Advancing Past “Baseload” to a Flexible Grid
How Grid Planners and Power Markets Are Better Defining System Needs to Achieve a Cost-Effective and Reliable Supply Mix

PREPARED BY:
Johannes P. Pfeifenberger
Judy Chang
Mariko Geronimo Aydin

July 28, 2017
Traditional Concept of “Baseload”

Under the traditional resource planning paradigm:

- “Baseload” as a staple resource, providing large volumes of power
- “Baseload” resources primarily coal-fired, nuclear, and some types of hydroelectric generation
- Attractiveness of “baseload” resources depended on its uniquely low variable costs at the time (not on unique services provided by these resources)

Source: The Brattle Group.
# Uses of the Term “Baseload”

<table>
<thead>
<tr>
<th>Traditional Meaning</th>
<th>Limited to Coal/Nuclear?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum round-the-clock electricity demand or supply</td>
<td><strong>No.</strong> Minimum demand has always been met by a portfolio of generating units. Neither coal nor nuclear units can produce power in all hours of the year.</td>
</tr>
<tr>
<td>“Price-takers” with low variable production cost and best economics when operating whenever available</td>
<td><strong>No.</strong> New technologies and low natural gas prices have made renewables and efficient natural gas-fired plants more economical than coal and nuclear in some areas.</td>
</tr>
<tr>
<td>Reliable supply that ensures the grid provides power to customers whenever needed</td>
<td><strong>No.</strong> All generating units are prone to outages. Also, the reliability services coal and nuclear provide can be provided by other technologies.</td>
</tr>
</tbody>
</table>
The Electricity Landscape Has Changed

The economics of traditional "baseload" generation have changed

- 70,000 MW coal retirements
- 13,000 MW nuclear retirements completed/announced, more at risk
- Driven by:
  - Lower cost of natural gas-fired generation (a major driver)
  - Low demand growth
  - Renewable energy development and declining costs
  - High capital investment costs of aging and new coal/nuclear
  - Some recognition of GHG emissions costs
  - Customer preferences

Cumulative U.S. Capacity Retirements and Additions by Fuel Type (GW), 2010–2020

The Term “Baseload” is No Longer Very Relevant

The term does not refer to specific or unique services or resource attributes that are needed to reliably serve electricity customers.

- **Ability to produce large volumes of power in most hours of the year**
  - Historically, economics (not system need) pointed to concentrating this in a smaller set of very large plants, but those economics have changed.

- **Ability to provide specific reliability services**
  - Many different types of resources can provide these services.

- **Contribution to fuel diversity**
  - Many wholesale power markets have more fuel diversity today than ever before.
The Optimal Cost-Effective Supply Mix is Changing

The result is a cleaner, more diverse supply mix

Electricity Demand and Supply Mix in Traditional Planning

Electricity Demand and Supply Mix with High Renewable Generation

Source: The Brattle Group.

Source: The Brattle Group.
Resources with Operating Flexibility are Becoming Increasingly Important

Technologies, policies, and economics are pointing to a combination of variable and flexible resources to meet system needs cost-effectively in the modern grid.

Flexible resources are particularly economical in systems with high penetration of solar and wind resources that provide low-cost energy and emissions reductions.

Flexible resources can provide high-quality ramping, load-following, and other ancillary services, at relatively low cost.

Source: The Brattle Group.
Instead, Planners and Operators Focus on Resource Services and Attributes to Meet System Needs

Define specific **system needs** for reliable power supply

- Energy production
- Resource adequacy: available capacity during peak or constrained hours (including reliable fuel supply)
- 10 or 30-minute operating reserves
- Regulation, frequency control
- Voltage control, black-start
- Load-following
- Ramping, other flexibility needs

Develop planning tools, scheduling processes, and market mechanisms to elicit and compensate a **broad range of resources** that can meet those needs

- Traditional generators
- Variable energy resources: wind and solar, utility-scale and distributed
- Demand-side resources: demand response, energy efficiency
- Storage technologies
- Resources in neighboring systems (through improved coordination and markets)
A Portfolio of Resources (Including Wind and Solar) Provides Reliable Power Supply

Despite retirements and changes in resource mix, system operators have been able to meet the industry’s high reliability standards

- **Example:** PJM found that its resource mix has become more balanced over time and that its expected near-term portfolio is among the highest-performing. [Link](http://www.pjm.com/~/media/library/reports-notices/special-reports/20170330-pjms-evolving-resource-mix-and-system-reliability.ashx)

Numerous industry studies show that a supply mix with high renewables penetration can be operated reliably

- **Example:** Southwest Power Pool (SPP) 2016 Wind Integration Study concluded that it can reliably manage up to 60% of wind penetration with their current resource mix. [Link](https://www.spp.org/documents/34200/2016%20wind%20integration%20study%20(wis)%20final.pdf)

Studies also show that improved operating flexibility can provide better tools for achieving that reliability

- **Example:** The National Renewable Energy Laboratory’s (NREL’s) 2016 Low Carbon Grid Study found that increased flexibility and more geographically diversified generation can decrease curtailments by 10%, reduce costs up to $800 million, and reduce GHG emissions by up to 14%. [Link](http://lowcarbongrid2030.org/wp-content/uploads/2016/01/1601_Low-Carbon-Grid-Study-Analysis-of-a-50-Emission-Reduction-in-CA.pdf)
Advances for Meeting the Grid’s Flexibility Needs

Flexibility has become a new dimension of system planning.

Policy-makers, planners, system operators, and market administrators are developing new methods to:

- **Identify** specific flexibility needs
- **Create incentives** for resources to provide flexibility in operations timeframe—in both centralized markets and utility systems
- **Enable a wide range of resources** to meet flexibility needs
- **Incorporate** flexibility needs into integrated system planning
- **Align clean-energy policies** with system needs
Conclusions and Recommendations

- Historically, “baseload” generation was shorthand for a category of resources (largely coal and nuclear) that produced electricity at relatively low variable cost.
- Today, some “baseload” plants are earning lower market revenues.
- The term “baseload” does not correspond to specific or unique operational services.
- The industry has been focused on better defining today’s system needs, and developing mechanisms for meeting those needs in least-cost manner.
- Operational flexibility is becoming more important in the context of today’s energy technologies, economics, policies, and customer preferences.
Mr. Pfeifenberger is an economist with a background in electrical engineering and over twenty-five years of experience in the areas of electricity markets, regulation, and finance. He has assisted clients in the formulation of business and regulatory strategy, submitted expert testimony to the U.S. Congress, courts, arbitration panels, and regulatory agencies around the world, and provided support in mediation, arbitration, settlement, and stakeholder processes.

Mr. Pfeifenberger specializes in electricity market design, utility industry regulation, transmission, financial valuation, energy industry litigation, and business strategy.

On behalf of his clients, Mr. Pfeifenberger has addressed resource adequacy and capacity market designs, the economic benefits and cost allocation of transmission projects, the reasons behind rate increases, implications of restructuring policies, competitive conduct in electric power markets, and the effects of proposed mergers. He has also explored the benefits of alternative regulation, the desirability of settlement proposals, and the impact of regulatory and legislative actions in the context of evolving market conditions.

He is retained frequently by counsel to testify in regulatory and litigation cases or provide litigation support, including identifying and coordinating expert witnesses and assistance with discovery, depositions, and cross examination on economic or highly technical industry matters.

Before joining The Brattle Group, Mr. Pfeifenberger was a Consultant for Cambridge Energy Research Associates and a Research Assistant at the Institute of Energy Economics at the University of Technology in Vienna, Austria.

The views expressed in this presentation are strictly those of the presenter(s) and do not necessarily state or reflect the views of The Brattle Group.
End Notes


About Brattle

The Brattle Group provides consulting and expert testimony in economics, finance, and regulation to corporations, law firms, and governments around the world. We aim for the highest level of client service and quality in our industry.

We are distinguished by our credibility and the clarity of our insights, which arise from the stature of our experts, affiliations with leading international academics and industry specialists, and thoughtful, timely, and transparent work. Our clients value our commitment to providing clear, independent results that withstand critical review.
Our Practices

ENERGY & UTILITIES
- Competition & Market Manipulation
- Distributed Energy Resources
- Electric Transmission
- Electricity Market Modeling & Resource Planning
- Energy Litigation
- Environmental Policy, Planning and Compliance
- Finance and Ratemaking
- Gas/Electric Coordination
- Market Design
- Natural Gas & Petroleum
- Nuclear
- Renewable & Alternative Energy

LITIGATION
- Accounting
- Analysis of Market Manipulation
- Antitrust/Competition
- Bankruptcy & Restructuring
- Big Data & Document Analytics
- Commercial Damages
- Environmental Litigation & Regulation
- Intellectual Property
- International Arbitration
- International Trade
- Labor & Employment
- Mergers & Acquisitions Litigation
- Product Liability
- Securities & Finance
- Tax Controversy & Transfer Pricing
- Valuation
- White Collar Investigations & Litigation

INDUSTRIES
- Electric Power
- Financial Institutions
- Natural Gas & Petroleum
- Pharmaceuticals & Medical Devices
- Telecommunications, Internet, and Media
- Transportation
- Water
Electric Power

Brattle’s economists provide clients with regulatory economic consulting, business strategy, and expert testimony before regulatory agencies, courts, and arbitration panels.

AREAS OF EXPERTISE

- Auctions
- Climate Change Policy and Planning
- Demand Response, Energy Efficiency, and the Smart Grid
- Electricity Market Modeling
- Energy Asset Valuation
- Energy Contract Litigation
- Energy Mergers and Acquisitions
- Energy Risk Management
- Environmental Compliance
- European Energy Markets
- Fuel and Power Procurement
- Market-Based Rates
- Market Design and Competitive Analysis
- Renewable Energy
- Transmission
Appendix
## Reliability Services

Supply and demand-side resources provide a wide variety of reliability services in the bulk power grid; coal and nuclear generating units are not unique in what they can provide.

<table>
<thead>
<tr>
<th>Reliability Services</th>
<th>Coal / Nuclear</th>
<th>Examples of other resource types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource adequacy</td>
<td>Contribute to planning reserves to meet peak load</td>
<td>DR, NG-fired generation, (increasingly) wind and solar</td>
</tr>
<tr>
<td>Regulation and frequency control</td>
<td>Provide spinning mass to maintain electrical frequency and system-wide stability</td>
<td>NG-fired generation, batteries, solar, wind</td>
</tr>
<tr>
<td>Operating reserves</td>
<td>Coal can provide some, but constrained by slow ramp rates and expensive startup/shutdown; nuclear very limited (if any)</td>
<td>NG-fired generation, storage, some DR</td>
</tr>
<tr>
<td>Reliable fuel supply</td>
<td>Onsite storage may help but not guaranteed (e.g., frozen coal piles)</td>
<td>Wind/sun not reliant on delivery systems: variable but not interruptible, NG supply can be supported by backup fuel or firm delivery contracts</td>
</tr>
</tbody>
</table>

DR = Demand response  
NG = Natural gas