Opportunities and Challenges to Capturing Distributed Battery System Value via Retail Utility Rates and Programs

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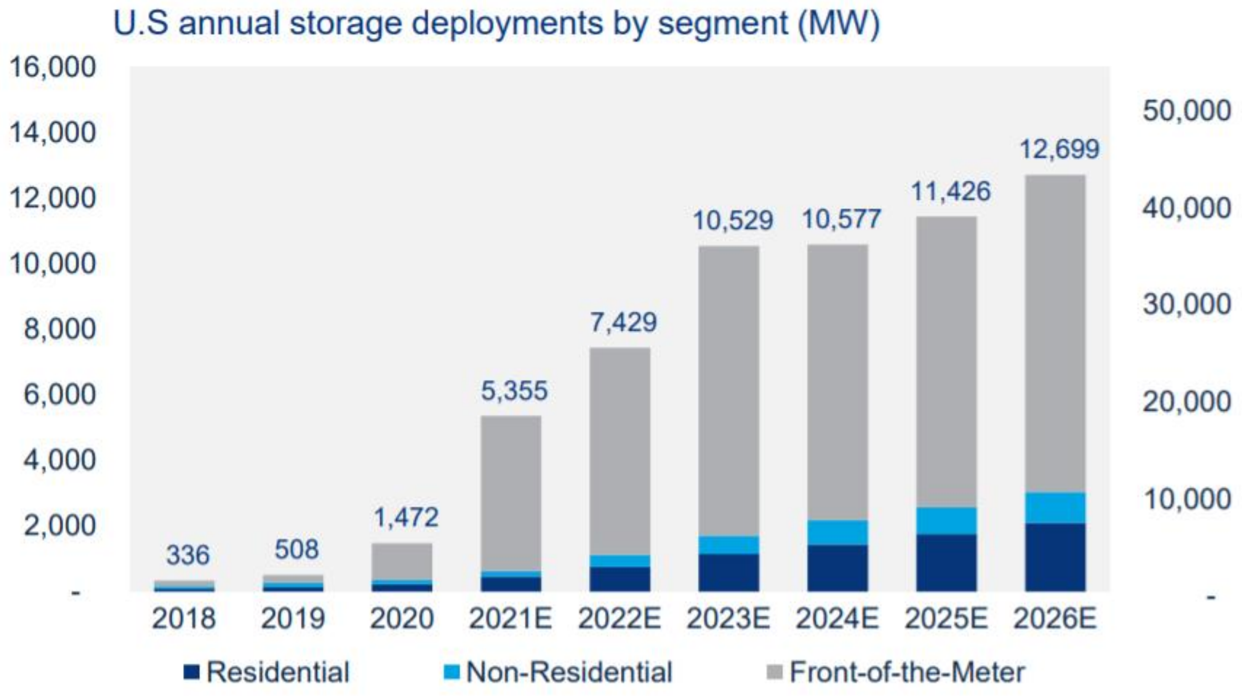
ELECTRICITY MARKETS & POLICY

Outline

- **Background and motivation**
- **Utility rates and programs**
- **Stacking services**
- **Future applications**
- **Discussion**

Distributed battery adoption in the US is increasing

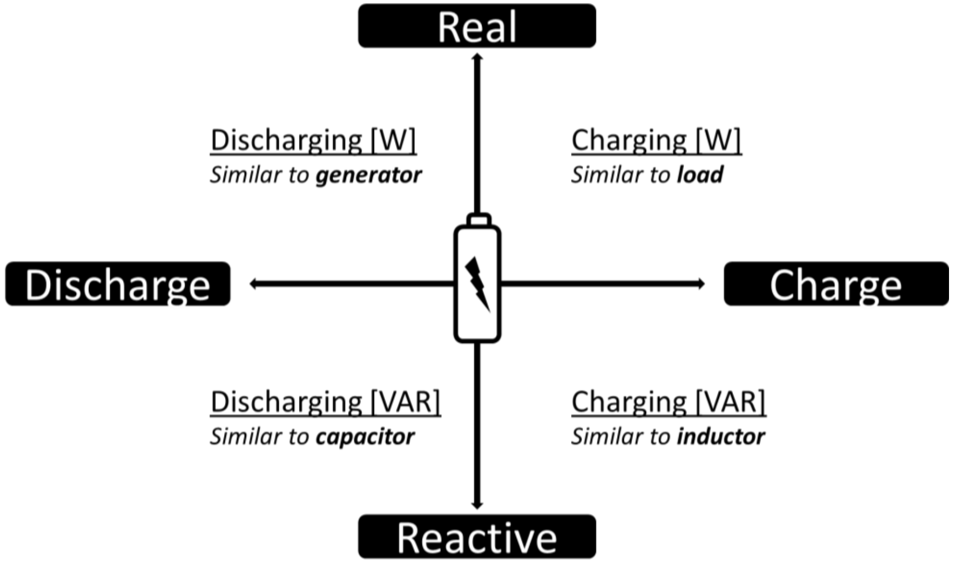


Drivers

- Federal and state-level
  - Storage targets, studies, incentives, etc.
  - Market rule changes and new value streams (e.g., flexibility services, allowing Distributed Energy Resource (DER) participation)
- Utility-level
  - Rate reform
  - Incorporating batteries in resource or distribution planning
- Other
  - Cost declines
  - Attachment offerings by solar developers
  - Resilience

Source: U.S. energy storage monitor Q4 2021 ES (Wood Mackenzie/ESA, 2021)

Distributed batteries can provide a suite of services



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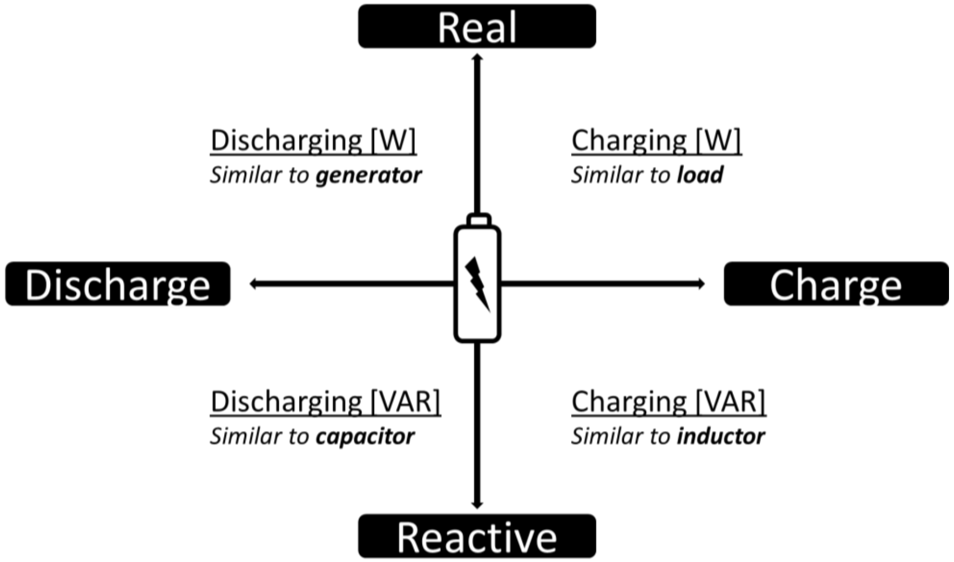
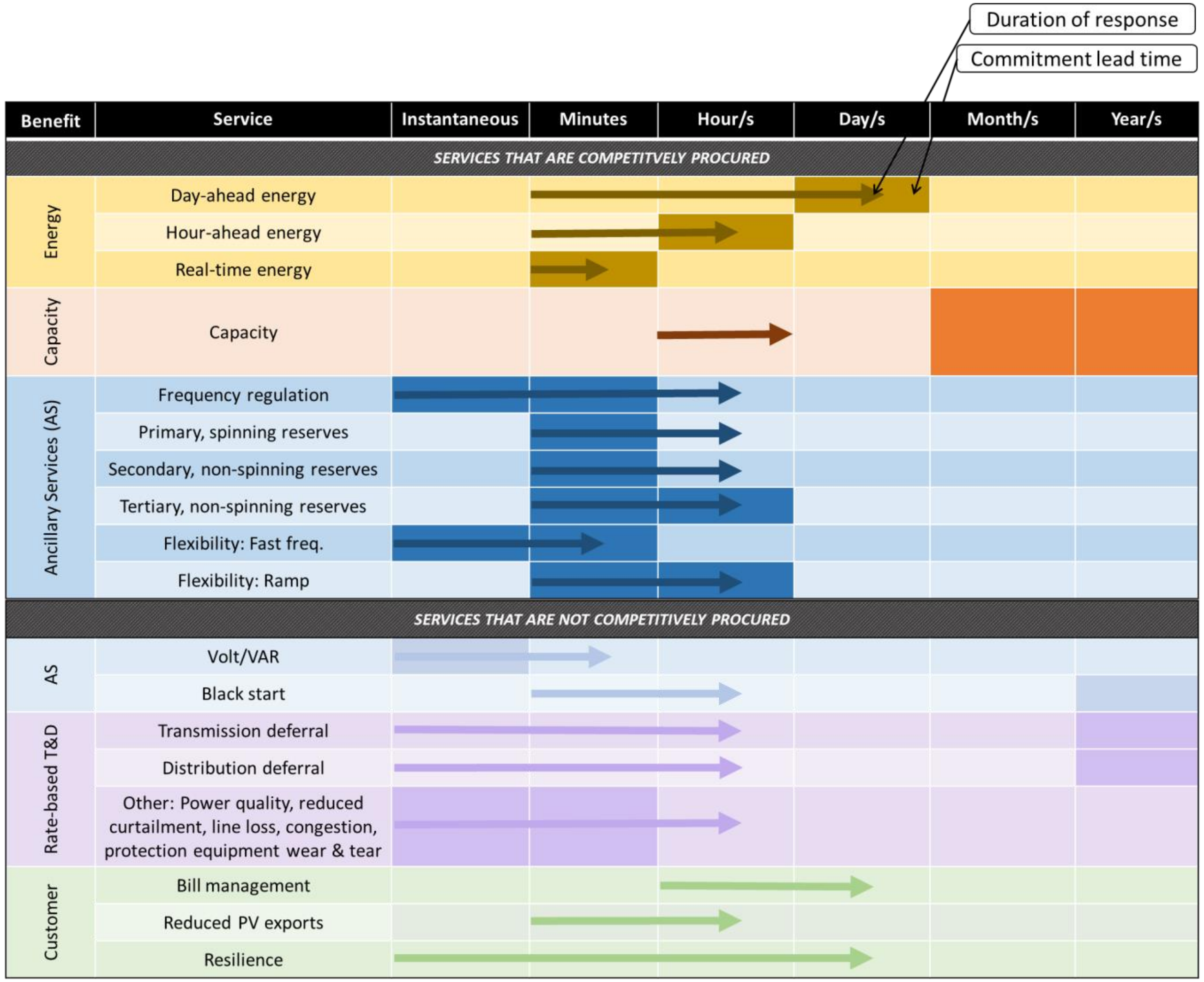




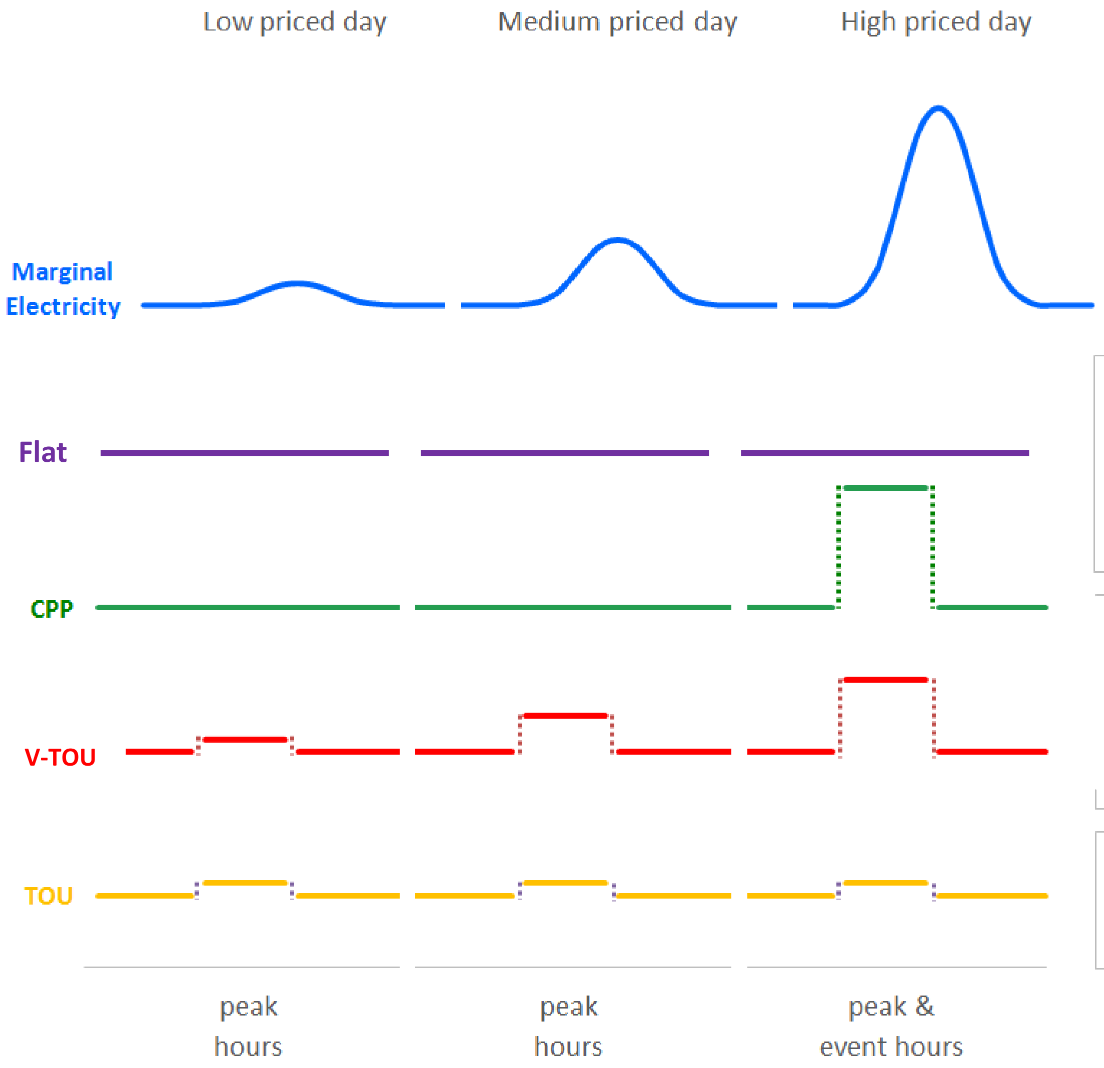
Research Objective

- Investigate how utilities could align rates and/or incentive-based programs in the near future with grid service value
  - Provide value for both utility and customer
  - Optimize fleet of existing distributed batteries
  - Encourage adoption of distributed batteries where most helpful

- Understand current challenges and opportunities
  - Trade-offs of accuracy and simplicity/feasibility
  - New policies and supporting technology

- Audience: policymakers and utilities

Utility rate structures



Under CPP, event *hours* are set one day ahead (based on the wholesale price forecast), and the event *price* is static and pre-determined in advance

Under V-TOU, peak *hours* are defined in advance, and the peak *price* is variable and set one day ahead, based on the wholesale price forecast

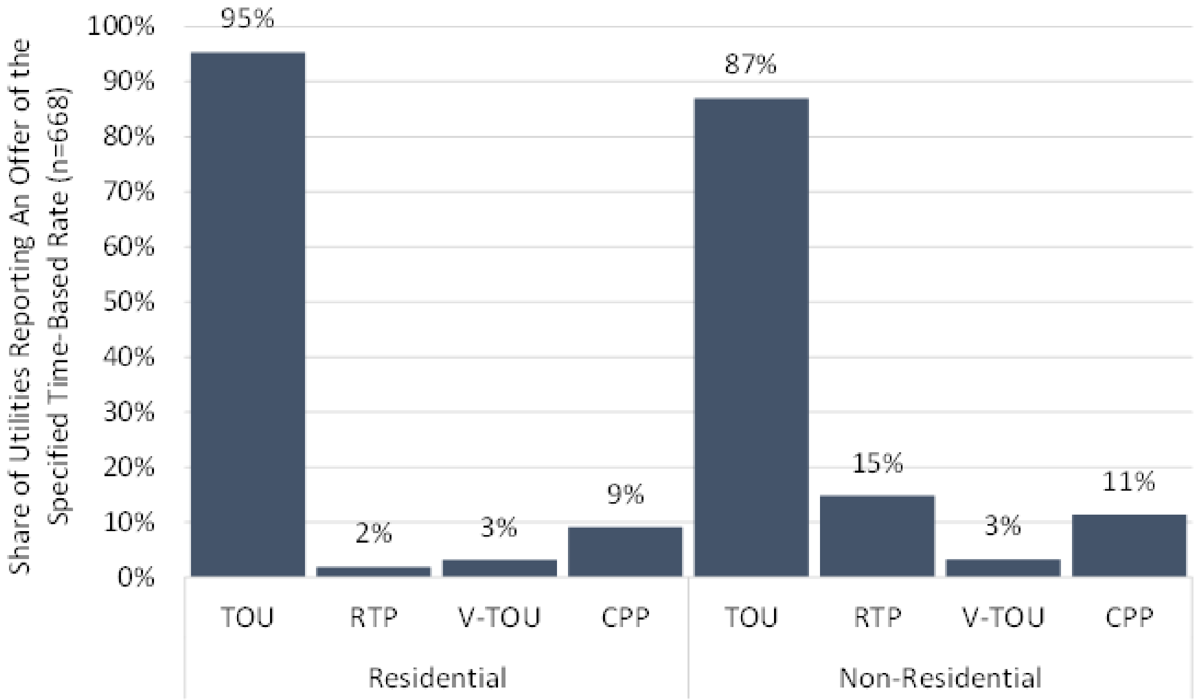
Under TOU, the peak *hours* and *price* are static and pre-determined in advance

Utility rate structures

- Over half of small electricity customers in the U.S. have advanced meters
- Large percent of utility dynamic rate offerings are time of use rates
  - Most rates are opt-in
  - Only 9.5% of commercial customers and 5.9% of residential customers were enrolled in dynamic rates

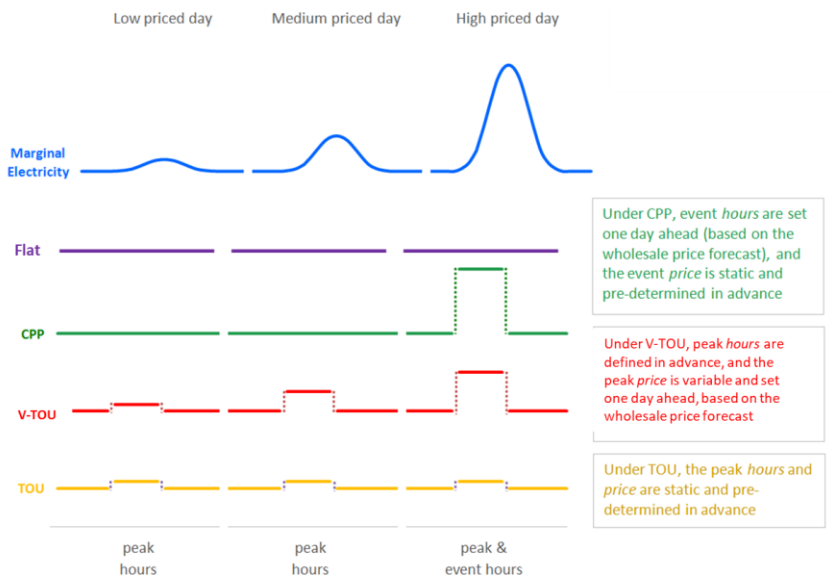
2019 U.S. Residential and Commercial Dynamic Utility Rate Offerings

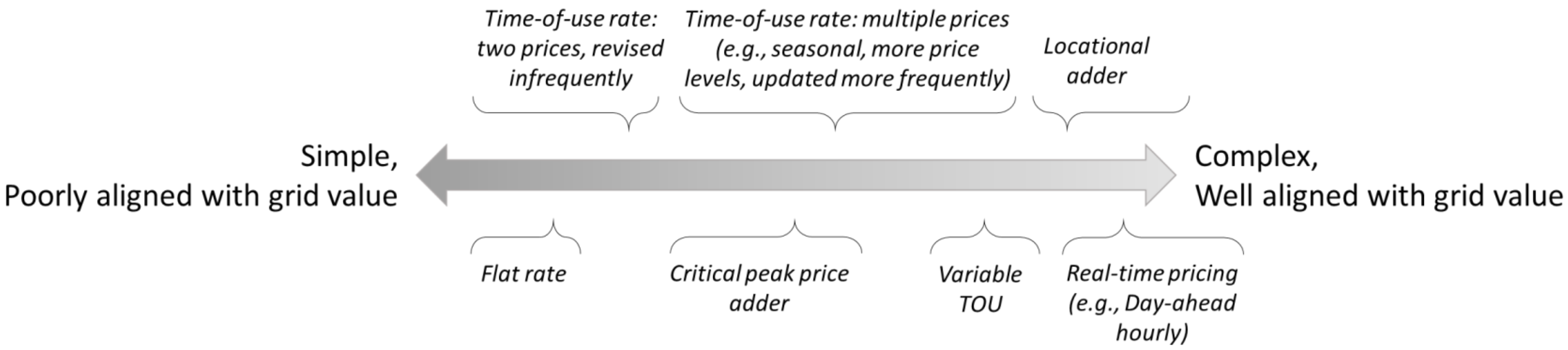
Note: Despite offerings, only 9.5% and 5.9% of commercial and residential customers, respectively, were enrolled in dynamic rates



Source: U.S. EIA, 2020. *Form 861*

Utility rate structures





Utility programs

- Demand Response (Demand-side flexibility)
- Non-Wires Alternatives (T&D flexibility)
- Virtual Power Plants (Supply-side flexibility)

Manual → Configurable → Direct Control

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Manual → Configurable → Direct Control

Added controls and communication.
Unidirectional signal response.

Simple,
Capable of providing fewer grid services ↔ Complex,
Capable of providing more grid services

Manual response.
Day-ahead notification.
Limited calls to peak season and low number of hours.

Added controls and communication.
Multi-directional signal response.

Changing policies and standards

Coordination

Control

Communication

- More inclusive policies
  - Wholesale market changes (e.g., Orders 841, 2222)
  - Integrated resource planning
  - Distribution system planning
- Opportunities
  - Increase distributed battery value streams
  - Improve grid efficiency and operation
- Remaining challenges
  - Prioritizing battery commitments and scheduling, optimizing dispatch
  - Compensation while avoiding double counting, etc.
  - Ensuring fulfillment of commitments, modeling

Changing policies and standards

Coordination

Control

Communication

- Inverter standards (IEEE 1547-2018, CA Rule 21)

- Opportunities
  - Increased visibility/interoperability between DER, distribution operator, and bulk system operator for both grid economics and reliability
  - Allows for provision of more dynamic grid services (e.g., volt/VAR)
  - More operational control (e.g., maximum export settings/profiles)

- Remaining challenges
  - Capabilities are required, but use of them is not
  - Data collection, management, etc.

Changing policies and standards

What services are most valuable?

Can distributed batteries provide these services effectively?

If so, how long and how frequently will this service be required?

What level of controls and communication are necessary?

How to distinguish multiple services for scheduling, dispatch, compensation, modeling?

…Especially when participating across both distribution and bulk systems

Segmenting battery commitments temporally or by capacity

Temporal Segmentation

- For anything that can be scheduled ahead of time
  - Cyclic
  - Peak-Driven (e.g., day ahead notice)
- Existing examples:
  - TOU rates + DR (retail)
  - Energy/AS + Capacity (bulk)
- Dual participation examples include any combination
  - Energy/AS + NWA for local peaks
  - Exceptions exist (e.g., NEM + wholesale service)

	Cyclic	Peak-Driven
Examples	• Diurnal morning and evening ramps • Diurnal energy arbitrage	• Economic arbitrage • Resource adequacy/ capacity • Emergency DR • Location-specific transmission or distribution relief
Utility Rate or Program	• Dynamic rates (updated for accurate diurnal, seasonal value)	• Manual DR program or dynamic time-based rates (e.g., CPP, V-TOU or RTP) for economic services • DR or VPP for resource adequacy, capacity, emergency DR • NWA for T&D relief

Segmenting battery commitments temporally or by capacity

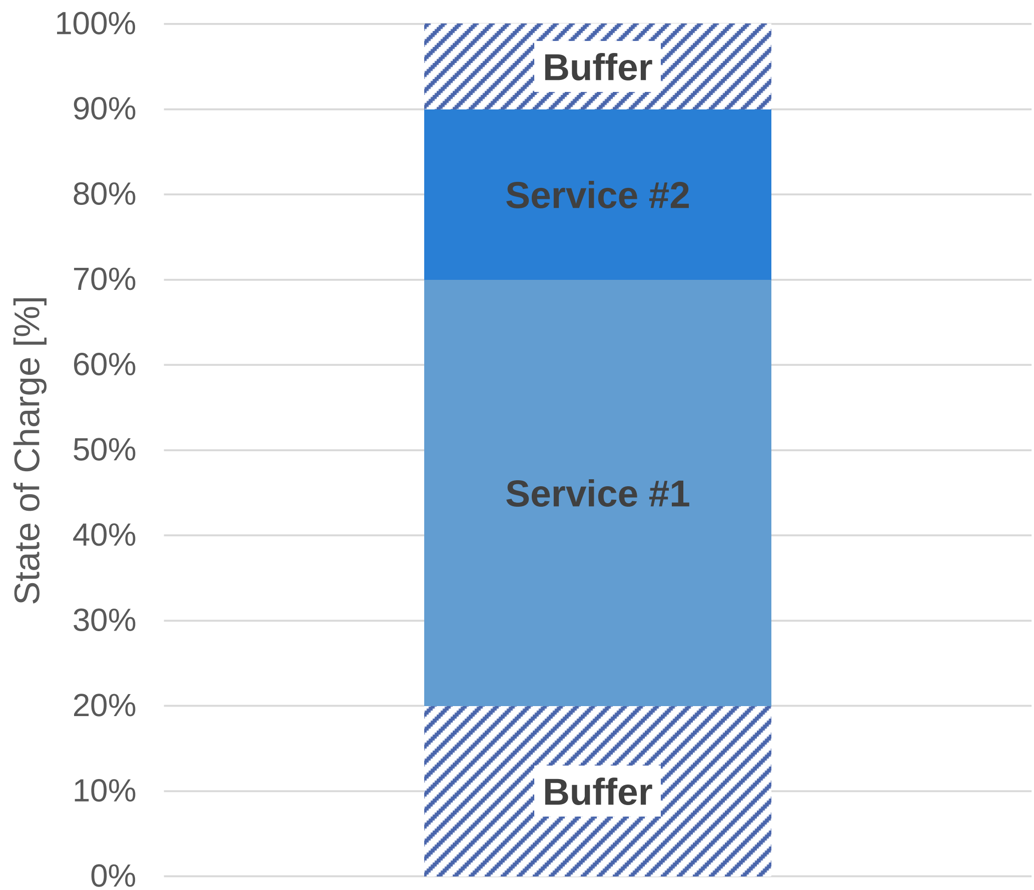
Capacity Segmentation

- For anything that requires dynamic, continuous service, or instantaneous response that cannot be anticipated or scheduled ahead of time
  - Continuous
  - Unexpected
- Existing examples:
  - Reserving a % SoC for battery health or resilience
- Dual participation/other potential examples:
  - Any service + reserving % SoC for frequency or voltage regulation

	Continuous	Unexpected
Examples	• Frequency regulation • volt/VAR services • VRE smoothing for hybrid systems	• Reserves • Local reliability during short-duration outages
Utility Rate or Program	• Direct Control DR, NWA, or VPP program	• Direct Control or Configurable DR or VPP program for reserves • Direct Control DR or VPP program for high-value reserves or contingency support

Segmenting battery commitments temporally or by capacity

Capacity Segmentation



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Stacking services in a resource-constrained environment

Insufficient generating resources → **Value impacts** → **Impact categories** → **Temporal segmentation**

Value impacts
- Increased capacity costs
- Increased marginal energy costs
- Congestion when constrained (T&D value)

Impact categories
- Peak driven

Temporal segmentation
- Time-sensitive rates or adders (e.g., CPP)
- DR, NWA, and/or VPP (any level of control), depending on need

Stacking services in a high-renewables environment

High VRE penetration → **Value impacts** → **Impact categories** → **Temporal and/or capacity segmentation**

Value impacts
- Increased variability and uncertainty
- Increased need for flexible resources

Impact categories
- Cyclic (diurnal and seasonal, especially for high-PV penetration)
- Unexpected (intermittency and forecasting errors)
- Continuous (smoothing)

Temporal and/or capacity segmentation
- Time-based rates to capture cyclic patterns in net generation
- Direct control utility program (DR, VPP) for dynamic response

Stacking services to alleviate distribution constraints

Distribution constraints → **Value impacts** → **Impact categories** → **Temporal and capacity segmentation**

Value impacts
- Very location-specific value in distribution value that may not align with bulk system needs

Impact categories
- Location-specific peak driven
- Unexpected (resiliency)
- Continuous (reliability)

Temporal and capacity segmentation
- Time and location-based rates with CPP for locational cyclic and peak value
- NWA (any level of control for peak-driven, controls for dynamic response)

Main takeaways

- Resilience will continue to drive distributed battery adoption in the residential sector, even where otherwise not cost-effective. Changes to DER compensation structures will continue to drive adoption for all sectors.
  - Additional drivers include declining costs, favorable policies and incentives, and new value streams

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- Customers are mostly on flat rates, even as advanced technology adoption increases. Aligning rates and programs with grid value could improve economics and operation
  - Increase customers' revenue streams
  - Reduce utility need for additional infrastructure
  - Drive beneficial adoption and operation

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- Capabilities and opportunities to participate at the bulk system level are increasing
  - Changing wholesale market rules, availability of aggregations may force distribution operators to address dual participation issues, but also provides the opportunity to proactively design rates/programs
  - Advanced metering, inverters, management technology provide necessary capabilities, but challenges surrounding dual participation remain

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- There are tradeoffs between fully maximizing distributed battery utilization and cost/simplicity. Considerations include:
  - Grid constraints and value of distributed battery services
  - Battery adoption levels
  - Software, hardware, communication capabilities
  - Policy

Thank you!
Questions?

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