The Brattle Group

The Economics of Reliability And Resource Adequacy Planning

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Resource Adequacy vs. Reliability

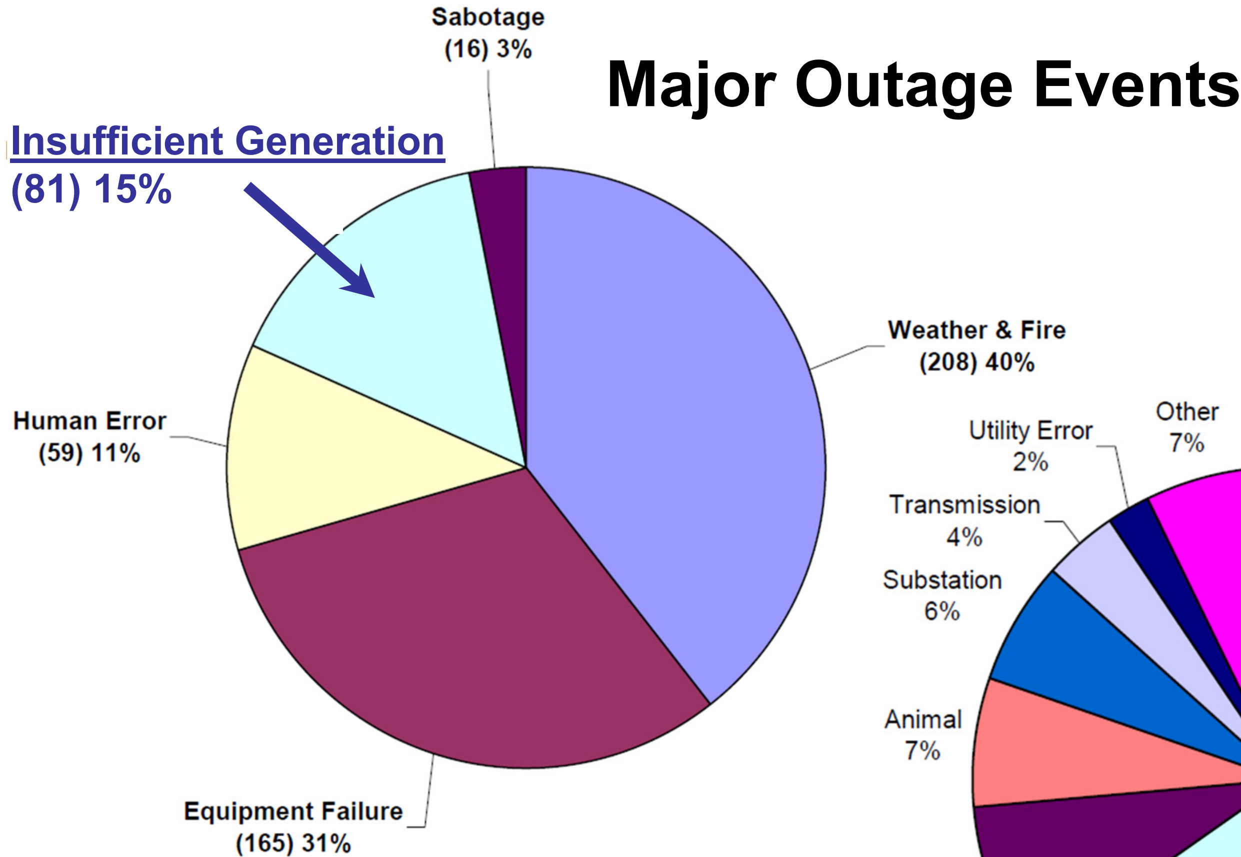
For end users, "reliability" is a combination of three distinct components:

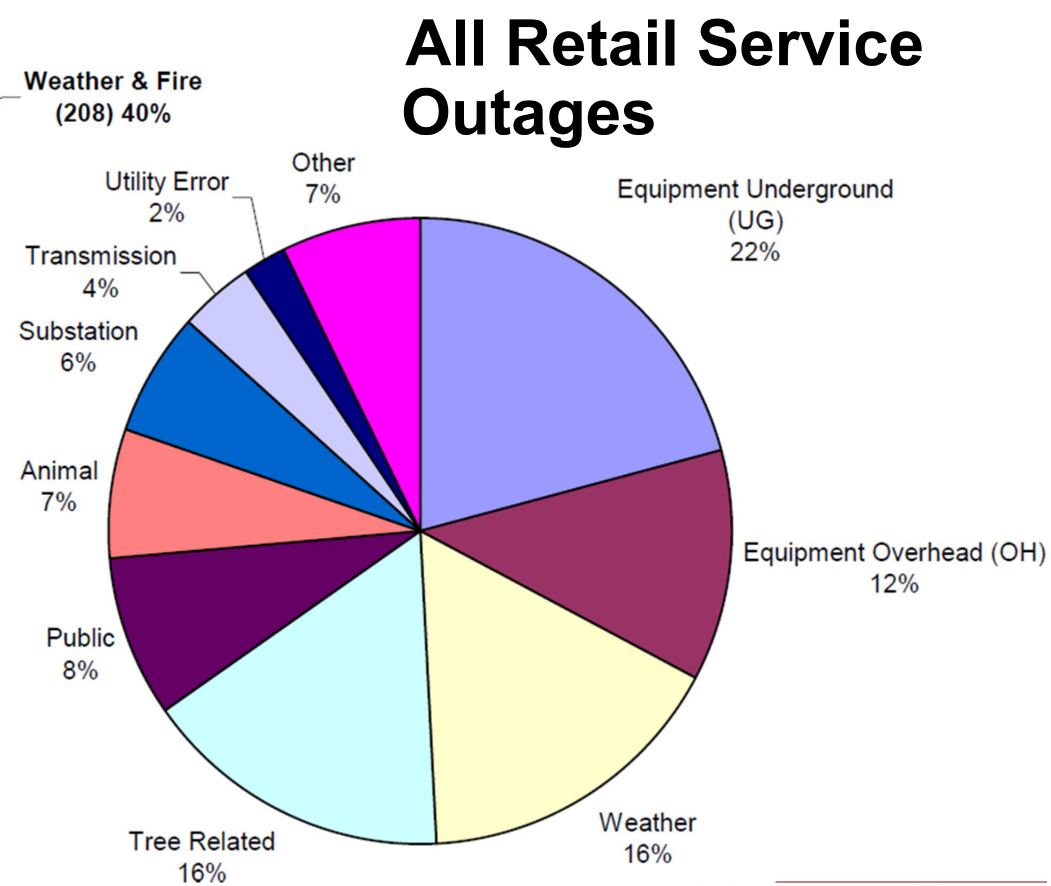
- Distribution system reliability
- Transmission system reliability
- Resource adequacy (bulk power supply vs. load)

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)

Resource Adequacy's Share of Outage Events





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

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)
    - **ERCOT Study:** 2.4 hours per year (as used in SPP) requires a 10% reserve margin while 0.1 event per year requires a 15% reserve margin (up from 13.75% considering 2011 weather)

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 (2004-08)
- Increased renewable generation and demand response

Industry is exploring new physical metrics

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

Resource Adequacy vs. Total Customer Reliability

Our recent resource adequacy and investment incentive review for ERCOT estimated:

Planning Reserve Margin	**10%**		**15%**	
Resulting resource adequacy	1 day in 10 years		1 event in 10 years	
Reliability statistics	**Average** (15 yrs)	**Worst** (2011)	**Average** (15 yrs)	**Worst** (2011)
Loss of load events (LOLE)	**0.95** events/yr	**14** events/yr	**0.1** events/yr	**1.5** events/yr
Loss of load hours (LOLE)	**2.4** hours/yr	**35** hours/yr	**0.18** hours/yr	**2.7** hours/yr
Exp. Unserved Energy (EUE)	**2,700** MWh	**40,000** MWh	**130** MWh	**2,000** MWh
Average customer outage due to resource adequacy	**2.8** min/yr/cust	**42** min/yr/cust	**0.1** min/yr/cust	**2.0** min/yr/cust
Compare to: Distribution-level customer outage w/o major storms:	**100 – 300** minutes per year per customer			
….with major storm:	**1,000 – 10,000** min/yr/customer (e.g., 2008)			

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Why Resource Adequacy Standards?

RAS offer several attractive benefits

- Ensure adequate supply, prevent high levels of curtailments
- Address common-good/free-ridership problem (leaning on others)
- 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: environmental rules, vehicle safety standards, building codes, appliance efficiency requirements
- Imposing RAS creates (an at least bilateral) market for capacity

Will RAS be able to fully "fade away" as DR grows?

- Not likely: 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 ISOs can curtail others

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 for resource adequacy assessments, but allows planning to consider other factors, such as costs
- Some utilities and state commissions (e.g., in GA, FL, AL, KU) have explicitly 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 EUE)
- 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 emergency 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, retail access)

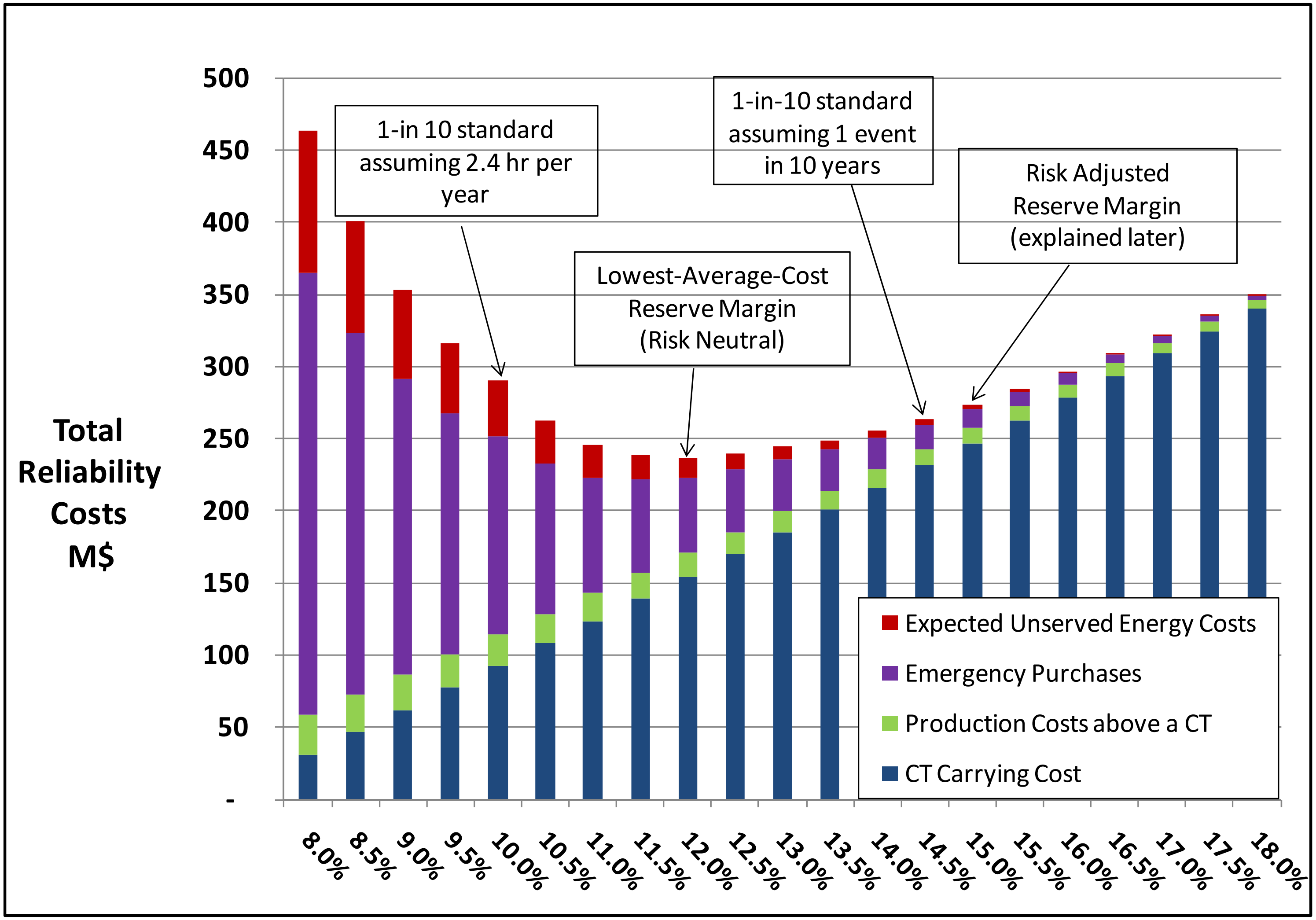
Case Study: Economic Reliability Simulations

Used SERVM to simulate economic & reliability outcomes for case study derived from analyses evaluated and adopted in state regulatory proceeding:

- 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
- Cost of emergency/market purchases and Value of Lost Load
- Total customer cost perspective (cost-of-service regulated utility)
- Simulated total cost outcomes for reserve margins from 8% to 18%
- 112,000 annual simulations (280 load x 400 generation availability cases with 8,670 hours) to measure uncertainty

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 Customer Costs at Different Reserve Margins



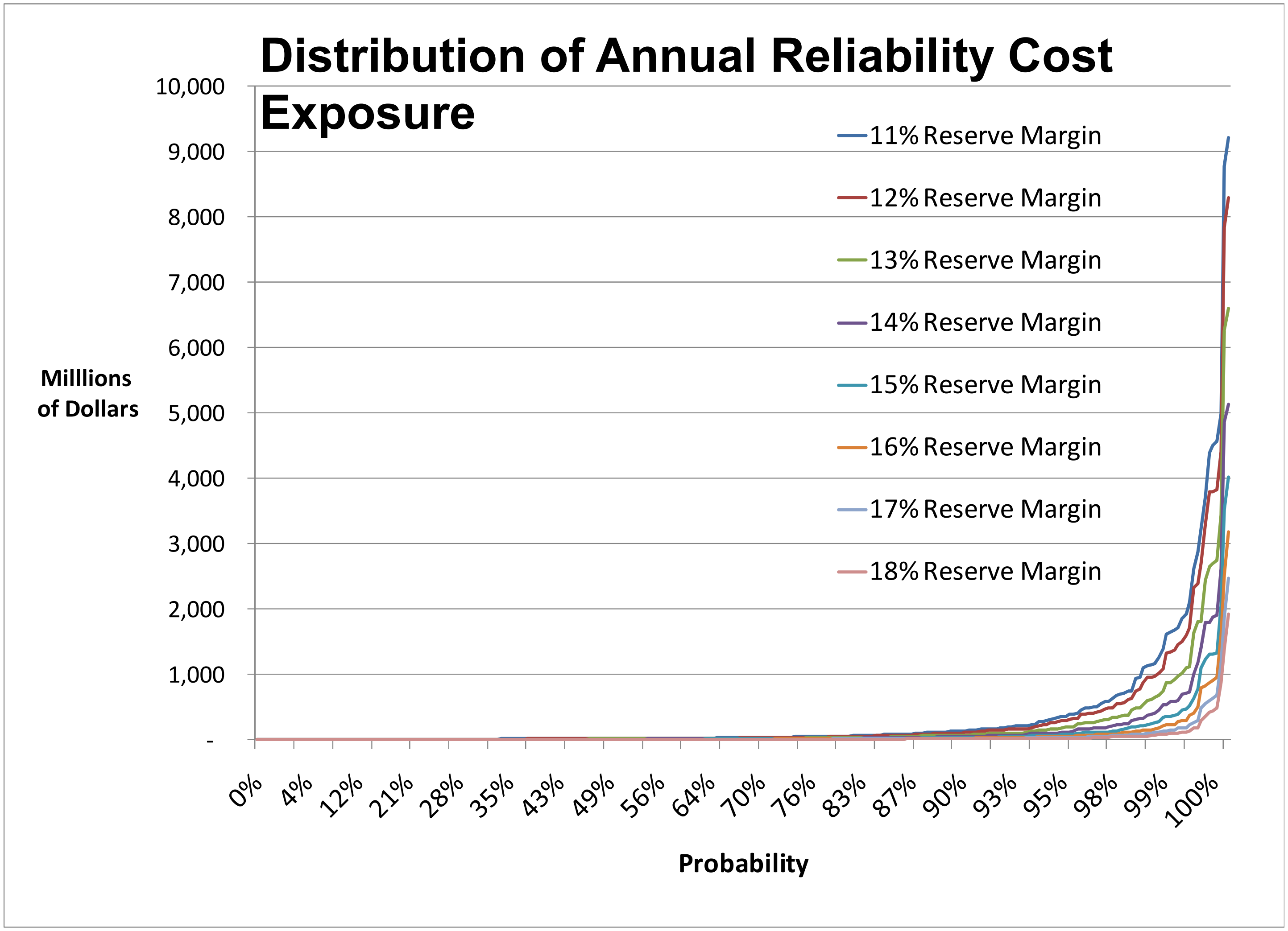
Source: Carden, Pfeifenberger and Wintermantel, *The Economics of Resource Adequacy Planning: Why Reserve Margins Are Not Just About Keeping the Lights On*, NRRI Report 11-09, April 2011.

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

Same shown in ERCOT analysis



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.

Other Results of Economic Reliability Simulations

Economic simulation of resource adequacy also allows the assessment of:

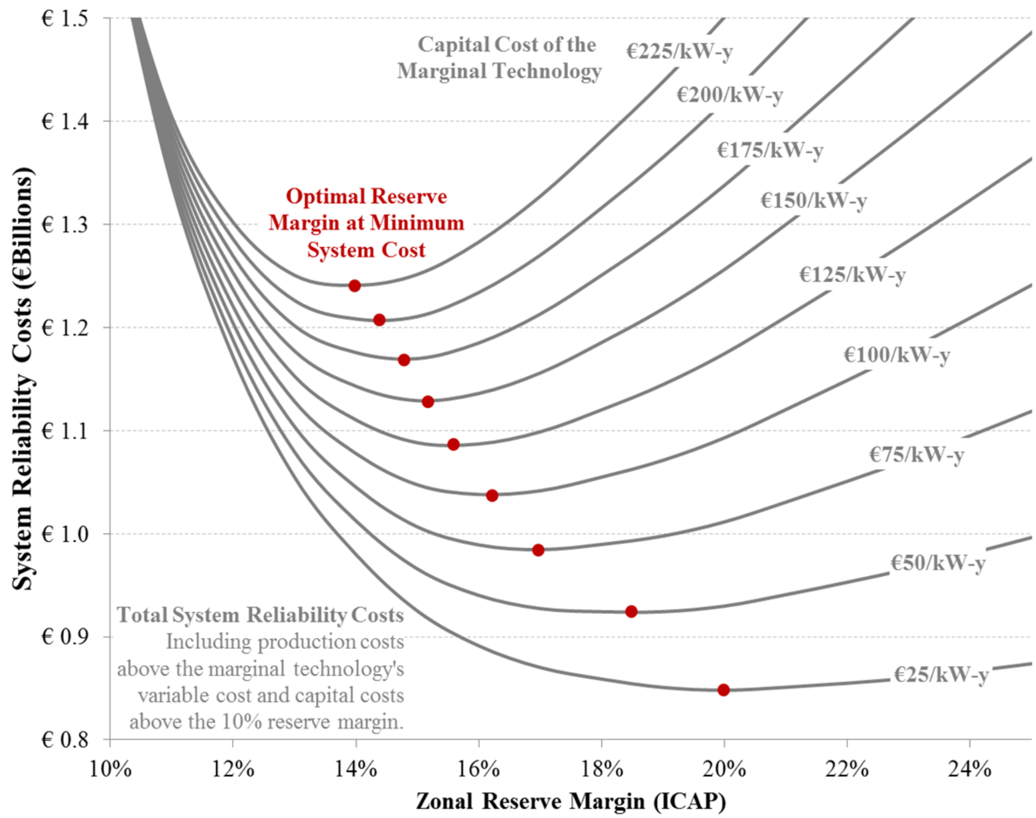
- Capacity value of energy-limited resources (*e.g.*, demand response, hydro, storage)
- Capacity value of intermittent resources as a function of resource mix (*e.g.*, amount of energy-limited resources)
- Economic value of interties in multi-area setting and reliability assistance from neighbors
- 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) and system size
- How optimal reserve margins change as the cost of capacity increases

Optimal Reserve Margins Change Over Time

The "optimal" planning reserve margin will change over time as:

- The cost of adding capacity increases or decreases (see chart)
- The resource mix changes (e.g., level of intermittent renewable generation)
- Customer preferences and reliance on electricity change (VOLL)
- DR penetration increases
- System size and interconnection with neighbors increase

Example: Optimal Reserve Margin Study for Italian System Operator (Northern Zone)



Source: Harris, Pfeifenberger, Spees, "Italian Capacity Market Design: Efficient Market Signals for Resource Adequacy" The Brattle Group, forthcoming.

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Resource Adequacy – Market Design

- **Administrative Mechanisms**
  - Resource adequacy achieved through administrative means
  - Examples: **Regulated utility planning**, administrative PPAs, administratively-determined capacity payments
  - Cost recovery through regulated approval or contract payments
  - Risk of uneconomic investment decisions borne by customers
- **Market-Based Mechanisms**
  - Utilize market forces to achieve resource adequacy
  - Examples: **Energy-only markets**, RA requirements for LSEs, near-term or forward **Capacity markets**
  - Challenge: achieve revenues to attract and retain supply when/where needed for resource adequacy; discourage investments during surplus
  - Risk of uneconomic investment decisions borne by suppliers (but increases investment and financing costs)
  - Price volatility and uncertainty are a key concern

Resource Adequacy – Market Design

	Administrative Mechanisms (Customers Bear Risk)		**Market-based Mechanisms** (Suppliers Bear Risk)		
	Regulated Utilities	**PPAs or Capacity Payments**	**LSE RA Requirement**	**Capacity Markets**	**Energy-Only Markets**
Examples	SPP, BC Hydro, SaskPower, most of WECC, Southeast U.S.	Ontario, Argentina, Chile, Colombia, Peru, Spain, South Korea	California, MISO	PJM, NYISO, ISO-NE, Brazil, Australia's SWIS, Italy, Russia	Texas, Alberta, Australia's NEM, NordPool, Great Britain (current)
Resource Adequacy Requirement?	Yes (Utility IRP)	Yes/No (Yes through PPAs; No if relying on capacity payments)	Yes (Creates bilateral capacity market)	Yes (Mandatory near-term or forward capacity auction)	No (RA not assured)
How are Capital Costs Recovered?	Regulated retail rate recovery	Long-term PPAs or capacity payment plus energy market	Bilateral capacity payments and energy market	Capacity and energy markets	Energy market only

See also: Pfeifenberger & Spees (2009, 2010). Review of Alternative Market Designs for Resource Adequacy.

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 of 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)

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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:

- Climate Change Policy and Planning
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- Demand Response and Energy Efficiency
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- Energy Contract Litigation
- Environmental Compliance
- Fuel and Power Procurement
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- Mergers and Acquisitions
- Transmission

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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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