Understanding the Value of Uninterrupted Service

Paul Centolella, Vice President
Analysis Group

Mark McGranaghan, Vice President – Power Delivery and Utilization
Electric Power Research Institute

CIGRE Grid of the Future 2013
Technological Solutions to Regulatory Challenges
October 21, 2013
Renewed Focus on Reliability

• Superstorm Sandy Changed the Perception of Weather Risks
  • Sandy costs: $27 - $52 billion
  • Cost of weather related power outages: $20 billion - $55 billion/yr.
  • Over last 20 years >178 million customers lost power in major weather related outages
  • Number of major weather related outage more than doubled in 20 years
  • National Climate Assessment: increased potential for extreme weather, peak electric demands, coastal flooding, & cooling water shortages
Renewed Focus on Reliability

- Increasing cost of service interruptions
  - Technological Change & Smart Manufacturing: greater reliance on information, communications, & digital control technologies
  - Systemic Risks in Major Outage: Interdependence of critical infrastructure

- Growing Risk of Cyber & Physical Security Events
  - Cyber Security: “The cyber threat to critical infrastructure continues to grow and represents one of the most serious national security challenges we must confront.” Executive Order (Feb. 2013)
  - Physical Security: April 16, 2013 Attack on PG&E Metcalf Substation
  - National Academy of Sciences: Economic costs of terrorist attack on U.S. power delivery system could be as high as hundreds of billions of dollars

- Impacts on Utility Business Model
  - Customers invest in dispersed generation if grid perceived to be unreliable
How Reliability is Addressed in Regulation

- Quality Regulation - Reporting or targets: 23 States, Penalties: 11 States, Adjust rates for performance: 5 States
- Storms lead to regulatory reviews in affected states: MD, NJ, NY, CT, MA, IL
  - Standards often did not address storm restoration, but evolve
- Value of uninterrupted service is seldom quantified
  - Economic justification for reliability investments typically lacking
- Regulator balances reliability & cost based on limited information
  - Least cost focus can lead to externalizing costs to consumers
  - Equivalent reliability leads to focus on worst circuits rather than greatest value

Regulatory Reliability Standards 2005

Average Minutes of Service Interruption Per Customer

- Poland
- United States
- Portugal
- Czech Republic
- Great Britian
- France
- Italy
- Netherlands
- Germany

All Events vs Excluding Major Events
Value of Uninterrupted Service

• Value of uninterrupted service varies between customer classes

  • U.S. Department of Energy Meta-analysis results:

    |                      | Cost per Unserved kWh | Cost per Event |
    |----------------------|-----------------------|----------------|
    |                      | 30 Minute Outage      | 8 Hour Outage  |
    | Residential          | $3.50                 | $0.90          |
    | Small C&I            | $396.30               | $296.10        |
    | Medium & Large C&I   | $22.60                | $10.60         |

    |                      | 30 Minute Outage      | 8 Hour Outage  |
    | Residential          | $2.70                 | $10.60         |
    | Small C&I            | $435.00               | $5,195.00      |
    | Medium & Large C&I   | $9,217.00             | $69,284.00     |

• Value of uninterrupted service varies within customer classes

  • U.S. Department of Energy Meta-analysis results:

    Average Electric Medium & Large Customer Interruption Cost per Event (2008$)

    |                      | Momentary | 1 Hour | 8 Hour |
    |----------------------|-----------|--------|--------|
    | Agriculture          | $4,382    | $8,049 | $41,250|
    | Trade & Retail       | $7,625    | $13,025| $58,694|
    | Mining               | $9,874    | $16,366| $70,281|
    | Services             | $8,283    | $14,793| $71,997|
    | Manufacturing        | $22,106   | $37,238| $164,033|
    | Construction         | $27,048   | $46,733| $214,644|
Limitations of DOE Outage Cost Analysis

- U.S. Department of Energy through Lawrence Berkeley National Lab has developed tools for estimating outage costs to customers
  - Interruption Cost Estimate Calculator: http://www.icecalculator.com/
  - Most accessible data on U.S. customer outage costs
  - Based on utility surveys using standard 1995 EPRI methodology
  - Underlying data needs to be updated and expanded
    - Based on surveys conducted for 9 utilities from 1989 to 2005
    - Only 2 utility datasets include surveys conducted after the year 2000
    - None of the data from Northeastern, Mid-Atlantic, or Mountain West states
    - None of the surveys asked about outages lasting longer than 8 hours
Methods for Estimating Value of Uninterrupted Service

- **Survey-based methods**: Most widely used approach
  - Can obtain outage costs for variety of conditions by asking about outages of varying durations, with / without advance notice, in different seasons, or at different times of day
  - Properly structured surveys can provide robust content validity: customer is in the best position to assess the impacts based upon their experience & requirements
  - Stratified sampling can ensure desired precision and representation of customer populations of interest

- **Commercial and industrial surveys** use “Direct Worth: approach:
  - Customers asked about the value of lost production, other outage related costs, & outage related savings, taking into account their ability to make up for any lost production

- **Residential surveys** use “Willingness to Pay” and/or “Willingness to Accept” approach:
  - Most residential impacts are not directly observable economic costs but quality of life impacts
  - Survey “willingness to pay” to avoid specific outages and / or the amount of compensation required to agree to specific interruption, “willingness to accept”
Alternative Methods for Estimating Outage Costs

• Proxy “revealed preference” methods: Uses an observable behavior to estimate value of outage avoidance, e.g. if customer purchases back-up generator, the customer’s expected cost of avoided outages may be equal to or exceed the cost of the backup power supply
  • Proxy methods are available in limited circumstances where behavior is observed & suggest only an upper or lower bound on outage costs.

• Consumer surplus: Estimates based on observations of longer term price elasticity.
  • Drawback of relying on assumed correspondence between long-term elasticity for known price changes and short-term outage costs has severely restricted its use

• Reliability demand models: In developing countries may include the quality of service purchased in a demand models
  • Given uniformly high levels of U.S. reliability, approach is not been applied here
Extending Survey Methods

- Customer segmentation: Modern statistical methods applied to additional customer data may identify segments that place the greatest value on reliability.
  - Traditional customer classifications may not be the only or most important drivers of differences in the value of uninterrupted service
  - Linking to other demographic and / or psychographic information may identify customer characteristics most associated with valuing reliability
  - By providing targeted service offerings, utility may be able to provide greater reliability, at less cost, & with reduced environmental impacts compared to customer dispersed generation

- Service Quality Index: For key customers service quality & customer satisfaction not related only to traditional reliability indicators (SAIFI, SAIDI, CAIDI), may be impacted by:
  - Power quality characteristics affecting customer equipment
  - Disturbances including momentary outages and voltage sags
  - Weighting different effects based on their potential economic impacts for the customer can help characterize the quality of service provided
Service Quality Index

- Service Quality Index provides:
  - Exploring options for key customers
  - Including steady state power quality, momentary outage & voltage sag impacts
  - Exploring probability of such impacts
  - Incorporating representative or customer specific economic value

Procedure for Applying Service Quality Index
Reliability from a Customer Perspective

• Utilities face significant investment requirements in a challenging environment – setting reasonable priorities requires a consistent economic framework

• Understanding the value of uninterrupted service can enable utilities to:
  • Support and prioritize investments to replace aging infrastructure, in advanced distribution automation, in outage management systems and advanced metering infrastructure, and in grid hardening and climate adaptation
  • Help utilities assess business risks: Customers will tend to pursue dispersed generation based on value they place on uninterrupted service
  • Enable utilities to offer value added services to customers willing to pay for enhanced levels of reliability

• New studies needed to understand reliability from a customer perspective
Paul Centolella  
Vice President  
111 Huntington Ave. 10th Floor  
Boston, MA 02199  
(617) 425-8182  
pcentolella@analysisgroup.com

Mark McGranaghan  
Vice President, Power Delivery and Utilization  
942 Corridor Park Boulevard  
Knoxville, TN 37932  
(865) 218-8029  
mmcgranaghan@epri.com