An incomplete and oversimplified history of demand flexibility, in 10 mins (and where we're headed)

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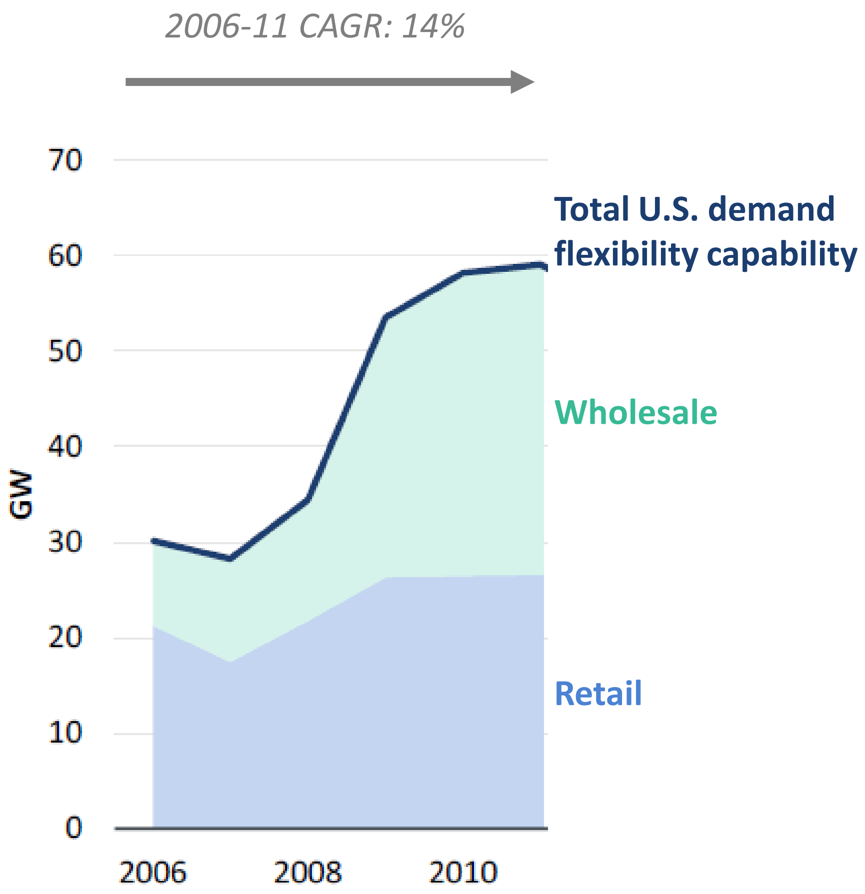
Wait, I thought it's called demand response?

	2005 – 2010: Demand Response	2015 – 2020: Demand Flexibility	2025: Virtual Power Plants
Key Growth Drivers	AMI; Opening of wholesale markets	DERMS; Climate goals	DER adoption; Sudden, rapid load growth
Defining Use Cases (Additive)	Low-cost summer capacity; Emergency value	More frequent load shifting; Geographically-targeted flex	Year-round resource adequacy; Exports to the grid; Value stacking
Representative Program	A/C load control (mostly switch-based)	Grid-interactive water heating	BTM batteries; Vehicle-to-grid

Some good news

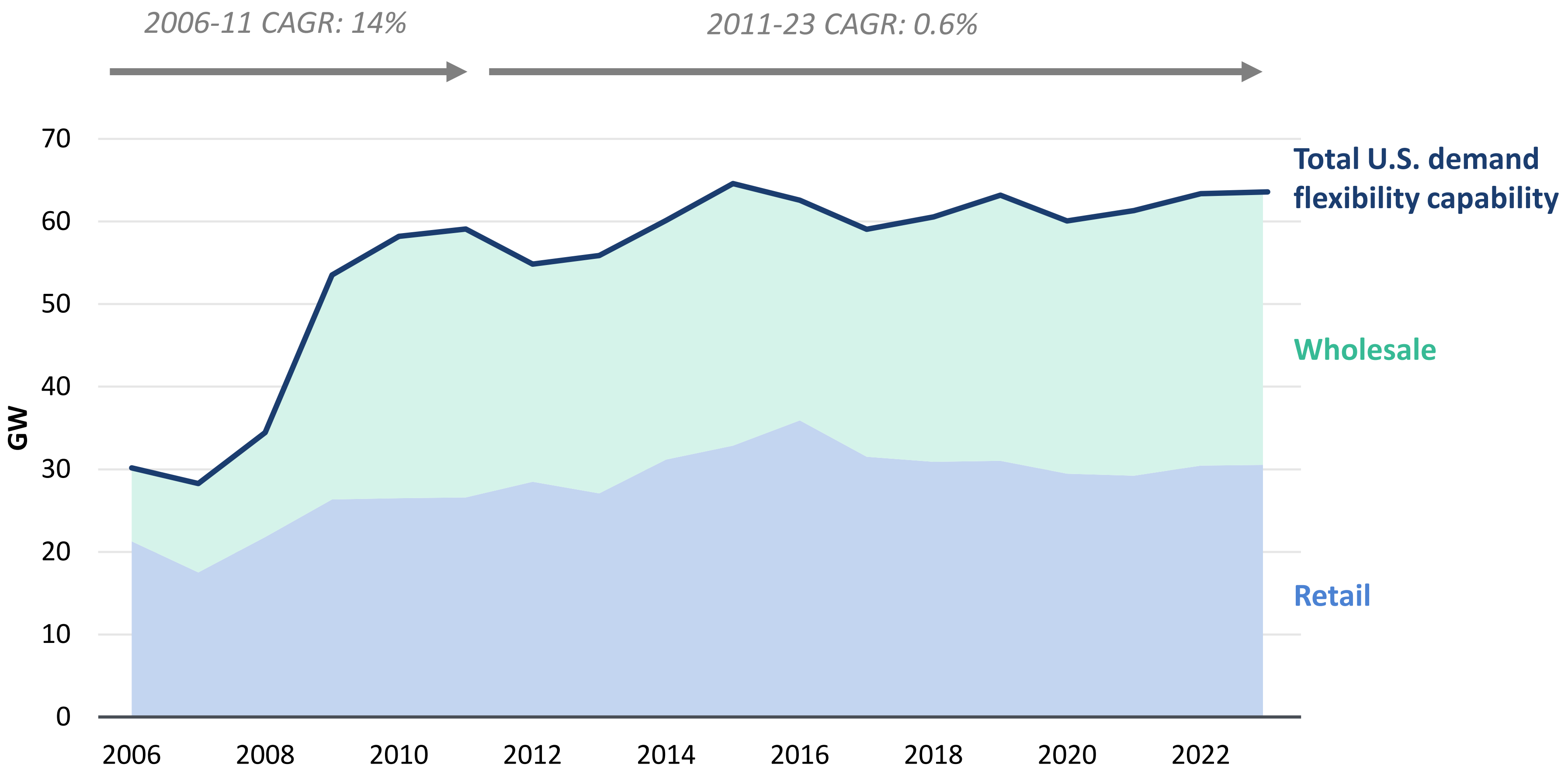
Demand flexibility can scale quickly– national capability doubled in five years.



Sources: EIA-861 database, FERC annual DR reports. Note that wholesale and retail DR may not be entirely additive.

Some ~~good news~~ sobering news

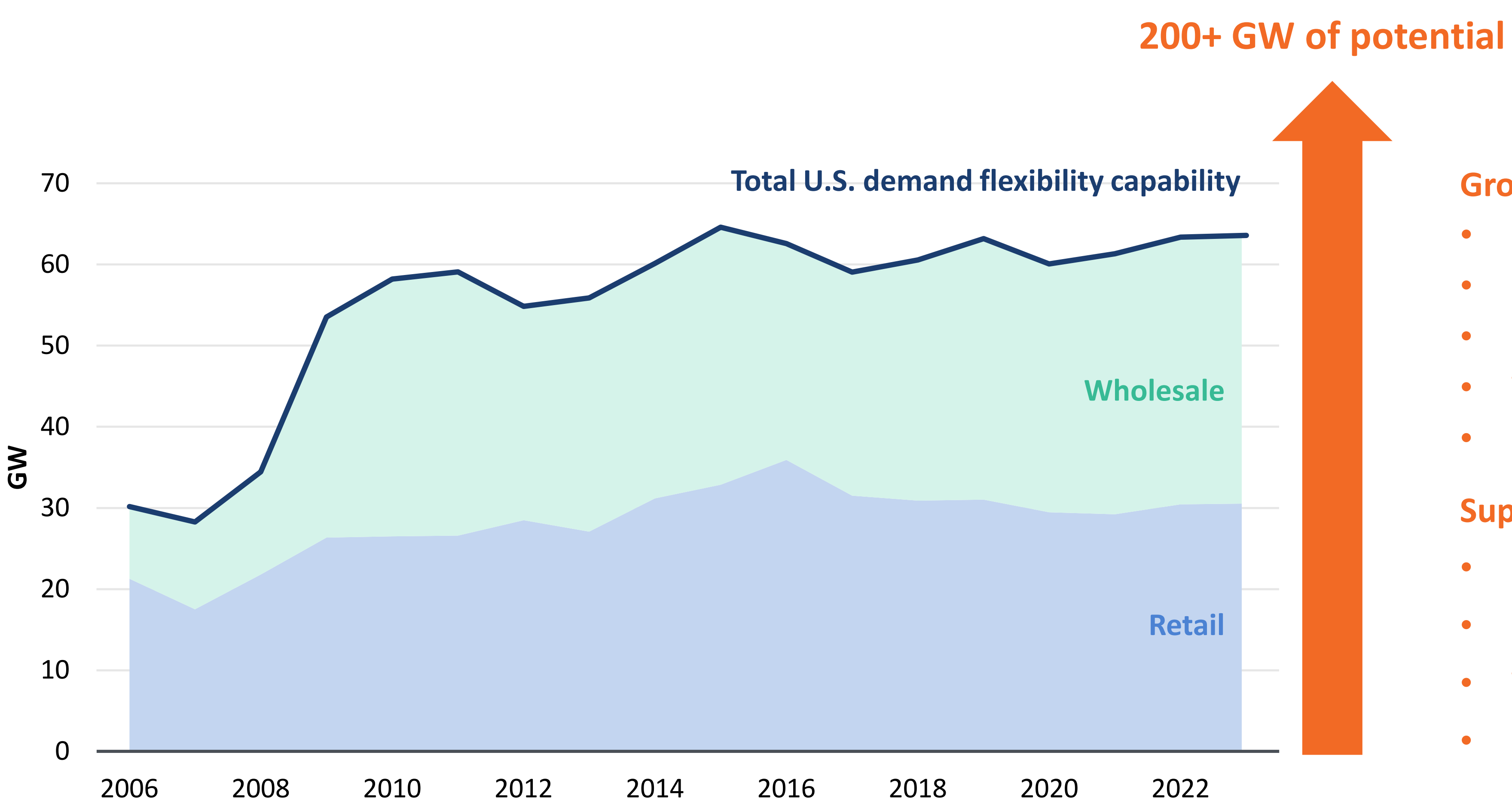
Relative to load growth, U.S. demand flexibility has been treading water since 2011.



Sources: EIA-861 database, FERC annual DR reports. Note that wholesale and retail DR may not be entirely additive.

Some ~~good news~~ ~~sobering news~~ reasons for hope!

U.S. demand flexibility has the potential to triple (or more)… under the right conditions.



Growth areas

- Data center on-site generation
- Vehicle-to-grid
- Distributed batteries
- Thermal storage
- Residential HVAC

Supporting advancements

- DERMS innovation
- Flexibility marketplaces
- Time-varying rates
- AMI 2.0 / smart panels

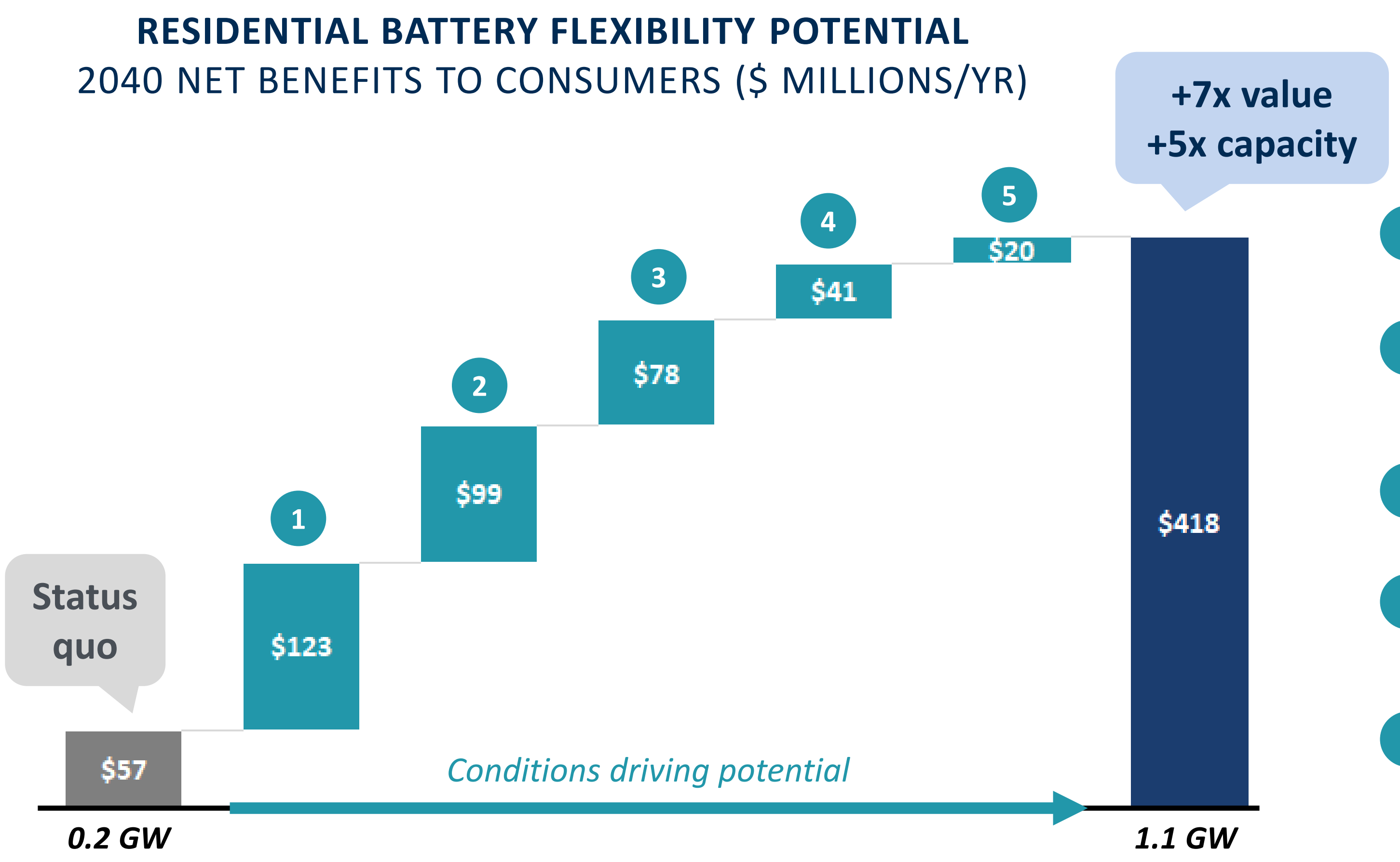
Sources: EIA-861 database, FERC annual DR reports. Note that wholesale and retail DR may not be entirely additive.

Why the optimism? A new paradigm.

	Critical industry challenges	The opportunity for demand flexibility
Affordability	• Concerns about a cost shift from data centers • Cost increases due to tariffs / supply chain	• Leverages underutilized on-site assets • Costs only 40-60% of the alternatives (or less…) • Somewhat insulated from tariff / supply chain uncertainty
Environmental Impacts	• Major gas generation expansion plans • Potential for delayed coal retirements	• Reduces need for other capacity additions • Can drive alternatives to diesel backup • Enables electrification
Fairness	• Who decides "beneficial" load when available grid capacity is scarce?	• Pays *customers* for grid services • Hyperscalers could support DR market expansion • New alignment with utility business model
Reliability	• Supply struggling to keep up with demand • Equipment shortages, interconnection delays	• Not constrained by interconnection queue • Can scale as new load materializes • Can be a bridge to transmission expansion

A lot of work remains: NY storage case study

Scaling demand flexibility will require customer-focused technical, regulatory, and market innovation.



1. **Expanded participation**: As the value and customer experience improve, more customers enroll in the program.
2. **Improved utilization:** Better forecasting and dispatch strategies allow higher utilization while maintaining a reserve for customer use in case of an outage.
3. **Permitting reform:** Finalizing permitting process for indoor energy storage systems opens NYC market.
4. **Distribution grid services:** As DER control and visibility improve, more customers will be able to provide distribution services and monetize the associated value.
5. **Program cost reduction:** As utility grid flexibility programs reach scale, efficiencies can reduce the fixed costs of implementing the programs.

Source: New York's Grid Flexibility Potential, prepared by The Brattle Group for NYSERDA and NY DPS, 2025.

Three grid flexibility priorities for the next five years

Instead of…	Let's…
Rushing to add 100 GW of centralized fossil generation plus 100 GW of backup diesel	Fully consider the speed and value with which grid flexibility can provide resource adequacy
Exclusively building wires in anticipation of new load	Leverage the option value of grid flexibility in proactive grid planning
Piloting with a plan to learn	Pilot with a plan to scale

Appendix

U.S. generation capacity outlook: Mind the gap

U.S. electricity demand is projected to accelerate enormously through the end of the decade. Traditional generation resources are unlikely to bridge the supply gap due to several constraints. Innovative new solutions are needed.

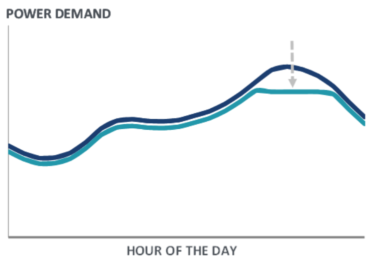
	2016 to 2023 (Historical)		2023 to 2030 (Forecast)	
Demand: Peak Load Growth	(+3%) 24 GW	**Limited growth** • Overhang from 2009 recession • Efficiency improvements • Decoupling of GDP and electricity demand	(+14%) >100 GW	**Significant load growth** • Data centers • Building electrification • Electric vehicles • Advanced manufacturing
Supply: Needed Investment in Capacity for Resource Adequacy	$90 billion 83 GW	**Persistent investment despite limited demand growth** • Coal replacement • Renewables integration • Increasingly volatile weather	$250-$350 billion ~240 GW	**Likely infeasible with traditional generation resources** • Equipment shortages • Interconnection delays • Affordability concerns • Decarbonization constraints

Innovative solutions are needed to address supply/demand gap

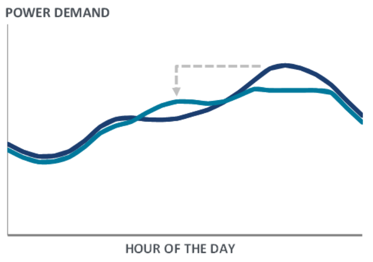
Benefits of VPPs

VPPs provide many operational benefits, along with the potential to mitigate other concerns such as lengthy resource interconnection delays and unprecedented uncertainty in load forecasting.

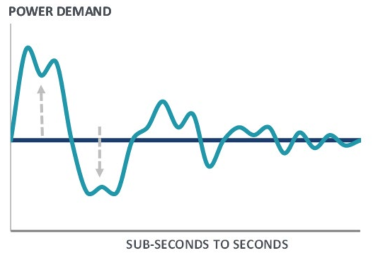
Sources of VPP Operational Value



Peak demand reduction
Dispatchable and event-based, with a limited number of events per season. Primarily provides capacity value.



Load shifting
Occurs frequently. Provides capacity and energy value, and potentially GHG emissions reductions. Helps to integrate renewables by reducing curtailments.



Real-time grid balancing
Some VPPs elements, such as batteries or grid-interactive water heaters, can provide ancillary services to address real-time imbalances on the grid.

Speed and Flexibility of VPPs

	Supply-centric approach	VPP-centric approach
Resource development timeline	Transmission-connected resources constrained by 4+ year interconnection approval process	VPPs can be "built" as quickly as customers enroll and the required control software is implemented
Resource development flexibility	Investments in traditional capacity are a 20-40 year commitment once steel is in the ground	VPPs can scale as demand grows and, to an extent, downsize if needed

Other Sources of VPP Value

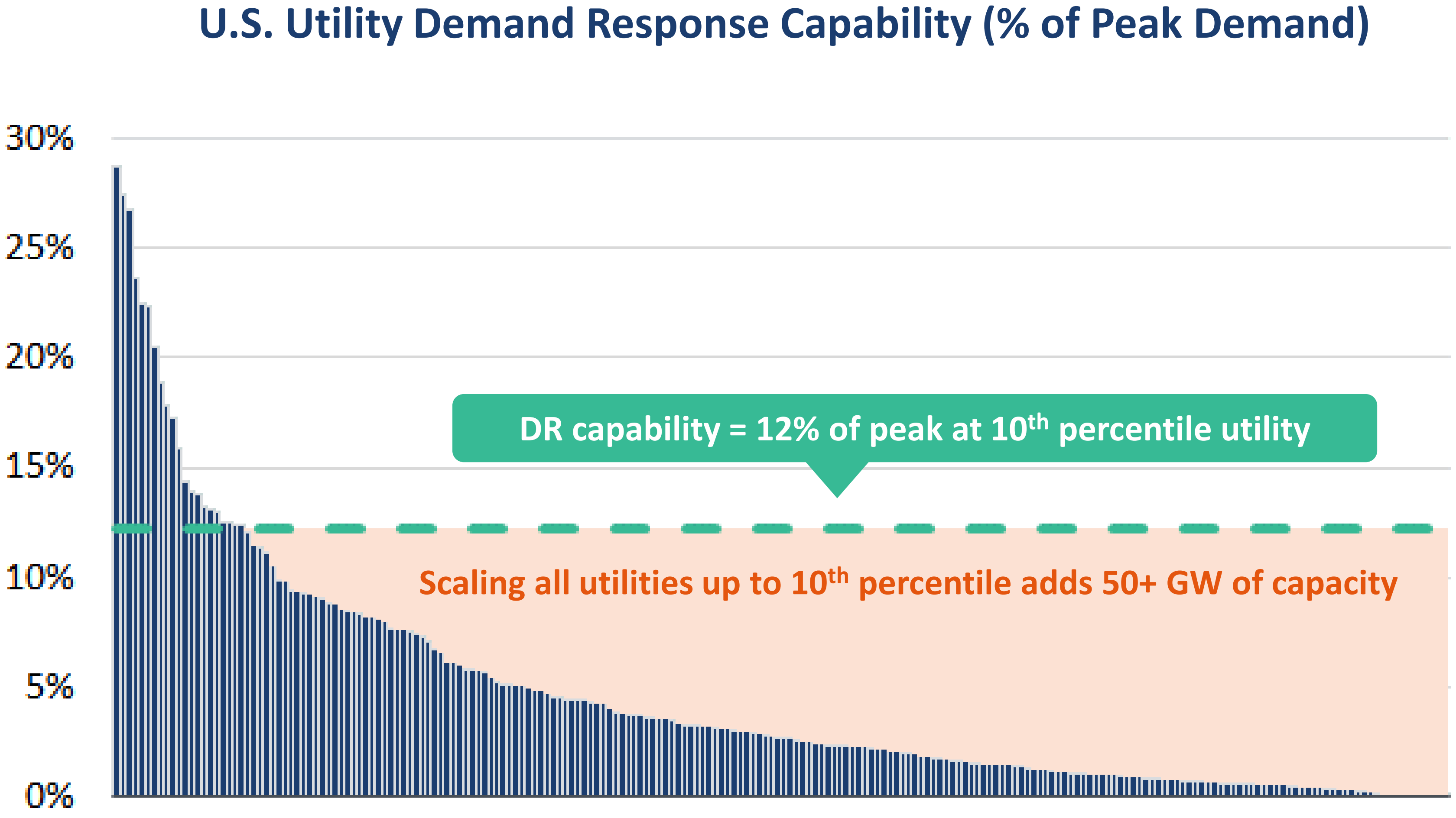
VPPs can provide other benefits as well, such as:

- Avoided infrastructure buildout
- Increased renewables deployment
- Better power system integration of electrification
- Enhanced customer satisfaction
- Improved behind-the-meter grid intelligence
- Overall energy savings
- Improved resilience

Additionally, VPPs are the only resource that pays customers to participate in the energy transition.

For further discussion, see Real Reliability: The Value of Virtual Power and Power Shift.

A lot can be done in the near term



Source: Brattle analysis of data from Form EIA-861 2022. The 50+ GW opportunity to scale is estimated as the additional capacity that would result from all analyzed utilities scaling capability to 12% of their peak load. The analysis includes the 214 utilities that: (i) reported DR capability to EIA in 2022, (ii) reported peak demand of at least 100 MW, and (iii) are investor-owned, municipal, cooperative, state, or federal utilities. 12 utilities are excluded due to data anomalies.

30 strategies to increase enrollment

Marketing

1. Concise messaging about program benefits
2. Multiple motivators for participation
3. Top-of-funnel marketing
4. In-person promotional events

Enrollment Process

5. Create a seamless enrollment process
6. Pre-enroll devices sold on utility marketplaces
7. Point-of-sale enrollment at retailers
8. Offer easy enrollment in multiple programs
9. Integrate value-add services into programs
10. Provide referral incentives

Ecosystem Partners

11. Harmonized messaging from utilities and OEMs
12. Engage customers through trusted entity
13. Partner with local installers
14. Exchange learnings with other utilities

Incentive Design

15. Maximize the financial incentive
16. Ensure customer pays a portion of device cost
17. Offer ongoing participation payments
18. Bundle device financing options with programs
19. Align price signals
20. Offer active and passive control models

Engagement and Retention

21. Improve program design over time
22. Regularly remind customers of their rewards
23. Compensate through channels customer will notice
24. Communicate societal impact of participation
25. Call regular testing events
26. Offer easy unenrollment
27. Offer flexibility to opt out of events
28. Limit event notifications in automated programs
29. Allow customers to set control range
30. Offer technology choice where available

30 Strategies: Impact and Ease of Implementation

Based on perspectives of VPP solutions providers

Key highlights

1 **Concise messaging about benefits.** The headline should be the financial incentive. Also, key program features such as the ability to opt out

5 **Seamless enrollment process.** E.g., offering multiple options for user authentication, pre-populating forms with customer data, and minimizing the number of clicks/forms

7 **Point-of-sale enrollment at retailers.** For example, a checkbox to indicate enrollment when adding a device to the cart on a marketplace or retailer website

9 **Package with other value-add services.** For example, subscription pricing or real-time energy monitoring.

15 **Maximize the financial incentive.** Requires navigating the tension between financial attractiveness and cost-effectiveness.

16 **Ensure customer pays a portion of the device cost.** This ensures customers are emotionally invested in their purchase.

23 **Pay through channels customers will notice.** It is important for customers to realize that they are benefitting from participation

30 **Offer technology choice where available.** E.g., smart thermostats and A/C switches have different advantages and disadvantages.

30 Strategies: Impact and Ease of Implementation

Based on perspectives of VPP solutions providers