cost Literature Review* (memo to the CEIDS project team), Berkeley, CA, Lawrence Berkeley National Laboratories, December 2000.

Study Objectives

The Consortium for Electric Infrastructure to Support a Digital Society (CEIDS) commissioned this study to obtain a definitive estimate of the direct costs of power disturbances to U.S. businesses. Rather than extrapolating from anecdotes or studies confined to a single utility service territory or single outage event, the intent was to survey a representative sample of U.S. business customers in key sectors about their costs from outages and PQ phenomena. These data on the cost of power disturbances can then provide a solid foundation for discussions of what actions, if any, utilities and policy makers should take to ensure more reliable, higher-quality power for business.

The study also sought to quantify the cost of brief outages — for example, outages of one second or a couple of minutes long. Most previous studies of outage costs have confined their analysis to longer outages — for example, of one hour or longer — even though shorter outages are more common and can cause data loss and damage to industrial equipment.

Approach to Assessing Costs

Primen's study took a survey-based approach to assessing costs. A statistically representative random sample of 985 business establishments were surveyed concerning the frequency and duration of power outages at their facility and the impact on their business operations. Survey respondents were then given them a series of *outage scenarios*, each describing a hypothetical outage striking their facility at a specific time, for a specific duration, with or without advance warning.

For each outage scenario, survey respondents estimated the costs they would incur from various sources, including idled labor, materials loss, equipment damage, and lost production or sales (net of any "lost" production that would actually be made up later through working overtime, etc.).[2] Respondents were also asked about the frequency and cost of PQ phenomena. Details of the survey and outage scenarios are in Appendix A; the survey instruments are in Appendix B.

These data provided the basis for comparing the net cost of outages as a function of length and advance notification; the annual cost of power outages and power quality phenomena for an individual business, based on how many outages of various lengths they experience; and the aggregate cost of power outages and PQ phenomena to U.S. businesses.

[2] This approach, called *direct costing*, is widely used by utilities, often in the context of regulatory filings, to determine how business customers value power reliability. It contrasts with the other commonly used survey-based approach to assessing outage costs, called *contingent valuation* or *willingness-to-pay (WTP)*. The WTP method, which asks how much a business would pay to avoid an outage, provides data that is more relevant to sizing the market for power-disruption solutions than for estimating the real economic impact of power disruptions.

Industries and Establishments Surveyed

Business establishments were surveyed within the following three broad sectors.

- **Digital economy (DE).** This sector includes businesses that rely heavily on data storage and retrieval, data processing, or research and development operations that are highly sensitive to power disruptions. Industries in this sector include telecommunications; computer programming; data storage and retrieval services, including collocation facilities or Internet hotels; biotechnology; electronics manufacturing; and the finance, insurance, and real estate industries.

- **Continuous process manufacturing (CPM).** This sector includes manufacturing facilities that continuously feed raw materials, often at high temperatures, through an industrial process. Because of the nature of their operations and the materials they are dealing with, these establishments often experience unique problems as a result of power disruptions. Industries in this sector include paper; chemicals; petroleum; rubber and plastic; stone, clay, and glass; and primary metals.

- **Fabrication and essential services (F&ES).** This sector includes all manufacturing industries not included in DE or CPM, plus utilities and transportation facilities whose services are essential to the overall functioning of the economy. The latter include railroads and mass transit, water and wastewater treatment, and gas utilities and pipelines.

The SIC codes for each sector are listed in Appendix C.

These three sectors were chosen both for their unique sensitivities to power disruptions and their importance to the U.S. economy. Although they account for only 17 percent of all business establishments in the U.S., these sectors account for approximately 40 percent of the GDP. Moreover, disruptions in each of these sectors — but especially DE and F&ES — have an almost immediate effect on other sectors that depend on the services they provide.[3]

[3] Costs associated with such cascade effects — for example, the cost to a manufacturing firm if telephone or data communications are interrupted due to an outage affecting a DE firm — are not captured in this study.

These sectors were chosen in part for their sensitivity to power disruptions, based on research previously conducted by the Electric Power Research Institute (EPRI).[4] Therefore, the survey data is only directly relevant to the costs incurred by establishments in these three sectors. It is possible to extrapolate from these costs to estimate the total cost of power outages to all business establishments if one makes an assumption about how much lower, on an establishment basis, the costs for other sectors would be. Such extrapolations, along with a detailed description of the assumptions underlying them, are presented in Chapters 3 and 4.

Table 1-1 shows the distribution of the 985 completed surveys by sector and size. In an effort to oversample larger establishments, establishments in each of the three sectors were sampled according to the number of employees onsite. This allowed for the comparison of outage costs of establishments as a function of size. Because of the way the survey data was weighted for analysis, this overrepresentation of large establishments did not bias any of the overall means presented in the report (see Appendix A for details).

[4] EPRI, *An Assessment of Distribution System Power Quality* (TR 106294, Vol. 1-3), Palo Alto, CA, May 1996.

Table 1-1: Number of business establishments surveyed by sector and size

	Digital Economy	Continuous Process Manufacturing (CPM)	Fabrication & Essential Services (F&ES)	Total
1 to 19 employees	179	166	159	**504**
20 to 249 employees	101	87	101	**289**
250 + employees	62	74	56	**192**
Total	**342**	**327**	**316**	**985**

Chapter 2
Cost of Individual Outages

The cost of an individual outage can vary dramatically from one business to the next, depending on the size of the establishment, the industry it represents, and the processes or end-use technologies it employs. Costs also vary by the duration and other characteristics of the outage. In this chapter, the survey data are used to quantify the impact of these factors on the cost of a single outage event to an individual business establishment.

Outage Costs as a Function of Duration of Outage

Figure 2-1 compares the average cost[5] to an individual business establishment of outages of three different lengths — one second, three minutes, and one hour — and from a combination of brief outages called a *recloser event* consisting of a one-second outage followed, a few seconds later, by another one-second outage.[6]

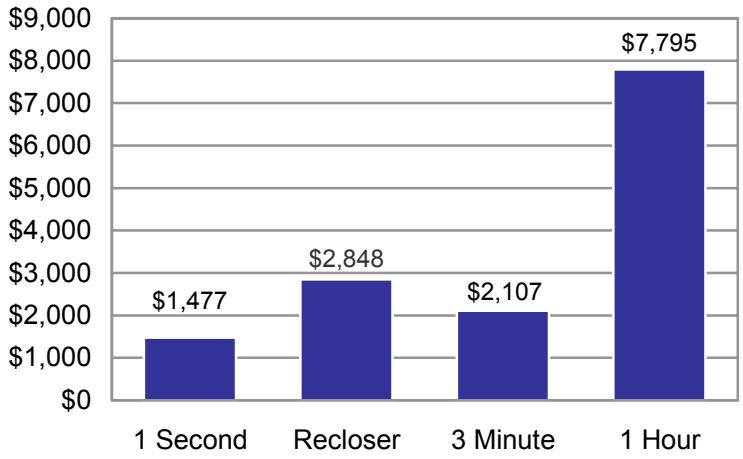
Recloser events are relatively common and result when one or more automated switches in the distribution system try to interrupt an electrical fault by opening, interrupting electrical current, and then quickly reclosing in the hope that the fault will cease or "self-clear." If the fault does not self-clear after two or three switch opening/closing cycles (the recloser event), the reclosers lock open and must be manually reset.

The means shown in Figure 2-1 combine the data from all three of the sectors surveyed.

[5] Unless otherwise specified, all references to outage costs are to *net costs*. Net costs were built up from respondents' estimates of the specific costs they would incur (from lost production/sales, idled labor, etc.) net of any portion of their lost production/sales they would make up later and any savings they thought they would realize such as from sending workers home without pay or from unused materials. See Appendix A for a more on the cost and savings elements used to calculate net cost.

[6] The precise timing and sequence varies by region according to local utility practice.

Figure 2-1: Average cost per outage by duration



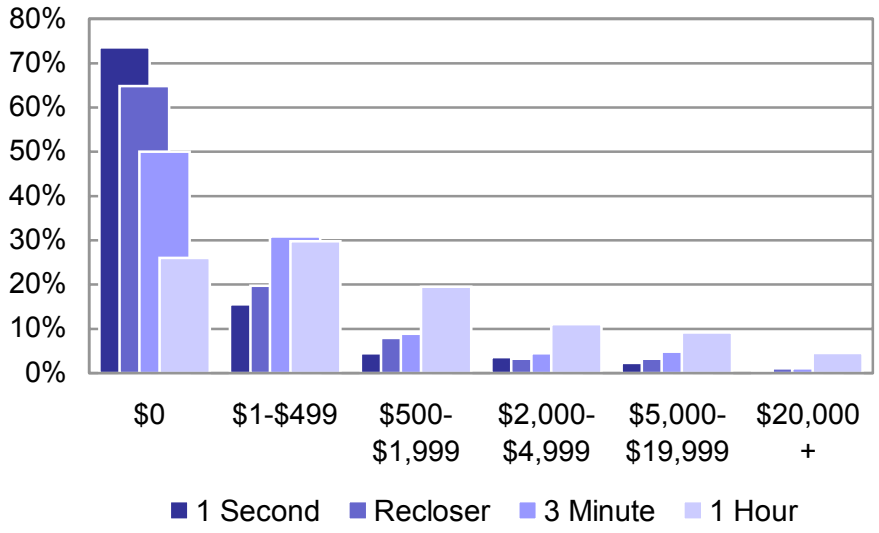
Longer outages create greater costs for businesses, but, as shown in Figure 2-1, the relationship between outage length and cost is far from linear. The average cost of a one-second outage across the three sectors surveyed is $1,477, whereas the average cost of a three-minute outage is somewhat higher at $2,107.

Although the average cost of a one-hour outage is considerably higher at $7,795, the difference between the cost of a one-hour outage and a one-second outage is far less than you would expect if costs accrued evenly from the beginning of an outage until its end. A one- second outage is less than 0.03 percent as long as a one-hour outage, but the *cost* of a one-second outage is almost 20 percent of the cost of a one-hour outage.

Instead, the data shows that an outage of any length, even one-second, creates a substantial loss. Furthermore, the average cost of a recloser event is higher than a simple one-second outage or even a one-minute outage. The implication is that the way many utilities have designed their recloser cycles may be causing more harm than good.

What is not clear from the average costs in Figure 2-1, however, is the tremendous variability in costs across business establishments. Figure 2-2 shows, for the three sectors surveyed, the percentage of all business establishments that experience different levels of costs from each type of outage.

Figure 2-2: Distribution of costs per outage by duration



What is most striking in Figure 2-2 is how many business establishments experience no costs at all from outages. Almost three-quarters (74 percent) of business establishments can ride through a one-second outage with no costs, whereas 65 percent experience no costs from recloser events. Half of all businesses (50 percent) would not suffer measurable costs from a three-minute outage and a quarter (26 percent) would not experience real costs from a one-hour outage. The typical cost of a one-hour outage to most (56 percent) DE, CPM, and F&ES establishments is less than $500.

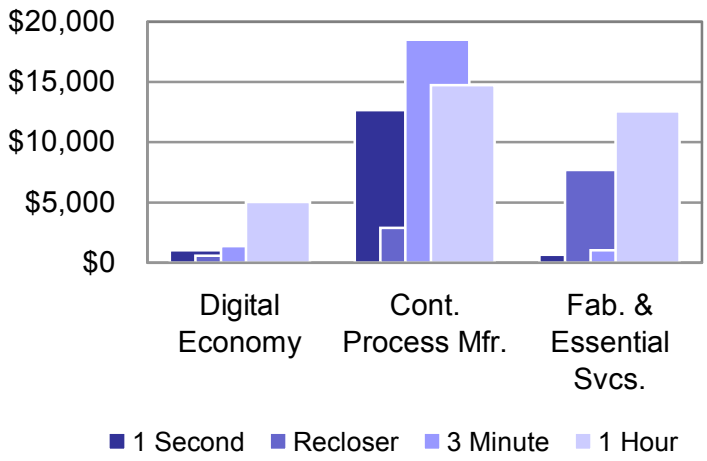
How can the average cost of a one-hour outage be almost $8,000? The answer is that the majority of establishments with relatively small costs are balanced by a small number of establishments with very large costs. Five percent of the establishments in these sectors incur costs from a one-hour outage of $20,000 or more, with costs for individual establishments ranging as high as $1.5 million.[7]

[7] This was not the largest value found in the raw data. Several extremely high-outage cost values were determined to be false outliers and were recoded so they would not artificially inflate the average values reported above. For treatment of questionable large values, see Appendix A.

Outage Costs by Sector and kWh Consumption

Outage costs vary both by the duration of the outage and by sector. Figure 2-3 shows the average cost of each of the four outage types discussed above for each of the three sectors surveyed.

Figure 2-3: Average cost per outage by sector and duration

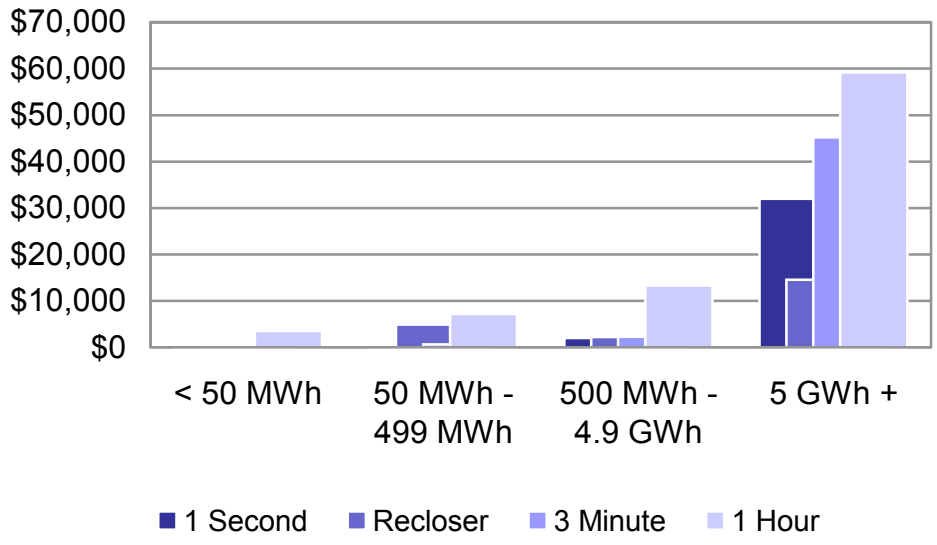


As shown in Figure 2-3, outage costs are highest in the CPM sector for one- second, one-minute, and one-hour outages, with average costs of $12,654, $18,476, and $14,746, respectively. The F&ES sector has the highest costs for recloser events, averaging $7,704. The DE sector has lower outage costs than the other two sectors across the board.

Figure 2-4 charts these same outage costs, this time broken out by annual kWh consumption rather than sector. In terms of power consumption, larger business establishments experience larger costs from outages.

The pattern is most dramatic at the highest end of the scale, with establishments that consume 5 GWh or more annually experiencing very high costs — for example, $32,000 for a one-second outage and more than $59,000 for a one-hour outage. To put this into perspective, the survey data shows that 3 percent of all establishments across these sectors consume 5 GWh or more annually.

Figure 2-4: Average cost per outage by annual kWh and duration

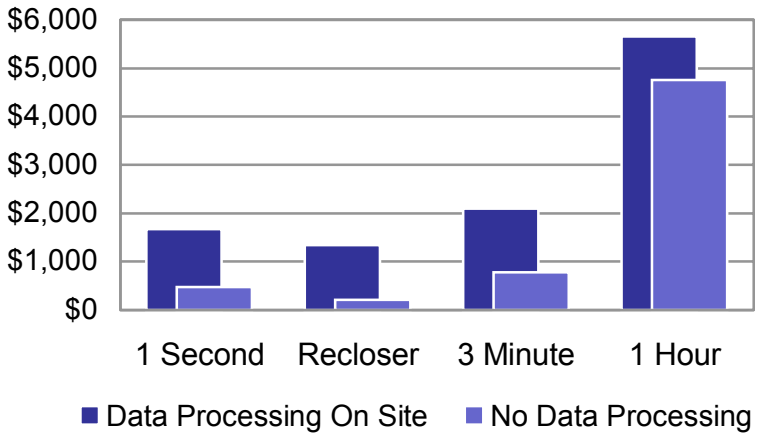


Outage Costs as a Function of Business Activities and Equipment

The logic for assuming that certain sectors, such as those surveyed for this study, have higher outage costs than others is that certain types of industrial equipment or certain business processes are likely to be more costly when disrupted. Where it was possible to capture data on the presence or absence of specific technologies, equipment, or processes among the establishments surveyed, their impact on outage costs was tested.

Figure 2-5, for example, compares the average cost of outages among DE establishments that have a significant data processing operation onsite and DE sites that are not engaged in large-scale data processing.

Figure 2-5: Average cost per outage for DE by data processing and duration

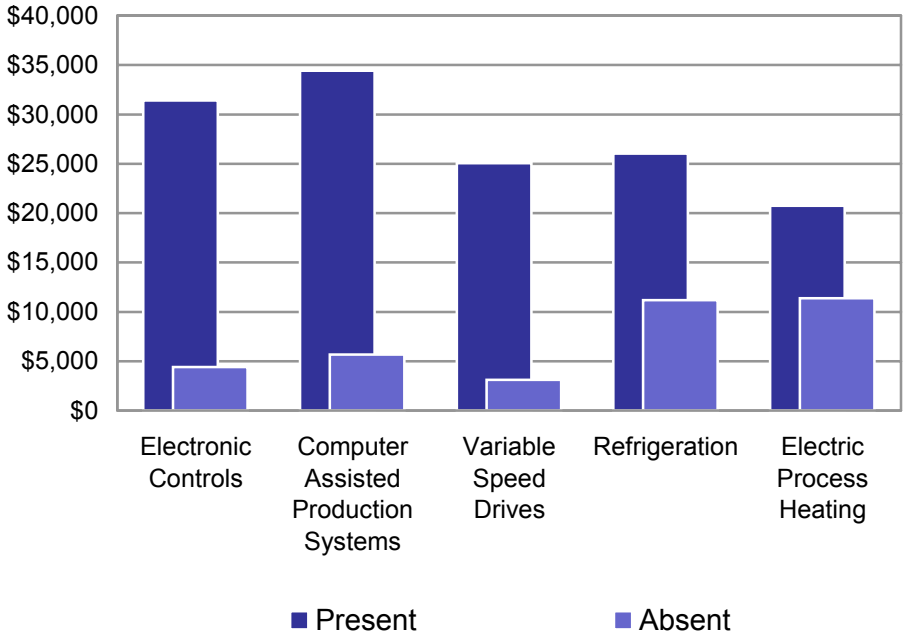


As expected, outage costs are consistently higher for DE establishments engaged in data processing. The difference is especially pronounced for the shortest outages. The cost of a one-second outage is 3.5 times higher for DE establishments with data processing operations than for those without such operations; for recloser events there is a six-fold difference in costs between the two types of establishments.

Figure 2-6 makes similar comparisons for industrial establishments, both CPM and F&ES, with and without a variety of specific equipment and processes.[8] To simplify the presentation, we focus on a single outage type: one-hour. Similar patterns emerge for the other outage types.

[8] Digital economy establishments were excluded from Figure 2-6 due to the low incidence of these types of equipment and processes in the DE sector.

Figure 2-6: Average cost of one-hour outage by selected industrial equipment and processes



Here, the most dramatic cost differentials are for variable speed drives — an eight-fold increase in costs vs. establishments without these devices — although electronic controls and computer-assisted production systems yield similar cost increases.[9]

The Impact of Advance Notice on Outage Costs

In the case of *planned* outages, in which the electric utility knows in advance when a power outage will be and which customers will be affected, the utility can notify business customers that an outage is on the way. In theory, such notification should allow them to change their operations and schedules to minimize the financial impact of the outage.

Historically, a planned outage was benign: an occasional maintenance outage. With the frequent rolling blackouts in California and the threat of potential rolling blackouts in other regions, however, prior notification has taken on new meaning.

In California, the Independent System Operator (ISO) can often provide customers with a warning that rolling blackouts are *possible* the following day. The ISO typically has less advance information about when a rolling blackout will *actually* happen. Realistically, the most

[9] Note that the cost increases associated with different technologies and processes are not additive.

advance notice that the ISO can give customers for an actual rolling blackout is one hour and the available notice is often much less.

But does either form of advance notice — a day's notice that rolling blackouts are likely or an hour's notice that a rolling blackout will occur — really allow businesses to reduce their outage costs? To explore this question, two additional outage scenarios were included in the survey to test the impact of advance notification. The first described a one-hour outage, preceded 24 hours earlier by a notice that rolling blackouts were possible the following day. The second described a one-hour outage, preceded one-hour earlier by a notice that a rolling blackout would occur.[10]

The survey findings show that advance notice can be effective if it is definitive about whether the outage will occur. The average cost for a one-hour outage when the customer was informed an hour before that it would occur was $6,918, vs. a cost of $7,795 for a one-hour outage with no advance notice.

Being told the day before that an outage *might* occur, however, appears to be less helpful and perhaps even counterproductive. The average cost for a one-hour outage in this scenario was $8,173 — slightly *higher* than the cost of a one-hour outage with no notification.

Elements of Outage Costs – Where Does the Money Go?

Table 2-1 breaks out the average net cost of outages of different durations by the individual cost elements that survey participants provided. The table also shows the generally small savings that were subtracted from the total cost to calculate net cost.

[10] Obviously there are other issues beyond whether advance notification is helpful to customers, notably the public safety and security implications of broadcasting that a particular area will be without power at a particular time.

Table 2-1: Average costs and savings per outage by duration

	1 Second	Recloser	3 Minute	1 Hour
Costs	**$1,489**	**$2,848**	**$2,124**	**$8,080**
Net Lost Production[a]	$284	$274	$466	$2,922
Labor	$433	$263	$590	$1,763
Materials Loss or Spoilage	$99	$68	$248	$231
Equipment Damage	$554	$2,011	$500	$576
Backup Generation[b]	$21	$64	$89	$449
Overhead	$33	$49	$101	$364
Other Restart Costs	$60	$46	$121	$1,457
Misc.	$5	$73	$9	$318
Savings	**$12**	**$0**	**$17**	**$285**
Unused Materials	$10	$0	$14	$263
Savings on Energy Bill	$2	$0	$2	$16
Unpaid Labor	$0	$0	$1	$6
Net Cost	**$1,477**	**$2,848**	**$2,107**	**$7,795**

[a]Or net lost sales

[b]Includes cost to run and / or rent backup generation

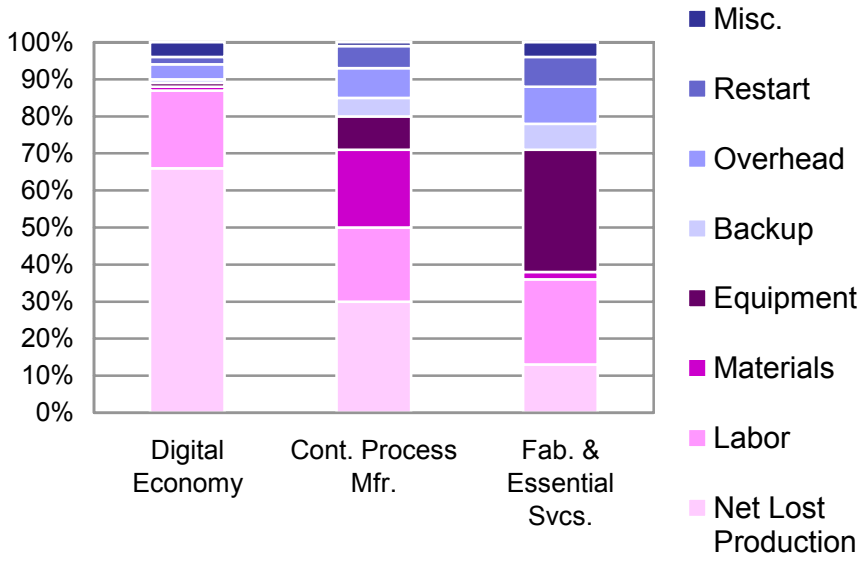
Table 2-1 shows the surprisingly high average cost of recloser events. Most of the cost for a recloser event comes from damage to the customer's equipment, presumably from the strain of stopping and restarting so quickly.

Table 2-1 also reveals that the primary cost differences between a longer (one-hour) outage and a brief outage arise from lost production or sales, idled labor, and costs of restarting operations after a significant amount of downtime.

At first glance, some of the losses in Table 2-1 may seem out of proportion to the length of the outage. How is it possible, for example, that a one-second outage can yield measurable losses in production? The answer is that the disruption of a business's operations don't end the instant power is restored.

Instead, the businesses surveyed for this study indicated that a one-second outage creates, on average, almost 9 minutes of downtime for their operations (8.9 minutes). Recloser events and three-minute outages disrupt operations for almost 14 minutes (13.6 minutes and 13.7 minutes, respectively), and a one-hour outage disrupts operations for 71.6 minutes on average.

Figure 2-7: Breakdown of costs for a one-hour outage by sector



The three sectors surveyed also differ in the types of outage costs they experience. Figure 2-7 shows the difference for a one-hour outage. The DE sector, which has the lowest net cost for a one-hour outage ($5,053), incurs most of its costs from lost production / sales and labor costs.

In contrast, CPM establishments, which have the highest net cost for a one-hour outage ($14,746), experience significant costs from raw materials loss, as well as some equipment damage. The F&ES sector, which also has a relatively high net cost of $12,562 for a one-hour outage, shows yet a third pattern: high losses from equipment damage but virtually no loss of raw materials.

Chapter 3
Aggregate Cost of Power Outages

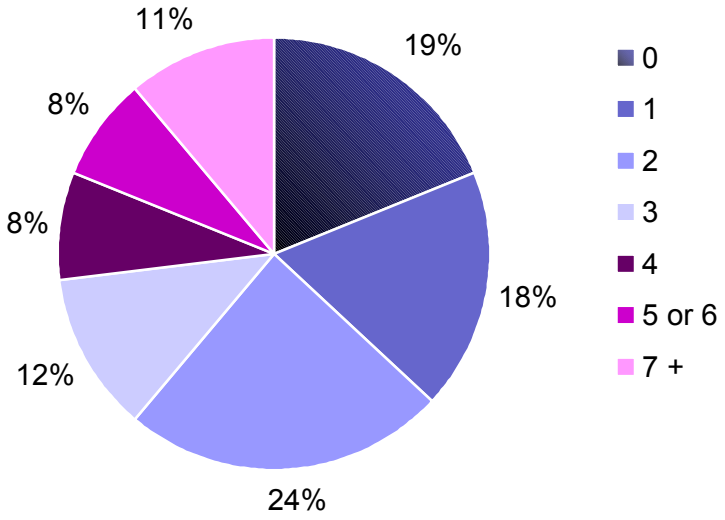
Understanding the costs to business establishments of individual power outages and how these costs vary provides significant insights into how power reliability affects business operations. To understand the overall impact of power outages on U.S. businesses, one needs to know the cumulative cost of all outages experienced by businesses in a typical year. This chapter addresses this key question, using businesses' self-reports of annual outages to calculate the annual cost of power outages for each of the sectors surveyed and, by extrapolation, for all U.S. businesses.

Frequency and Duration of Power Outages

Survey respondents reported an average of 3.9 power outages in a typical year.[11] Once again, there was substantial variability around this number, as shown in Figure 3-1. Most businesses said they experience fewer than three outages a year, with 19 percent typically having *no* power outages. At the other extreme, 11 percent report seven or more outages per year.

[11] Interestingly, the businesses surveyed reported the same number on average when asked how many outages they had experienced in the past 12 months (3.9).

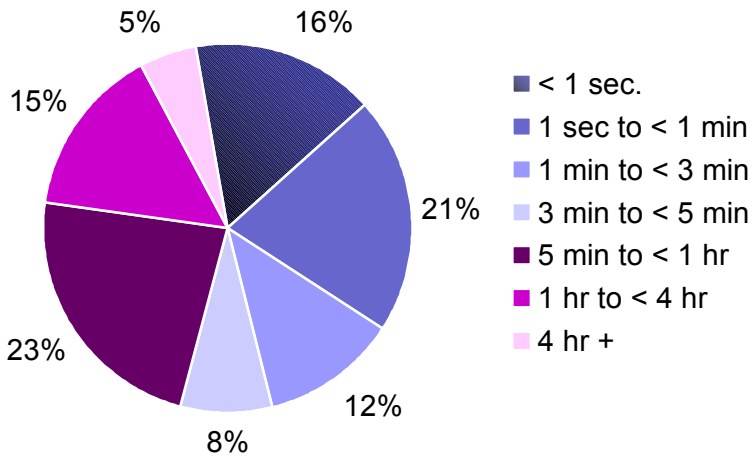
Figure 3-1: Percent of establishments by number of outages in a typical year (Avg. = 3.9)



The survey results also showed that almost half of the outages experienced by these sectors (49 percent) are less than 3 minutes long (Figure 3-2). Outages of 1 hour or more account for only 20 percent of the outages experienced by these sectors.

This point is worth noting because brief outages are often not recorded in the "official" outage statistics maintained by utilities and public utility commissions. In California, for example, utilities are not required to report to the Public Utility Commission outages of less than 3 minutes.

Figure 3-2: Average length of outages in a typical year



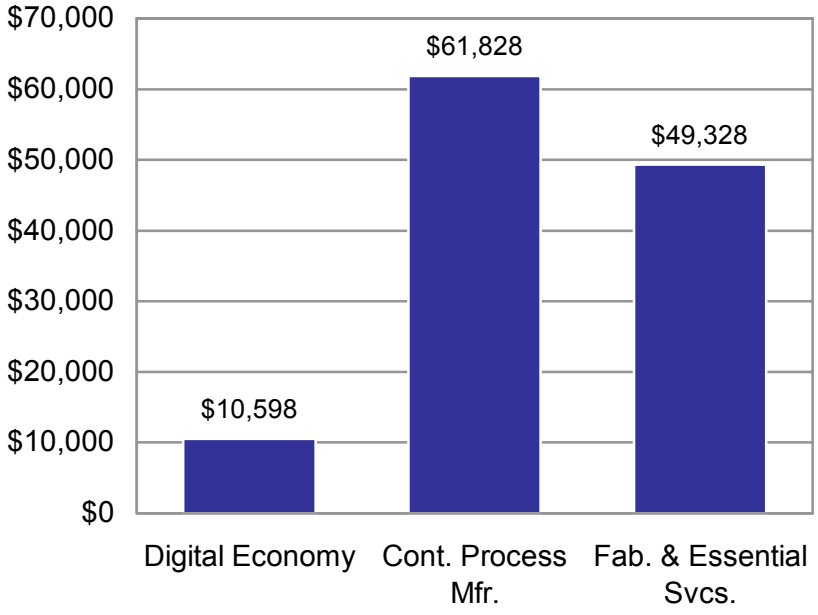
Annual Losses from Power Outages for Individual Establishments

Learning how many outages of various lengths survey respondents experience in a typical year and the costs from outages of varying lengths allowed us to calculate the total annual cost of outages for each establishment.[12] On average across all three sectors, the typical business establishment incurs losses of $23,318 a year from outages.

Figure 3-3 shows how the average annual cost of power outages to an individual establishment varies by sector. Again, the DE sector has the lowest costs per establishment ($10,598) and the CPM sector has the highest ($61,828).

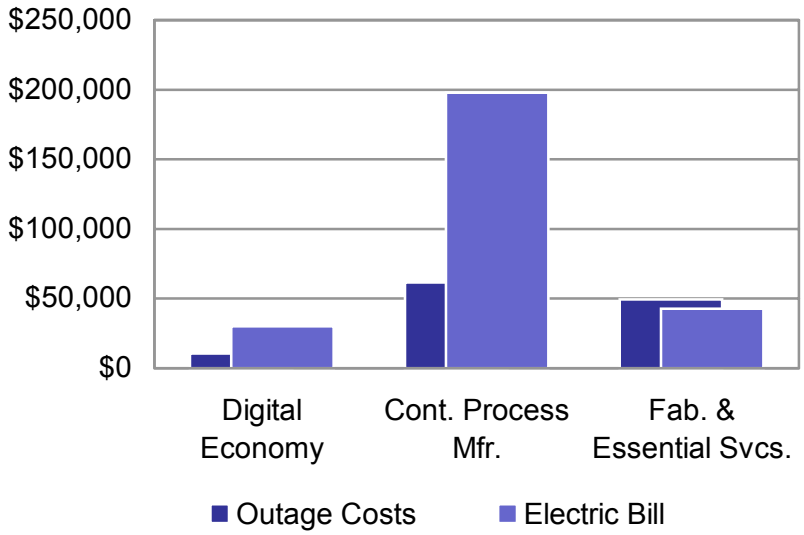
[12] Because the survey did not capture cost data for all possible outage lengths, the costs for some lengths were interpolated from the existing data. See Appendix A for details.

Figure 3-3: Average annual per-establishment cost of outages by sector (avg. across sectors = $23,318)



One way to put these costs in perspective is by comparing them to the amount of money each sector spends on electricity. Figure 3-4 contrasts the average annual cost of power outages per establishment with the estimated annual electric bill for each sector.

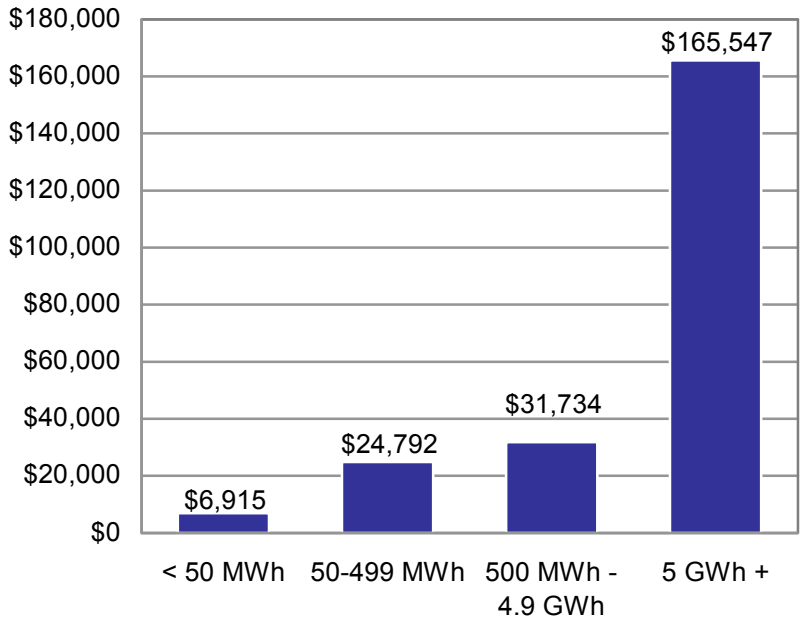
Figure 3-4: Average annual per-establishment cost of outages vs. average annual electric bill by sector



For establishments in both the DE and CPM sectors, the annual cost from power outages is roughly one-third the size of their annual electric bill (35 percent and 31 percent, respectively). In the F&ES sector, however, the annual cost for a given establishment from power outages is actually greater than the average annual electric bill.

Finally, Figure 3-5 charts the average annual cost of power outages per establishment by annual kWh consumption. Annual costs increase with size but don't become dramatically higher until consumption reaches the 5-GWh level.

Figure 3-5: Average annual per-establishment cost of outages by annual kWh (avg. across sectors = $23,318)



Aggregate Annual Cost of Power Outages

The DE, CPM, and FE&S sectors collectively represent just under 2 million business establishments in the U.S. With an average annual loss of $23,318 per establishment, these industries are losing $45.7 billion a year as a result of outages.

As shown in Figure 3-6, the majority of these losses, $29.2 billion, occur within the FE&S sector. Although CPM firms have the highest losses per establishment, there are far fewer of these establishments than DE or F&ES establishments, resulting in aggregate losses of only $5.9 billion.

Figure 3-6: Aggregate annual cost of outages by sector (total across sectors = $45.7 billion)

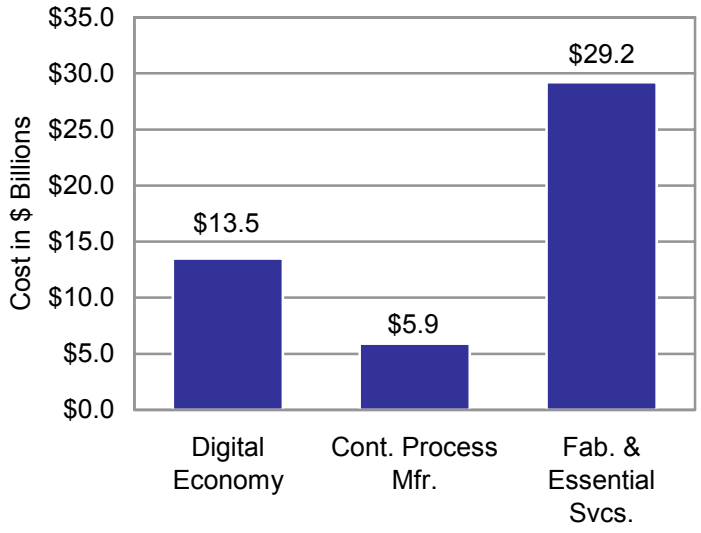
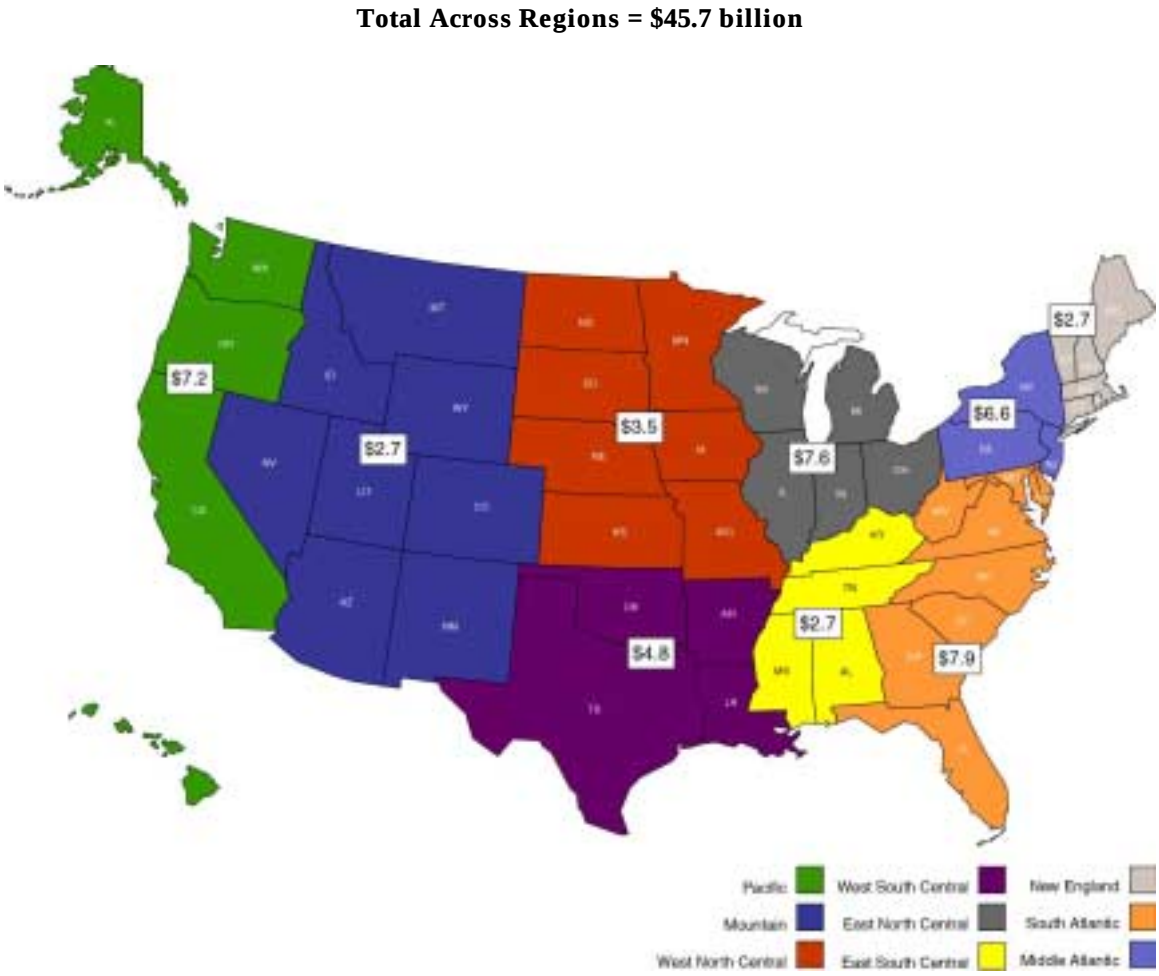


Figure 3-7 shows how the aggregate annual outage costs for these three sectors distribute across census regions.[13] The South Atlantic region has the highest costs for these sectors at $7.9 billion, closely followed by the East North Central and Pacific regions, with $7.6 billion and $7.2 billion respectively. In general, the regions with the highest costs are those with the highest populations (and hence the greatest number of business establishments) and those with the highest proportions of industrial facilities.

[13] The survey sample was not large enough to estimate regional or state level costs directly. Instead, the number of establishments in each region in each sector and size range, and the average cost per establishment by sector and size were used to estimate regional and state level costs. This approach takes into account that a given region may have a higher proportion of DE firms and a lower proportion of CPM firms, say, than another region.

Figure 3-7: Aggregate annual cost of outages by region ($billions)



Cost of Outages Across All U.S. Businesses

The costs reported so far accurately reflect the losses from outages suffered by the three sectors surveyed but don't provide a direct estimate of the cost of power outages across all U.S. businesses. To obtain such an estimate, one must extrapolate from the average annual cost per establishment for the industries surveyed ($23,318) to the average annual cost per establishment for those industries that were *not* surveyed.

This number can then be multiplied by the number of U.S. business establishments not sampled, roughly 10 million, to get the total annual cost of power outages across all businesses

not included in the survey. This value, added to the $45.7 billion annual loss for the three sectors surveyed, provides an estimate of the total cost of power outages to U.S. businesses.

To make the extrapolation, one must start with the assumption that the average annual cost per establishment for industries not surveyed is *lower* than the $23,318 value observed for DE and CPM customers. This assumption is reasonable since these three sectors were chosen in part because they are particularly sensitive to power disturbances and so should have higher costs.

The question is: how much lower would the per-establishment cost be? A fairly conservative estimate would put the per-establishment cost of outages for these other industries at somewhere between 25 percent and 50 percent of the per-establishment cost for industries surveyed — that is, between $5,830 and $11,659. Multiplying these values by the number of establishments these industries represent and adding in the $45.7 billion annual loss for the three sectors surveyed gives an estimated annual cost of power outages across all sectors of between $104 billion and $164 billion.

Figure 3-8 shows the estimated range of annual power outage costs for all sectors of the U.S. economy by region. The rank ordering of regions by costs is virtually identical to the order in Figure 3-7; minor exceptions are driven by some regions having a higher proportion of industries in the sectors that were not included in the survey — that is, lower-cost sectors. The South Atlantic region has the greatest total losses from power outages across all businesses: between $18.3 billion and $28.7 billion per year).

Figure 3-8: Estimated annual cost of outages for all business sectors by region ($billions)

Total Across Regions = $104 billion to $164 billion

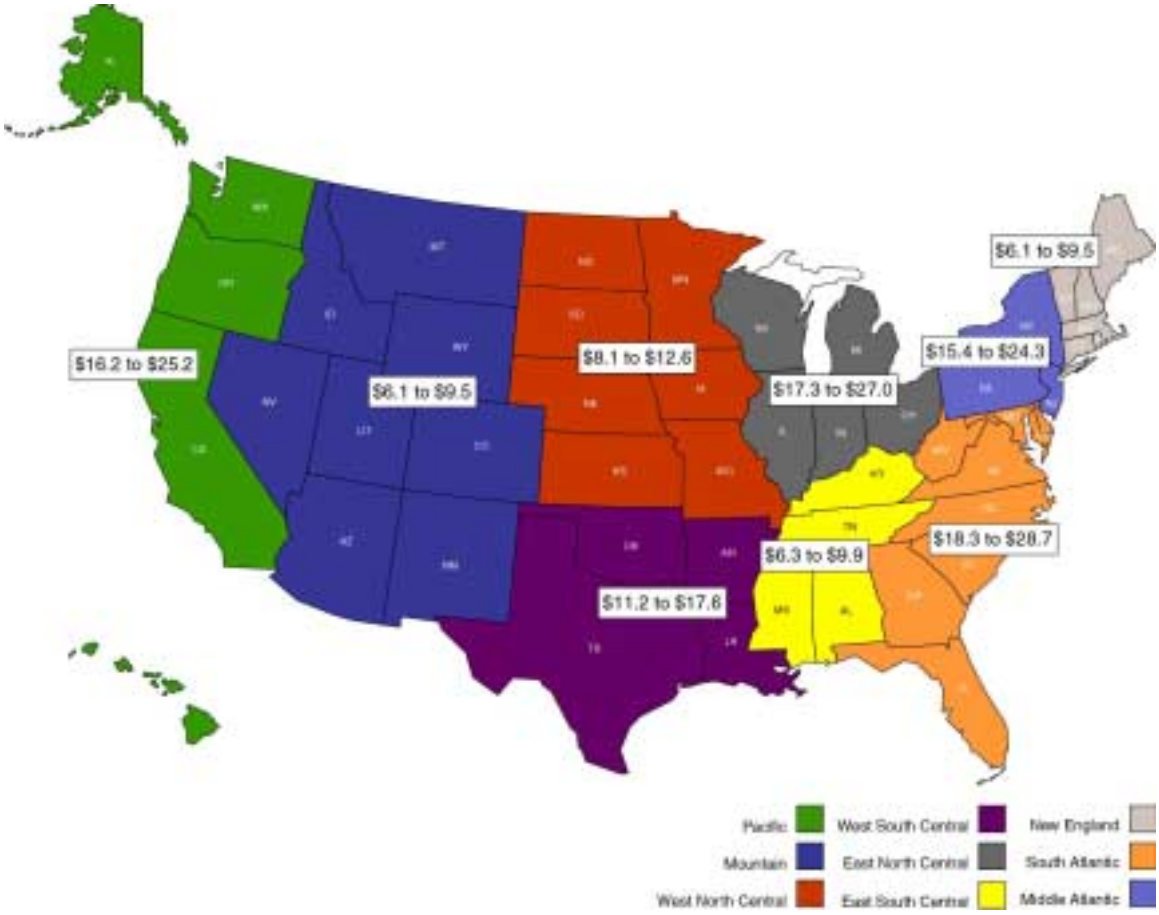


Table 3-1 lists the 10 states with the highest total outage costs.[14] California has the highest costs by far, with average annual losses of $5.2 billion for the DE, CPM, and F&ES sectors, and estimated losses across all business sectors of between $11.5 billion and $17.8 billion a year.

Note that these losses are for a *typical* year and do not address the question of how much California businesses stand to lose from the rash of rolling blackouts predicted for the summer of 2001. This issue is discussed in the next section.

[14] A similar table showing all 50 states is in Appendix D.

Table 3-1: Top 10 states with the highest annual outage costs ($millions)

State	Aggregate Annual Outage Costs for Sectors Surveyed ($millions)	Estimated Annual Outage Costs for All Sectors	
		Low Estimate ($millions)	High Estimate ($millions)
CA	$5,170	$11,489	$17,808
TX	3,124	7,339	11,553
NY	2,983	6,932	10,881
FL	2,297	5,265	8,233
PA	2,087	4,948	7,810
IL	2,015	4,499	6,983
OH	1,910	4,348	6,787
MI	1,559	3,765	5,971
NJ	1,482	3,522	5,562
NC	1,427	3,247	5,067

California and the Cost of Rolling Blackouts

The North American Electric Reliability Council (NERC), in its 2001 Summer Special Assessment,[15] forecast 260 hours of forced outages (rolling blackouts) for California during the summer of 2001, with an average of 2,160 MW unserved in each instance or 4.5 percent of peak demand.[16] If one assumes that these outages will be randomly spread across the customer base and uses the average cost of a one-hour outage from the current survey, then 260 hours of rolling blackouts would cost California's DE, CPM, and F&ES industries an additional $18.8 billion.

This is in addition to the $5.2 billion these industries would already lose in California during a typical year. Thus these sectors stand to lose as much in three months this summer as they would typically lose in 3.5 years.

[15] North American Electric Reliability Council, *2001 Summer Special Assessment: Reliability of the Bulk Electricity Supply in North America*, Princeton, NJ, May 2001.

[16] California's peak summer demand will be 47,703 MW according to the NERC report (*Ibid*).

Extrapolating from the survey data to all business sectors in California as described above yields a total cost to California businesses from 260 hours of rolling blackouts of between $46.3 billion and $71.7 billion. Once again, this is in addition to the estimated cost of $11.5 billion to $17.8 billion that California businesses would lose to outages in a typical year.

Additional Outage Costs Not Included in This Model

As large as these numbers are, they reflect only the direct costs of outages to the individual businesses that experience them. They do not include the cost of PQ phenomena, discussed in the next chapter. They also do not include any secondary costs incurred by one business as a result of an outage that occurs at another company's location.

As noted in Chapter 1, delays in production or shipments, or interruptions in service, particularly among DE firms, can easily impose costs on other firms that rely on those shipments or services to maintain their own business schedules. These costs can't be readily estimated using survey methods, however, and are not addressed in this study.

Finally, the costs discussed above do not include the money that firms have already invested in products and services designed to avoid or mitigate the effects of outages. One reason that the cost of individual outage events is low for many customers, as discussed in Chapter 2, is that they may have installed uninterruptible power supplies (UPSs) on critical systems.

In fact, all the DE and industrial establishments surveyed reported having at least one UPS installed. Eighty-seven percent reported using surge protectors[17] in addition to UPSs, 13 percent had backup generators, and two percent had installed cogeneration systems to deal with power reliability or power quality concerns.

Investments in these systems, although they can rarely be linked to a specific outage or PQ phenomenon, are costs that businesses have incurred over time because of power disturbances. And these costs, in aggregate, are not trivial.

The average establishment in the survey reported having invested $1,300 in equipment to mitigate against outages or PQ phenomena. This means that the DE, CPM, and F&ES sectors have collectively spent more than $2.5 billion on these solutions.

[17] Surge protectors mitigate against power quality events, not outages. Because available technologies such as UPSs mitigate against both outages and PQ phenomena, the two were not distinguished in this context.

Chapter 4
Cost of Power Quality Phenomena

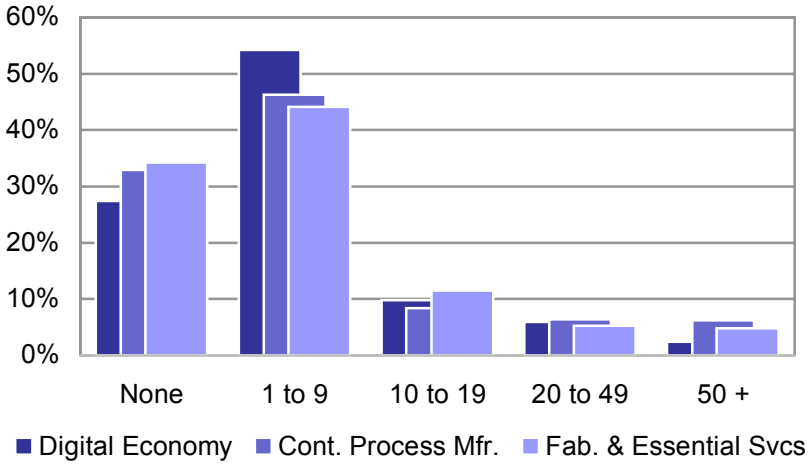
Power quality is a more elusive concept for most business customers than power reliability. Outages are typically easy to spot, whereas PQ phenomena are often detected only by their symptoms — flickering lights, excessive equipment heating and failure rates, computer or controller malfunctions, etc.

Because of this, even businesses that are relatively sophisticated about energy may not be as knowledgeable about how PQ phenomena affect their operations as they are about how outages affect their operations. Nevertheless, business customers' perceptions of PQ phenomena can provide at least a rough estimate — or underestimate — of their financial impact.

Businesses' Experience of PQ Phenomena

As with outages, there is substantial variability in the number of PQ problems businesses report in a typical year. Although 30 percent report no PQ problems, 20 percent report 10 or more and 2 percent report 100 or more. As shown in Figure 4-1, the reported frequency of power quality problems is relatively constant across sectors.

Figure 4-1: Number of PQ problems by sector



Although survey respondents estimated the number of PQ problems they experience in a typical year in ranges — for example, zero, 1 to 4, 5 to 9 — one can derive an average number of events by using the midpoint of each range.[18] Using this approach, the average DE or industrial customer is aware of 8.3 PQ problems per year.

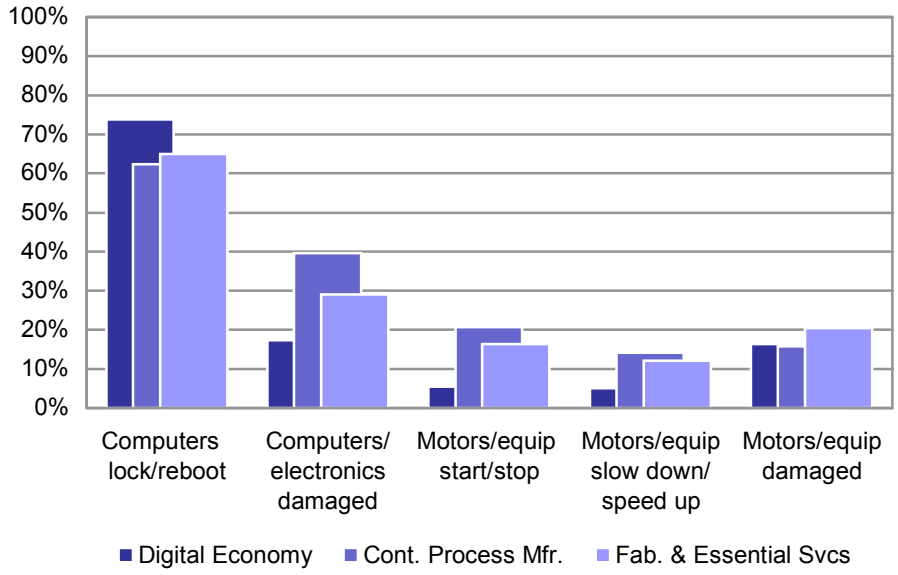
As expected, the most commonly reported symptoms of PQ problems among those who had experienced them were lights flickering (93 percent), and power strips or circuit breakers tripping (100 percent). Other common results included computers locking up or restarting (71 percent) and employees getting shocks when touching equipment (34 percent).

Figure 4-2 shows the percentage of establishments reporting certain effects of PQ phenomena by sector. As expected, computers locking up or restarting is most common in the DE sector, but damage to computers or electronics is more common in the CPM and F&ES sectors (presumably damage to electronic controls).

Damage to motors or other equipment is slightly more common among F&ES establishments, whereas abnormal electrical motor behavior (spontaneous stopping, speeding up, or slowing down) occurs more often among CPM establishments.

[18] For the highest range, 100 or more, a value of 100 was used. This yields a conservative estimate of the true mean.

Figure 4-2: Percent of establishments with problems from PQ phenomena by sector



The Cost of Power Quality Phenomena

Annual Costs per Establishment

On average, establishments in the three sectors report annual losses from PQ problems of $3,406.[19] As with outage costs, the average annual cost of PQ problems varies considerably across establishments. In fact, serious losses from PQ problems seem to be confined to a relatively small proportion of the firms in these sectors: 69 percent of all establishments in the DE, CPM, and F&ES sectors report no costs associated with PQ problems in a typical year.

For a handful of large and highly sensitive establishments, however, losses from PQ phenomena are significant. One percent of the establishments in these sectors experience annual losses of $20,000 or more from PQ problems, and one establishment reported losses as high as $3 million.[20]

[19] No attempt was made to break this down by type of PQ phenomenon or cost because most respondents would be unable to make these distinctions.

[20] This facility is a large fabrication plant engaged in specialized millwork producing wood products covered with metal or plastic. It has an annual power consumption of 30 GWh, runs 24/7, and experiences more than 100 PQ problems per year, which cause damage to computers, motors, and dynamic brakes.

Figure 4-3 shows how the average annual cost of PQ problems varies by sector. The F&ES sector has the highest costs by far, with an average loss of $9,643 per year. The lowest costs, surprisingly, are in the DE sector. This suggests that damage to industrial equipment from PQ problems is typically greater than the cost of damage to computers or lost productivity that a DE firm might suffer.

Figure 4-3: Average annual per-establishment cost of PQ problems by sector (avg. across sectors = $3,406)

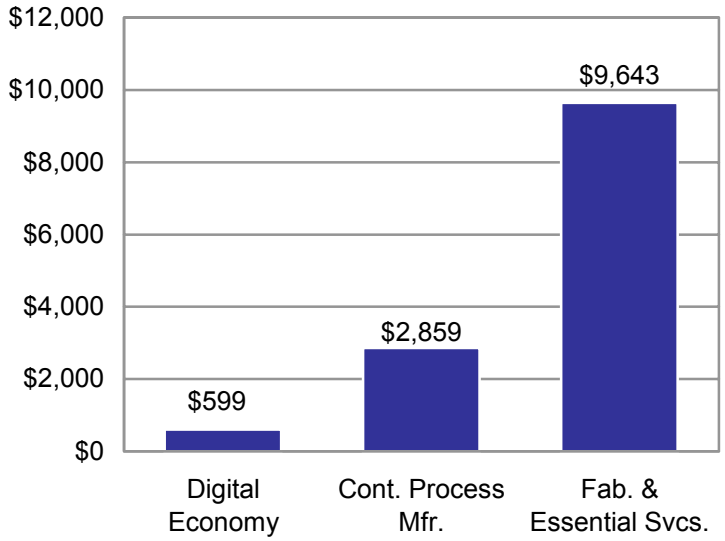
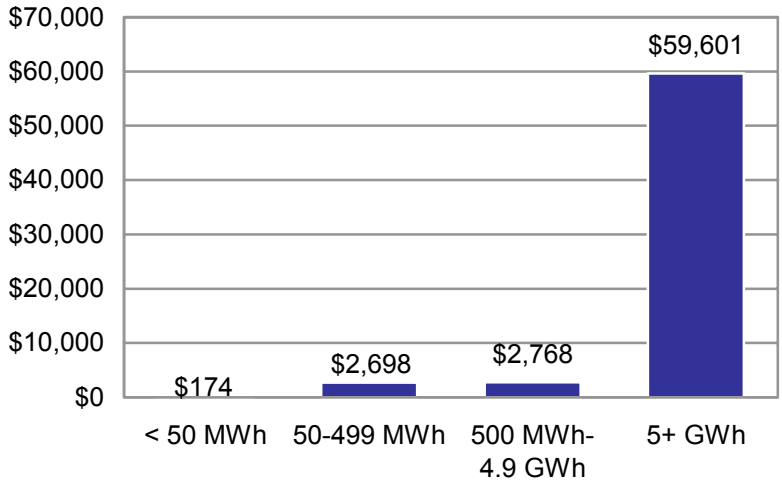


Figure 4-4 underscores the link between PQ costs and the size of the establishment. Costs increase at the 50-MWh threshold and even more dramatically at the 5- GWh level.

Figure 4-4: Average annual per-establishment cost of PQ problems by annual kWh (avg. across sectors = $3,406)



Aggregate Costs Across All Establishments

With an average annual loss of $3,406 from PQ problems, the establishments in these three sectors collectively lose $6.7 billion a year to power quality. As shown in Figure 4-5, the F&ES sector accounts for the majority of these costs. The DE sector has larger annual losses than CPM firms, even though its per-establishment costs are lower. This is because of the greater number of DE establishments vs. CPM establishments.

Figure 4-5: Aggregate annual cost of PQ problems by sector (total across sectors = $6.7 billion)

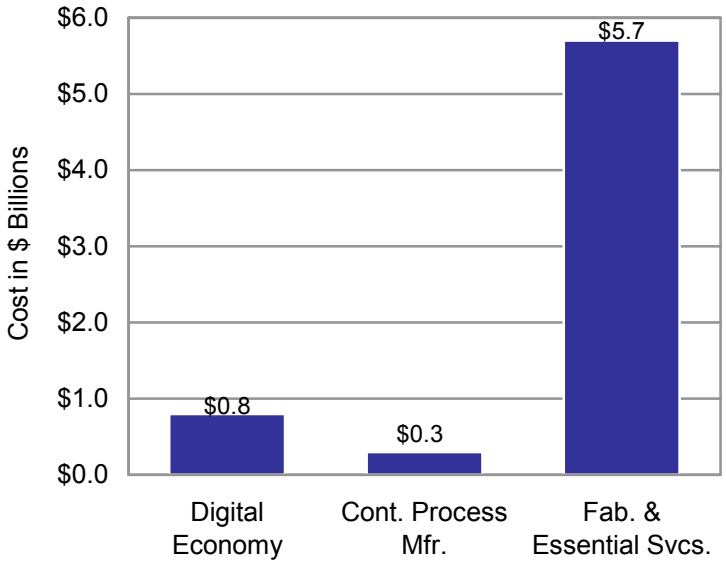
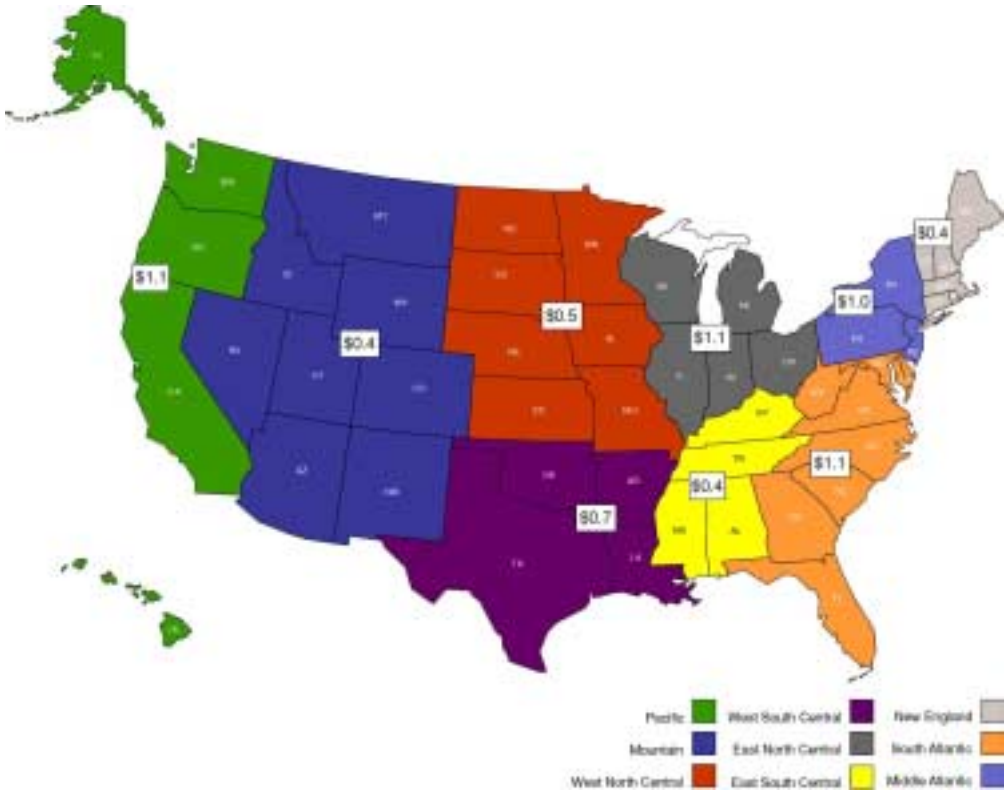


Figure 4-6 shows how the aggregate annual PQ costs for the three sectors distribute across census regions.[21] The South Atlantic, East North Central, and Pacific regions have the highest costs for these sectors at $1.1 Billion a piece. These are the same three regions that had the highest outage costs as seen in Chapter 3. In general, the regions with the highest costs are those with the highest populations (and hence the greatest number of business establishments) and those with the highest proportions of F&ES facilities.

Figure 4-6: Aggregate annual cost of PQ problems by region ($billions)

Total Across Regions = $6.7 billion

[21] The survey sample was not large enough to estimate regional or state level costs directly. Instead, the number of establishments in each region in each sector and size range and the average cost per establishment by sector and size were used to estimate regional and state level costs. This approach takes account of the fact that a given region may have a higher proportion of digital economy firms and a lower proportion of continuous process manufacturing firms (for example) than another region.



The costs reported so far accurately reflect the losses from PQ problems suffered by the three sectors surveyed but don't provide a direct estimate of the cost of PQ problems across all U.S. businesses. To estimate these, one must extrapolate from the average annual cost per establishment for the industries surveyed ($3,406) to the average annual cost per establishment for those industries that were *not* surveyed as was done with outage costs in Chapter 3.

One then multiplies this number by the number of U.S. business establishments not sampled (roughly 10 million) to get the total annual cost of power quality problems across all businesses that were not included in the survey. This value, added to the $6.7 billion annual loss for the three sectors surveyed, provides an estimate of the total cost of power quality problems to U.S. businesses.

In making this extrapolation, we started, as we did for outage costs, with the assumption that the average annual cost per establishment for industries not surveyed will be *lower* than the $3,406 value observed for digital economy and industrial customers. This assumption is reasonable because these three sectors were chosen for the survey in part because they are particularly sensitive to power problems and so should have higher costs.

The question is: how much lower would the per-establishment cost be? A fairly conservative estimate would put the per-establishment cost of PQ problems for these other industries at somewhere between 25 percent and 50 percent of the per-establishment cost for industries surveyed (between $852 and $1,703). Multiplying these values by the number of establishments these industries represent and adding in the $6.7 billion annual loss for the three sectors surveyed gives an estimated annual cost of PQ problems across all sectors of between $15 billion and $24 billion.

Figure 4-7 shows the estimated range of annual PQ problems costs for all sectors of the U.S. economy by region. The rank ordering of regions by costs is virtually identical to the order observed in Figure 4-6; minor exceptions are driven by some regions having a higher proportion of industries in the sectors that were not included in the survey (lower-cost sectors). The South Atlantic region has the greatest total losses from PQ problems across all businesses (between $2.6 billion and $4.1 billion per year).

Figure 4-7: Estimated annual cost of PQ problems for all business sectors by region ($billions)

Total Across Regions = $15 billion to $24 billion

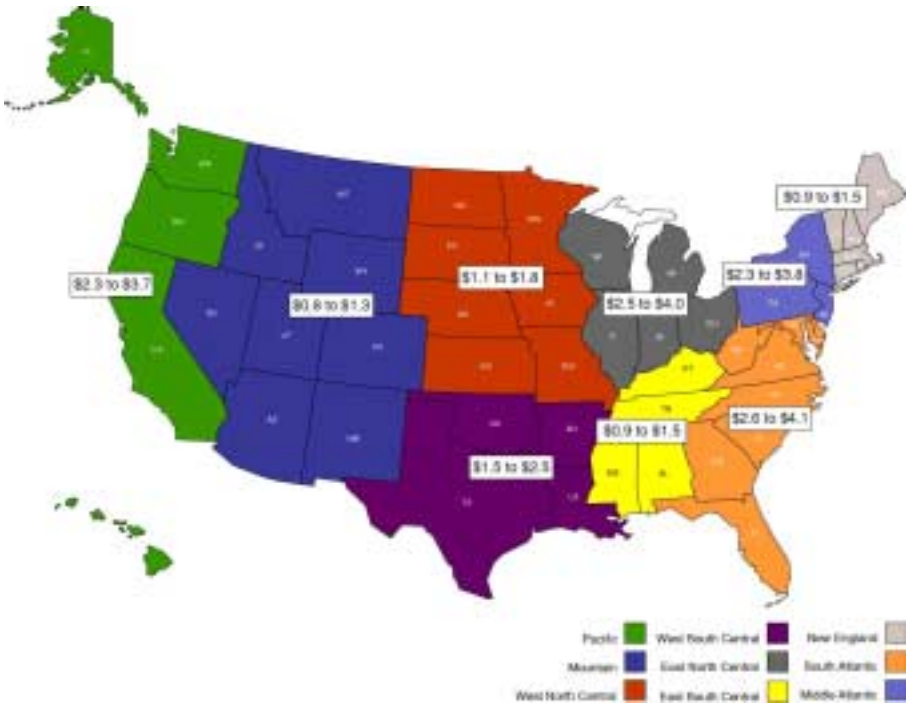


Table 4-1 lists the 10 states with the highest total PQ problems costs.[22] California has the highest costs by far, with average annual losses of $766 million for the DE, CPM, and F&ES sectors, and estimated losses across all business sectors of between $1.7 billion and $2.6 billion a year.

Table 4-1: Top 10 states with highest annual PQ problem costs ($millions)

State	Aggregate Annual PQ Costs for Sectors Surveyed ($millions)	Estimated Annual PQ Costs for All Sectors	
		Low Estimate ($millions)	High Estimate ($millions)
CA	$766	$1,659	$2,630
NY	470	1,066	1,710
TX	431	986	1,587
PA	321	741	1,196
FL	318	710	1,135
IL	298	649	1,029
OH	269	598	954
MI	235	552	895
NJ	228	527	852
NC	224	498	794

[22] A similar table showing all 50 states is found in Appendix D.

Appendix A
Survey Methodology

Survey Development

The CEIDS survey was designed to achieve the following objectives:

- Quantify the costs incurred by business customers due to power quality and reliability problems.
- Examine differential effects of power quality and reliability across distinct business segments.
- Examine broader economic implications encompassing all businesses sectors.

Outage Scenarios

The effects of power outages vary based on several factors. The survey examined the effects of six specific outage scenarios.[23] These scenarios vary in length and in prior notification of the outage:

Scenario	Length of Outage	Prior Outage Notification
1	1 second	None
2	3 minutes	None
3	1 Hour	24 hour notice of possible outages
4	1 second, followed by another 1 second two seconds later (recloser)	None
5	1 hour	None
6	1 hour	1 hour notice outage will occur

[23] For all scenarios, the outage(s) occurred during the summer at 2:00 p.m.

Two versions (A & B) of the survey were constructed, each containing three outage scenarios:

Version A	Version B
1 second, No notification	1 sec recloser, No notification
3 minutes, No notification	1 hour, no notification
1 hour, 24 hr notification of possible outages	1 hour, 1 hour notice outage will occur

The scenarios contained within each survey version remained constant. However, the sequence of the scenarios (e.g., 1,2,3; 2,3,1; 3,1,2; etc) was randomized to eliminate potential ordering effects[24].

Assessment of Impact

For each scenario, several measures of outage impact were assessed:

- Slow down of activities
- Lost Production
- Costs
- Savings

In addition to specific outage costs, issues relating to power quality (PQ) phenomena were also assessed. Specifically, respondents were asked about the number, impact, and overall costs incurred due to power quality problems.

[24] References to Version A and Version B implicitly include all respective rotations of the outage cost scenarios.

Finally, to provide a framework in which to interpret outage and power quality costs, background information on business establishments was collected:

- Annual Revenue
- Operating Expenses
- Hours of operation
- Investments in mitigating technologies

Sample Plan

The sample plan targeted one thousand survey completes from a representative sampled of identified SIC codes (see Appendix C for list of sampled SIC codes):

- Digital Economy
  - Telecom
  - Computer programming
  - Data storage and retrieval
  - Biotech
  - Electronics manufacturing
  - Finance, Insurance, and Real Estate
- Continuous Process Manufacturing
  - Paper
  - Chemicals
  - Petroleum
  - Rubber & plastic
  - Stone, clay, glass
  - Primary metals

- Fabrication and Essential Services
    - Railroads & mass transit
    - Water and wastewater
    - Gas utilities & pipelines
    - All manufacturing not included in CPM

Within each of these sectors, establishments were classified into three size categories based on the number of employees, resulting in nine segments (3 X 3) overall:

- Small: 1 to 19 employees
- Medium: 20 to 249 employees
- Large: 250+ employees

Population counts for all segments were obtained from Dunn & Bradstreet. From these population counts, the following sample plan was constructed:

	Sector			
Size of Establishment (# Employees)	**Digital Economy**	**Continuous Process Manufacturing**	**Fabrication and Essential Services**	**Total**
1 to 19	166	167	167	500
20 to 249	100	100	100	300
250+	67	66	67	200
Total	**333**	**333**	**334**	**1000**

Establishments were sampled equally across sectors. Large establishments were over-sampled relative to their prevalence in the population.

The logic of focusing on a few key sectors, rather than all businesses, was to provide a large enough sample in each sector that one could do meaningful analysis by SIC and size. SIC codes were selected to achieve the following objectives:

- Capture those businesses most likely to have significant losses from power outages and power quality phenomena
- Account for a significant proportion of the overall GDP (40 percent)

Data Collection

Respondent recruitment began on February 6, 2001. Data collection was completed by April 17, 2001. One thousand surveys were to be completed across all nine segments.

Respondents were originally recruited through a phone screener questionnaire. The screener determined respondents' eligibility to take part in the study. Eligible participants were invited to participate in the Power Reliability and Quality Survey via either mail or over the Internet.

Several benefits were realized when respondents completed the survey over the web. Distribution of the survey was very simple and respondents could easily access the survey at their convenience. In addition, the Internet version eliminated lag time between completion of the survey and data entry. Data was electronically entered into the database upon completion of the survey, a process that reduced the possibility of transcription error. Finally, the Internet survey eliminated the occurrence of missing data. If a respondent inadvertently omitted a response, he or she would be prompted to complete the missing item before continuing with the survey.

Although Internet surveys provided several benefits, not all respondents either had access to the Internet or felt comfortable completing the survey online. To not discourage otherwise eligible respondents from participating, respondents were given the option of completing the survey by mail.

Overall, 681 surveys were completed via the Internet and 322 surveys were completed by mail. Attempts were made to distribute survey versions A and B equally within each survey method (i.e., mail vs. Internet).

Number of Completes

The survey targets and corresponding completes are as follows:

	Sector							
	Digital Economy		Continuous Process Manufacturing		Fabrication and Essential Services			
Size of Establishment (# Employees)	Targeted	Actual	Targeted	Actual	Targeted	Actual	Total (Targeted)	Total (Actual)
1 to 19	166	184	167	166	167	164	500	514
20 to 249	100	105	100	88	100	101	300	294
250+	67	64	66	74	67	57	200	195
Total	**333**	**353**	**333**	**328**	**334**	**322**	**1000**	**1003**

Response Rates

The telephone screening process identified business establishments that were qualified to participate in the survey. The cooperation rate among qualified respondents (i.e., the percentage who agreed to complete the survey online or by mail) was 39 percent. The response rate to the mail / web survey (i.e., the percent of those who agreed to complete the survey who ultimately did so) was 30 percent.

Data Cleaning

Handling Missing Data

Survey Completion

To be included in the data analyses, >50 percent of the questions on the survey must have been answered. Of the original 1003 completed surveys, 18 respondents completed <50 percent of the questions, leaving 985 surveys in the sample.

Missing Costs Values

Missing cost values (e.g., production loss, labor costs, etc.) for given scenarios were estimated to be $0. Using $0 estimate accounts for those respondents leaving the information blank due to

lack of costs resulting from an outage and provides a more conservative estimate than other methods of estimation (i.e., mean replacement).

Handling Outliers

Mean replacement

Initially, 45 cases were identified as outliers based on the criterion that respondents' reported outage costs were more than five times the size of their annual energy bills. Upon further examination, however, the reason most of these cases (40 out of 45) had outage costs disproportionate to their electric bills was that they had indicated an annual electric bill of $0.00.

There are many reasons why respondents may have indicated zero for their electric bills. Some may have simply not wanted to provide us with this information, while for others their electric bill may be included in their lease payment (the percent of respondents leasing their facilities is quite high among those indicating "zero" electric bills).

Regardless of the reason, it is reasonable to assume that these firms do use electricity. Therefore, missing data for annual electric bills were estimated using mean replacement. The average annual electric bill of the respondent's corresponding segment replaced the missing data point. For example, if annual electric bill information from a respondent in the small DE segment was missing, this data point would be replaced with the average annual electric bill of small DE establishments (~$17,784).

Capping

As mentioned above, five cases were identified where the reported outage costs appeared suspect compared with their reported electric bill. Upon further examination of other data for these five cases (e.g., segment, annual operating costs, outage costs, etc.), it was determined that three of the five cases potentially should be capped. Attempts were made to re-contact these three respondents to clarify their information. Only one respondent was successfully contacted. For the remaining two cases, the cost data were capped.

The appropriate cap for each of the two remaining cases was determined based on whether each case fell under commercial (Digital Economy) or industrial (Continuous Process Manufacturing and Fabrication & Essential Services) segments. The average price per kWh was estimated to be slightly different for these groups (i.e., 0.072 and 0.0445, respectively). The annual electric bill for each of these respondents was then divided by the corresponding price

per kWh[25], providing the number of annual kWh consumed. The kWh value was then multiplied by $5 to establish the cap. This threshold has been used in previous direct costing studies by utilities. For most cases, this cap would be approximately 100 times the customer's annual electric bill. Costs for the two cases mentioned above were capped using this equation.

Elimination of Other Outliers

For the remaining data, extreme values were examined on a case-by-case basis and outliers were eliminated. When calculating the estimated downtime caused by a specific outage (e.g., 1 minute, 3 minutes, 1 hour, etc.), distribution of the calculated downtimes was examined. For the downtime resulting from a 1 second outage (no warning), all but three of the cases fell at 600 minutes or below. The remaining three cases jumped to 2,160 minutes (1 case) and 2,880 minutes (2 cases). These outlying downtimes were capped at 600 minutes each.

Similarly, all but three of the downtime estimates calculated for the three-minute outage (no warning) fell at or below 720 minutes. The remaining cases (2160, 2880, and 6000 minutes) were capped at 720 minutes.

Finally, three cases were also capped for the one-hour downtime estimate. The majority of downtime fell at or below 1440 minutes. The remaining cases (2160, 2880, and 4800 minutes) were capped at 1440 minutes.

Weighting

The sample was weighted based on segment and survey version. Population estimates were obtained for each segment. Attempts were made to evenly distribute each survey version (A and B) within each segment. The resulting weights are based on the number of respondents from each segment answering the respective survey questions. Three weights for the survey versions were calculated:

- Total Weight: General questions asked in both version A and B
- Weight A: Questions asked only in version A
- Weight B: Questions asked only in version B

[25] Respondents estimated the average electric bill for (1) summer and (2) winter months. To calculate the annual electric bill for an establishment, the average summer bill was multiplied by six (months) and the average winter bill was multiplied by six (months). These two 6-month totals were then summed, providing an overall estimate of the electric bill for the entire year.

Analyses

Power reliability and power quality costs were calculated for each type of outage and for power quality phenomena. A number of factors contributed to net cost estimates for power outages (POs).

Lost Production

Lost production was calculated by taking the costs of lost production minus the cost of production that would be made up over time.

Cost Variables

Several factors were considered when calculating total cost of an outage:

- Labor Costs
  - *Idle Labor*: Salaries and wages paid to staff who are unable to work
  - *Additional Labor*: Labor costs to make up lost production, sales, or services (e.g., overtime pay, extra shifts, etc.)
- Material Costs: Damage or spoilage to materials, finished products, or inventory.
- Additional Costs
  - Extra restart Costs
  - Overhead: Ongoing overhead expenses incurred during the outage and the restart period.
  - Equipment Damages: Damage to an organization's building or equipment
  - Extra Backup Costs: Costs to run and / or rent backup equipment
  - Other: costs identified by respondents as a result of outage

Savings Variables

In addition, possible savings realized during an outage were also considered:

- Unused Material – Savings from unused materials or inventory
- Energy Savings – Realized savings on their energy bill
- Labor Unpaid – Savings from wages that were not paid
- Other – Other savings identified by respondents as a result of outage

Net Cost

Net cost for individuals outages were calculated by subtracting total savings from total cost. Negative net costs were recoded as $0.

Overall power quality costs were assessed based on average overall annual cost experienced by segment.

Average Annual Outage Costs

Average annual outage costs per establishment were calculated for each segment (DE, CP, F&ES). First, the average number of each type of outage (e.g., 1 second, 3 minute, 1 hour, etc.) was calculated for each segment. Then the average segment cost for each type of outage was calculated. The product of the total number of each type of outage and the average corresponding cost of the outage was calculated. Annual costs for the individual outage types were then totaled for each segment for an overall annual outage cost per establishment.

Projecting Total Outage and PQ Costs at Regional and State Levels

PO and PQ costs were calculated for the state, regional, and national levels. Regions are those identified by the National Census Bureau:

- New England
- Middle Atlantic
- East North Central
- West North Central
- South Atlantic

- East South Central
- West South Central
- Mountain
- Pacific

Overall Sampled SIC PO and PQ Costs

Average annual costs for both PO and PQ per establishment were calculated for each segment. Overall establishment counts (for both sampled and non-sampled SICs) were obtained by state. The average PO and PQ costs per establishment for each segment were then multiplied by national, regional, and state segment population counts to obtain respective cost estimates for these levels of analysis.

Overall Non-Sampled SIC PO and PQ Costs

A range of PO and PQ costs per establishment for non-sampled establishments was calculated as 25 percent and 50 percent of the average costs of sampled SIC establishments in a given state. For example, if the average annual cost of power outages for establishments in Alaska is $25,600, 25 percent = $6,400 and 50 percent = $12,800. If the number of non-sampled SIC establishments in Alaska is 28,362, the range of costs for non-sampled SIC establishments is $181,515,138 to $363,030,276[26]. These values were then multiplied by national and regional counts to obtain the respective ranges for total non-sampled PO and PQ costs.

Overall PO and PQ Costs by Region

The overall PO and PQ costs were calculated by adding the respective sampled and non-sampled SIC PO and PQ costs to obtain a range for each state. For example, to calculate the overall outage costs for Alaska, the above range brackets ($181,515,138 (25 percent) and $363,030,276 (50 percent)) for the non-sampled SIC establishments would each be added to the total sampled SIC costs for Alaska:

- $134,869,958 + $181,515,138 = $316,385,096
- $134,869,958 + $363,030,276 = $497,900,234

[26] Calculations differ slightly from state totals in Appendix D due to rounding error.

Therefore, annual power outage costs for Alaska would range from $316,385,096 to $497,900,234[27].

State PO and PQ costs were totaled to calculate the respective regional PO and PQ costs. In addition, the 10 states with the highest PO and PQ costs were identified.

[27] For overall PO and PQ total costs for each state, see Appendix D.

Appendix B
Survey Instruments

DISPOSITION_____CODE _____

CEIDS Outage Cost

RECRUITMENT SCREENER

_____

First Call: Date_____ Time_____ Interviewer_____

1st Callback _____ _____ _____

2nd Callback _____ _____ _____

3rd Callback _____ _____ _____

_____

Name _____ Title _____

Company _____

Address _____

City _____ State _____

Telephone A/C_____ Number _____

_____

May I please speak to (**NAME ON LIST**).

INTRODUCTION

Hello, this is _____ and I'm calling from The Dieringer Research Group, a national survey research center. We are conducting a study sponsored by EPRI, a non-profit organization that helps utility companies to better understand and serve their customers. Have I reached ___[BUSINESS]___ at __[ADDRESS]___?

1 YES_____ (CONTINUE)

2 NO _____ (CLARIFY BUSINESS NAME /ADDRESS AND CONTINUE)

Could I please speak with a person who is responsible for your organization's daily operations at this facility and would be knowledgeable about how those operations would be affected by electrical power problems?

We are conducting a survey of businesses concerning how their operations are affected by power outages and related problems. We are seeking only the opinions of selected professionals and all individual responses will be kept confidential.

[If respondent requests verification that this is a legitimate study: They can call Marek Samotyj at 650-855-2980.]

RESPONDENT SCREENING

S1. Hello, this is ____[NAME]_____calling from _____. We are conducting a study sponsored by EPRI, a non-profit organization that helps utility companies to better understand and serve their customers. Are you knowledgeable about the day-to-day operations of your facility located at ___[ADDRESS]___ and how those operations would be affected by power outages and other electrical disturbances?

Yes _____ (CONTINUE)

No _____ (ASK FOR APPROPRIATE PERSON AND REPEAT S1)

S2. Our firm is conducting a study to help quantify the losses that business customers experience as a result of disturbances in their power supply. I'd like to ask a few questions about your organization. Please answer for the facility located at ___[ADDRESS]___. Does your organization own or lease this facility?

Own.....1

Lease 2

S3. According to the information I have, your organization is primarily involved in _____[2-Digit SIC description]_____ at this location. Is this correct?

Yes .....1 (SKIP TO S4)

No..... 2 (PROCEED TO S3.1)

S3.1. How would you classify your organization's activities at this facility? (Make sure that they respond for the LOCATION. Wait for respondent to answer. If necessary, prompt with the following list of choices, then select appropriate category. Verify category or read list of choices if necessary.)

Hospital or other in-patient healthcare	1	(Qualify as DE and continue to S4)
Insurance	2	(Proceed to S3.2)
Banking or other financial services	3	(Proceed to S3.2)
Real estate services	4	(Qualify as DE and continue to S4)
Biotechnology	5	(Qualify as DE and continue to S4)
Data processing, data storage, or information retrieval	6	(Proceed to S3.2)
Computer programming, on-line services, or web hosting	7	(Proceed to S3.2)
Telecommunications services	8	(Proceed to S3.2)
Electronics or computer manufacturing	9	(Qualify as DE and continue to S4)
Manufacturing of paper or related products	10	(Qualify as CP and continue to S4)
Manufacturing of chemicals, pharmaceuticals, or related products	11	(Quality as CP and continue to S4)
Manufacturing of petroleum or coal products	12	(Qualify as CP and continue to S4)
Manufacturing of rubber or plastics products	13	(Quality as CP and continue to S4)
Manufacturing of stone, clay, or glass products	14	(Qualify as CP and continue to S4)
Manufacturing of primary metals	15	(Quality as CP and continue to S4)
Other manufacturing	16	(Qualify as TF and continue to S4)
Transportation services	17	(Quality as TF and continue to S4)
Water or wastewater treatment	18	(Qualify as TF and continue to S4)
Electric utility services	19	(TERMINATE)
Natural gas or other public utility services	20	(Qualify as TF and continue to S4)

S3.2. Does your organization have a significant data processing operation at this facility?

Yes → **Qualify as "DE-DP." Then continue with screening question S4.**

No → **Can respondent give a referral to another facility within the company that *does* have a significant data processing operation?**

- **Yes** → **Ask for appropriate contact information and repeat S1 with new contact.**
  AND
  Qualify current respondent as "DE." Then continue with screening question S4.
- **No** → **Qualify as "DE." Then continue with screening question S4.**

S4. Approximately how many full-time employees or full-time equivalent positions are there who work for your company **at this location**? **(WAIT FOR RESPONDENT TO ANSWER, THEN SELECT APPROPRIATE CATEGORY. READ LIST OF CHOICES IF NECESSARY.)**

4 or fewer	1	(Qualify as Small)
5 to 9	2	(Qualify as Small)
10 to 19	3	(Qualify as Small)
20 to 49	4	(Qualify as Med)
50 to 99	5	(Qualify as Med)
100 to 199	6	(Qualify as Med)
200 to 249	7	(Qualify as Med)
250 or More	8	(Qualify as Large)

S5. Is this facility part of a multi-site organization?

No	0 (Skip to S7)
Yes	1
Don't know	88

S6. Does your organization have facilities across different states?

No.....0
Yes.....1
Don't know.....88

S7. Now I'm going to read you a list of equipment and ask that you indicate whether or not your organization uses each type of equipment **at this location**. **(CHECK ALL MENTIONS)**

Personal computers.....1
Network servers.....2
Mainframe computers.....3
Life support equipment (e.g., ventilators.....4
Advanced medical diagnostic equipment (e.g., MRI, CT, PET).....5
Electronic controls for industrial process equipment 6
Computer automated production systems.....7
Electric motors or pumps 8
Variable speed drives 9
Printing presses 10
Commercial or industrial refrigeration systems 11
Electrically powered industrial process heating 12

RECRUIT QUALIFIED RESPONDENT FOR MAIL/WEB SURVEY [ASK OF ALL WHO CONTINUE BEYOND S7]

S8. Within the next few years, electric utilities, regulators, and policy makers will be faced with a variety of choices about how to improve power reliability to customers. Critical to making these decisions is the ability to quantify how power outages and other power disturbances affect business customers. To better understand these effects, we would like to ask you to complete a questionnaire on our website. The questionnaire will ask you to estimate the impact (in dollars) that several types of outages would have on your operations at this facility and can be completed at your convenience. In appreciation for your help with this survey, we will send you either $25 cash or a $25 gift certificate to Amazon.com once you have completed the questionnaire.

We are *not* trying to sell you anything; we are only trying to better understand how various types of businesses are affected by power disturbances. I want to assure you that all of your responses will be kept confidential, and that your name will not be released or sold.

I would like to email you a link to our web page so that you can complete the survey. Would you be able to help us participate in this study?

1 YES ---------> CONFIRM NAME, TITLE, EMAIL ADDRESS, MAILING ADDRESS AND PHONE NUMBER

2 YES, BUT CANNOT COMPLETE SURVEY ON THE WEB -→ OFFER TO SEND SURVEY BOOKLET BY MAIL. CONFIRM NAME, TITLE, MAILING ADDRESS AND PHONE NUMBER

3 NO ----------> THANK AND TERMINATE

NAME_____
TITLE_____
COMPANY NAME_____
EMAIL ADDRESS_____
STREET ADDRESS_____
PO BOX (IF APPLICABLE)_____
CITY_____STATE _____ ZIP_____
AREA CODE/PHONE NUMBER _____

S9. Would you prefer to receive a check for $25 or a $25 gift certificate to Amazon.com upon completion of the questionnaire?

Check.....0
Amazon gift certificate.....1

Closing for Web Survey Participants

We would like to thank you in advance for your time and help. Please look for an email with the link to the survey within the next 24 hours. You may receive another call from us sometime after you receive the email asking if you had any questions about the survey items or instructions. In the meantime if you have any questions please feel free to call Rachel Burr collect at (608) 829-3868, extension 31. We look forward to your responses.

Thanks again, and have a good day.

Closing for Mail Survey Participants

We would like to thank you in advance for your time and help. Please look for the survey packet to arrive within the next few days. You may receive another call from us sometime after you receive the survey asking if you had any questions about the survey items or instructions. In the meantime if you have any questions please feel free to call Rachel Burr collect at (608) 829-3868, extension 31. We look forward to your responses.

Thanks again, and have a good day.

Mail/Web Survey Version A

INSTRUCTIONS FOR COMPLETING THIS SURVEY

When completing this survey, please answer for the site or facility where you are located. Do **not** include other offices, branch locations, plants, stores, or subsidiaries.

It is very important that you try to answer all of the questions. If a question is difficult for you to answer, please give us your best guess.

For all questions, please assume that a **power outage** refers to a complete loss of electricity at this site. These outages can be caused by many factors such as bad weather, accidents, or equipment failures and can range in length from a second or less to several hours.

1. About how many outages has your organization experienced **in the last 12 months**? *(WRITE IN NUMBER)*

   _____ outages in the past 12 months

2. About how many outages does your organization experience **in a typical year**? *(WRITE IN NUMBER)*

   _____ outages in a typical year

3. Now we would like you to consider how long these outages or power interruptions typically last. What percent of the outages you listed in Question 2 typically fall into each of the following categories? *(WRITE IN PERCENT FOR EACH CATEGORY. PERCENTS SHOULD SUM TO 100%)*

Less than 1 second	**_____%**
1 second to less than 60 seconds	**_____%**
1 minute to less than 3 minutes	**_____%**
3 minutes to less than 5 minutes	**_____%**
5 minutes to less than 1 hour	**_____%**
1 hour to less than 4 hours	**_____%**
4 hours or longer	**_____%**
	100%

4. About how many times in a typical year does the following occur at this facility? The power goes off for a second or two, comes back on for a few seconds, then goes back off again. *(WRITE IN NUMBER – IF THIS DOES NEVER OCCURS, WRITE IN "ZERO")*

   _____ outages in a typical year

5. How satisfied are you with the overall power reliability your organization experiences (including the number of outages you typically experience, the average length of an outage, and the type of information the utility provides when you call about an outage)? *(Circle one number)*

Very Dissatisfied	Dissatisfied	Somewhat Dissatisfied	Neither Satisfied Nor Dissatisfied	Somewhat Satisfied	Satisfied	Very Satisfied
1	2	3	4	5	6	7

6. In general, how disruptive to your organization would outages of each of the following ***lengths*** be if they occurred **during normal operating hours** *(CIRCLE ONE NUMBER FOR EACH CATEGORY)*

	Not at All Disruptive						Extremely Disruptive
1 second	1	2	3	4	5	6	7
3 minutes	1	2	3	4	5	6	7
1 hour	1	2	3	4	5	6	7
4 hours	1	2	3	4	5	6	7

7. In general, how disruptive to your organization would outages be during each of the following ***seasons*** if they occurred **during normal operating hours**? *(CIRCLE ONE NUMBER FOR EACH CATEGORY)*

	Not at All Disruptive						Extremely Disruptive
Spring	1	2	3	4	5	6	7
Summer	1	2	3	4	5	6	7
Fall	1	2	3	4	5	6	7
Winter	1	2	3	4	5	6	7

The next few pages describe three different power outage "case studies." Each case describes an outage that your firm might experience and provides you with several details about the outage (e.g., when it occurs, how long it lasts, whether or not you have any advance warning that the outage might occur).

For each case, please imagine that **the outage described actually occurs** at this facility in exactly the manner described, and think about how this particular outage would affect your operations. Several of the questions will ask about specific dollar amounts that you might lose (or even save) as a result of the particular outage. We recognize that you may not have precise figures for most of these questions, but ask that you provide your best estimate in each case.

Case 1 Assume that the following outage occurs at this site.

Length of Outage: **1 second**
Time When Outage Occurs: **Summer Weekday starting at 2 PM**
Warning or Prior notification: **None**

8. In general, how disruptive would this outage be to your organization? (*CIRCLE ONE NUMBER*)

Not at All Disruptive						Extremely Disruptive
1	2	3	4	5	6	7

9. How much would your organization's activities slow down as a result of this outage? (*CIRCLE ONE NUMBER*)

1 None, activities would continue as usual -------→ SKIP TO QUESTION 15
2 None, no activities usually occur at this time ------→ SKIP TO QUESTION 15
3 Decline by less than 10 percent
4 Decline by 11-25 percent
5 Decline by 26-50 percent
6 Decline by 51-75 percent
7 Decline by 76-99 percent
8 Decline by 100 percent, all activities would stop

10. In general, how long would activities stop or slow down as a result of this 1-second outage? (*FILL IN ONLY ONE BLANK*)

Activities would stop or slow down for:

_____ Seconds OR _____ Minutes OR _____ Hours

11. What is the value of production, sales, or services that would be lost while activities are stopped or slowed down due to this 1-second outage? (*FILL IN BLANK --- PLEASE ESTIMATE IF UNSURE*)

$ _____ Value of lost production, sales, or services

12. Would any of the lost production, sales, or services be made up? (*CIRCLE ONE NUMBER*)

1 No → SKIP TO QUESTION 15
2 Yes

13. What percent of the lost production, sales, or services would likely be made up? (*FILL IN BLANK – PLEASE ESTIMATE IF UNSURE*)

    _____ %

14. How would the lost production, sales, or services most likely be made up? (*CIRCLE ONE NUMBER*)

    1 **Running extra shift(s) or extending business hours**

    2 **Working more intensively or increasing sales during normal business hours**

    3 **Other** (please specify: _____)

15. Please give us an estimate of the costs and savings you would generally expect your organization to experience due to this 1-second outage. If you think there would be no cost of savings for a specific item, please put zero in the blank. (*FILL IN BLANK – PLEASE ESTIMATE IF UNSURE*)

Labor Costs	**Estimated Costs**
Salaries and wages paid to staff who are unable to work	$ _____
Labor costs to make up lost production, sales, or services (such as overtime pay, extra shifts, etc.)	$ _____
Material Costs	
Damage or spoilage to materials, finished products, or inventory	$ _____
Additional Costs	
Extra restart costs	$ _____
Ongoing overhead expenses incurred during the outage and the restart period	$ _____
Damage to your organization's building or equipment	$ _____
Cost to run and/or rent backup equipment	$ _____
Other (please specify: _____)	$ _____

Savings

Savings from unused materials or inventory	$ _____
Savings on your energy bill	$ _____
Savings from wages that were not paid	$ _____
Other (please specify: _____)	$ _____

Case 2 Assume that the following outage occurs at this site.

Length of Outage: **3 minutes**
Time When Outage Occurs: **Summer Weekday starting at 2 PM**
Warning or Prior notification: **None**

16. In general, how disruptive would this outage be to your organization? (*CIRCLE ONE NUMBER*)

Not at All Disruptive						Extremely Disruptive
1	2	3	4	5	6	7

17. How much would your organization's activities slow down as a result of this outage? (*CIRCLE ONE NUMBER*)

1 None, activities would continue as usual -------→ SKIP TO QUESTION 23

2 None, no activities usually occur at this time ------→ SKIP TO QUESTION 23

3 Decline by less than 10 percent

4 Decline by 11-25 percent

5 Decline by 26-50 percent

6 Decline by 51-75 percent

7 Decline by 76-99 percent

8 Decline by 100 percent, all activities would stop

18. In general, how long would activities stop or slow down as a result of this 3-minute outage? (*FILL IN ONLY ONE BLANK*)

Activities would stop or slow down for:

_____ Seconds OR _____ Minutes OR _____ Hours

19. What is the value of production, sales, or services that would be lost while activities are stopped or slowed down due to this 3-minute outage? (*FILL IN BLANK --- PLEASE ESTIMATE IF UNSURE*)

$ _____ Value of lost production, sales, or services

20. Would any of the lost production, sales, or services be made up? (*CIRCLE ONE NUMBER*)

    1 No → **SKIP TO QUESTION 23**
    2 Yes

21. What percent of the lost production, sales, or services would likely be made up? (*FILL IN BLANK – PLEASE ESTIMATE IF UNSURE*)

    _____ %

22. How would the lost production, sales, or services most likely be made up? (*CIRCLE ONE NUMBER*)

    1 Running extra shift(s) or extending business hours

    2 Working more intensively or increasing sales during normal business hours

    3 Other (please specify: _____)

23. Please give us an estimate of the costs and savings you would generally expect your organization to experience due to this 3-minute outage. If you think there would be no cost of savings for a specific item, please put zero in the blank. (*FILL IN BLANK – PLEASE ESTIMATE IF UNSURE*)

Labor Costs	**Estimated Costs**
Salaries and wages paid to staff who are unable to work	$ _____
Labor costs to make up lost production, sales, or services (such as overtime pay, extra shifts, etc.)	$ _____

Material Costs	
Damage or spoilage to materials, finished products, or inventory	$ _____

Additional Costs

Extra restart costs $ _____

Ongoing overhead expenses incurred during the outage and the restart period $ _____

Damage to your organization's building or equipment $ _____

Cost to run and/or rent backup equipment $ _____

Other (please specify: _____) $ _____

Savings

Savings from unused materials or inventory $ _____

Savings on your energy bill $ _____

Savings from wages that were not paid $ _____

Other (please specify: _____) $ _____

Case 3	Assume that the following outage occurs at this site.	
	Length of Outage:	**1 hour**
	Time When Outage Occurs:	**Summer Weekday starting at 2 PM**
	Warning or Prior notification:	**24 hours before the outage, you are notified that "rotating outages are possible"**

24. In general, how disruptive would this outage be to your organization? (*CIRCLE ONE NUMBER*)

Not at All Disruptive						Extremely Disruptive
1	**2**	**3**	**4**	**5**	**6**	**7**

25. How much would your organization's activities slow down as a result of this outage? (*CIRCLE ONE NUMBER*)

1 None, activities would continue as usual --------→ SKIP TO QUESTION 31

2 None, no activities usually occur at this time ------→SKIP TO QUESTION 31

3 Decline by less than 10 percent

4 Decline by 11-25 percent

5 Decline by 26-50 percent

6 Decline by 51-75 percent

7 Decline by 76-99 percent

8 Decline by 100 percent, all activities would stop

26. In general, how long would activities stop or slow down as a result of this 1 hour outage? (*FILL IN ONLY ONE BLANK*)

Activities would stop or slow down for:

_____ Seconds OR _____ Minutes OR _____ Hours

27. What is the value of production, sales, or services that would be lost while activities are stopped or slowed down due to this 1 hour outage? (*FILL IN BLANK --- PLEASE ESTIMATE IF UNSURE*)

$ _____ Value of lost production, sales, or services

28. Would any of the lost production, sales, or services be made up? (*CIRCLE ONE NUMBER*)

1 No → SKIP TO QUESTION 31
2 Yes

29. What percent of the lost production, sales, or services would likely be made up? (*FILL IN BLANK – PLEASE ESTIMATE IF UNSURE*)

_____ %

30. How would the lost production, sales, or services most likely be made up? (*CIRCLE ONE NUMBER*)

1 Running extra shift(s) or extending business hours

2 Working more intensively or increasing sales during normal business hours

3 Other (please specify: _____)

31. Please give us an estimate of the costs and savings you would generally expect your organization to experience due to this 1 hour outage. If you think there would be no cost of savings for a specific item, please put zero in the blank. (*FILL IN BLANK – PLEASE ESTIMATE IF UNSURE*)

Labor Costs	**Estimated Costs**
Salaries and wages paid to staff who are unable to work	$ _____
Labor costs to make up lost production, sales, or services (such as overtime pay, extra shifts, etc.)	$ _____

Material Costs	
Damage or spoilage to materials, finished products, or inventory	$ _____

Additional Costs

Extra restart costs $ _____

Ongoing overhead expenses incurred during the outage and the restart period $ _____

Damage to your organization's building or equipment $ _____

Cost to run and/or rent backup equipment $ _____

Other (please specify: _____) $ _____

Savings

Savings from unused materials or inventory $ _____

Savings on your energy bill $ _____

Savings from wages that were not paid $ _____

Other (please specify: _____) $ _____

32. Approximately how much money does your organization lose **annually** in total as a result of **all** power outages or interruptions **at this facility**? (*PLEASE ESTIMATE – CONSIDER ALL OF THE OUTAGES THAT OCCUR IN A TYPICAL YEAR, REGARDLESS OF LENGTH*)

$ _____

Some background information about your organization will help us understand how power outages affect your type of business. All of your answers are **strictly confidential**. The information will be used only to report comparisons among different types of businesses. We will never identify individuals or businesses with their responses.

33. What was the approximate annual revenue for your organization at this site in 2000? (IF YOU DO NOT GENERATE REVENUE AT THIS SITE, PLEASE USE YOUR ANNUAL BUDGET AS A PROXY) (*FILL IN BLANK*)

    $ _____ per year

34. What were your organization's total annual operating expenses at this site in 2000 (including labor, rent, materials, energy, and other overhead expenses) (*FILL IN BLANK – PLEASE ESTIMATE IF UNSURE*)

    $ _____ per year

35. Which of the following most closely corresponds to your organization's normal hours of operation at this location? This would be when most employees or other occupants are present, and would include all shifts. Please do not include hours when only security or janitors are present (*CIRCLE ONE NUMBER*)

    1 **8 hours a day, 5 days a week**
    2 **12 hours a day, 5 days a week**
    3 **8 hours a day, 7 days a week**
    4 **12 hours a day, 7 days a week**
    5 **24 hours a day, 7 days a week**

36. Approximately how large are your typical monthly electric bills for this location in the summer and winter? (*WRITE IN YOUR BEST ESTIMATE ON EACH LINE BELOW*)

    Summer electric bill: $_____ per month
    Winter electric bill: $_____ per month

37. Which of the following has your company installed at this facility to deal with power quality or reliability concerns? (*CIRCLE ALL THAT APPLY*)

    1 Surge protectors on key pieces of equipment

    2 Uninterruptible power supply (UPS) devices

    3 Line conditioners or filters

    4 Back-up generator(s)

    5 A co-generation system capable of generating most or all of your power needs on-site

    6 Other (Please specify _____)

    7 None of the above -----→ SKIP TO QUESTION 40

38. Approximately how much money has your organization invested in the purchase and installation of the equipment described in Question 37 for this facility? (*WRITE IN NUMBER*)

    $ _____

39. Approximately what percentage of your facility's total electrical load is currently covered by . . .? (*WRITE IN A PERCENTAGE FOR EACH ITEM*)

	Percent of Load Covered
A standby or backup generator	_____ %
UPS devices, line conditioners, or filters	_____ %

40. In addition to power outages, there are a variety of power disturbances that a business may experience. These can include voltage fluctuations, sags, spikes, surges, harmonics, phase loss, and grounding problems. For purposes of this survey, we will refer to all of these as power quality events. Approximately how many of these events does your organization experience at this facility in a typical year? (*CIRCLE ONE NUMBER*)

1 None ------→ SKIP TO QUESTION 45
2 1 to 4
3 5 to 9
4 10 to 19
5 20 to 29
6 30 to 39
7 40 to 49
8 50 to 99
9 100 or more

41. Which of the following typically occurs at your facility when power quality events occur? (*CIRCLE ALL THAT APPLY*)

1 Lights flicker, blink, or dim
2 Circuit breakers or power strips trip
3 Computers lock up or reboot themselves
4 Motors or other process equipment start or stop by themselves
5 Motors or other process equipment slows down or speeds up unexpectedly
6 Motors or process equipment are damaged
7 Computers or other electronics are damaged
8 Employees receive electric shocks when touching equipment
9 Other (specify:_____)
10 None of the above

42. Are your organization's primary processes or activities at this facility significantly slowed down or stopped when power quality events occur? (*CIRCLE ONE NUMBER*)

1 No ----------→ SKIP TO QUESTION 44
2 Yes

43. In general, how long are activities stopped or slowed down when power quality events occur? *(FILL IN ONLY ONE BLANK)*

    Activities stop or slow down for:

    _____ Seconds OR _____ Minutes OR _____ Hours

44. Approximately how much money does your organization lose **annually** as a result of the type of power quality events described in Questions 40 through 43? (*PLEASE ESTIMATE – DO **NOT** INCLUDE LOSSES THAT RESULT FROM POWER **OUTAGES**, EVEN THOSE THAT LAST FOR ONLY A SECOND*)

    $ _____

45. Have any of the losses your organization has experienced at this site – whether from power quality events or outages – ever been reimbursed under an insurance policy? (*CIRCLE ONE NUMBER*)

    1 No -----→ SKIP TO QUESTION 47
    2 Yes

46. Historically, what percent of your organization's total monetary losses from power quality events or outages have been reimbursed by insurance? (*WRITE IN PERCENT – PLEASE ESTIMATE*)

    _____% of total power quality/outage losses

47. Does your organization currently participate in a curtailable load or interruptible load program with your electric utility at this site? (*CIRCLE ONE NUMBER*)

    1 No
    2 Yes -----→ (If yes, how many times have you been curtailed in the past 12 months? _____)

Mail/Web Survey – Version B

INSTRUCTIONS FOR COMPLETING THIS SURVEY

When completing this survey, please answer for the site or facility where you are located. Do **not** include other offices, branch locations, plants, stores, or subsidiaries.

It is very important that you try to answer all of the questions. If a question is difficult for you to answer, please give us your best guess.

For all questions, please assume that a **power outage** refers to a complete loss of electricity at this site. These outages can be caused by many factors such as bad weather, accidents, or equipment failures and can range in length from a second or less to several hours.

1. About how many outages has your organization experienced **in the last 12 months**? (*WRITE IN NUMBER*)

   _____ outages in the past 12 months

2. About how many outages does your organization experience **in a typical year**? (*WRITE IN NUMBER*)

   _____ outages in a typical year

3. Now we would like you to consider how long these outages or power interruptions typically last. What percent of the outages you listed in Question 2 typically fall into each of the following categories? (*WRITE IN PERCENT FOR EACH CATEGORY. PERCENTS SHOULD SUM TO 100%*)

Less than 1 second	**_____%**
1 second to less than 60 seconds	**_____%**
1 minute to less than 3 minutes	**_____%**
3 minutes to less than 5 minutes	**_____%**
5 minutes to less than 1 hour	**_____%**
1 hour to less than 4 hours	**_____%**
4 hours or longer	**_____%**
	100%

4. About how many times in a typical year does the following occur at this facility? The power goes off for a second or two, comes back on for a few seconds, then goes back off again. (*WRITE IN NUMBER – IF THIS NEVER OCCURS, WRITE IN "ZERO"*)

   _____ outages in a typical year

5. How satisfied are you with the overall power reliability your organization experiences (including the number of outages you typically experience, the average length of an outage, and the type of information the utility provides when you call about an outage)? (*Circle one number*)

Very Dissatisfied	Dissatisfied	Somewhat Dissatisfied	Neither Satisfied Nor Dissatisfied	Somewhat Satisfied	Satisfied	Very Satisfied
1	2	3	4	5	6	7

6. In general, how disruptive to your organization would outages of each of the following ***lengths*** be if they occurred **during normal operating hours** (*CIRCLE ONE NUMBER FOR EACH CATEGORY*)

	Not at All Disruptive						Extremely Disruptive
1 second	1	2	3	4	5	6	7
3 minutes	1	2	3	4	5	6	7
1 hour	1	2	3	4	5	6	7
4 hours	1	2	3	4	5	6	7

7. In general, how disruptive to your organization would outages be during each of the following ***seasons*** if they occurred **during normal operating hours**? (*CIRCLE ONE NUMBER FOR EACH CATEGORY*)

	Not at All Disruptive						Extremely Disruptive
Spring	1	2	3	4	5	6	7
Summer	1	2	3	4	5	6	7
Fall	1	2	3	4	5	6	7
Winter	1	2	3	4	5	6	7

The next few pages describe three different power outage "case studies." Each case describes an outage that your firm might experience and provides you with several details about the outage (e.g., when it occurs, how long it lasts, whether or not you have any advance warning that the outage might occur).

For each case, please imagine that **the outage described actually occurs** at this facility in exactly the manner described, and think about how this particular outage would affect your operations. Several of the questions will ask about specific dollar amounts that you might lose (or even save) as a result of the particular outage. We recognize that you may not have precise figures for most of these questions, but ask that you provide your best estimate in each case.

Case 1	Assume that the following outage occurs at this site.	
	Length of Outage:	**1 second, followed by another 1 second interruption 2 seconds later**
	Time When Outage Occurs:	**Summer Weekday starting at 2 PM**
	Warning or Prior notification:	**None**

8. In general, how disruptive would this outage be to your organization? (*CIRCLE ONE NUMBER*)

Not at All Disruptive						Extremely Disruptive
1	**2**	**3**	**4**	**5**	**6**	**7**

9. How much would your organization's activities slow down as a result of this outage? (*CIRCLE ONE NUMBER*)

1 None, activities would continue as usual -------→ SKIP TO QUESTION 15

2 None, no activities usually occur at this time ------→ SKIP TO QUESTION 15

3 Decline by less than 10 percent

4 Decline by 11-25 percent

5 Decline by 26-50 percent

6 Decline by 51-75 percent

7 Decline by 76-99 percent

8 Decline by 100 percent, all activities would stop

10. In general, how long would activities stop or slow down as a result of these two 1-second outages within a 2-second time period? (*FILL IN ONLY ONE BLANK*)

Activities would stop or slow down for:

_____ Seconds OR _____ Minutes OR _____ Hours

11. What is the value of production, sales, or services that would be lost while activities are stopped or slowed down due to this outage? (*FILL IN BLANK --- PLEASE ESTIMATE IF UNSURE*)

$ _____ Value of lost production, sales, or services

12. Would any of the lost production, sales, or services be made up? (*CIRCLE ONE NUMBER*)

1 No ⟶ SKIP TO QUESTION 15
2 Yes

13. What percent of the lost production, sales, or services would likely be made up? (*FILL IN BLANK – PLEASE ESTIMATE IF UNSURE*)

    _____ %

14. How would the lost production, sales, or services most likely be made up? (*CIRCLE ONE NUMBER*)

    1 Running extra shift(s) or extending business hours

    2 Working more intensively or increasing sales during normal business hours

    3 Other (please specify: _____)

15. Please give us an estimate of the costs and savings you would generally expect your organization to experience due to these two 1-second outages within a 2-second time period. If you think there would be no cost of savings for a specific item, please put zero in the blank. (*FILL IN BLANK – PLEASE ESTIMATE IF UNSURE*)

Labor Costs	**Estimated Costs**
Salaries and wages paid to staff who are unable to work	$ _____
Labor costs to make up lost production, sales, or services (such as overtime pay, extra shifts, etc.)	$ _____
Material Costs	
Damage or spoilage to materials, finished products, or inventory	$ _____
Additional Costs	
Extra restart costs	$ _____
Ongoing overhead expenses incurred during the outage and the restart period	$ _____
Damage to your organization's building or equipment	$ _____
Cost to run and/or rent backup equipment	$ _____
Other (please specify: _____)	$ _____

Savings

Savings from unused materials or inventory	$ _____
Savings on your energy bill	$ _____
Savings from wages that were not paid	$ _____
Other (please specify: _____)	$ _____

Case 2 Assume that the following outage occurs at this site.

Length of Outage: **1 hour**
Time When Outage Occurs: **Summer Weekday starting at 2 PM**
Warning or Prior notification: **None**

16. In general, how disruptive would this outage be to your organization? (*CIRCLE ONE NUMBER*)

Not at All Disruptive						Extremely Disruptive
1	**2**	**3**	**4**	**5**	**6**	**7**

17. How much would your organization's activities slow down as a result of this outage? (*CIRCLE ONE NUMBER*)

1 None, activities would continue as usual -------→ SKIP TO QUESTION 23

2 None, no activities usually occur at this time ------→SKIP TO QUESTION 23

3 Decline by less than 10 percent
4 Decline by 11-25 percent
5 Decline by 26-50 percent

6 Decline by 51-75 percent

7 Decline by 76-99 percent

8 Decline by 100 percent, all activities would stop

18. In general, how long would activities stop or slow down as a result of this 1-hour outage? (*FILL IN ONLY ONE BLANK*)

Activities would stop or slow down for:

_____ Seconds OR _____ Minutes OR _____ Hours

19. What is the value of production, sales, or services that would be lost while activities are stopped or slowed down due to this 1-hour outage? (*FILL IN BLANK --- PLEASE ESTIMATE IF UNSURE*)

$ _____ Value of lost production, sales, or services

20. Would any of the lost production, sales, or services be made up? (*CIRCLE ONE NUMBER*)

1 No ⟶ SKIP TO QUESTION 23
2 Yes

21. What percent of the lost production, sales, or services would likely be made up? (*FILL IN BLANK – PLEASE ESTIMATE IF UNSURE*)

_____ %

22. How would the lost production, sales, or services most likely be made up? (*CIRCLE ONE NUMBER*)

1 Running extra shift(s) or extending business hours

2 Working more intensively or increasing sales during normal business hours

3 Other (please specify: _____)

23. Please give us an estimate of the costs and savings you would generally expect your organization to experience due to this 1-hour outage. If you think there would be no cost of savings for a specific item, please put zero in the blank. (*FILL IN BLANK – PLEASE ESTIMATE IF UNSURE*)

Labor Costs	**Estimated Costs**
Salaries and wages paid to staff who are unable to work	$ _____
Labor costs to make up lost production, sales, or services (such as overtime pay, extra shifts, etc.)	$ _____
Material Costs	
Damage or spoilage to materials, finished products, or inventory	$ _____
Additional Costs	
Extra restart costs	$ _____
Ongoing overhead expenses incurred during the outage and the restart period	$ _____
Damage to your organization's building or equipment	$ _____
Cost to run and/or rent backup equipment	$ _____
Other (please specify: _____)	$ _____
Savings	
Savings from unused materials or inventory	$ _____
Savings on your energy bill	$ _____
Savings from wages that were not paid	$ _____
Other (please specify: _____)	$ _____

Case 3 Assume that the following outage occurs at this site.

Length of Outage:	**1 hour**
Time When Outage Occurs:	**Summer Weekday starting at 2 PM**
Warning or Prior notification:	**1 hour notice that a rotating outage will occur**

24. In general, how disruptive would this outage be to your organization? (CIRCLE ONE NUMBER)

Not at All Disruptive						Extremely Disruptive
1	2	3	4	5	6	7

25. How much would your organization's activities slow down as a result of this outage? (*CIRCLE ONE NUMBER*)

1 None, activities would continue as usual -------→ SKIP TO QUESTION 31

2 None, no activities usually occur at this time ------→ SKIP TO QUESTION 31

3 Decline by less than 10 percent

4 Decline by 11-25 percent

5 Decline by 26-50 percent

6 Decline by 51-75 percent

7 Decline by 76-99 percent

8 Decline by 100 percent, all activities would stop

26. In general, how long would activities stop or slow down as a result of this 1-hour outage? (*FILL IN ONLY ONE BLANK*)

Activities would stop or slow down for:

_____ Seconds OR _____ Minutes OR _____ Hours

27. What is the value of production, sales, or services that would be lost while activities are stopped or slowed down due to this 1-hour outage? (*FILL IN BLANK --- PLEASE ESTIMATE IF UNSURE*)

$ _____ Value of lost production, sales, or services

28. Would any of the lost production, sales, or services be made up? (*CIRCLE ONE NUMBER*)

1 No → SKIP TO QUESTION 31
2 Yes

29. What percent of the lost production, sales, or services would likely be made up? (*FILL IN BLANK – PLEASE ESTIMATE IF UNSURE*)

_____ %

30. How would the lost production, sales, or services most likely be made up? (*CIRCLE ONE NUMBER*)

1 Running extra shift(s) or extending business hours

2 Working more intensively or increasing sales during normal business hours

3 Other (please specify: _____)

31. Please give us an estimate of the costs and savings you would generally expect your organization to experience due to this 1-hour outage. If you think there would be no cost of savings for a specific item, please put zero in the blank. (*FILL IN BLANK – PLEASE ESTIMATE IF UNSURE*)

Labor Costs	**Estimated Costs**
Salaries and wages paid to staff who are unable to work	$ _____
Labor costs to make up lost production, sales, or services (such as overtime pay, extra shifts, etc.)	$ _____
Material Costs	
Damage or spoilage to materials, finished products, or inventory	$ _____
Additional Costs	
Extra restart costs	$ _____
Ongoing overhead expenses incurred during the outage and the restart period	$ _____
Damage to your organization's building or equipment	$ _____
Cost to run and/or rent backup equipment	$ _____
Other (please specify: _____)	$ _____
Savings	
Savings from unused materials or inventory	$ _____
Savings on your energy bill	$ _____
Savings from wages that were not paid	$ _____
Other (please specify: _____)	$ _____

32. Approximately how much money does your organization lose **annually** in total as a result of **all** power outages or interruptions **at this facility**? (*PLEASE ESTIMATE – CONSIDER ALL OF THE OUTAGES THAT OCCUR IN A TYPICAL YEAR, REGARDLESS OF LENGTH*)

$ _____

Some background information about your organization will help us understand how power outages affect your type of business. All of your answers are **strictly confidential**. The information will be used only to report comparisons among different types of businesses. We will never identify individuals or businesses with their responses.

33. What was the approximate annual revenue for your organization at this site in 2000? (IF YOU DO NOT GENERATE REVENUE AT THIS SITE, PLEASE USE YOUR ANNUAL BUDGET AS A PROXY) (FILL IN BLANK)

$ _____ per year

34. What were your organization's total annual operating expenses at this site in 2000 (including labor, rent, materials, energy, and other overhead expenses) (*FILL IN BLANK – PLEASE ESTIMATE IF UNSURE*)

$ _____ per year

35. Which of the following most closely corresponds to your organization's normal hours of operation at this location? This would be when most employees or other occupants are present, and would include all shifts. Please do not include hours when only security or janitors are present (*CIRCLE ONE NUMBER*)

1 hours a day, 5 days a week

2 12 hours a day, 5 days a week

3 hours a day, 7 days a week

4 12 hours a day, 7 days a week

5 24 hours a day, 7 days a week

36. Approximately how large are your typical monthly electric bills for this location in the summer and winter? (*WRITE IN YOUR BEST ESTIMATE ON EACH LINE BELOW*)

Summer electric bill: $_____ per month
Winter electric bill: $_____ per month

37. Which of the following has your company installed at this facility to deal with power quality or reliability concerns? (*CIRCLE ALL THAT APPLY*)

1 Surge protectors on key pieces of equipment

2 Uninterruptible power supply (UPS) devices

3 Line conditioners or filters

4 Back-up generator(s)

5 A co-generation system capable of generating most or all of your power needs on-site

6 Other (Please specify _____)

7 None of the above -----→ SKIP TO QUESTION 40

38. Approximately how much money has your organization invested in the purchase and installation of the equipment described in Question 37 for this facility? (*WRITE IN NUMBER*)

$ _____

39. Approximately what percentage of your facility's total electrical load is currently covered by . . .? (*WRITE IN A PERCENTAGE FOR EACH ITEM*)

	Percent of Load Covered
A standby or backup generator	_____ %
UPS devices, line conditioners, or filters	_____ %

40. In addition to power outages, there are a variety of power disturbances that a business may experience. These can include voltage fluctuations, sags, spikes, surges, harmonics, phase loss, and grounding problems. For purposes of this survey, we will refer to all of these as power quality events. Approximately how many of these events does your organization experience at this facility in a typical year? (*CIRCLE ONE NUMBER*)

1 None ------→ SKIP TO QUESTION 45

2 to 4

3 to 9

4 to 19

5 20 to 29

6 30 to 39

7 40 to 49

8 50 to 99

9 100 or more

41. Which of the following typically occurs at your facility when power quality events occur? (*CIRCLE ALL THAT APPLY*)

1 Lights flicker, blink, or dim

2 Circuit breakers or power strips trip

3 Computers lock up or reboot themselves

4 Motors or other process equipment start or stop by themselves

5 Motors or other process equipment slows down or speeds up unexpectedly

6 Motors or process equipment are damaged

7 Computers or other electronics are damaged

8 Employees receive electric shocks when touching equipment

9 Other (specify:_____)

10 None of the above

42. Are your organization's primary processes or activities at this facility significantly slowed down or stopped when power quality events occur? (*CIRCLE ONE NUMBER*)

1 No ----------→ *SKIP TO QUESTION 44*

2 Yes

43. In general, how long are activities stopped or slowed down when power quality events occur? (*FILL IN ONLY ONE BLANK*)

Activities stop or slow down for:

_____ Seconds OR _____ Minutes OR _____ Hours

44. Approximately how much money does your organization lose **annually** as a result of the type of power quality events described in Questions 40 through 43? (*PLEASE ESTIMATE – DO **NOT** INCLUDE LOSSES THAT RESULT FROM POWER **OUTAGES**, EVEN THOSE THAT LAST FOR ONLY A SECOND*)

$ _____

45. Have any of the losses your organization has experienced at this site – whether from power quality events or outages – ever been reimbursed under an insurance policy? *(CIRCLE ONE NUMBER)*

    1 *No -----→ SKIP TO QUESTION 47*
    2 **Yes**

46. Historically, what percent of your organization's total monetary losses from power quality events or outages have been reimbursed by insurance? *(WRITE IN PERCENT – PLEASE ESTIMATE)*

    _____% of total power quality/outage losses

47. Does your organization currently participate in a curtailable load or interruptible load program with your electric utility at this site? *(CIRCLE ONE NUMBER)*

    1 *No*
    2 **Yes -----→ (If yes, how many times have you been curtailed in the past 12 months? _____)**

Appendix C

Industries/SIC Codes Sampled

Digital Economy

Industry	SIC
Custom Computer Programming Services	7371
Systems Integration Services	7373
Data Processing and Preparation	7374
Information Retrieval Services	7375
Insurance Carriers	63
Biological Research	873101
Noncommercial Biological Research	873301
Chemical Manufacturing - Biological products, except Diagnostic	2836
Computer And Office Equipment	357
Electronic And Other Electrical Equipment And Components, Except Computer Equipment	36
Measuring, Analyzing, And Controlling Instruments; Photographic, Medical And Optical Goods; Watches And Clocks	38
Communications	48
Nursing And Personal Care Facilities	805
Hospitals	806
Depository Institutions	60
Non-Depository Credit Institutions	61
Security And Commodity Brokers, Dealers, Exchanges, and Services	62
Insurance Agents, Brokers, and Service	64
Real Estate	65
Holding And Other Investments Offices	67

Continuous Process Manufacturing

Industry	SIC
Paper & Allied Products	26
Chemical & Allied Products	28[1]
Petroleum & Coal Products	29
Rubber & Misc. Plastics Products	30
Stone, Clay & Glass Products	32
Primary Metals Industries	33

[1]Does not include 2836 (see Digital Economy).

Fabrication & Essential Services

Railroad Transportation	40
Local and Suburban Transit And Interurban Highway Passenger Transportation	41
United States Postal Service	43
Water Transportation	44
Transportation By Air	45
Pipelines, Except Natural Gas	46
Gas and Sanitary Services	49[1]
Food and Kindred Products	20
Tobacco Products	21
Textile Mill Products	22
Apparel and other Finished Products Made from Fabrics and Similar Materials	23
Lumber and Wood Products, Except Furniture	
Furniture and Fixtures	25
Printing, Publishing, and Allied Industries	27
Leather and Leather Products	31
Fabricated Metal Products, Except Machinery and Transportation	34
Industrial and Commercial Machinery and Computer Equipment	35[2]
Transportation Equipment	37
Miscellaneous Manufacturing Industries	39

[1] Does not include 4911 (Electric Services) or 4931 (Electric and Other Services Combined).

[2] Does not include 357 (see Digital Economy).

Appendix D

Annual Outage and Power Quality Costs by State

Table D-1: Annual Outage Costs for Sectors Surveyed and Estimated Annual Outage Costs for All Sectors

State	Aggregate Annual Outage Costs for Sectors Surveyed ($Millions)	Estimated Annual Outage Costs for All Sectors	
		Low Estimate ($Millions)	High Estimate ($Millions)
AK	$135	$316	$498
AL	700	1,625	2,551
AR	490	1,140	1,790
AZ	629	1,381	2,132
CA	5,170	11,489	17,808
CO	767	1,684	2,601
CT	615	1,474	2,333
DC	112	287	462
DE	132	313	495
FL	2,297	5,265	8,233
GA	1,344	3,041	4,738
HI	146	343	540
IA	577	1,346	2,114
ID	249	576	903
IL	2,015	4,499	6,983
IN	1,026	2,299	3,571
KS	458	1,065	1,672
KY	631	1,477	2,322
LA	622	1,480	2,337
MA	1,164	2,609	4,053

State	Aggregate Annual Outage Costs for Sectors Surveyed ($Millions)	Estimated Annual Outage Costs for All Sectors	
		Low Estimate ($Millions)	High Estimate ($Millions)
MD	724	1,712	2,700
ME	285	639	993
MI	1,559	3,765	5,971
MN	$962	$2,135	$3,309
MO	935	2,159	3,383
MS	422	964	1,507
MT	193	457	721
NC	1,427	3,247	5,067
ND	114	274	435
NE	320	739	1,158
NH	276	614	951
NJ	1,482	3,522	5,562
NM	227	540	853
NV	214	489	764
NY	2,983	6,932	10,881
OH	1,910	4,348	6,787
OK	531	1,250	1,968
OR	683	1,516	2,348
PA	2,087	4,948	7,810
RI	180	403	626
SC	625	1,468	2,311
SD	142	341	539
TN	975	2,240	3,504
TX	3,124	7,339	11,553
UT	358	763	1,169
VA	1,007	2,372	3,736
VT	151	330	510
WA	1,115	2,564	4,014
WI	1,044	2,354	3,663

State	Aggregate Annual Outage Costs for Sectors Surveyed ($Millions)	Estimated Annual Outage Costs for All Sectors	
		Low Estimate ($Millions)	High Estimate ($Millions)
WV	270	611	952
WY	95	234	373
Total	**$45,700**	**$104,977**	**$164,254**

Table D-2: Annual Power Quality Costs for Sectors Surveyed and Estimated Annual Power Quality Costs for All Sectors

State	Aggregate Annual Power Quality Costs for Sectors Surveyed ($Millions)	Estimated Annual Power Quality Costs for All Sectors	
		Low Estimate ($Millions)	High Estimate ($Millions)
AK	$21	$48	$77
AL	105	238	382
AR	69	157	252
AZ	90	193	304
CA	766	1,659	2,630
CO	100	214	337
CT	95	223	361
DC	16	40	66
DE	16	37	60
FL	318	710	1,135
GA	190	420	669
HI	24	54	87
IA	78	176	283
ID	37	83	134
IL	298	649	1,029
IN	151	329	522
KS	64	145	234
KY	92	209	336
LA	94	218	352
MA	177	386	613
MD	104	240	386
ME	45	97	155
MI	235	552	895
MN	139	301	477
MO	135	305	488
MS	65	144	230

State	Aggregate Annual Power Quality Costs for Sectors Surveyed ($Millions)	Estimated Annual Power Quality Costs for All Sectors	
		Low Estimate ($Millions)	High Estimate ($Millions)
MT	$27	$63	$102
NC	224	498	794
ND	17	40	65
NE	42	94	150
NH	40	86	136
NJ	228	527	852
NM	33	75	122
NV	30	66	105
NY	470	1,066	1,710
OH	470	1,066	1,710
OK	74	171	275
OR	102	222	351
PA	321	741	1,196
RI	30	66	105
SC	92	210	338
SD	20	46	75
TN	142	319	510
TX	431	986	1,587
UT	50	105	164
VA	140	320	516
VT	24	52	82
WA	158	354	566
WI	159	350	557
WV	40	88	140
WY	14	34	56
Total	**$6,700**	**$15,000**	**$24,000**