

Finding the Balance Between Reliability and Cost: How Much Risk Should Consumers Bear?

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Contents

- ◆ Balancing Reliability and Cost Foundational Economics
 - Cost of Reliability “Insurance”
 - Value (VOLL)

- ◆ Resource Adequacy

- ◆ Delivery System
 - Reliability
 - Resiliency

- ◆ Reliability Costs and Benefits In Perspective

Cost of Reliability

Breakdown of Cost of Delivered Power

Bill Components	Percentage
Fuel and Power Supply	70.0%
- Energy	52.5%
- Firm Capacity	15.8%
- Reserve Capacity	1.8%
Electric Delivery	30.0%
TOTAL	100.0%

Source:

Analysis of FERC Form 1 data; breakdown between fuel and power supply and electric delivery were rounded for ease of presentation. Breakdown of fuel and power supply based on panel of utility data.

Reliability “insurance” is included in utility rates

- ◆ Reserve requirements for generating capacity
- ◆ N-1 contingencies in transmission
- ◆ Redundant equipment and systems and hardened assets built in to distribution system

How much should customers pay to ensure (highly) reliable electric service?

Conversely, how much risk (of outage) should customers bear in order to keep rates down?

Foundational Economics

$$\textit{Incremental benefit (demand)} = \textit{Incremental cost (supply)}$$

- ◆ Slightly different context than traditional cost-benefit analysis
- ◆ Costs can be traced to investment borne by the electric utility
- ◆ Benefits may be realized by the utility via efficiency gains or factors which lower overall production costs (and then passed in whole or in part to customers), but...
- ◆ ... benefits are frequently realized directly by customers in the form of reduced frequencies and durations of outages and measured by the value they place on avoiding outages

Value of Lost Load

- ◆ Demand curve for incremental investment may be approximated by customer *willingness to pay (WTP)* or *the value that customers place on avoiding losing load (VOLL)*
- ◆ VOLL = survey-based estimate of value to various categories of customers by duration of outage event (Berkeley National Lab / DOE, 2009)
 - Total VOLL higher for longer duration events, but lower on unserved kWh basis
 - Lower for Residential than Commercial and Industrial (which face lost revenues)
- ◆ VOLL can be as high as \$95,000 for an 8 hour outage event during a summer day for a large commercial or industrial customer

Value of Lost Load

Much higher than cost – and utility would not charge rates that are equal to VOLL – but indicator of potential benefits

VOLL For “Anyday” (Average) Berkeley / DOE Study (2009)

Interruption Cost	Interruption Duration				
	Momentary	30 minutes	1 hour	4 hours	8 hours
Medium and Large C&I					
Cost Per Event	\$6,558	\$9,217	\$12,487	\$42,506	\$69,284
Cost Per Average kW	\$8.0	\$11.3	\$15.3	\$52.1	\$85.0
Cost Per Un-served kWh	\$96.5	\$22.6	\$15.3	\$13.0	\$10.6
Cost Per Annual kWh	\$0.0009	\$0.0013	\$0.0018	\$0.0060	\$0.0097
Small C&I					
Cost Per Event	\$293	\$435	\$619	\$2,623	\$5,195
Cost Per Average kW	\$133.7	\$198.1	\$282.0	\$1,195.8	\$2,368.6
Cost Per Un-served kWh	\$1,604.1	\$396.3	\$282.0	\$298.9	\$296.1
Cost Per Annual kWh	\$0.0153	\$0.0226	\$0.0322	\$0.1370	\$0.2700
Residential					
Cost Per Event	\$2.1	\$2.7	\$3.3	\$7.4	\$10.6
Cost Per Average kW	\$1.4	\$1.8	\$2.2	\$4.9	\$6.9
Cost Per Un-served kWh	\$16.8	\$3.5	\$2.2	\$1.2	\$0.9
Cost Per Annual kWh	\$0.0002	\$0.0002	\$0.0002	\$0.0006	\$0.0008

Source: Sullivan, M., Mercurio, M., and Schellenberg, J. (2009) *Estimated Value of Service Reliability for Electric Utility Customers in the United States*. Lawrence Berkeley National Laboratory . Table ES-5.

Generating Reserve Requirements

Breakdown of Cost of Delivered Power

Bill Components	Percentage
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Source:

Analysis of FERC Form 1 data; breakdown between fuel and power supply and electric delivery were rounded for ease of presentation. Breakdown of fuel and power supply based on panel of utility data.

- ◆ Cost of generating reserves are currently included in the cost of power
- ◆ Current RA (planning reserve margin) requirements typically based on “1-day-in-10-year” standard
 - Not defined uniformly (0.1 event per year vs. 2.4 hours per year)
 - Has not been updated in decades
- ◆ Translates into 10% or 15% reserve margin

Reserve Requirements Costs and Benefits

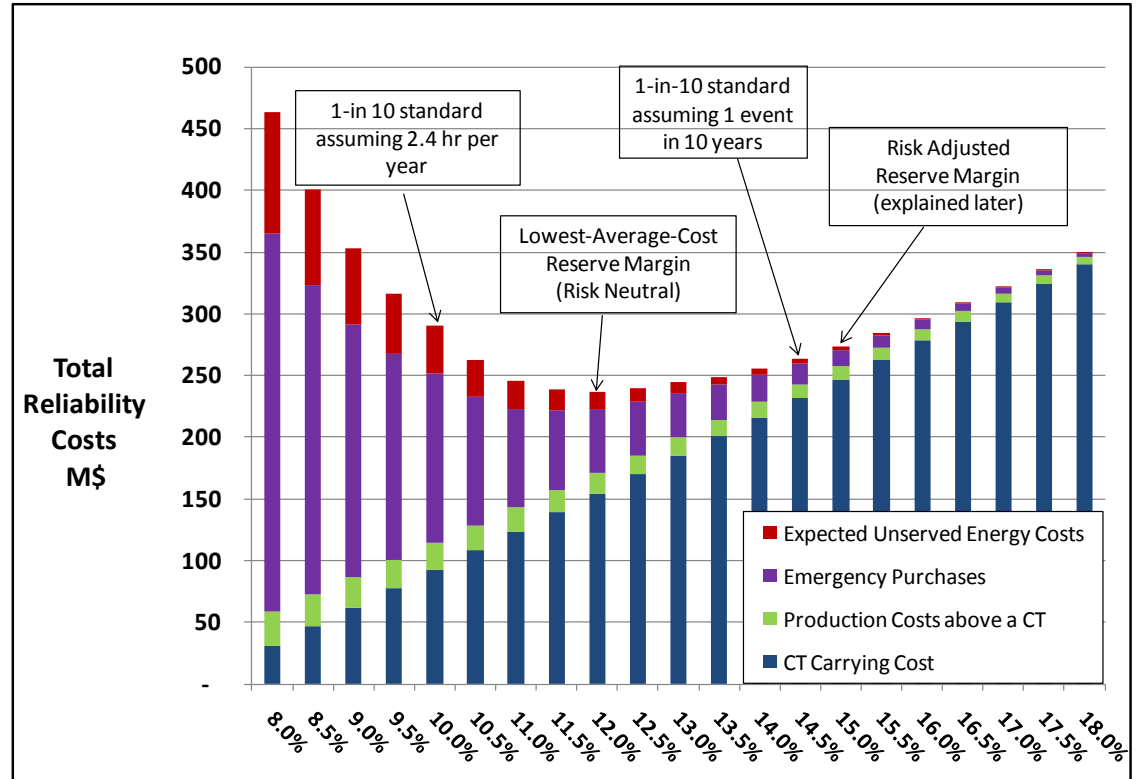
Are RR set so incremental costs = incremental benefits?

- ◆ “Reasonable level”: probability of failure to carry load 1 day in 8 – 10 years. (Calabrese, 1947; Watchorn, 1950)
- ◆ Reserve requirements could be lower than 1-in-10 if based on economics of incremental benefits (VOLL) = incremental costs. (Telson, 1973; PGE 1990)
- ◆ Optimal reserve requirements may be higher than 1-in-10 if all costs are considered
 - Production related reliability costs
 - Emergency purchase costs
 - Unserved energy costs (EUE and VOLL)(Astrape Consulting and The Brattle Group, NRRI, 2011)

Reserve Requirements Costs vs. VOLL

- ◆ Benefit of optimal RR % = overall lower cost to customers
- ◆ Estimated impact of EUE (VOLL) is relatively low – *because risk of firm load shed events is relatively low*
- ◆ Major impact of reduced RR is more on cost of purchases of power (emergency) than value of lost load.

Cost To Customers Vs. Reserve Requirements



Source: Carden, Pfeifenberger and Wintermantel, *The Economics of Resource Adequacy Planning: Why Reserve Margins Are Not Just About Keeping the Lights On*, NRRI Report 11-09, April 2011.

Investments In Electric Delivery

Breakdown of Cost of Delivered Power

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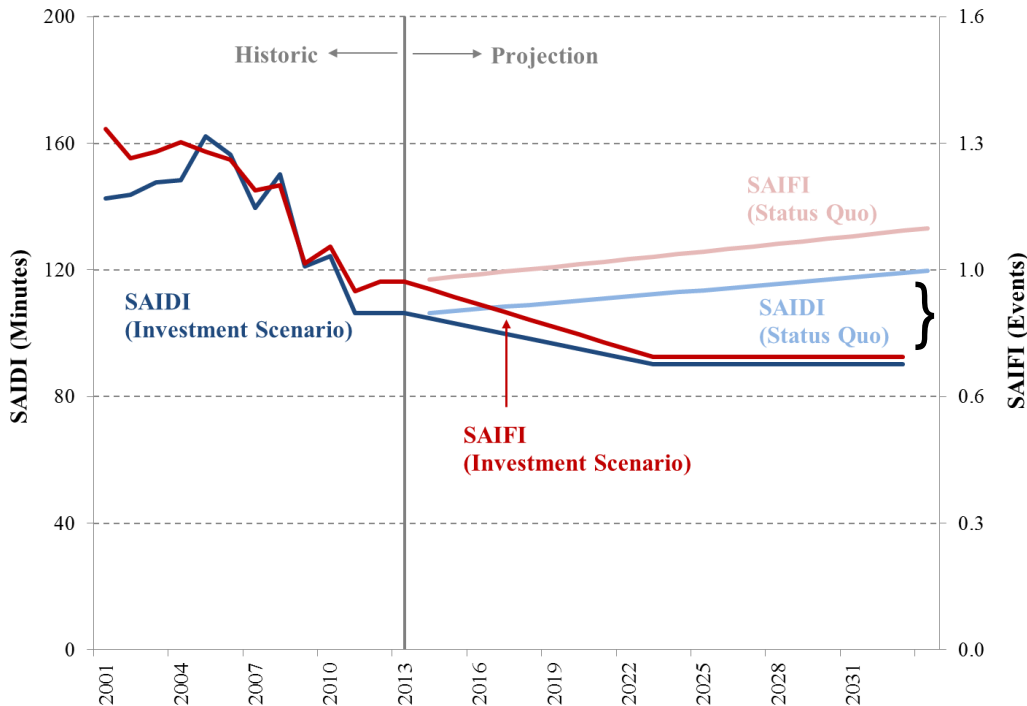
Source:
Analysis of FERC Form 1 data; breakdown between fuel and power supply and electric delivery were rounded for ease of presentation. Breakdown of fuel and power supply based on panel of utility data.

- ◆ Upgrades in T&D system, AMI and SG
 - Net book value of IOUs ~\$300 billion (not replacement value)
 - Upgrading aging distribution system + smart grid investment over next 20 years ~\$600 billion
- ◆ Additional investments required to bring renewables (wind) to load centers
 - New transmission to integrate renewables and maintain reliability: ~\$250 billion
 - Plus more in flexible backup generation (gas CTs)
- ◆ New investments in reliability and resiliency ~ \$multi billion per mid-large utility (region-specific)

Sources:
Brattle analysis; *Transforming America's Power Industry: The Investment Challenge 2010-2030*, by *The Brattle Group* for the Edison Foundation.
Brattle analysis of FERC Form 1 data; upgrade and replacement estimates based on *Brattle* analysis

Value of Distribution System Investment: Reliability

**Projected SAIDI-x and SAIFI-x
Status Quo Case vs. Incremental Investment Case
Midwestern Electric Utility**



Source:
Based on analysis for midwestern U.S. electric utility.

$$\text{SAIDI} = \frac{\text{Sum of customer minutes of interruption}}{\text{Number of customers served}}$$

$\Delta \text{SAIDI} \rightarrow \Delta \text{CMI}$

Outage duration profile

Allocation among customer classes

VOLL per class and outage duration

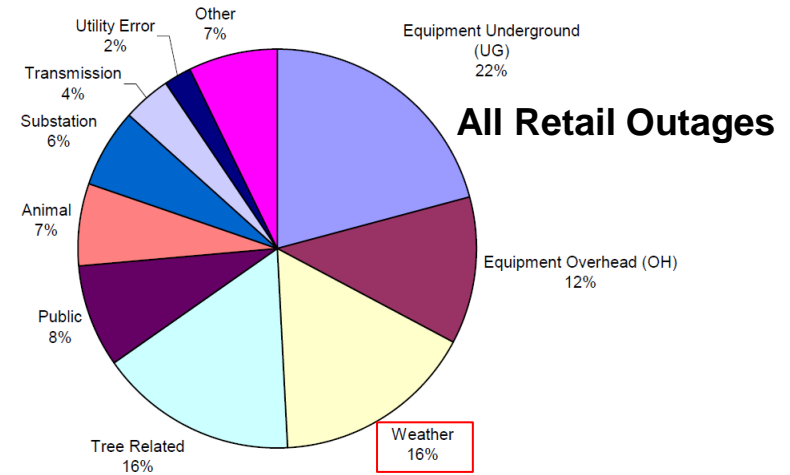
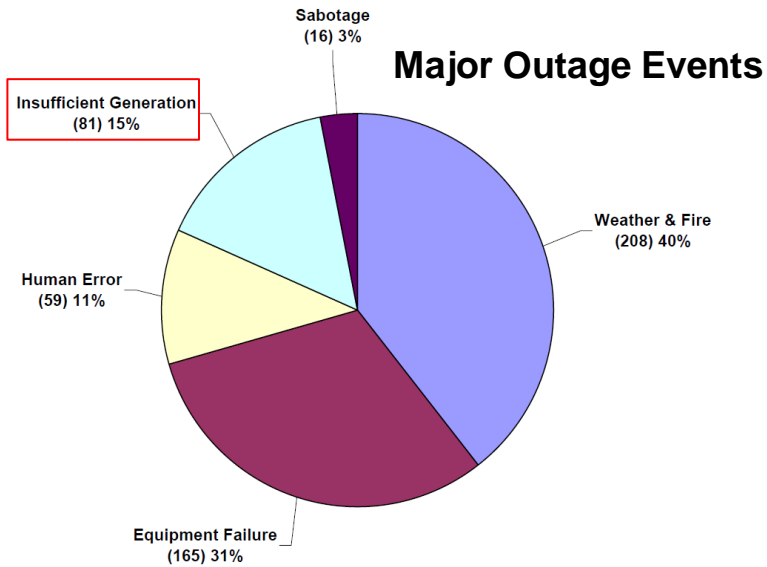
Estimated value of improved SAIDI and SAIFI

NPV when compared to investment schedule

Value of Distribution System Investment: *Resiliency*

- ◆ Investments in resiliency are aimed at bringing service back on line following unavoidable outages (typically caused by extreme weather events)
- ◆ Frequently involves application of system intelligence and asset hardening
 - Costs tend not be justified on operational grounds alone
 - Cost justification for Smart Grid investments may come load shifting and EE related benefits
- ◆ Assessing value to customers requires analysis of risk and probabilities, more so than for investments in reliability
 - Outage impacts reduced (if event strikes) and VOLL may well exceed investment costs
 - Similar to insurance products – which are paid for, but may never be called upon

Loss of Electric Service



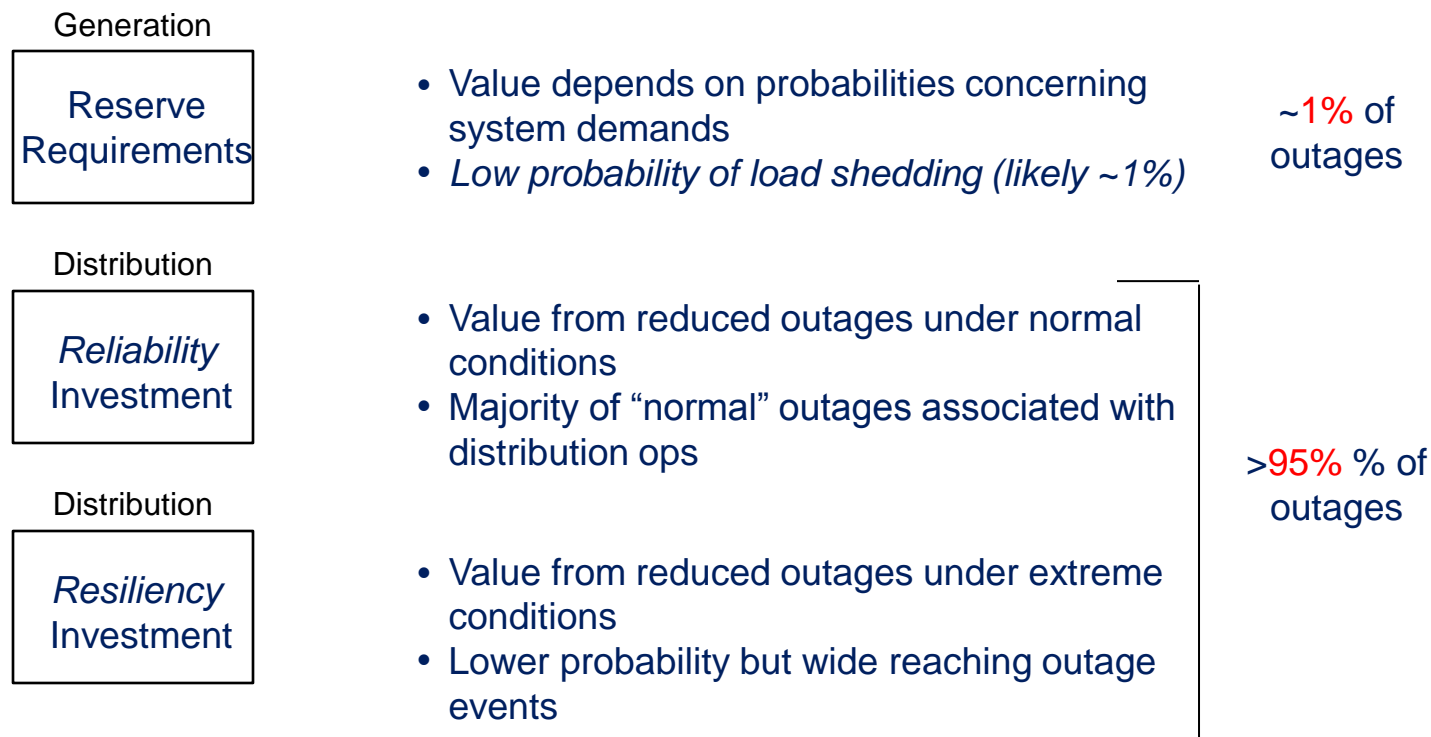
	G & T: 1 to 5% of Outages	Distribution: > 95% of Outages
ERCOT 1-in-10	Average CMI = 1	Average CMI > 100

Source:

1. Lave, Apt and Morgan, *Worst Case Electricity Scenarios: The Benefits & Costs of Prevention*, CREATE Symposium, University of Southern California, August 2005
2. Breakdown of outage causation between Generation and Distribution : Brattle estimate
3. CMI in 1-in-10 scenario: *ERCOT Investment Incentives and Resource Adequacy* The Brattle Group, 2011

Reliability Costs and Benefits In Perspective

Unclear – but unlikely – that investments in reserve requirements and distribution reliability reflect the relative risk of customer outages



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Note:

The views expressed in this presentation are strictly those of the presenter and do not necessarily state or reflect the views of *The Brattle Group, Inc.*

Bill Zarakas is an economist who specializes in the electric utility and telecommunications industries. He works extensively on the strategic and regulatory issues facing those industries, and has authored numerous reports, presentations and articles concerning the issues associated with investments in utility infrastructure, costs and benefits relating to system reliability and resiliency, and the evolving factors that are affecting utility business models.

Bill has worked extensively with electric utilities, telecommunications carriers, industry associations, regulatory commissions, and governmental agencies. He has testified before state and federal regulatory commissions and authored reports submitted to governments, regulatory commissions, courts of law, and arbitration panels. He has also headed regulatory audits of utilities and telephone carriers performed on behalf of regulatory commissions.