Scoping Study on Trends in the Economic Value of Electricity Reliability to the U.S. Economy

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Consortium for Electric Infrastructure to Support a Digital Society

An Initiative by EPRI and the Electricity Innovation Institute

June 2001

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Abstract

During the past three years, working with more than 150 organizations representing public and private stakeholders, EPRI has developed the Electricity Technology Roadmap. The Roadmap identifies several major strategic challenges that must be successfully addressed to ensure a sustainable future in which electricity continues to play an important role in economic growth. Articulation of these anticipated trends and challenges requires a detailed understanding of the role and importance of reliable electricity in different sectors of the economy. This report is intended to contribute to that understanding by analyzing key aspects of trends in the economic value of electricity reliability in the U.S. economy.

We first present a review of recent literature on electricity reliability costs. Next, we describe three distinct end-use approaches for tracking trends in reliability needs: 1) an analysis of the electricity-use requirements of office equipment in different commercial sectors; 2) an examination of the use of aggregate statistical indicators of industrial electricity use and economic activity to identify high reliability-requirement customer market segments; and 3) a case study of cleanrooms, which is a cross-cutting market segment known to have high reliability requirements. Finally, we present insurance industry perspectives on electricity reliability as an example of a financial tool for addressing customers' reliability needs.

Executive Summary

During the past three years, working with more than 150 organizations representing public and private stakeholders, EPRI has developed the Electricity Technology Roadmap (EPRI 2000). The Roadmap is a dynamic "living" document that provides context for EPRI's R&D planning and a resource for energy policy makers in the U.S. and abroad.

The roadmap identifies several major strategic challenges that must be successfully addressed to ensure a sustainable future in which electricity continues to play an important role in economic growth. A significant element of these challenges is the anticipation of increasingly "digitized" economies in which, in addition to the increased direct use of computers, distributed microprocessor based measurement and control is a critical infrastructure element for a wide range of applications in the residential, commercial, and industrial sectors.

Articulation of these anticipated trends and challenges requires a detailed understanding of the role and importance of reliable electricity in different sectors of the economy. Electric power availability, reliability, and quality are anticipated to have somewhat independently varying economic importance in different applications and industries.

In order to frame the issue of reliability comprehensively, the following key questions must be addressed:

1. What is the cost to the U.S. economy of unreliable electricity?
2. How is the value of reliable electricity to the U.S. economy likely to change in the future?
3. How are customers addressing their reliability needs and risk management preferences?[1]

This scoping study offers partial, not final, answers to each of the three key questions. It is a first step toward defining a future program of investigation to address the many unanswered aspects of these questions. Accordingly, an integral element of the project has been to develop recommendations for high-priority next steps.

The Cost of Unreliable Electricity to the U.S. Economy

As a first step toward assessing the cost of unreliable electricity to the U.S. economy, we reviewed recent literature on electricity reliability costs. The objectives of the literature review are to: 1) supplement older literature reviews with information on more recent events and studies, and 2) integrate the literature on utility system outage costs with that on customer power quality costs.

We developed a database reporting on 117 documents. We grouped the findings from these documents in six categories: the aggregate cost of reliability problems; the cost of specific power system events; customer surveys of outage costs; other estimates of outage costs; applications of outage cost estimates (which cite additional estimates of outage costs); and site-specific power quality studies.

[1] Though not pursued in the present study, this question also could be framed with utilities as "customers" for many of the same risk management approaches being undertaken by electricity consumers.

Key Findings:

1. There are few estimates of the aggregate cost of unreliable power to the U.S. economy. Documentation for existing estimates is either absent or based on assumptions that need additional review.
2. Reports on the costs of large outage events are not well documented; they are often developed based on applying rules of thumb derived from existing studies extrapolated to a current situation. There have been few systematic studies of the costs of actual large-scale outages. In reviewing costs reported for some events, we encountered complications in tying reported costs uniquely to electricity (e.g., much of the literature includes other costs from the natural disasters that precipitate outages). Insurance claims as a measure of cost are reported on in separate section of this report.
3. Studies of hypothetical outages are typically organized in ways that appear to support extrapolation of outage costs to the preparation of aggregate estimates of these costs. However, differences in methodology and data limitations prevent rigorous meta-analysis. Caution must be used in extrapolating results from existing studies to larger populations.
4. Studies of power quality generally involve case studies of specific sites and do not focus on cost issues.

The Changing Reliability Needs of the U.S. Economy

We adopted an end-use perspective for tracking changing reliability needs in the U.S. economy and prepared three examples of analysis from this perspective. In the commercial sector, we examined the electricity use requirements of office equipment. In the industrial sector, we assessed the viability of using aggregate statistics on industrial electricity use and economic activity to identify high-reliability-requirement customer market segments. A final approach was a case study of cleanrooms, which is a cross-cutting market segment known to have high reliability requirements.

Office Equipment Electricity Use

We developed estimates of electricity use by office equipment according to commercial building type. We accomplished this by combining information developed previously on total U.S. electricity use by office equipment with information on commercial building office equipment stocks. The framework developed for assembling this information can be used to evaluate scenarios for future office equipment load growth.

Key Findings:

1. Total U.S. office equipment electricity use in the commercial sector is about 58 TWh/yr., which is less than 2 percent of total U.S. electricity use.
2. Personal Computers (PCs), Monitors, and Minicomputers together account for more than half of all commercial sector office equipment electricity use.
3. Offices account for almost half of all commercial sector office equipment electricity use.
4. PCs and Monitors in offices account for almost one-quarter of all commercial sector office equipment electricity use.
5. Because electronic technologies change quickly, there are significant uncertainties in these calculations.

Statistical Indicators of High Reliability Requirements in the Industrial Sector

We next implemented a direct approach to better understand the variations in sensitivity to power-quality and reliability issues among industrial subsectors. Specifically, we developed and evaluated statistical indicators for high-reliability-requirement customer market segments based on aggregate data on industrial sector electricity use and economic activity.

Key Findings:

1. We identify 43 industries likely to be most susceptible to economic harm from disruptions in electricity supply. Together these industries consume almost 370 TWh/yr.
2. The method provides a direct approach for identifying high-reliability-requirement market segments in the U.S. economy. Nevertheless, it should be recognized that these data by themselves cannot be used to formulate mitigation strategies to address these requirements or to find the particular electricity uses in those sectors that have high reliability demands.
3. The method is not sufficient to provide information on the need for high quality power needs, aside from the likelihood of economic damage resulting from delivery disruptions.
4. To identify specific electricity applications with high reliability requirements a bottom-up analysis is needed. A bottom-up analysis would start by identifying the electricity end uses that are most sensitive to changes in power quality, e.g. adjustable-speed drives (ASDs).

High Reliability Requirements Case Study – Cleanrooms

We then reviewed the importance of electricity reliability for cleanrooms, which typically combine production of highly valuable products (e.g., computer chips fabrication) with 24/7 operation. We described the diversity of cleanroom types and applications (by industry), the costs of power disruptions to cleanrooms, and risk-management strategies currently in use. We propose this case study as a model for future case studies of other high-reliability-requirement processes or industries.

Key Findings:

1. Cleanrooms are a fast-growing part of the industrial sector; floorspace growth rates are forecasted at greater than 10% annually.
2. While cleanrooms are typically associated with high-tech manufacturing (production of semiconductor-based integrated circuits and other electronic components, and with the pharmaceutical and biotechnology industries), they are found throughout many other sectors, ranging from optics, to food, to medical settings. Cleanrooms can be found in at least 37 SIC categories
3. Primary energy consumption for cleanrooms is estimated at 230-260 TBTU/yr.
4. Semiconductor manufacturing and related industries account for two-thirds of cleanroom heating, ventilation, and air conditioning (HVAC) electricity use.
5. Class 1-10 cleanrooms, which include those used for semiconductor manufacturing, tend to have high reliability demands and can experience significant losses from disruptions in electricity service.
6. While some cleanroom fabrication facilities do spend money to support backup power for improved power quality and reliability, there is anecdotal evidence that over the past decade the willingness of industry to invest in reliability, even with two-year paybacks, may be limited.

Customer Options for and Trends in Addressing Reliability Needs – Insurance Industry Perspectives

EPRI has already conducted a number of studies on specific technological options for addressing customer's reliability needs, such as back-up generation, uninterruptible power supply (UPS) systems, and other power-quality-enhancing technologies and approaches. We have complemented this work with new information on insurance as an indicator of the costs of electricity outages and reliability problems, and as a strategy for managing risk.

Key Findings:

1. Power outages are a material issue for insurers. Insured loss data are, in turn, a valuable source of information on electricity reliability costs for the power sector and are more rigorous than many estimates promulgated by others.
2. Because of limited penetration of the relevant forms of insurance and role of deductibles, insurance loss data represent only part of the total cost. Some costs are covered by self-insurance, governments, and utilities who pay claims made by customers or municipalities.
3. Reliability-related insurance risks are perceived by insurers as being on the rise as customers become increasingly vulnerable to power outages. These losses can be triggered by natural or manmade catastrophes or localized interruptions in the utility system.
4. Power outages can precipitate various types of insurance claims from residential, commercial, or industrial customers (e.g., business interruption, property loss, machinery breakdown, additional living expense, and claims as well as claims by utilities for unserved energy). Insurance claims for "data losses" are a growing issue.
5. Risk management options for insurance companies fall into two broad categories. Financial techniques include limiting insurance exposure e.g., by means of deductibles or loss limits (for insurance providers). Engineering risk management techniques include a host of technology responses that may be promoted by insurers, ranging from specific technologies such as back-up generation to management strategies such as early warning systems and post-event business continuity planning.
6. Insurers are likely to increase their participation in risk management in the future (both to reduce their exposure and the loss potential on the customer side) and have begun to explore collaborations with electricity and equipment providers. Some innovative examples are already visible. In some instances, energy-efficient technologies offer ancillary loss-control benefits by making systems more resilient following power disruptions.

Next Steps

In the final section of the report, we integrated recommendations for next steps developed separately for each section of the report and prioritized them into a single list.

Our primary recommendation is to initiate development of a comprehensive framework and then estimate a range for the cost of unreliable electricity to the U.S. economy. We recommend a "bottom-up" approach in order to support sub-analyses for specific events, regions, or market sectors. First and most importantly, while an aggregate estimate is valuable for strategic reasons, estimates for specific events, regions, or market sectors are more useful for planning specific R&D initiatives. Second, a bottom-up approach is wellsuited to future integration of information from different sources and perspectives. The organizing principle for future efforts should be triangulation. Third, a bottom-up approach will permit a more structured approach to assessing uncertainty and prioritizing incremental data collection and analysis. Credibility will be enhanced by clear statements regarding the limitations of future analyses.

In view of these considerations, we developed a consolidated short-list of recommended priorities:

1. Collect, consolidate, and improve the quality of information on customer reliability costs.
   - Extend the database on outage and power quality event costs to include older assessments, including work summarized in earlier surveys of the literature, and to include studies in the “gray” literature.
   - Conduct meta-analysis to synthesize and better understand the limits of extrapolation of the database toward supporting development of a comprehensive national estimate and related sub analyses. For any given event, location, or customer type, we are limited by available data. Meta-analysis can help to improve confidence in extrapolating from existing data.
   - Integrate information on costs of outages and power quality events with information on frequency of occurrence.
   - Collect additional information on customer power quality costs.

2. Systematically approach developing information on customer spending on capital and operations to address electricity reliability.
   - Work with vendors, manufacturers, trade associations (back-up generation, UPS, etc.) to gather aggregate information on spending and mitigation approaches. This is a “supply-side” approach to this issue.
   - Continue case studies to track high-reliability requirements customer market segments (cleanrooms, data centers, etc.) and/or equipment (PCs, ASDs, process controls). This is a complementary, “demand-side” approach to this issue.

3. Develop relationships with the insurance industry to develop information on customer spending on insurance. This scoping study has indentified the insurance industry as key source of information on the cost of electricity reliability and as a potential partner for promoting technology solutions.
   - Use insurance techniques to provide a new proxy for the value of electricity reliability nationally in order to seek additional insight on how insurers “Value” electricity reliability.
   - Obtain quantitative information from self insurers on reliability related losses, as well as on risk-management strategies.
   - Conduct analysis for and pursue coordination among insurers and energy-focused firms to identify and value the risk-management characteristics of electricity reliability enhancing and energy efficiency technologies in the context of the insurance marketplace, both from technical and market standpoints.