The Brattle Group

Reliability and Economics:
Separate Realities or Part of the Same Continuum?

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Harvard Electricity Policy Group

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Contents

What is Reliability … and its Cost?

For end users, "reliability" is a combination of three distinct components:

- Distribution system reliability
- Transmission system reliability
- Resource adequacy (supply vs. load)

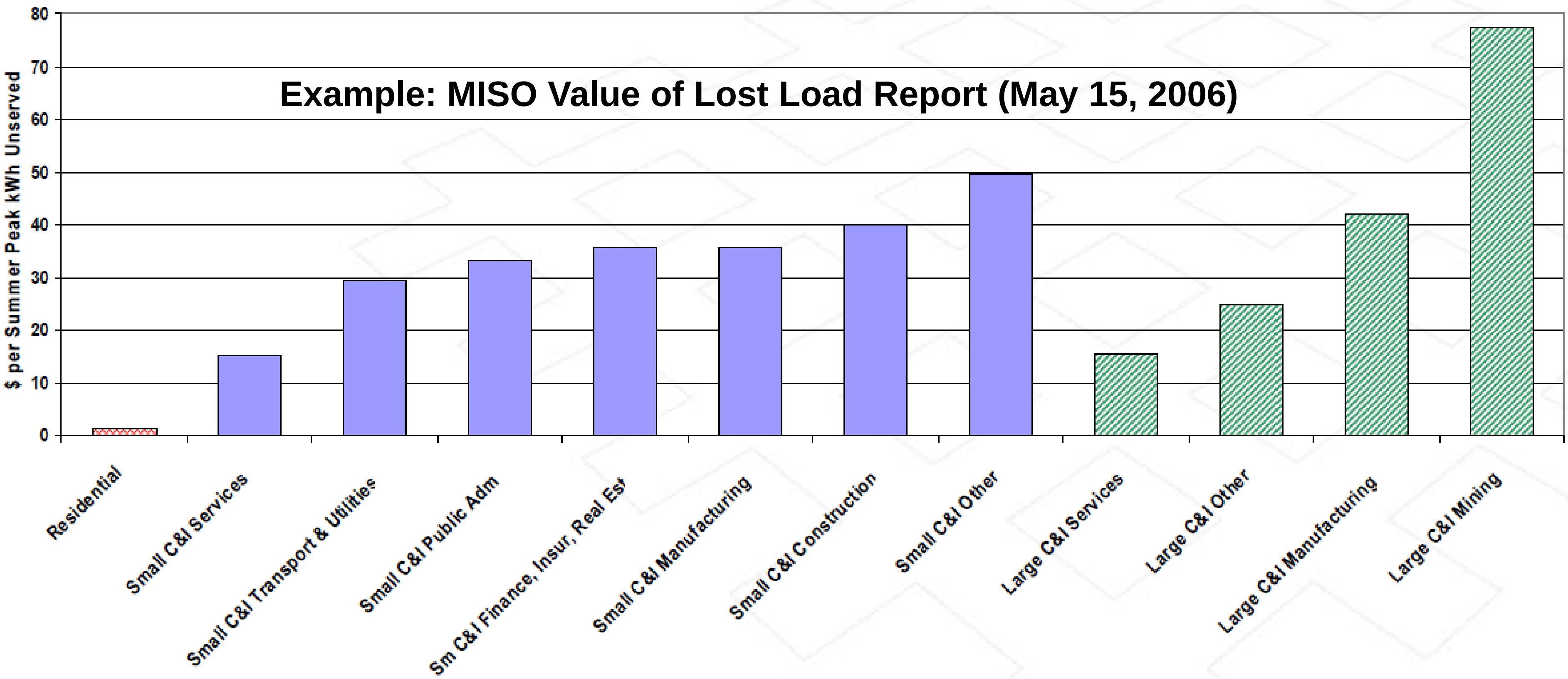
Estimates for U.S.-wide customer cost of power outages range from $20 billion to $150 billion per year:

- EPRI (1993): $26 billion/yr
- Swaminathan and Sen (Sandia 1998): $150 billion/yr
- Primen (EPRI 2001): $119 billion/yr
- LaCommare and Eto (LNBL 2004): $80 billion/yr (ranging from $22-135 billion)

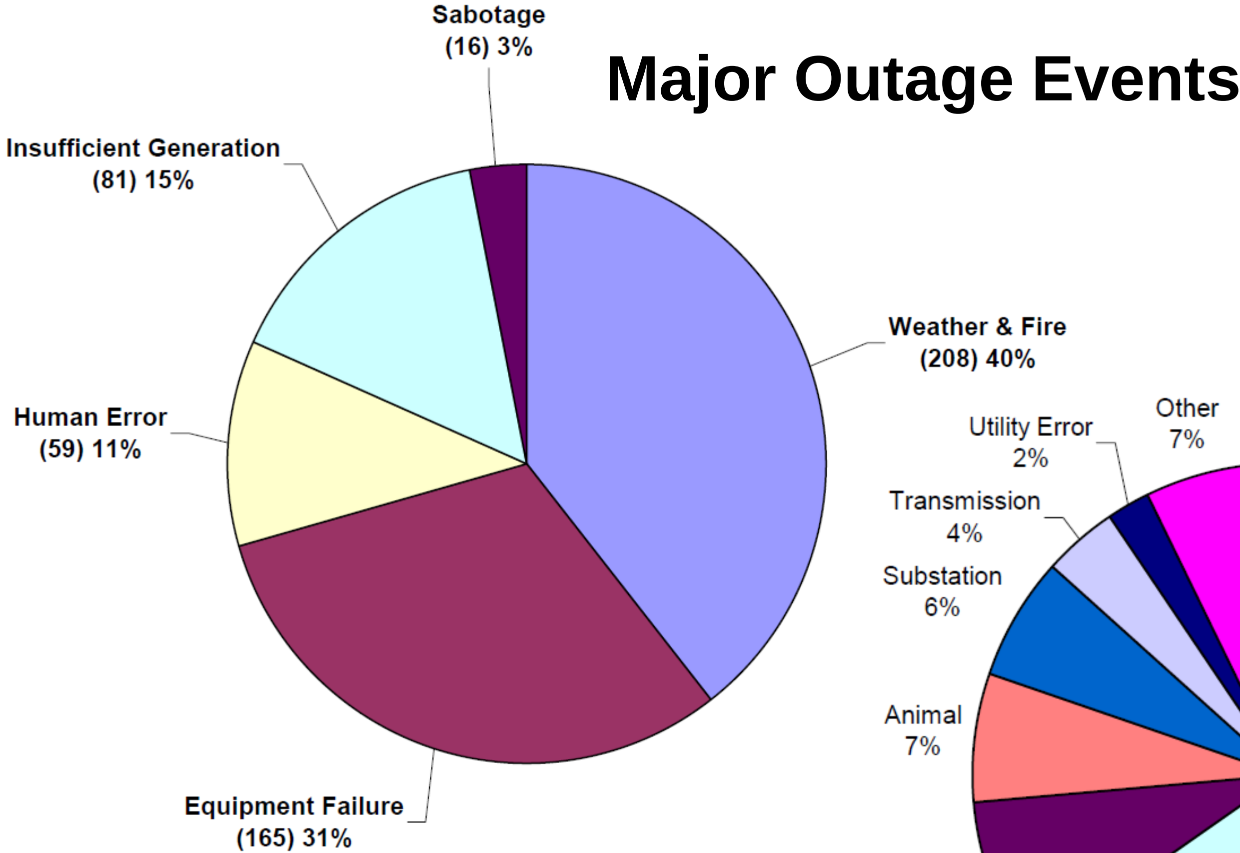
Customer Costs of Outage Events

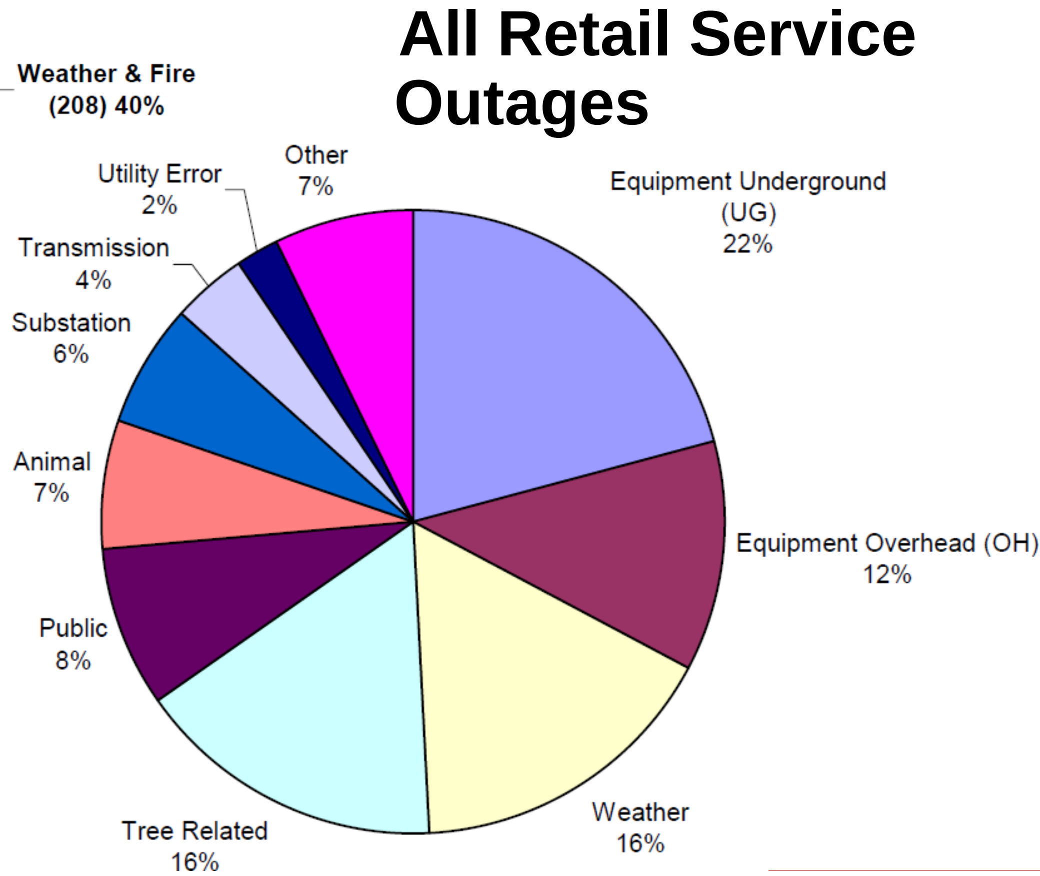
Outage costs measured as the Value of Lost Load (VOLL):

- Residential customers have VOLL in $1,500 to $3,000/MWh range
- Commercial and industrial VOLL well in excess of $10,000/MWh



Causes of Power Outages





Source: Lave, Apt and Morgan, *Worst Case Electricity Scenarios: The Benefits & Costs of Prevention*, CREATE Symposium, University of Southern California, August 2005.

Frequency of Major Outages Events

While large-scale outages are rare, there are many events in the 100 MW to 10,000 MW range

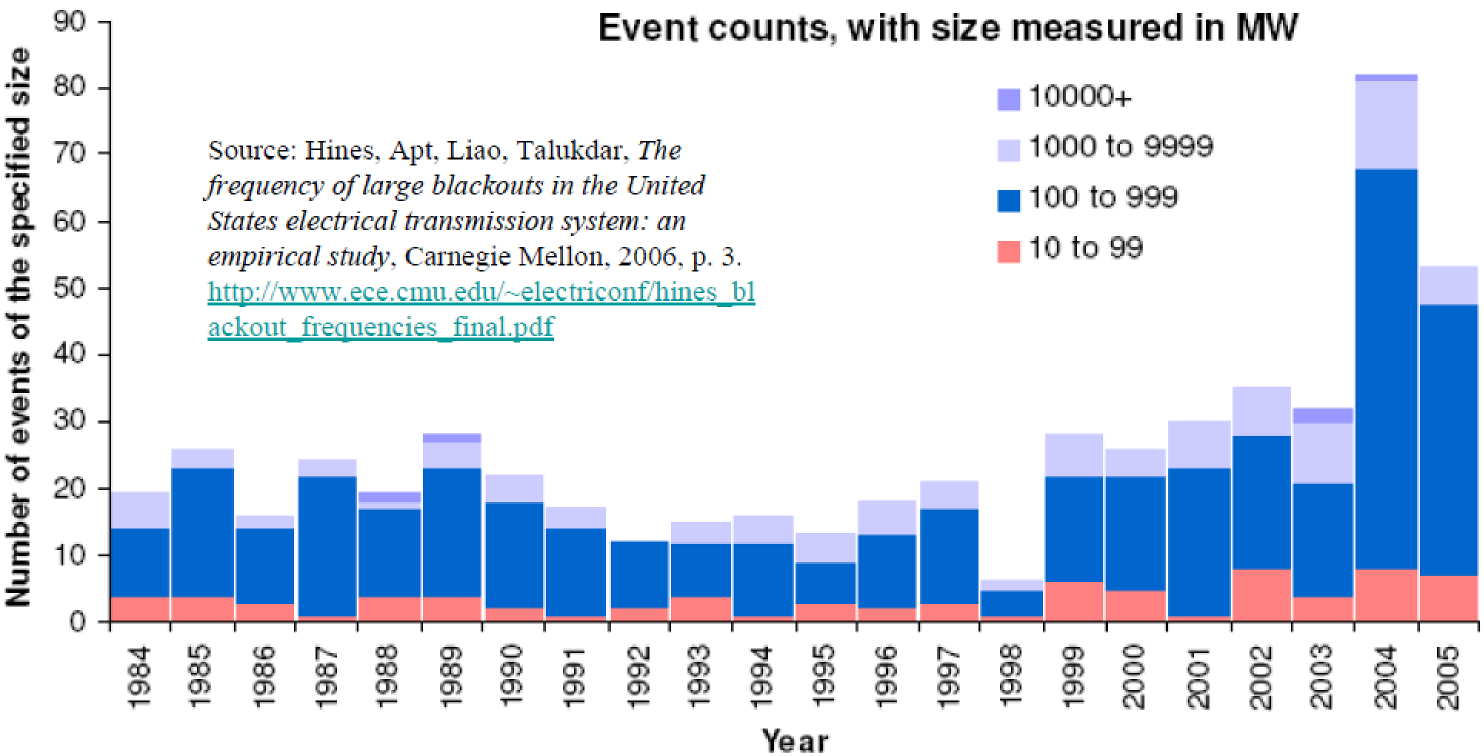


Figure 2.2 — Blackout frequencies for the years 1984 to 2005. Size here is measured in the number of MW interrupted. 2004 and 2005 data come from the EIA (2005 data is for Jan-Sept only), all other data is from the NERC DAWG records.

~ 24 events/yr in 100-1,000 MW range

~ 5 a year in 1,000-10,000 MW range

~ 1 event every 4 years above 10,000 MW

Number of events may be increasing over time

What is Reliability?

Economic Analysis of Resource Adequacy

Additional Reading / About the Brattle Group

Why Resource Adequacy Standards?

RAS offer several attractive benefits

- Ensure adequate reliability, prevent curtailments
- Address common-good/free-ridership problem
- Reduce price volatility and investment risk premiums
- Mitigate market power in spot energy markets

Do RAS distort energy markets?

- Yes, but similar to requirements imposed in other markets
- Examples: vehicle safety standards, building codes, appliance efficiency requirements

Will RAS be able to “fade away” as DR grows?

- Not entirely: creating additional “non-firm” service (DR) does not eliminate the need for reliability of serving the residual “firm” load
- Only if (1) customers can choose to purchase higher reliability for their firm residual load and (2) the ISO can curtail others

Resource Adequacy: The 1-in-10 Standard

Current RA (planning reserve margin) requirements typically based on "1-day-in-10-year" standard:

- Does not consider MW size of event nor size of system
- Does not consider duration of events
- Is not defined uniformly (0.1 event per year vs. 2.4 hours per year)

Has not been updated in decades for:

- Changes in how electricity is used
- Growing and more interconnected balancing areas, RTOs
- Substantial increases in costs of peaking plants
- Increased renewable generation and demand response

Industry is exploring new physical metrics

- "normalized EUE" (exp. unserved energy normalized for system size)

What's the "Right" Level of Resource Adequacy?

Unclear who "owns" question whether physical reliability metrics are cost effective (States, RTOs, NERC, FERC?)

- FERC Order 747 approved 1-in-10 as just and reasonable, but allows RAS to consider other factors, such as costs
- Some utilities and state commissions (e.g., in GA, FL, AL, KU) have considered costs and economic benefits in setting target reserve margins

Physical reliability is important but understanding the cost, economic value, and risk mitigation of different levels of planning reserves is necessary to:

- Determine cost effectiveness of target reserve margin
- Document value of reserves to customers and regulators

Our April 2011 NRRI report discusses this in greater detail

(Carden, Pfeifenberger, Wintermantel, NRRI 11-09, April 2011)

What's the "Right" Level of Resource Adequacy?

Determining the "right" level of RA should consider:

- Cost of incremental capacity
- Reduced outage costs (VOLL x LOLP)
- Reduced reliance on high-cost purchases and resources
  - Dispatch of high cost resources such as oil units, high-heat-rate units, generation emergency limits
  - Calls on high-dispatch-cost demand-side resources
  - Opportunity costs of energy limited resources such as hydro, pumped storage, environmentally-limited plants
  - Expensive purchases (e.g., imports, scarcity pricing)
- Reduced price volatility (lower investment risk premium, customer value, and policy value)
- Increased competition in short-term energy markets
- System characteristics (size, interties, generation mix, load uncertainty)
- Market structure (regulated vs. restructured)

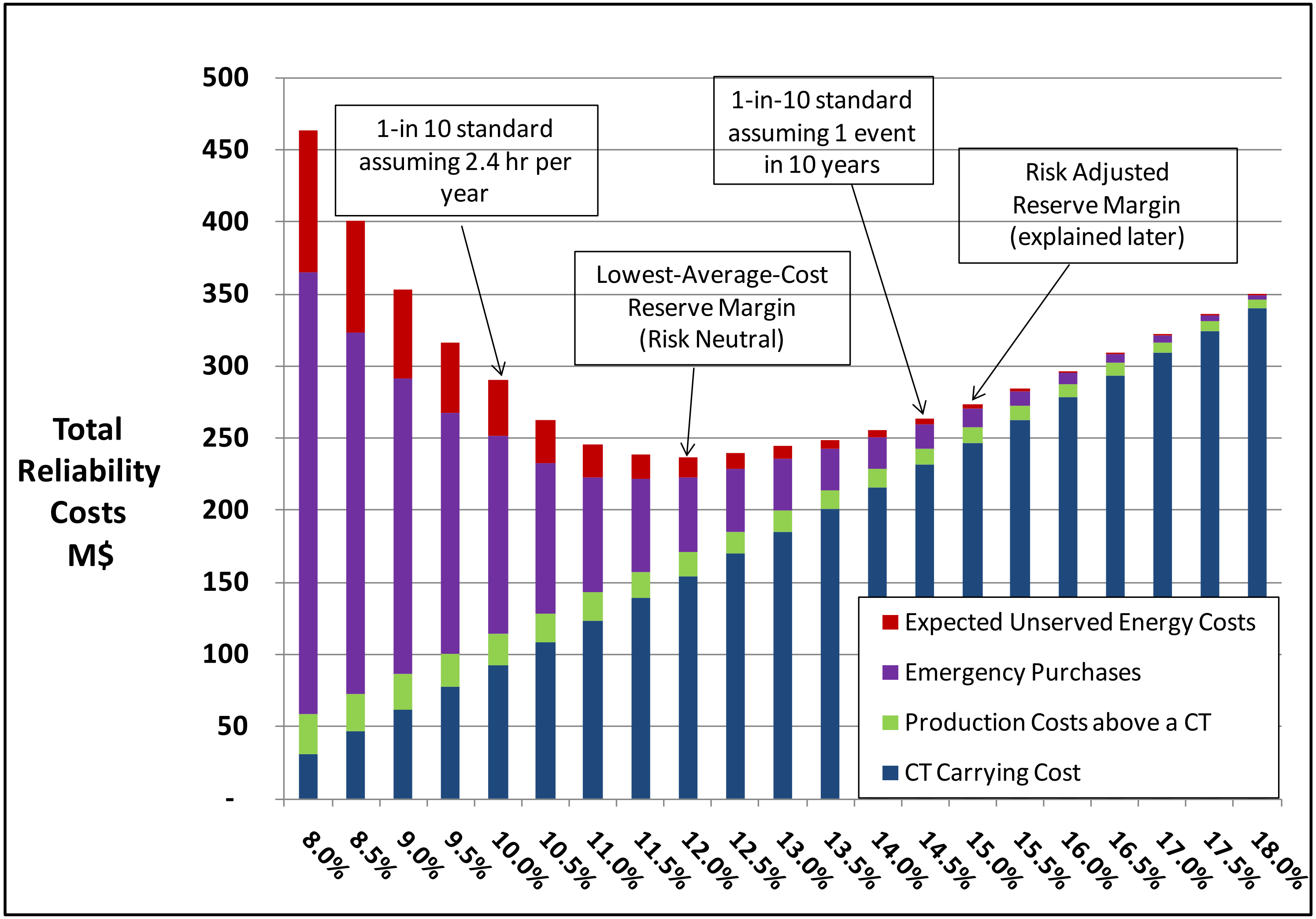
Case Study: Economic Reliabilty Simulations

Used SERVM to simulate economic & reliability outcomes:

- 40,000 MW system with mix of coal, nuclear, natural gas, and hydro plants and 10,000 MW of interties to neighboring systems
- CT as incremental capacity resource
- Calibrated scarcity pricing curves for market purchases
- VOLL for curtailed load
- Total customer cost perspective (cost-of-service regulated utility)
- Modeled reserve margins in 1% increments from 8% to 18%
- 112,000 annual simulations (280 load x 400 generation availability cases with 8,670 hours) for each level of reserve margin

SERVM, a reliability simulation model like GE-Mars, can also model emergency operating procedures, dispatch DR, and emergency purchases (scarcity pricing) to evaluate economic implications of reliability events and extreme system conditions

Average Costs at Different Reserve Margins (Customer Costs, Assuming Risk-Neutrality)

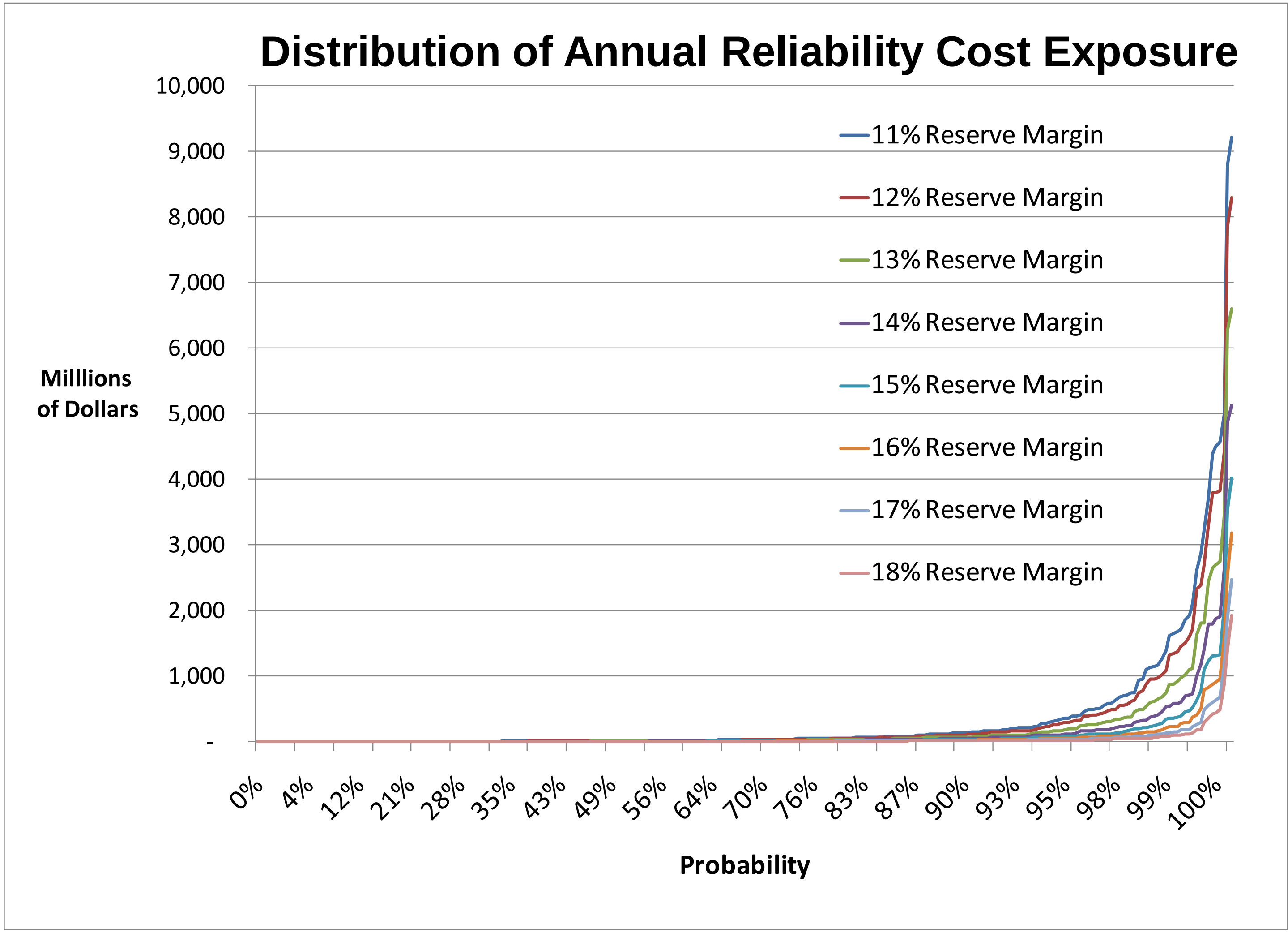


Source: Carden, Pfeifenberger and Wintermantel, *The Economics of Resource Adequacy Planning: Why Reserve Margins Are Not Just About Keeping the Lights On*, NRRI Report 11-09, April 2011.

Considering Risk in Addition to Average Costs

Significant risk to customers at lowest-average cost reserve margins (here 12%)

Adding modest amounts of reserve capacity significantly reduces risk of infrequent but very-high-cost outcomes



<u>Source</u>: 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.

Other Results of Economic Reliability Simulations

Economic simulation of resource adequacy also allows the assessment of:

- Capacity value of energy-limited resources (*e.g.*, demand response, hydro, storage)
- Capacity value of intermittent resources as a function of resource mix (*e.g.*, amount of energy-limited resources)
- Economic value of interties in multi-area setting and reliability assistance from neighbors
- Impact of extreme weather and hydro cases (including correlations with plant availability)
- Impact of cost and type of incremental capacity (*e.g.*, CT)
- Implications of different market structure (*e.g.*, cost-of-service vs. restructured)

Takeaways

Policy initiatives focused on reliability need to recognize:

- End use reliability is the combination of (1) distribution reliability; (2) transmission reliability; and (3) resource adequacy of supply
- Customer classes are affected differently by these reliability categories
- The level, cost, and value of reliability likely is changing over time
- Different types on cost-benefit analyses need to be applied to these reliability categories

Economic analysis of resource adequacy should supplement physical (1-in-10) metrics to:

- Improve understanding of resource adequacy, particularly given an evolving market structures and resource mix
- Document the reliability, economic, and risk mitigation value that customers receive in exchange for paying for reserve capacity
- Determine cost effective reserve margins (or confirm cost effectiveness of current reserve margins)

What is Reliability?

Economic Analysis of Resource Adequacy

Additional Reading / About the Brattle Group

Additional Reading

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 http://www.nrri.org/pubs/electricity/NRRI_resource_adequacy_planning_april11-09.pdf.

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About *The Brattle Group*

The Brattle Group provides consulting and expert testimony in economics, finance, and regulation to corporations, law firms, and governmental agencies around the world.

We combine in-depth industry experience, rigorous analyses, and principled techniques to help clients answer complex economic and financial questions in litigation and regulation, develop strategies for changing markets, and make critical business decisions.

Our services to the electric power industry include:

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- Energy Contract Litigation
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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*.

Johannes (Hannes) Pfeifenberger is an economist with a background in power engineering and over 20 years of experience in the areas of public utility economics and finance. He has published widely, assisted clients and stakeholder groups in the formulation of business and regulatory strategy, and submitted expert testimony to the U.S. Congress, courts, state and federal regulatory agencies, and in arbitration proceedings.

Hannes has extensive experience in the economic analyses of electricity wholesale markets and transmission systems. His recent experience includes reviews of RTO capacity market and resource adequacy designs, testimony in contract disputes, and the analysis of transmission benefits, cost allocation, and rate design. He has performed market assessments, market design reviews, asset valuations, and cost-benefit studies for investor-owned utilities, independent system operators, transmission companies, regulatory agencies, public power companies, and generators across North America.

Hannes received an M.A. in Economics and Finance from Brandeis University and an M.S. in Power Engineering and Energy Economics from the University of Technology in Vienna, Austria

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