Understanding the Value of Uninterrupted Service

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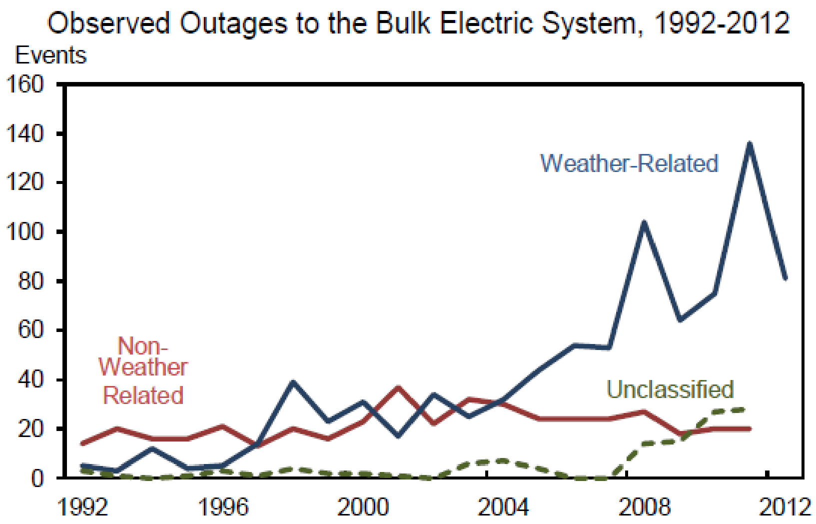
Renewed Focus on Reliability

- **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

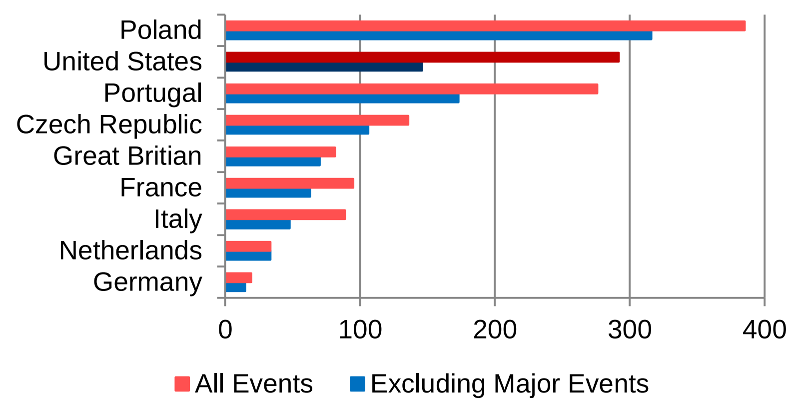
- **Increasing cost of service interruptions**
  - Technological Change & Smart Manufacturing: greater reliance on information, communications, & digital control technologies
  - Systemic Risks in Major Outage: Interdependence of critical infrastructure
- **Growing Risk of Cyber & Physical Security Events**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



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	30 Minute Outage	8 Hour Outage
Residential	$ 3.50	$ 0.90	$ 2.70	$10.60
Small C&I	$396.30	$ 296.10	$435.00	$ 5,195.00
Medium & Large C&I	$ 22.60	$10.60	$ 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

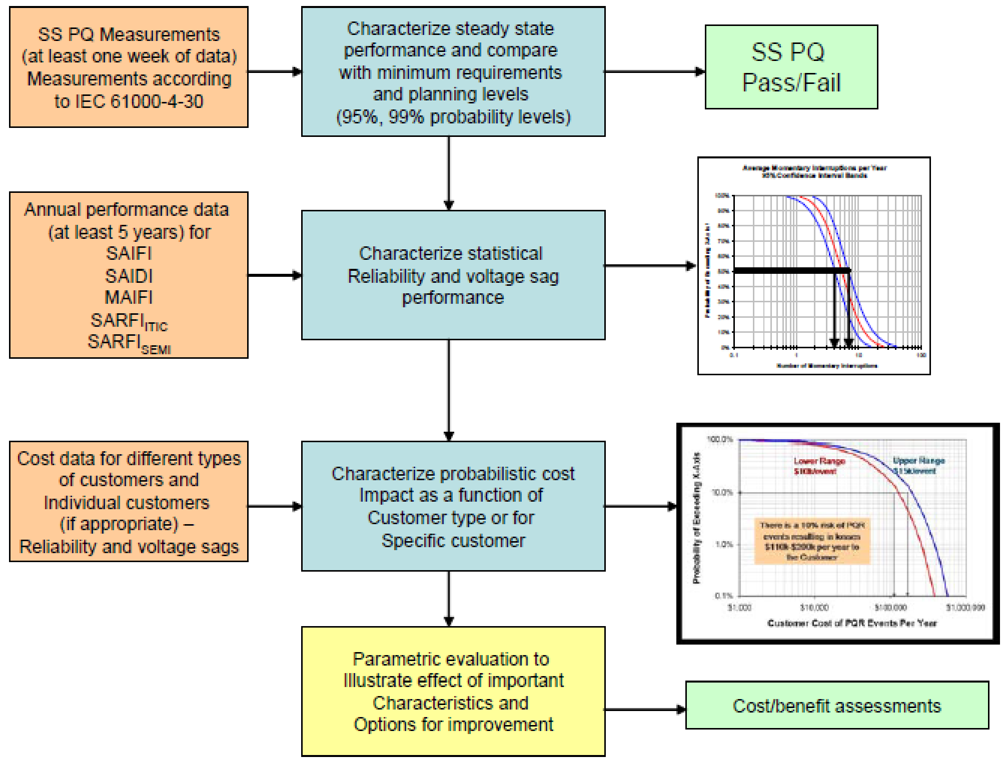
Extending Survey Methods

- **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**

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