

EXECUTIVE SUMMARY

As the electricity grid transitions to accommodate more renewable energy and electrification, demand response can play a vital role in ensuring grid reliability and dampening price volatility in wholesale electricity markets. However, despite its recognized potential to help manage electricity demand, particularly during peak load periods when generation may be scarce, the actual deployment of demand response in wholesale electricity markets has stagnated or even declined in recent years.

The ESIG report *Gaps, Barriers, and Solutions to Demand Response Participation in Wholesale Markets* examines why demand response participation remains limited in wholesale markets and proposes actionable solutions to unlock its full potential. The analysis draws from extensive interviews with industry stakeholders, including system operators, regulators, aggregators, and consumers, to (1) identify five critical gaps that must be bridged to accelerate demand response deployment, and (2) offer targeted solutions to address each gap.

Current State of Demand Response

Despite studies that show high potential for demand response given technological advances and growing grid needs, demand response capacity is below 7% of peak load across U.S. wholesale markets. These low levels stand in stark contrast to the rapid growth of other clean energy resources like wind, solar, and battery storage that have attracted significant investment in recent years. It is important to identify the reasons behind the gap between demand response's significant promise but low deployment and to address these challenges to allow demand



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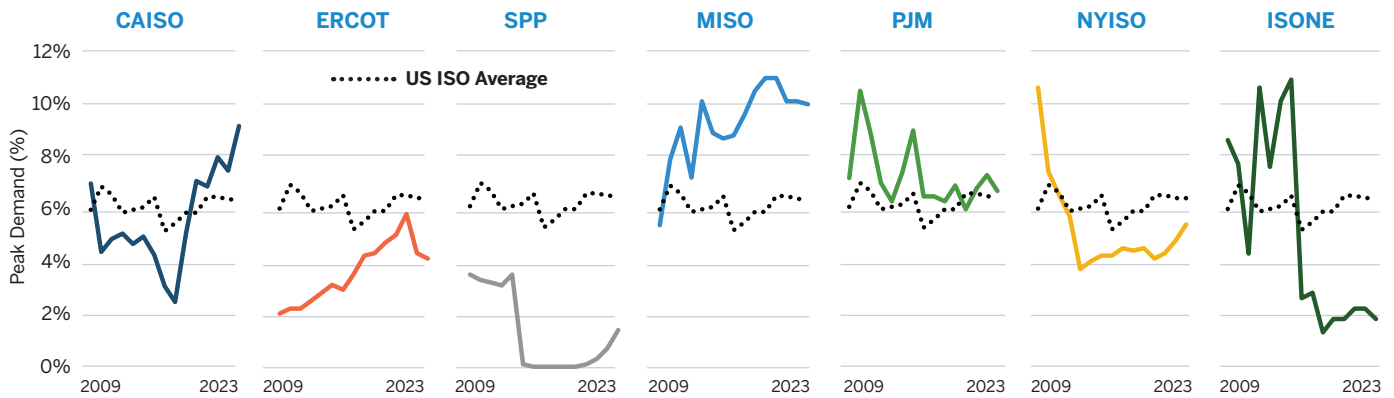
response in wholesale markets to provide the level of load flexibility that grid reliability requires.

Figure ES-1 shows the recent adoption levels of demand response in each of the U.S. wholesale electricity markets from 2009 through 2023. While there is variation across each system operator's loads, program rules, and size, the overall trends are similar: limited increases in demand response participation nationwide. Some have achieved demand response levels above 10%, but most have seen recent sharp declines or minimal growth from their high

See the full report:
Gaps, Barriers, and Solutions to Demand Response Participation in Wholesale Markets

FIGURE ES-1

Wholesale Demand Response Capacity by ISO as a Percentage of Peak Demand, Showing Stagnant or Declining Participation in Most Markets



Source: Energy Systems Integration Group; data from Federal Energy Regulatory Commission's 2023 *Assessment of Demand Response and Advanced Metering* (FERC, 2023).

points. Only the California Independent System Operator (CAISO) market—which has demand response programs administered outside of the market by the California Public Utilities Commission regulatory requirements—has seen notable increases in recent years.

Regional variations in demand response adoption are significant, with participation rates varying widely across different independent system operators and states. This disparity reflects both the fragmented nature of current market structures and the varying effectiveness of different policy approaches. While Figure ES-2 (p. 3) shows primarily retail demand response programs—which may or may not be included in the wholesale market—similar adoption levels are seen outside of the system operators' footprints. Participation levels across states show enrollment rates ranging between 2% and 8%, with an average of 6.5% nationwide. This figure indicates significant untapped potential for demand response to further contribute to grid flexibility and capacity needs. Interestingly, there appears to be little correlation between participation levels and the market structure and whether a customer is in a vertically integrated utility or wholesale market region.

Critical Gaps and Proposed Solutions

Our analysis identified five fundamental gaps limiting demand response participation in wholesale markets

(Figure ES-3, p. 3), along with targeted solutions to address each challenge (Figure ES-4, p. 6).

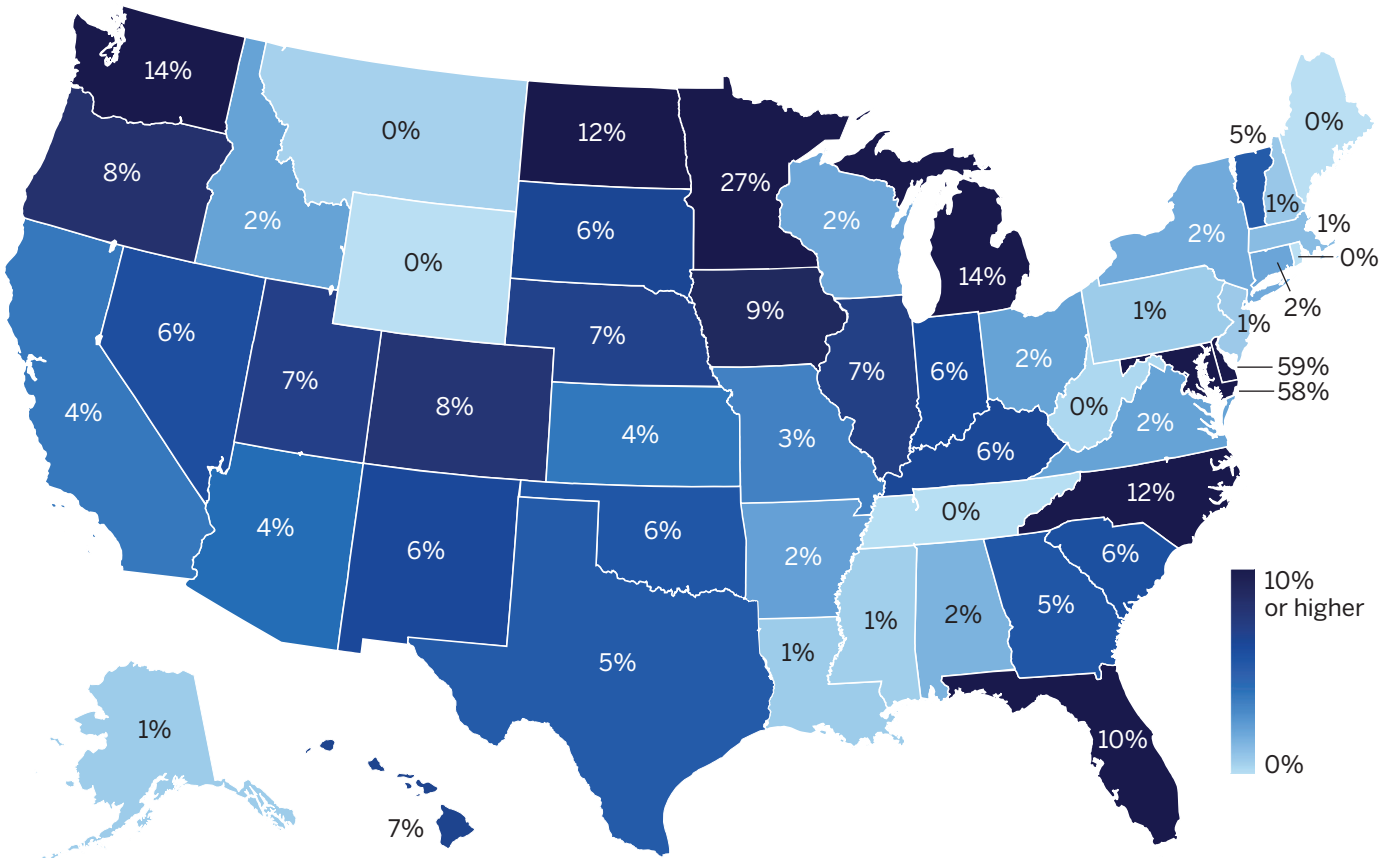
GAP 1. There is a lack of experience and knowledge about demand response technology and programs among system operators, state regulators, and consumers.

The widespread lack of experience and knowledge about demand response technology and programs among system operators, state regulators, and consumers represents a fundamental barrier to adoption. This knowledge gap manifests across multiple areas: a lack of subject-matter experts, changing technology and effectiveness, inconsistent definitions, lack of data around demand response participation, and low customer awareness. Feedback we received in our interviews with key stakeholders strongly suggests that when regions have knowledgeable and passionate champions—whether at the utility, system operator, or state regulator—this is directly linked to higher participation levels.

Solutions: To bridge this gap, regulators and system operators can identify dedicated subject-matter experts and establish working groups responsible for managing market design and demand response programs. These experts can then lead capacity-building workshops and educational programs to share best practices across regions. Additionally, load-serving entities can invest in

FIGURE ES-2

Percentage of Customers Enrolled in Retail Demand Response Programs by State (2023), Demonstrating Significant Regional Variations in Program Adoption

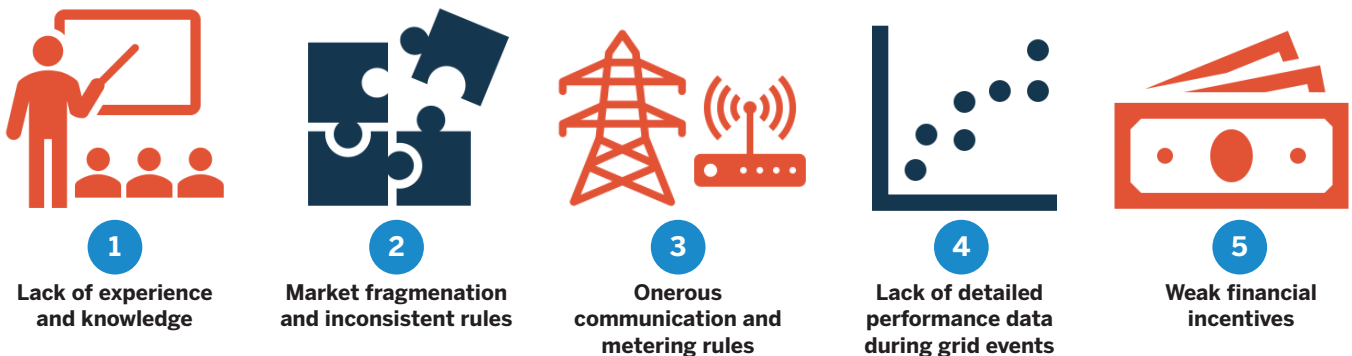


Customer enrollment is from 2023 and is based on surveyed data reported in EIA Form 861, including showing mostly retail demand response programs that may or may not be included in wholesale market programs. It shows that on average 6.5% of customers are enrolled nationwide, with significant regional variations.

Source: Energy Systems Integration Group; data from U.S. Energy Information Administration (U.S. EIA, 2024).

FIGURE ES-3

Five Gaps in Demand Response Participation in Wholesale Markets



Source: Energy Systems Integration Group.

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simplified enrollment processes and easy-to-use platforms that provide customers with clear information about their energy use and potential benefits. Some regions have found success with opt-out rather than opt-in programs, automatically enrolling customers in dynamic pricing or demand response programs while retaining their ability to opt out entirely or for individual events.

GAP 2. The demand response markets are limited by fragmentation and inconsistent rules.

The demand response market today can be summarized as a tale of two options: loads functioning as supply-side resources in wholesale programs or load-modifying resources in retail programs. This dual-participation model, with each model operating under different rules and incentives, creates confusion and inadequate data on current participation levels and characteristics. The study identified 16 different wholesale demand response programs across eight independent system operators, each with its own set of rules and regulations. This fragmentation makes it particularly challenging for aggregators to scale their operations, as they must customize their technological solutions for each program's specific requirements.

Solutions: To address this fragmentation, independent system operators need to work closely with their load-

One of the most important enablers for increased demand response participation is consistent and stable market rules, communications, and metering standards across wide areas.



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serving entities to clearly and transparently quantify and segment participation in wholesale and retail demand response programs by customer class and end use. Market designers can continue cooperative rulemaking that develops fair, stable, and competitive market structures. As one aggregator interviewed in this project emphasized, “one of the most important enablers for increased demand response participation is consistent and stable market rules, communications, and metering standards across wide areas.” Rather than pursuing perfect program rules, the focus should be on achieving consistency across jurisdictions to enable technology providers and aggregators to develop common products and business models.

GAP 3. Communication and metering requirements can be onerous. Individual load resources do not need the granularity required of large-scale generation.

Current metering and telemetry requirements pose excessive burdens, particularly for smaller or distributed resources. These requirements, originally designed for large generation resources, worked well when demand response was primarily offered by large industrial customers. However, they now inhibit the participation of residential and small commercial customers, where much of the untapped potential lies. The cost for load-serving-entity-specified meters alone can be several hundred dollars per installation, plus additional wiring and labor requirements, making it economically unfeasible for many smaller participants to contribute to grid reliability as a demand response resource.

Solutions: Solutions to this challenge include allowing embedded measurement devices, such as inverters, to be used as end-use meters. In addition, independent system operators can implement statistical sampling approaches for aggregated resources rather than requiring direct measurement of each end-use load. They can evaluate aggregations of less-accurate metering technologies to measure demand curtailment and grid injections, as large groups of energy-metering devices may provide sufficient accuracy when aggregated. Additionally, minimum size requirements for aggregations should be modified to encourage residential participation, and nodal congestion pricing should be integrated into demand response settlements to allow aggregations across multiple locations to meet administrative sizing requirements.

GAP 4: System operators lack detailed, publicly available information on demand response performance during emergency events, leading to inaccurate accreditation and eroding confidence in the resource.

The absence of detailed, publicly available information on demand response performance during emergency events erodes confidence in the resource and complicates accurate accreditation. This was evident during Winter Storm Elliott in December 2022, when PJM’s demand response resources were awarded nearly \$90 million in positive compliance payments despite actual load reductions reaching only 26-32% of expected levels. This disconnect between compliance measurements and actual performance undermines confidence in demand response as a reliable resource.

Additionally, accreditation methodologies must be stable and predictable—sudden changes can lead to significant volatility in participation. For example, in PJM, recent adjustments reduced the effective load-carrying capability for demand response from 100% to 76%, with projections suggesting further reductions to 50% by 2034/2035. This volatility in accreditation can create unnecessary risks for grid operators by undermining confidence in the resource.

Solutions: To address this gap, independent system operators can conduct detailed forensic reporting after every Energy Emergency Alert event, analyzing how demand response resources performed relative to their

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accredited capacity. These reports can be made publicly available to enhance transparency and build confidence.

GAP 5: There are weak financial incentives, and even disincentives, for demand response at the wholesale market, load-serving entity, and consumer levels.

Financial incentives for demand response participation remain too low to incent broad participation, particularly outside of capacity markets. While a low price does not indicate a market failure, low prices do create disincentives for load-serving entities and consumers to participate. Unlike other clean energy resources that benefit from federal tax incentives, state renewable portfolio standards, and long-term contracts, demand response is more exposed to short-term market conditions. Furthermore, load-serving entities can have financial disincentives to encourage demand response, as it reduces their ability to invest in new infrastructure and generate returns on those investments. Customers, who by and large pay a flat volumetric rate for their electricity, have little incentive to adopt load-control technologies or behaviors in the first place.

Solutions: Solutions to these financial challenges include creating incentives for load-serving entities to enter into long-term contracts for demand response, similar to power purchase agreements for renewable energy. A “contracts for differences” approach could provide stable revenue streams over longer time horizons. Additionally, rate structures should enable value stacking, allowing demand response to provide multiple services across the grid, from generation capacity to transmission and distribution deferral. By coordinating retail rate design with demand response programs, load-serving entities can provide customers with both the motivation and the financial means to participate in load management. Finally, regulators can consider allowing demand

FIGURE ES-4

Framework for Implementing Solutions Across Five Key Areas

Experience and Knowledge	Program Boundaries and Rules	Communication and Metering	Performance and Accreditation	Financial Incentives and Retail Rates
Strengthen experience and knowledge in demand response technology and programs among system operators, state regulators, and consumers	Clarify demand response program boundaries across retail and wholesale programs and harmonize market rules across independent system operators	Refine communication and metering requirements to facilitate the integration of demand response into wholesale markets	Use detailed information on demand response performance during emergency events to improve accreditation and ensure reliability, while building confidence across stakeholders	Align financial incentives to stabilize revenues from long-term demand response contracts, incent load-serving entities to defer new capacity, and align customer rates

Source: Energy Systems Integration Group.

response to participate as transmission and distribution assets, enabling access to long-term rate recovery mechanisms similar to transmission infrastructure.

Paths Forward

Implementing these solutions requires coordinated action across all levels of the energy supply chain, from federal and state regulators to system operators and market participants. The benefits of successful implementation include:

- **Faster integration** of demand response resources to keep pace with demand growth and plant retirements
- **A more diverse set of clean, emissions-free resources** providing alternatives to battery storage and combustion turbines that are often used as new capacity resources
- Greater grid flexibility through **modular deployment** to scale up or down as grid needs evolve, without the risk of stranded assets
- Enhanced **consumer empowerment and engagement** providing them with financial incentives to adopt clean energy technologies such as electric vehicles, heat pumps, and energy-efficient appliances

The time for action is now. As traditional power plants retire and renewable resources increase, demand response technologies offer a flexible, fast-acting solution for balancing supply and demand. Unlike new generation, which takes years to develop, demand response can provide immediate support to the grid. Furthermore, as new technologies and load types like electric vehicles, heat pumps, behind-the-meter battery storage, and data centers are adopted, it is important to capture their full flexibility potential. This requires laying a strong foundation for demand response participation now, to ensure new loads are integrated well. Taking these steps will help unlock the full potential of demand response as a flexible, scalable, reliable resource in wholesale electricity markets.

As traditional power plants retire and renewable resources increase, demand response technologies offer a flexible, fast-acting solution for balancing supply and demand. Unlike new generation, which takes years to develop, demand response can provide immediate support to the grid.

Gaps, Barriers, and Solutions to Demand Response Participation in Wholesale Markets by the Energy Systems Integration Group’s Distributed Energy Resources Working Group is available at <https://www.esig.energy/demand-response-in-wholesale-markets>.

To learn more about the topics discussed here, please send an email to info@esig.energy.

The Energy Systems Integration Group is a nonprofit organization that marshals the expertise of the electricity industry’s technical community to support grid transformation and energy systems integration and operation. <https://www.esig.energy>.

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