National Association of State Energy Officials

DER INTEGRATION & COMPENSATION INITIATIVE

WEBINAR #1: AGGREGATED DER GRID SERVICES

December 4, 2023

Problem Statement

Current and anticipated growth of distributed energy resources (DERs) and introduction of aggregated DERs into wholesale markets as a result of Order 2222 is fundamentally changing the way the grid is planned and operated.

Policy makers and regulators will increasingly need to evaluate, consider, and establish the rules and requirements as well as enabling policies and programs to bring these resources online safely and fairly to provide retail and wholesale services.

New myriad technical and economic issues will require new information and tools to make informed decisions related to the connection, technical operation, and compensation of aggregated distributed energy resources---in the distribution, bulk power system, and wholesale energy markets.

DER-I&C Initiative Description

Convene and support state members to understand the impact of their decision making related to the connection, operation, and compensation of aggregated DERs.

NARUC and NASEO will provide information, tools, access to experts, and peer sharing opportunities that assist members with FERC Order 2222 implementation in RTO/ISO regions and State oversight of transmission-distribution-customer (TDC) coordination outside of RTO/ISO regions.

Objectives:

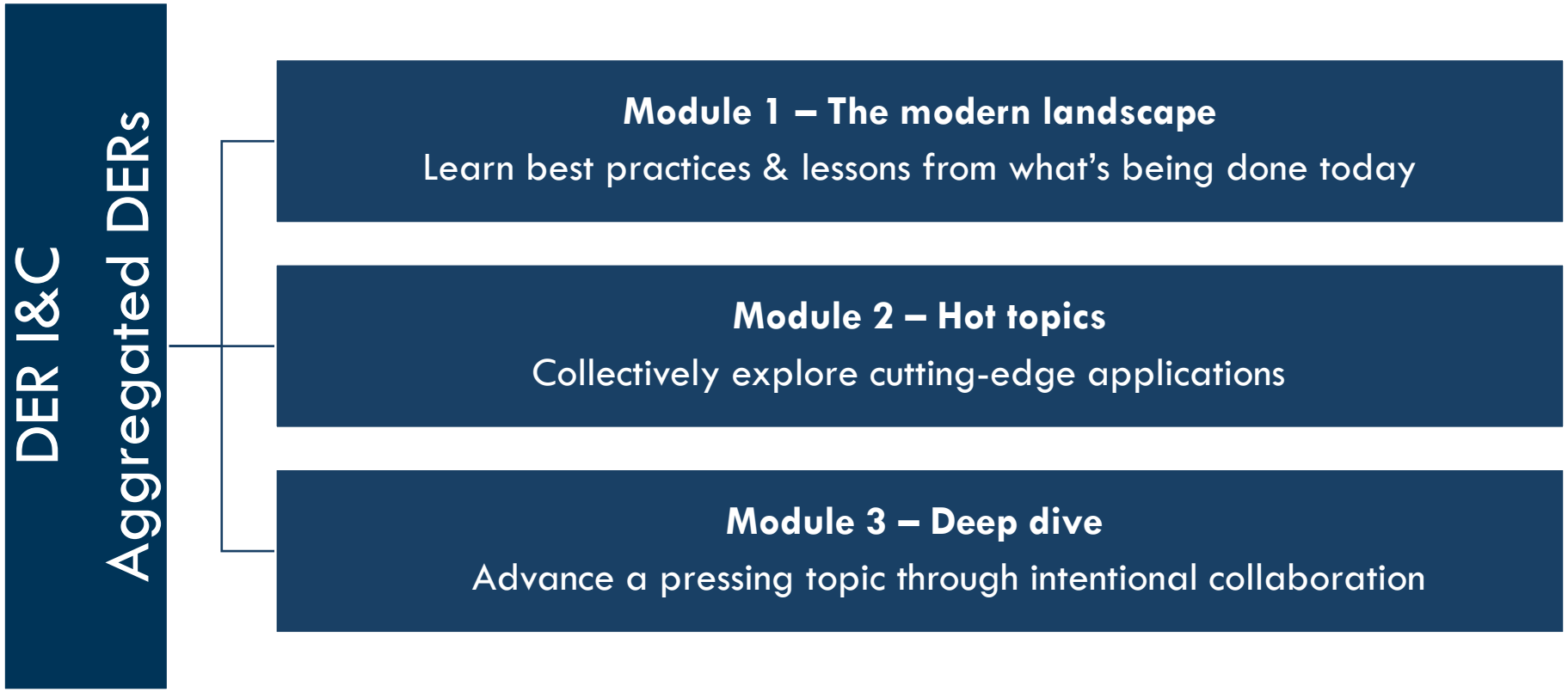
- Inform key state decision makers
- Raise and evaluate risks and opportunities of different decision options
- Bring different perspectives to the table

Advisory Group:

An advisory group of 10 NARUC and NASEO members representing diverse regional perspectives help guide the project.

Curriculum Design 2023-24

The DER I&C Initiative 2023-24 curriculum is designed around three sequential modules



Module 1: The Modern Landscape

Learn best practices & lessons from what's being done today

Module 1 begins with **three webinars** in December 2023 and January 2024:

- Webinar 1: Aggregated DER Grid Services, Monday, December 4, 2023, 3:00-4:30pm ET
  - Moderator: Chair Marissa Gillett, CT PURA
  - Expert: Paul De Martini, Newport Consulting
  - Panelist: Lyn Huckabee, MA DOER
  - Panelist: Vince Faherty, Google Nest
- Webinar 2: Aggregated DER Valuation , Monday, December 18, 2023, 3:00-4:30pm ET
  - Moderator: Commissioner Andrew McAllister, CEC
  - Expert: Samir Succar, ICF
  - Panelist: Natalie Mims Frick, LBL
  - Panelist: Sandra Sweet, NY DPS
- Webinar 3: Compensation Options for Aggregated DER Grid Services, Monday, January 8, 2024, 3:00-4:30pm ET

Today's Agenda

Objective: Establish a baseline understanding of the grid services aggregated DERs (ADER) can provide beyond non-aggregated DERs.

Time (ET)	Agenda
3:00-3:10pm	Welcome & introduction to DER I&C initiative
3:10-3:35pm	Expert presentation on ADER grid services Paul DeMartini, Newport Consulting Q&A
3:35-3:55pm	Panelist remarks: Lyn Huckabee, Massachusetts Dept. of Energy Resources Vince Faherty, Google Nest
3:55-4:25pm	Moderated & audience Q&A
4:25-4:30pm	Closing

NASEO
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U.S. DEPARTMENT OF ENERGY
Office of Electricity

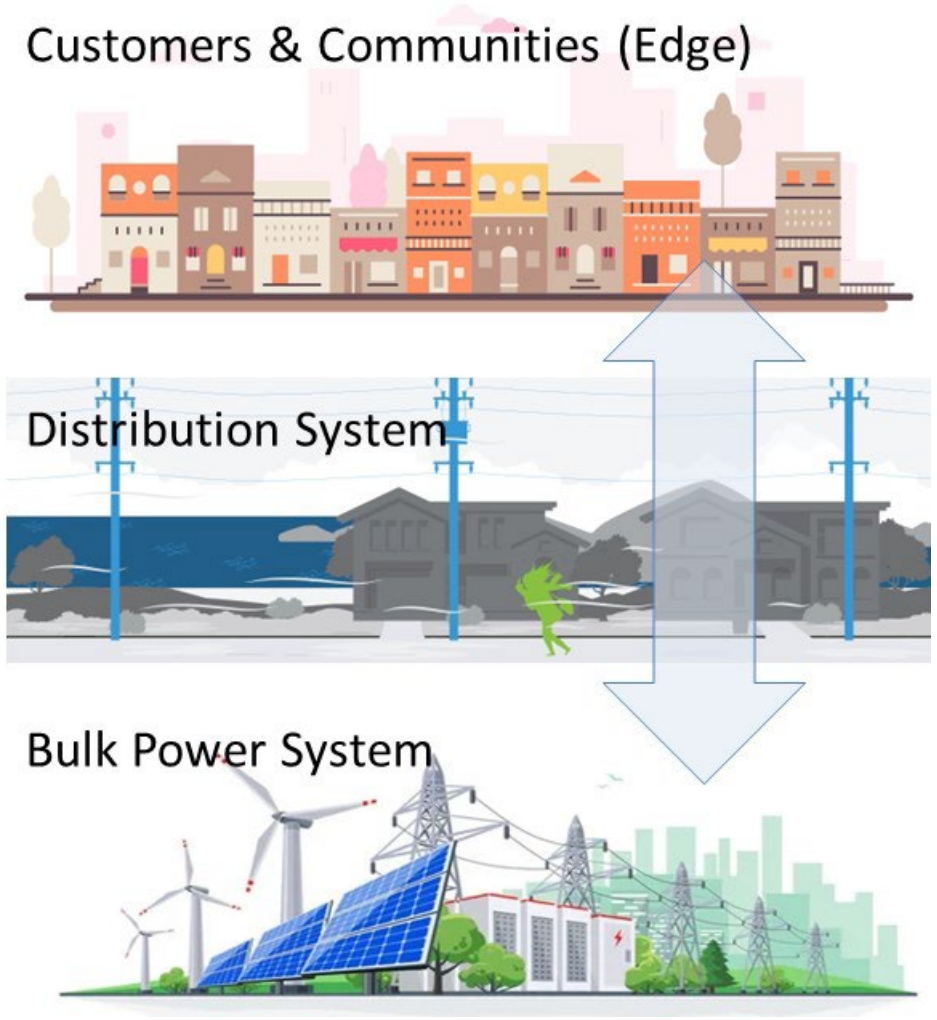
DER Services & Coordination

DOE-OE Operational Coordination Project

Paul De Martini
Newport Consulting

December 4, 2023

What are the Needs for DER Services?



Lower Cost Alternative Energy Supply
Electricity Reliability and Resilience
Resource & EV Integration Constraints

Grid Reliability and Resilience
Distribution Capacity Constraints
Power Quality

Resource Adequacy & Reliability
System Resilience
Balancing Variable Supply & Unpredictable Net Load

Appendix includes a defined list of the current and FERC Order 2222 enabled services that exist today, but not uniformly available at wholesale, distribution and the edge

Grid Reliability and Resilience are Pressing Concerns

ASCE 2021 Report Card:

- The majority of the nation's grid is aging, with **some over a century old** — far past their 50-year life expectancy — and others, including **70% of T&D lines, are well into the second half of their lifespans.**

Associated Press (Analysis of DOE data):

- Power outages from severe weather have **doubled over the past two decades** across the US due to climate change.
- **Forty states are experiencing longer outages** — and the problem is most acute in regions seeing more extreme weather.

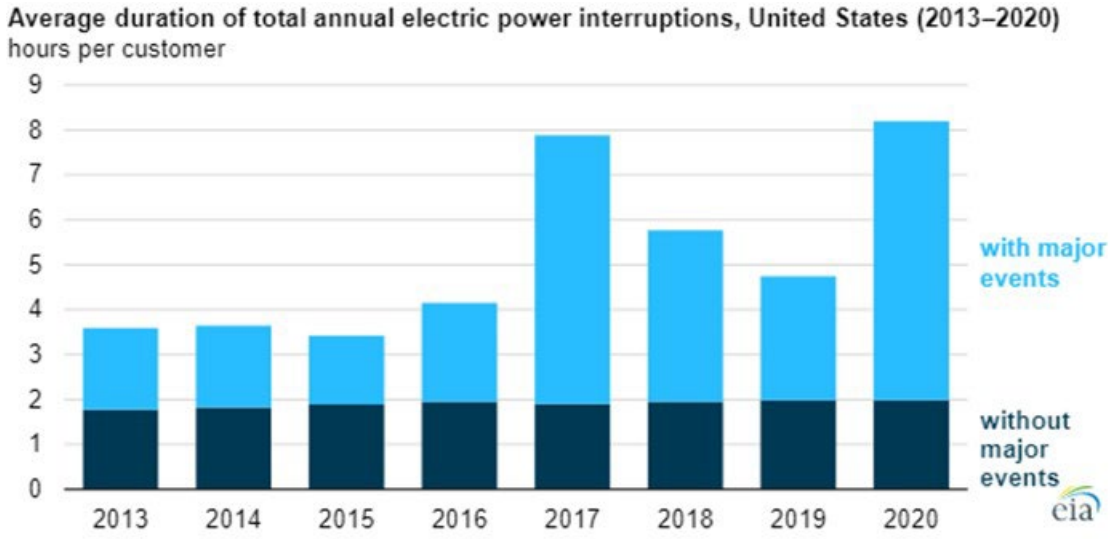
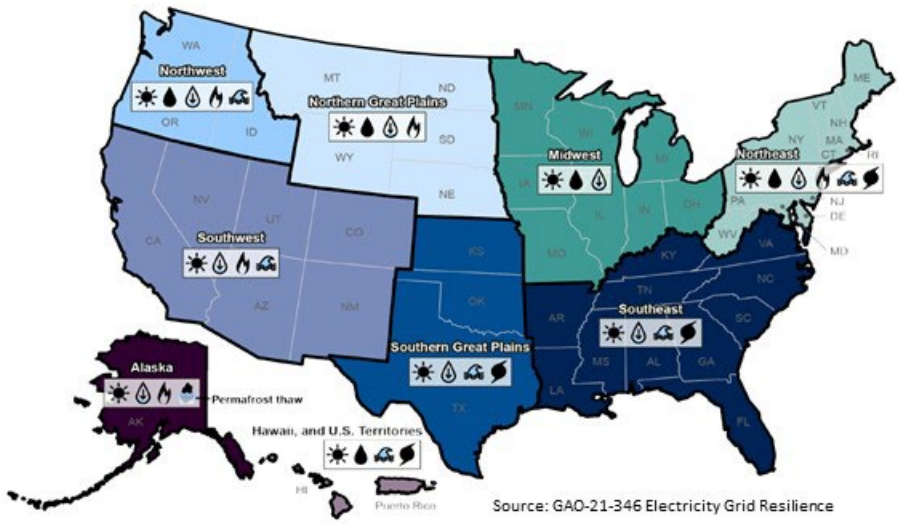


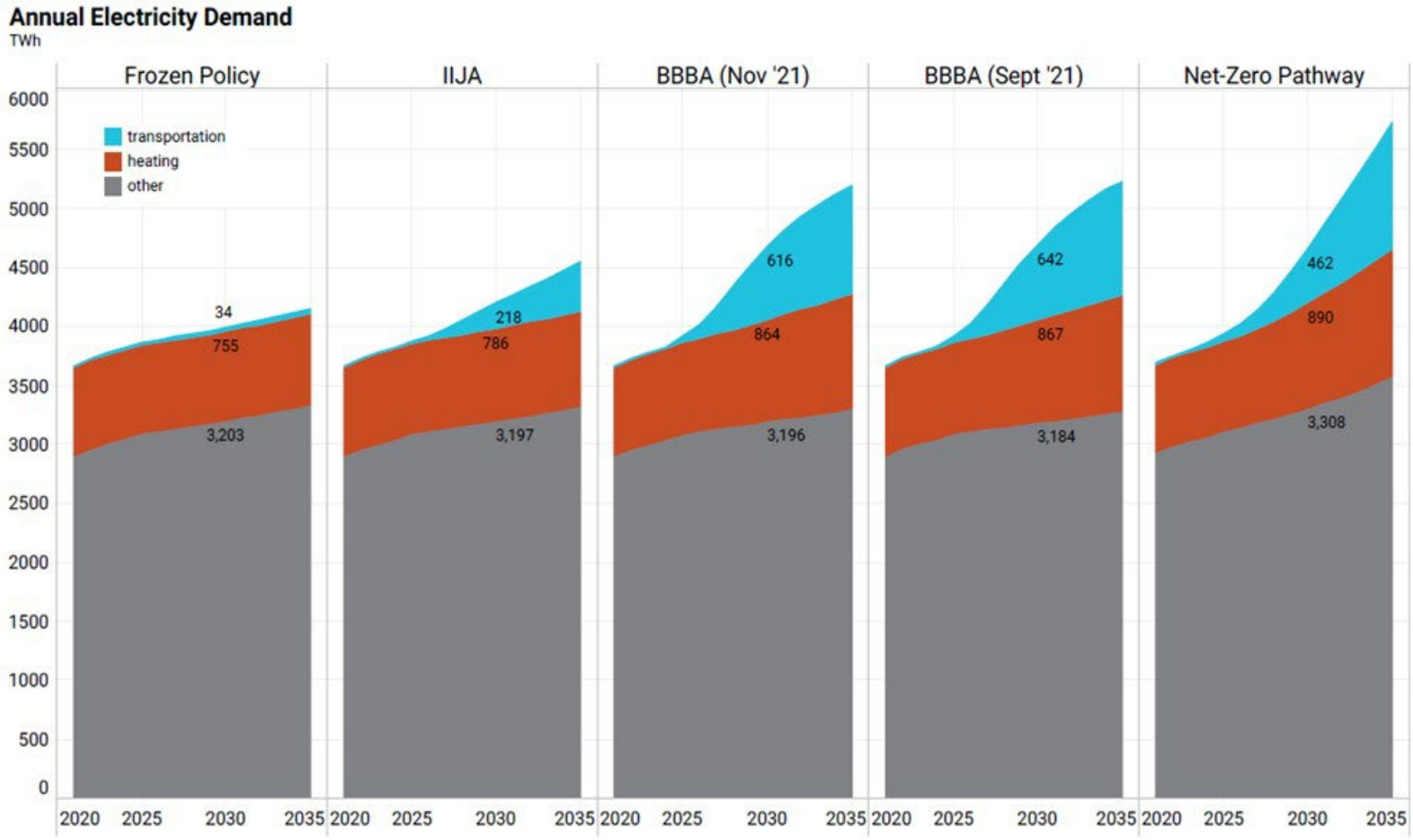
Figure 3: Potential Climate Change Effects by Region and Examples of Climate-Related Events on the Electricity Grid



Source: GAO-21-346 Electricity Grid Resilience

Electrification Poses Significant Distribution Challenges

Without mitigation, electricity demand may increase up to 18% by 2030 and 38% by 2035 compared to 2022. Incremental distribution capacity upgrade cost is estimated at US$116 billion to US$200 billion.[1]

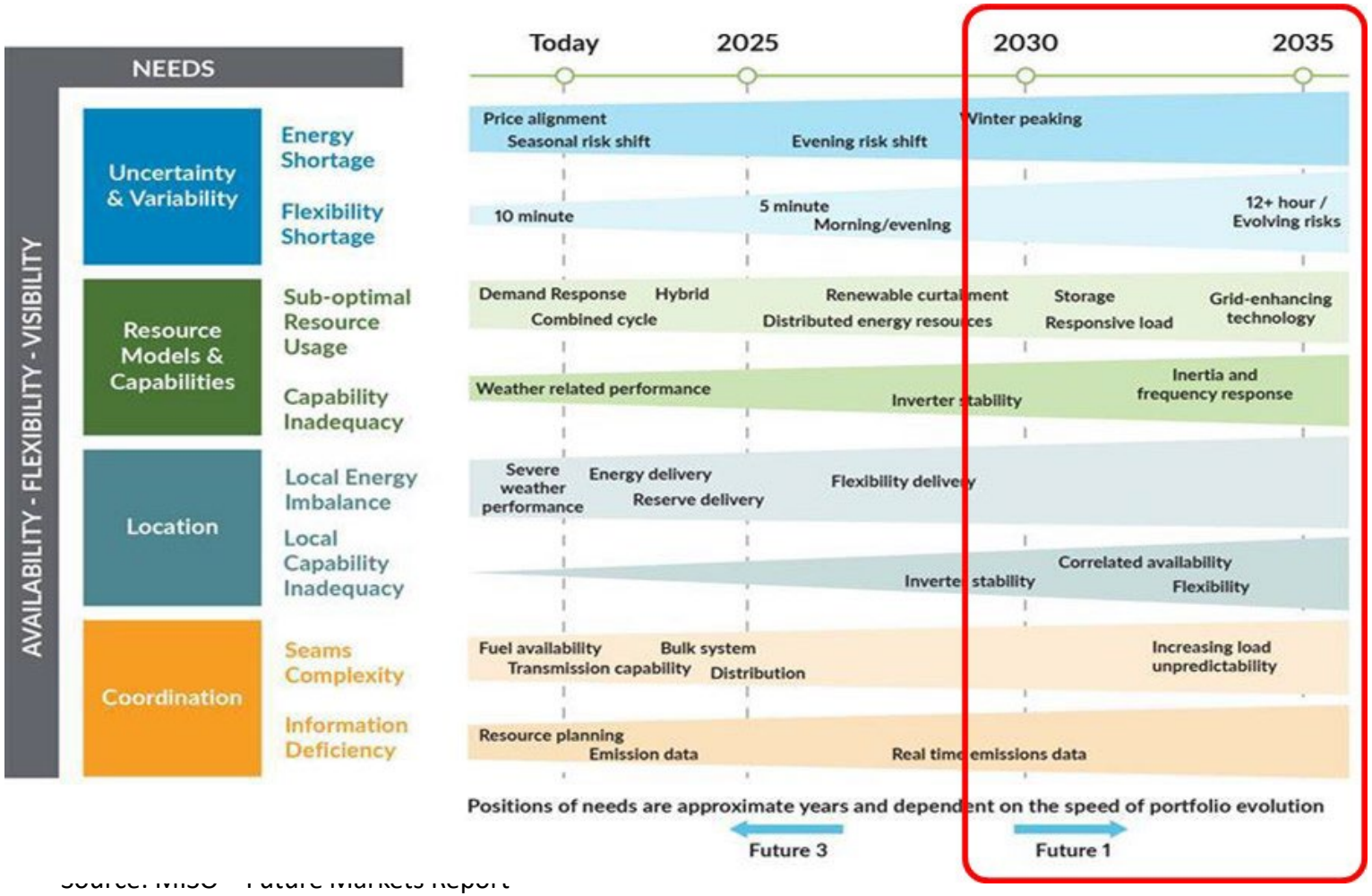


Source: Princeton University Zero Lab

1. Energy+Environmental Economics https://www.ethree.com/wp-content/uploads/2021/06/GridLab_2035-Transportation-Dist-Cost.pdf

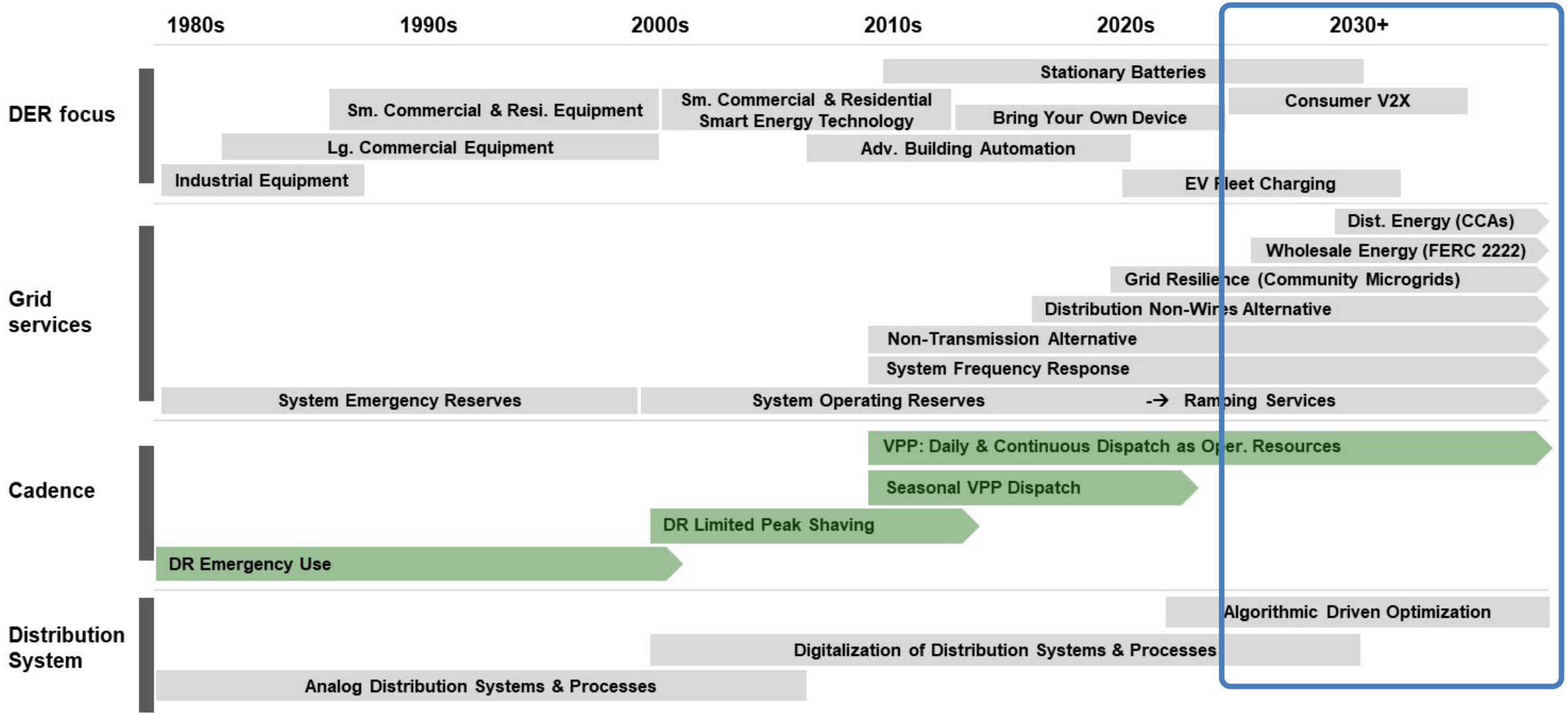
Bulk System Challenges

Increasing random variability of resources and loads poses T&D operational challenges



Source: MISO – Future Markets Report
https://cdn.misoenergy.org/MISO%20Markets%20of%20the%20Future604872.pdf

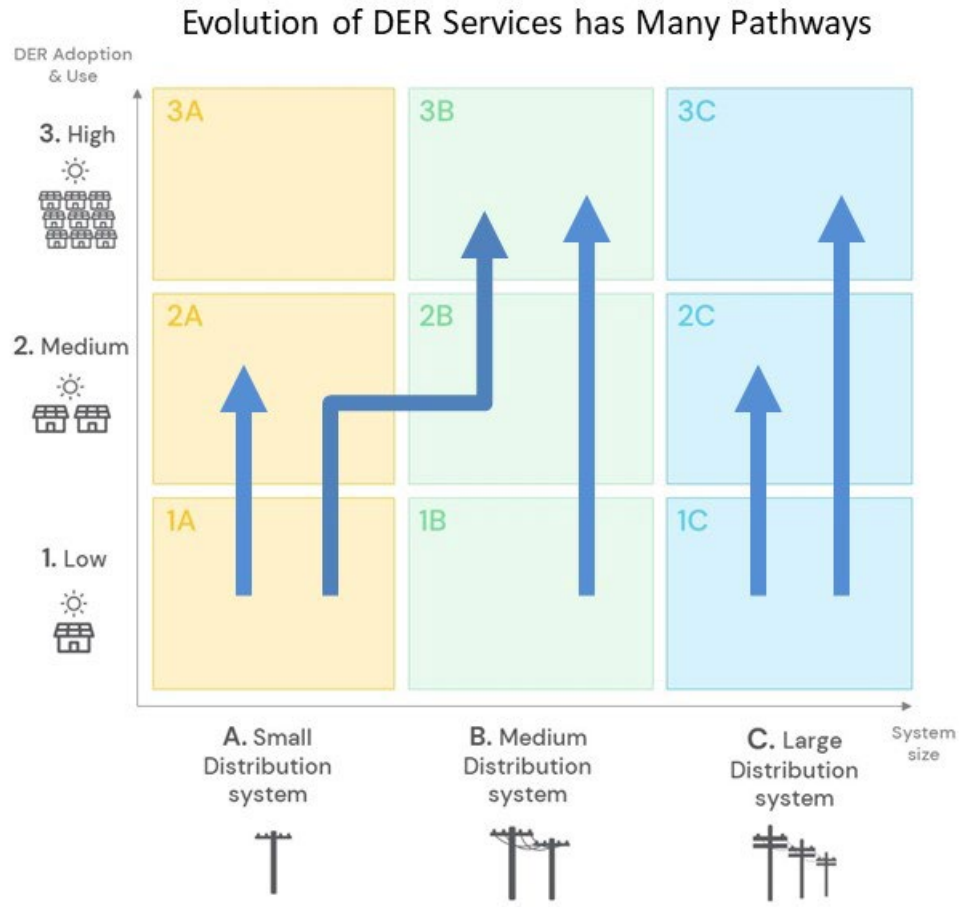
ADER Evolution – Next Stage Involves a Major Step Change



Source: Newport Consulting for DOE

Use of DER Services is Situational & Evolving

- Use of DER services is based on specific needs identified by customers/communities, and resource, distribution, and transmission planning
- Specific services and related performance requirements are derived from these planning efforts
- DER Use & related considerations vary by utility system and state policy and applicable regulation

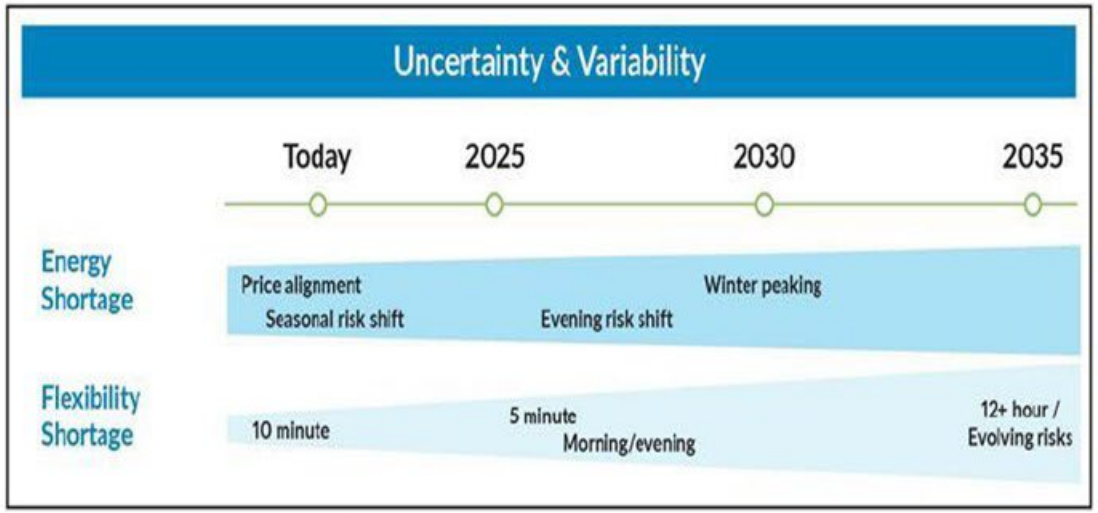


Considerations for DER Services

- **Alignment with specific grid service performance requirements**
  - Each grid service has unique performance requirements to realize value
  - Grid service requirements often overlap creating constraints on DERA to provide multiple services in wholesale and/or distribution and edge (e.g., microgrid)
- **Effective performance risk management & allocation**
  - Some grid services (e.g., distribution capacity avoidance) require very reliable performance.
  - Performance assurance (liquidated damages, Letters of credit, etc.) can create uneconomic financial burdens on DER Aggregators
- **Viable DER Aggregator business model considerations**
  - Revenue potential (“compensation”) is important
  - But, equally important is the cost of doing business

DER Orchestration Will Be Required

FERC Order 2222, and the need to manage distribution capacity constraints due to electrification and DER growth, will drive the need for sophisticated DER orchestration.



Source: MISO – Future Markets Report

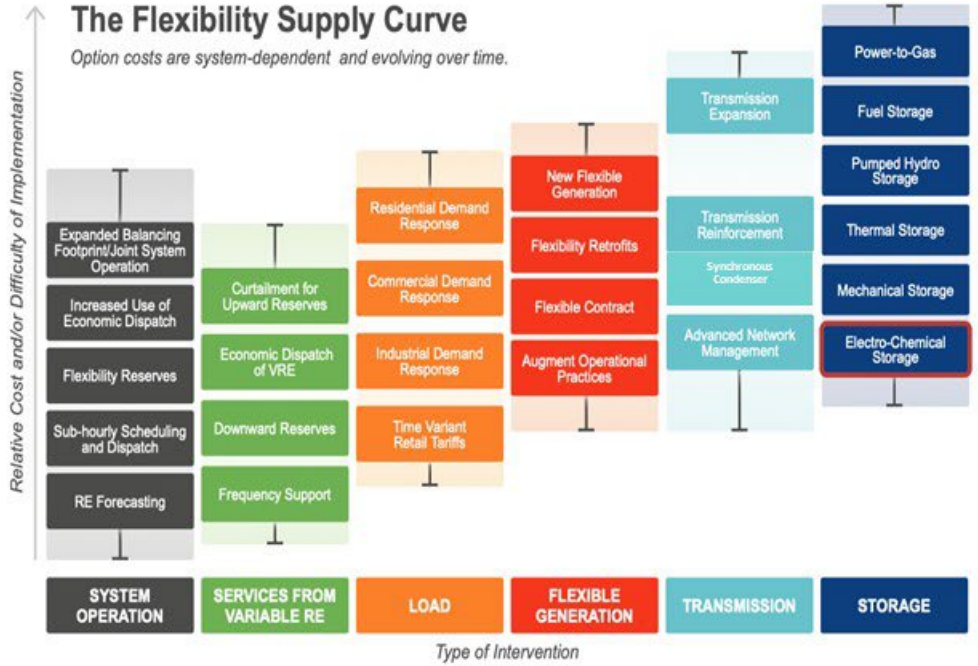


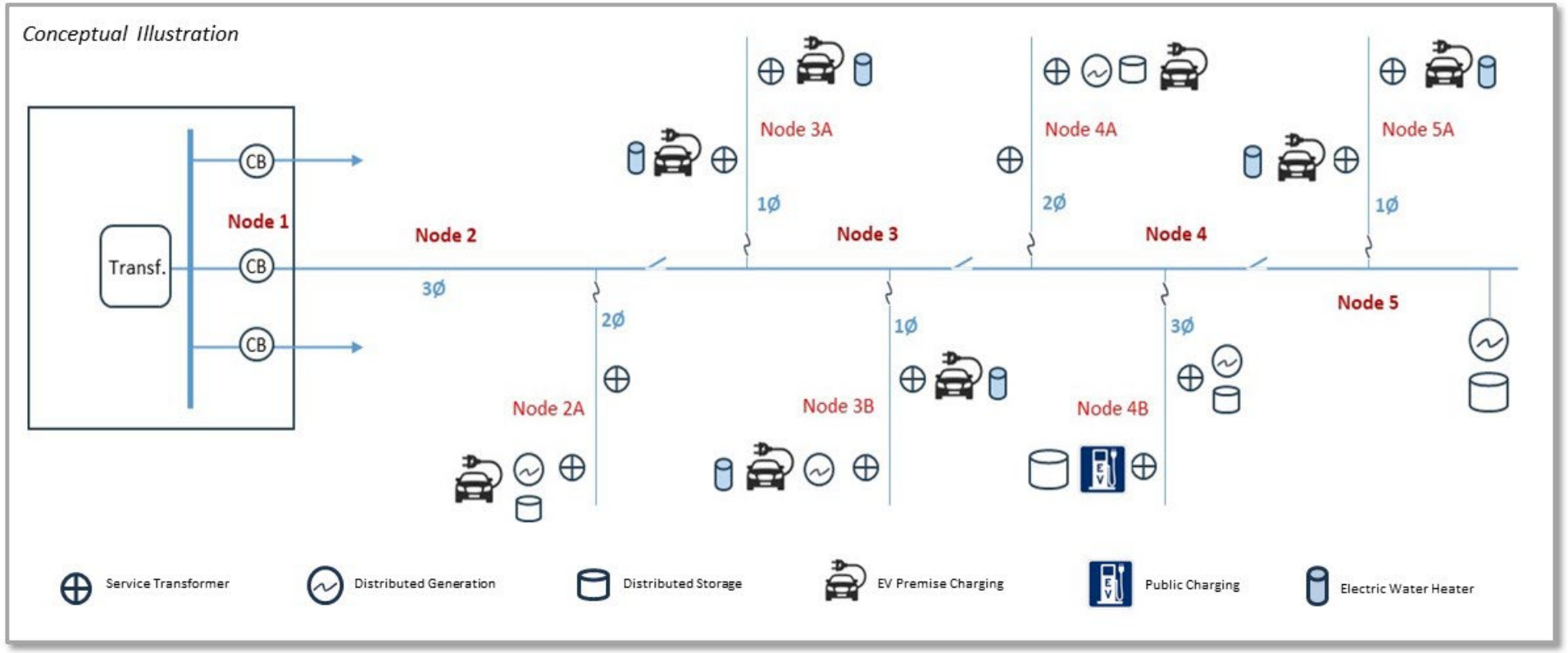
Figure 6. The flexibility supply curve

Source: NREL

- What operational coordination is needed between Distribution Operators and ISO/RTO?
- What operational systems and new procedures are required?
- What oversight/governance role will states (RERRA) play and what are the related processes & systems requirements?

Management of Distribution Feeder Capacity Is Getting More Complex

Managing hosting capacity on radial distribution over the next 15 years will much **more complex involving many "nodes".** Power flow **constraints in any node may occur at different times with other nodes** due to the nature of the flows resulting in non-coincident peaks that also nest with one another depending on the flow directions



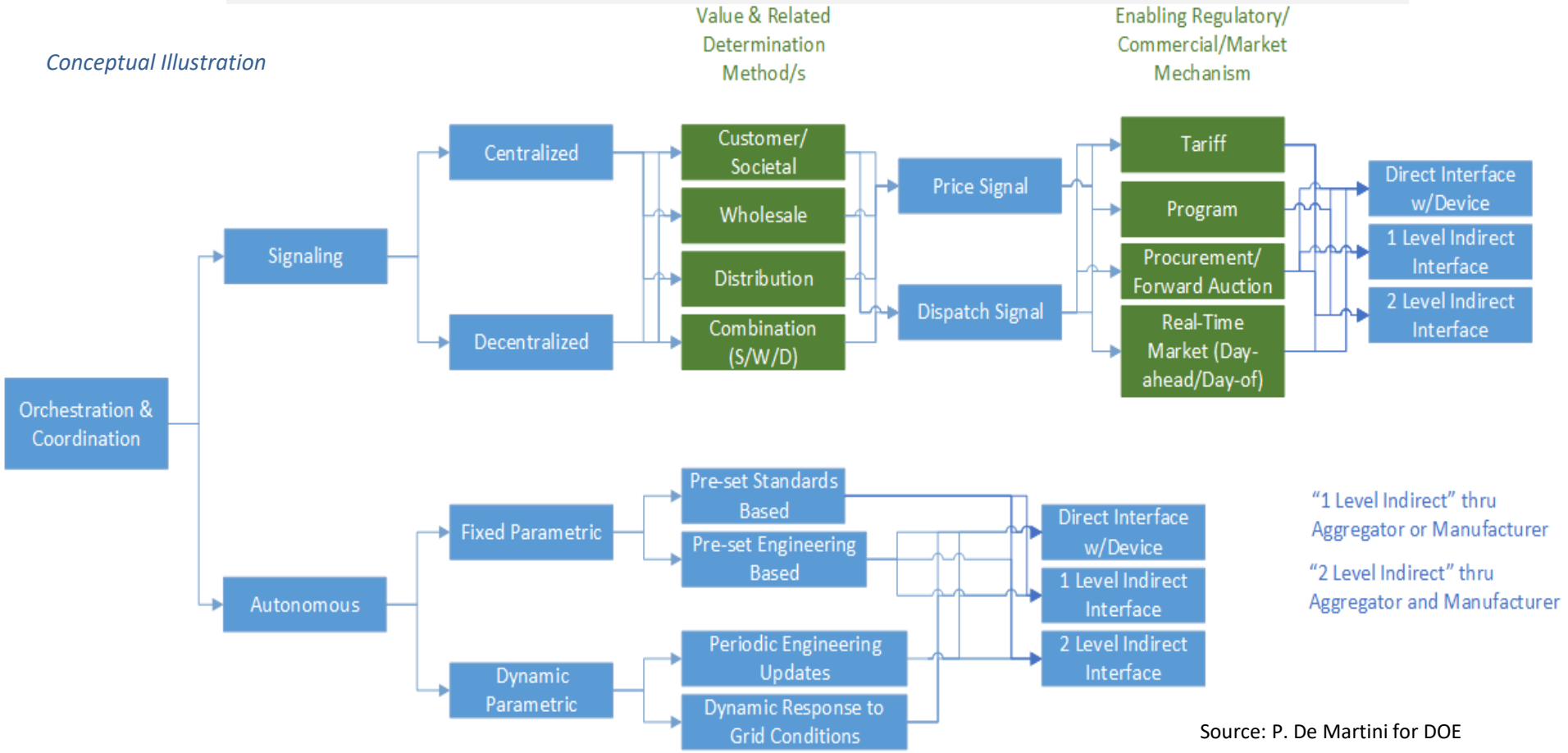
A Node (**dark red**) is created on a feeder between each isolation point from the feeder breaker to the end of the line.
Subnodes (bright red) are created within each feeder node by each fused lateral (laterals, as illustrated, are often not 3-phase which creates additional considerations)

Emerging DER Orchestration Challenge

Orchestration of DER/EV charging to address bulk power system and distribution needs will become increasingly complex.

Pricing, programs and procurements will need to be aligned

Conceptual Illustration



Source: P. De Martini for DOE

DER orchestration will involve both price/dispatch signals and DER autonomous response

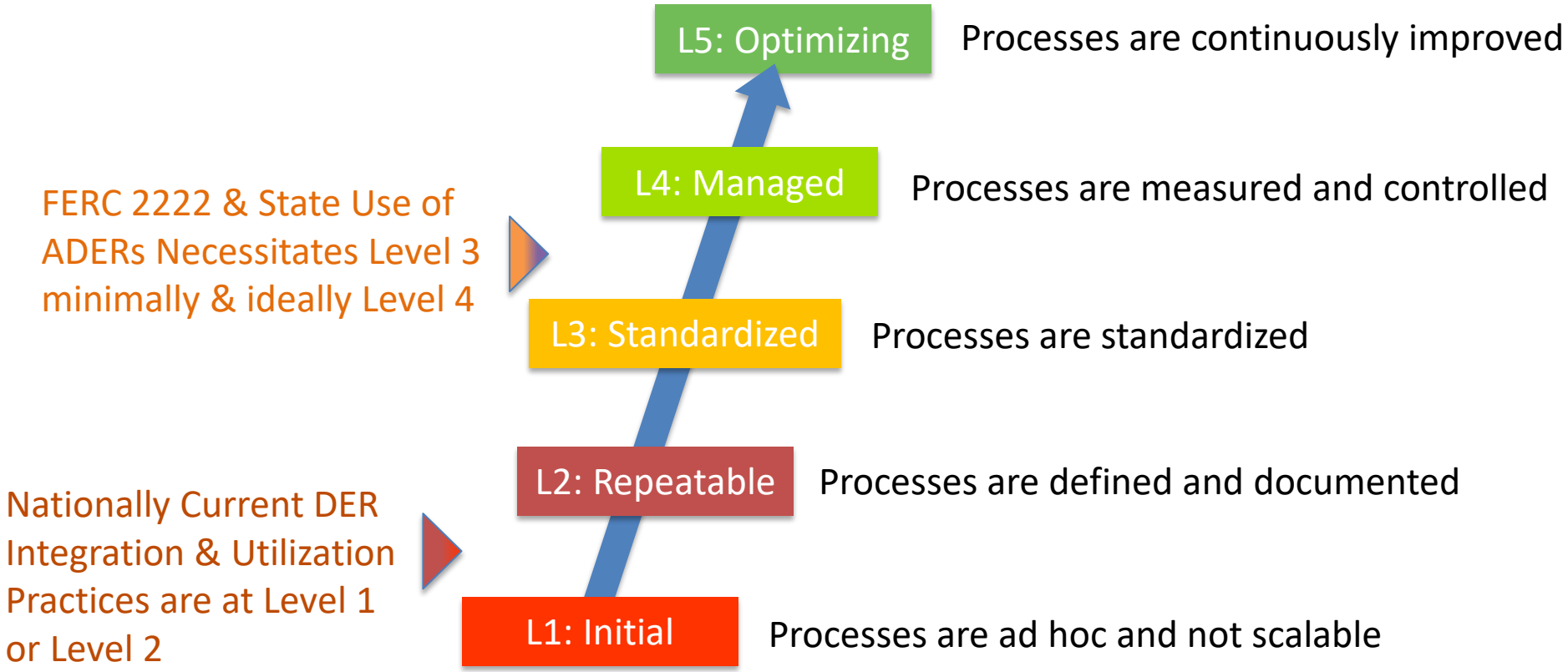
Standardization of Key Aspects is Needed

Non-standardized rules and practices create cost barriers to DER Aggregators

- Challenges to scaling ADER services as identified in DOE's VPP Liftoff Report are primarily related to lack of institutional, business and technical standardization
- Nationally, the use of DER services is currently done in an ad hoc manner often unique to each utility in each state, and each ISO/RTO
- FERC Order 2222 is addressing standardization at wholesale, but retail remains a checkerboard of unique institutional, business and technical rules and requirements
- There is an opportunity to adopt a key set of standard practices and technical standards that can facilitate ADER opportunities, which also allow for each state to chart an individual pathway

Advance Industry Maturity in the Use of DER Services

There is a need to advance the maturity of institutional & business processes, technical practices, and standards adoption to enable effective DER utilization



Adapted from the CMU Capability Maturity Model

Industry Maturity Advancements on Several Dimensions

Below is an illustration of some of the increasing maturity for processes, practices and standards adoption that will likely be required for FERC 2222 and greater use of DER by distribution utilities

Maturity	Institutional	Business	Technical	Standards
5. Optimizing	Evaluation of outcomes to identify areas for improvement and address continuing DER evolution	DER services and market evaluation and improvements	Distribution grid performance metrics evaluated for improvements to service quality and to achieve public policy outcomes	Advanced inverter functionality adjusted based on measured performance & grid needs
4. Managed	Policy & Process Outcome Metrics for Governance Roles	DER performance metrics established, measured and evaluated ex-post	Integrated distribution planning and grid architectural metrics established and measured	Advanced inverter performance measured in relation to grid need
3. Standardized	Standardized Cost-Effectiveness Methodology for DER Services, Distribution Standard of Conduct, Aggregator Code of Conduct, ADER Rules, Retail Eligibility & Participation Rules	Standard Flexibility Services & Performance Attributes and Standard Pro Forma Services Agreement, Standardized Operational Coordination processes	Best practice integrated distribution planning processes adoption, Grid architectural methods adopted, standardized market and operational coordination platforms for FERC 2222	1547-2018 and cybersecurity and information (IEEE 2030.5) requirements incorporated into Interconnection Rules & DER Services Agreements
2. Repeatable	Requirements for Hosting Capacity, DER Services Sourcing Integrated Distribution Planning	Non-wires evaluation methodology & sourcing approach	Incorporating DER and resilience considerations into distribution planning	IEEE 1547-2018 Released
1. Initial	Various traditional processes	Various traditional processes unique to each utility	Traditional engineering-economic practices	Basic service quality and reliability related standards

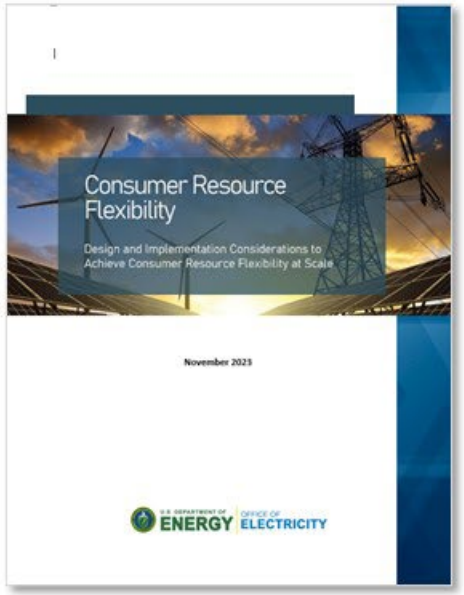
SEO & Regulator Considerations

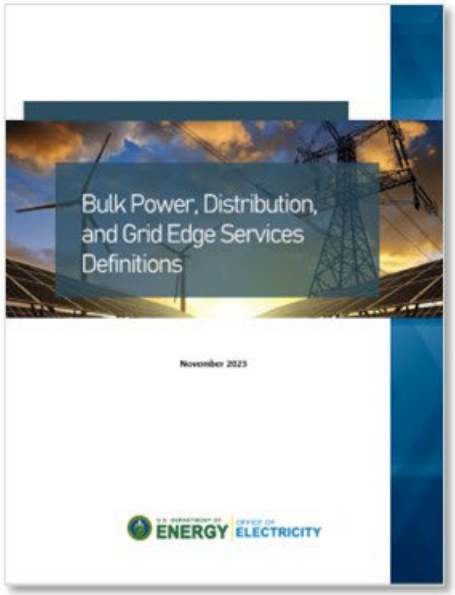
- Integrated System Planning
  - Include technology neutral system needs assessment in planning
  - Include opportunities for ADER services to address identified needs through tariffs (pricing), programs or procurements
  - Include community engagement regarding their sustainability and residence needs and initiatives as inputs into planning processes

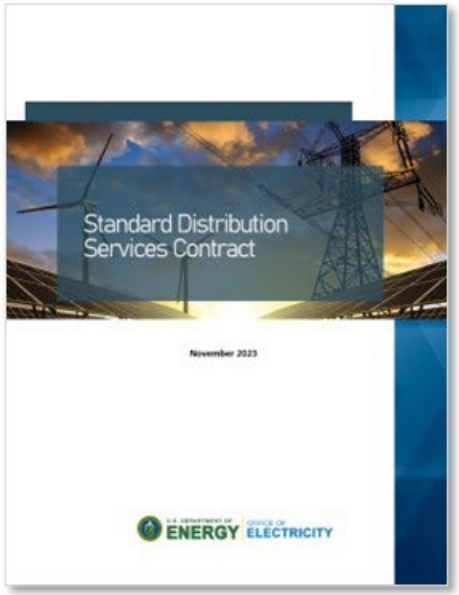
- Distribution Open Access (FERC 2222 related states)
  - Consider a Distribution Standard of Conduct to support nondiscriminatory use of DER services
  - Adoption of standard DER services agreement between distribution utility and aggregator
  - Standardize distribution and edge service definitions
  - Common state level FERC 2222 market and operational coordination platform for use by distribution utilities, ISO/RTO, DER aggregators, and retail regulator

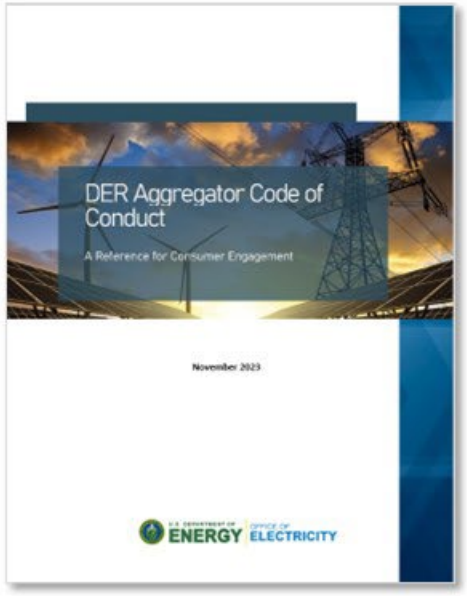
- Customer Engagement
  - Incorporate customer behavioral factors into design of retail tariffs, programs and procurements
  - Adopt an Aggregator Code of Conduct for small commercial and residential consumer participation

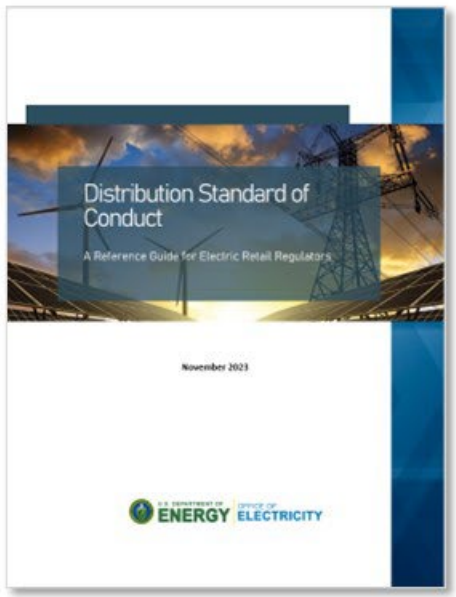
DOE ADER Reference Series *(available online in Dec)*

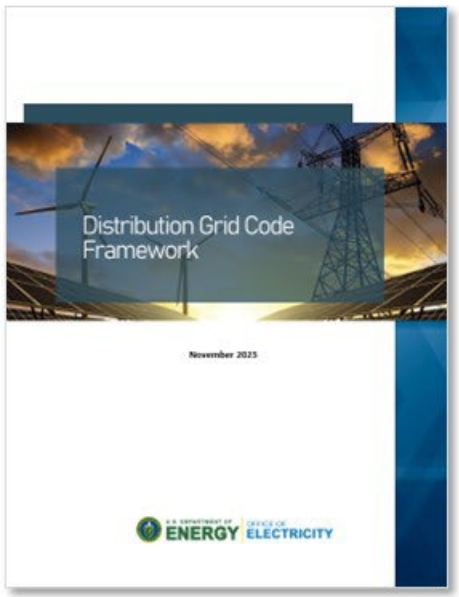




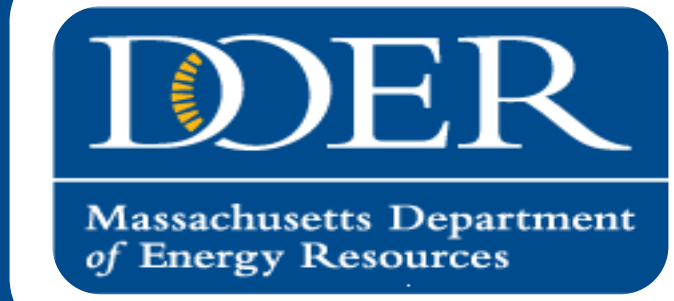








Creating A Clean, Affordable, Equitable and Resilient Energy Future For the Commonwealth

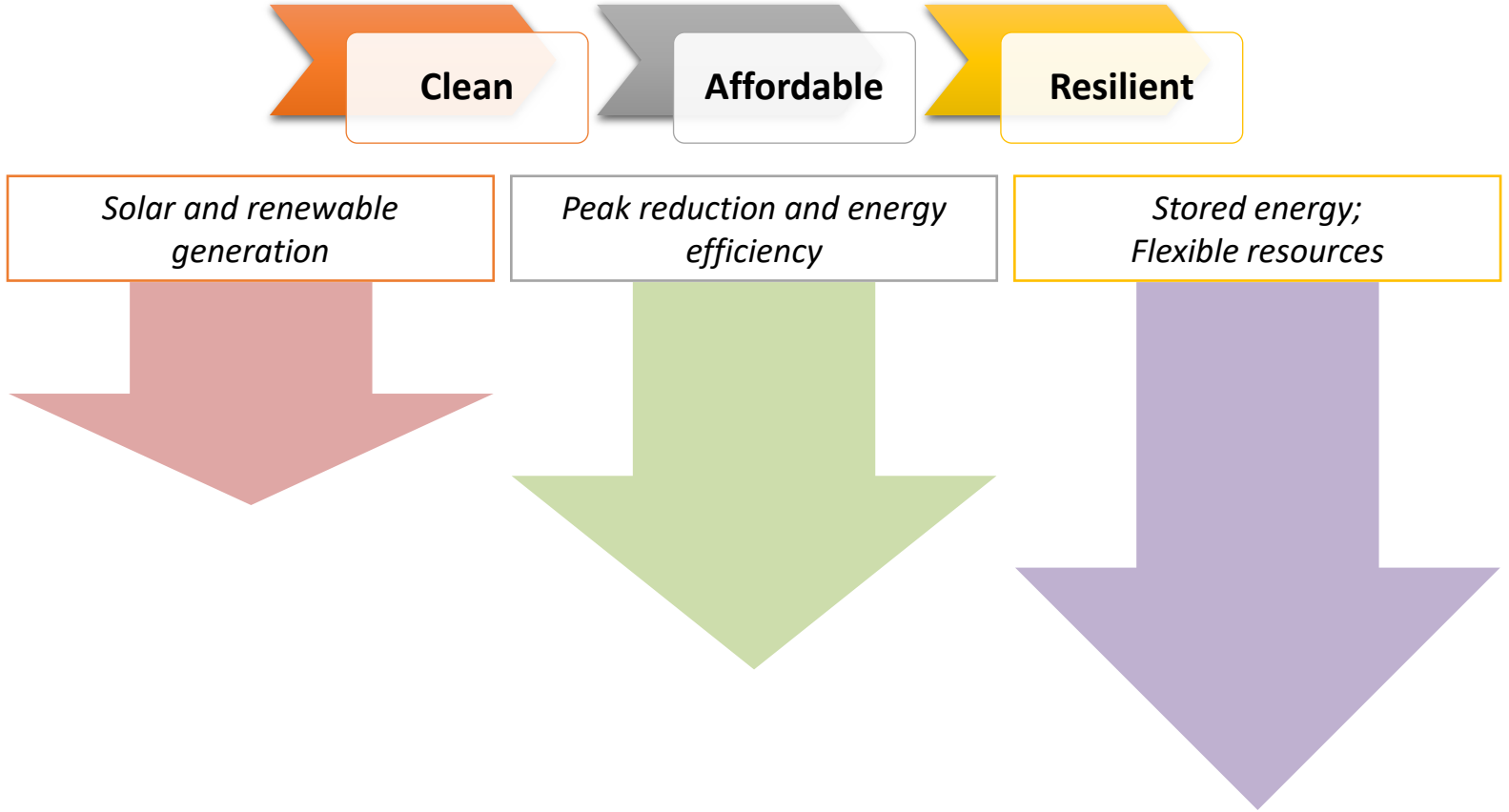


COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENERGY RESOURCES
Elizabeth Mahony, Commissioner

NASEO-NARUC DER Integration and Compensation – Demand Flexibility/Grid Enabled Buildings and Electrification in Utility Energy Efficiency Programs: MASS SAVE® Connected Solutions

December 4, 2023

DOER Mission



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Origin Story

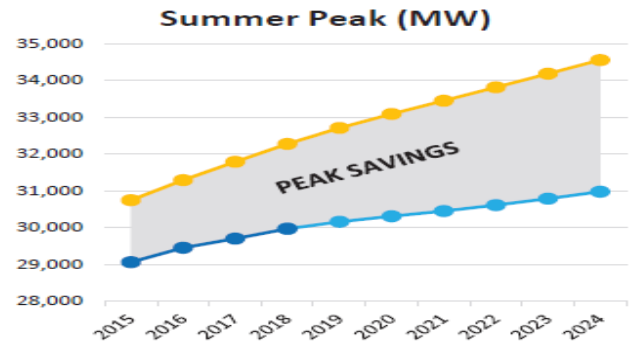
2016

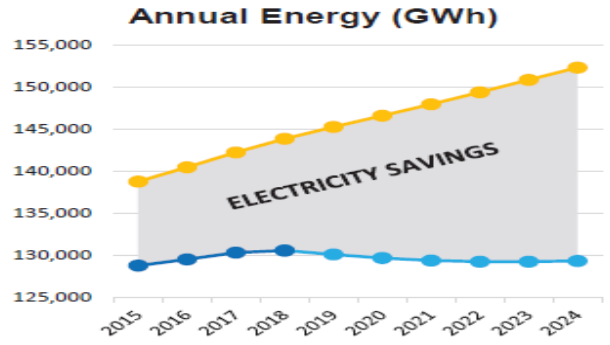
- Peaks getting “peakier”
- Increasing intermittent generation
- No smart meters in the short term
- EE statute that calls for “all cost-effective energy efficiency and demand reduction resources” starting in 2008

Origin Story

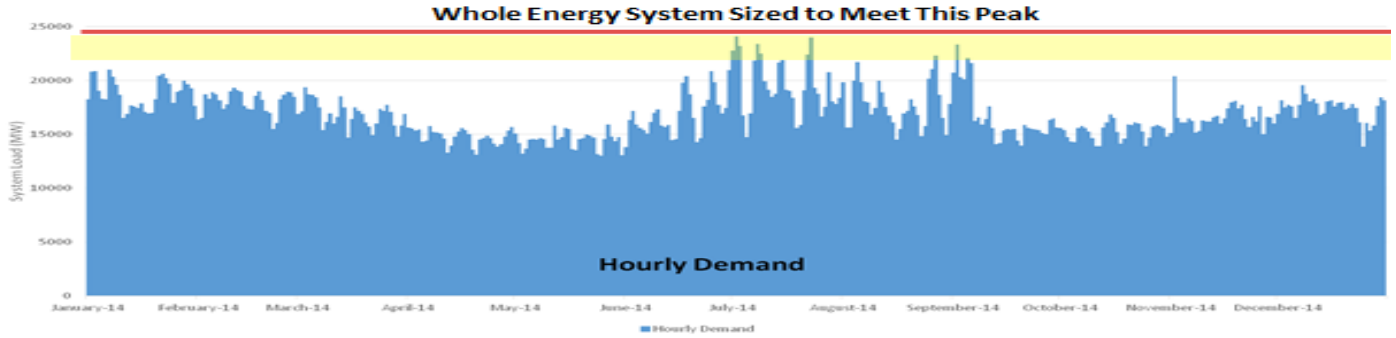
ISO-NE Summer Peak is the only value stream allowed for Active Demand Management under MA TRC test.

ISO-NE *State of the Grid 2016 and* System Annual Hourly and Weekly Demand





The need to size grid infrastructure to the highest peak usage results in system inefficiencies, underutilization of assets, and high cost



Top 1% of Hours accounts for 8% of MA Spend on Electricity
Top 10% of Hours accounts for 40% of Electricity Spend

Source: State of Charge – Massachusetts Energy Storage Initiative Study, 2016

Involving Electric EE Program Administrators

- **Existing Structure** - The mechanism to account for and incent shareholders to invest in passive coincident demand reduction already established
- **Other Pursuits were Long-Term** - As DOER established policies to manage increasingly uncertain loads, EE/DR infrastructure could be mobilized quickly
- **Pilot** - Included demonstrations of active demand management in the 2016-2018 Energy Efficiency Investment Plan (EEIP)
- **Scale** - First programs at scale were included in 2019-2021 EEIP
- **Process** – Energy Efficiency Advisory Council negotiated terms that were then reviewed and approved by DPU

**Program Administrators is defined as the utilities and the Cape Light Compact, a regional municipal load aggregation that manages Eversource ratepayer funds in its territory*

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How do Connected Solutions Programs Work?

All Performance-Based

Commercial – Primarily through Curtailment Service Providers ("CSP")

- Targeted
  - No more than 8 events per summer, 3 hours per event
  - "Last 10-of-10" baseline with same day adjustment
- Daily (thermal and battery storage)
  - No more than 60 events per summer, 2 or 3 hours per event
  - "Last 10-of-10" baseline without same day adjustment

Residential

- DLC primarily through equipment manufacturers – equipment owners can sign up online or through company
- Storage through approved inverter manufacturers

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How Are Connected Solutions Programs Performing?

Sector/Technology	Planned Particpants	Enrolled Participants	2023 Planned (MW)	2023 Enrolled (MW)
IE DLC Thermostats	1,540	2,587	0.8	1.18
Resi DLC	108,457	92,209	91	75.43
Storage	5,068	3,096	23.8	21.23
Thermostats	103,389	89,113	67.2	54.2
Grand Total	**109,997**	**94,796**	**92**	**77**

Sector/Technology	Planned Particpants	Enrolled Participants	2023 Planned (MW)	2023 Enrolled (MW)
C&I				
Targeted	**902**	**886**	**116.3**	**128.65**
Tech Neutral	898	879	115.3	127.77
Storage	4	7	1	0.88
Daily	**122**	**84**	**30.7**	**21.5**
Tech Neutral	35	49	6	4
Storage	87	35	24.7	17.5
Grand Total	**1024**	**970**	**147**	**150.15**

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Lessons Learned

DLC rolled-out relatively smoothly

Storage:

- 5-year incentive lock was essential
- Need to find ways to define benefits more broadly
- Find better incentives for installation
  - Find a way to better serve income eligible customers when all incentives are for performance
- Interaction with Clean Peak Standard and ISO-NE programs
- Residential needed to go through inverter manufacturers, not battery manufacturers
- Commercial battery limits

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Moving Forward

- Electrification
  - Heating
  - Transportation
- Increasing intermittent generation
  - Additional offshore wind procurements
  - Increasing installed solar base
- Climate resilience
- AMI/TVR
- Integration with other demand management policies

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THANK YOU!

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Aggregated DER Services

NARUC/NASEO DER I&C Module 1, Webinar 1

Vince Faherty, Google

December 4, 2023

Connecting the helpful home to the future of the grid

google_logo

We are still early in the smart thermostat story

Only ~20% of US households currently own a smart thermostat (Sources: DOE, EIA, Parks Associates)

Deliver savings* in utility EE programs...

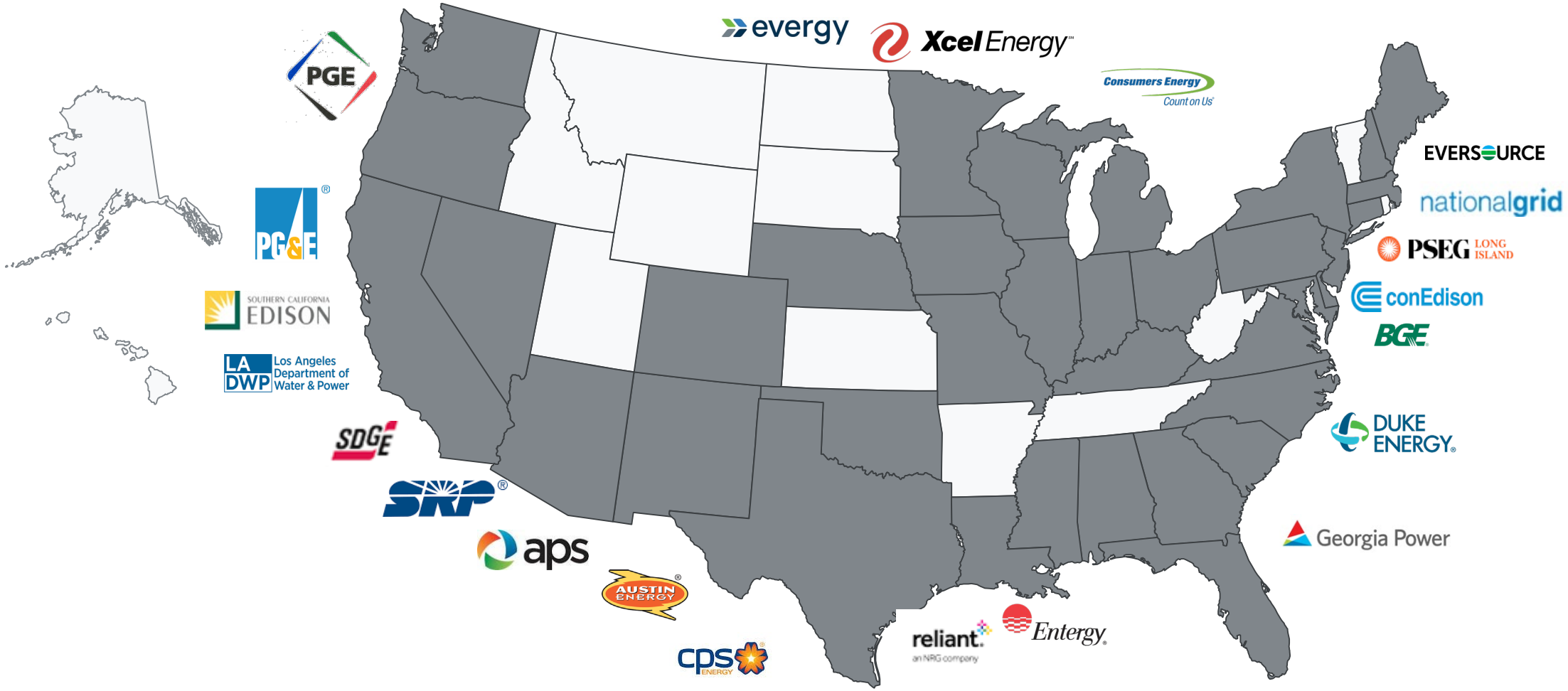
...AND dispatchable demand response

*Independent studies showed that Nest thermostats saved people an average of **10% to 12% on heating** and **15% on cooling**. Based on typical energy costs, we've estimated **average savings of $131 to $145 a year**.

**U.S. Energy Information Administration (EIA), accessed June 27, 2022;
"Smart thermostats gain traction in US, point to modest electricity savings," S&P Global Market Intelligence, accessed July 20, 2022

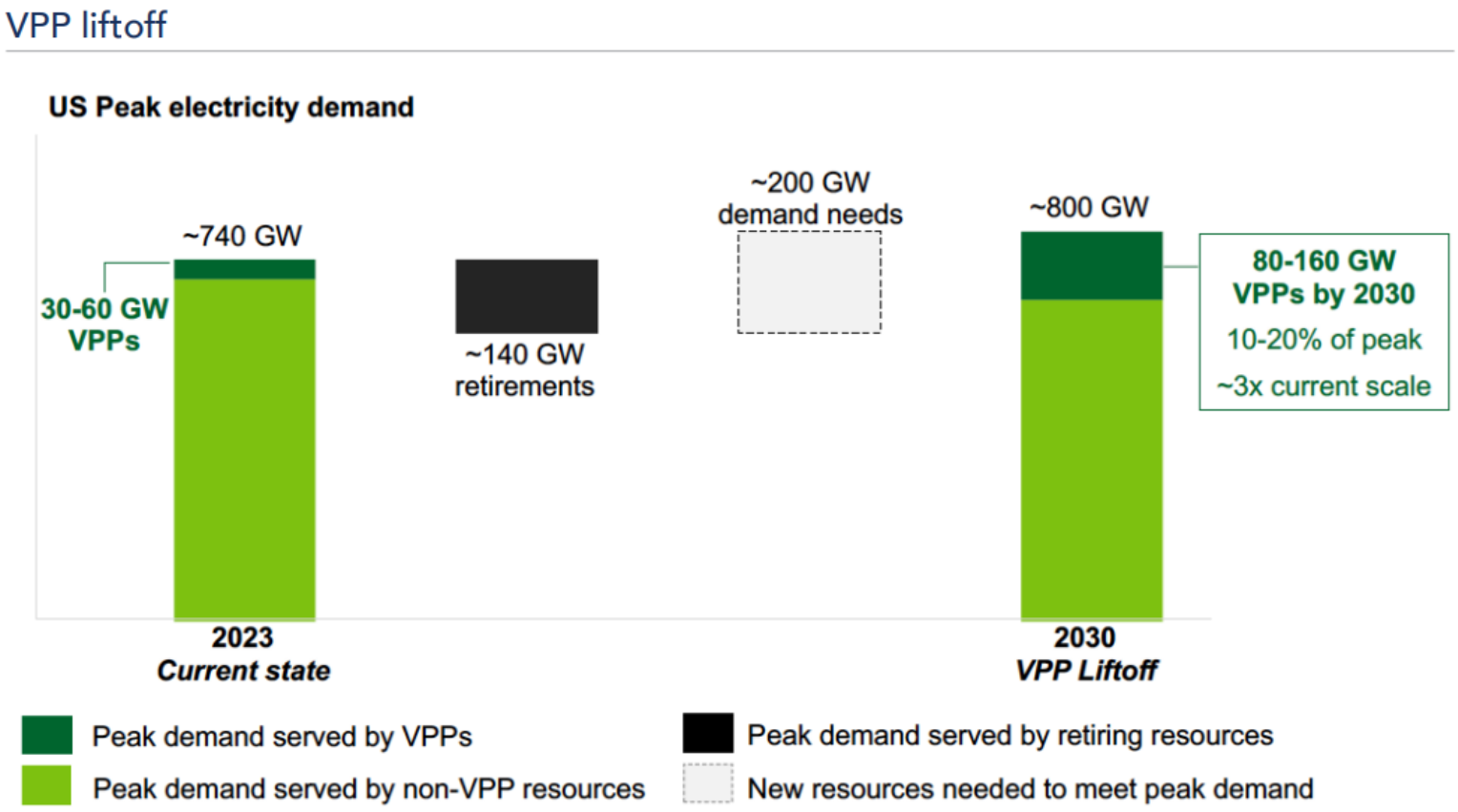
Smart thermostat demand response (DR) is proven at scale

Utilities across the country have built residential VPPs that deliver cost-effective grid reliability



100+ programs in 36 states

The need for VPPs in massive



Notes: 2023 VPP capacity based on estimates from Wood Mackenzie (2023) and FERC (2021). 2030 VPP capacity potential and savings potential based on industry interviews and analysis by The Brattle Group (2023) and Clack et al. (2021). See footnote 1 for detail on asset retirements and peak growth estimates.

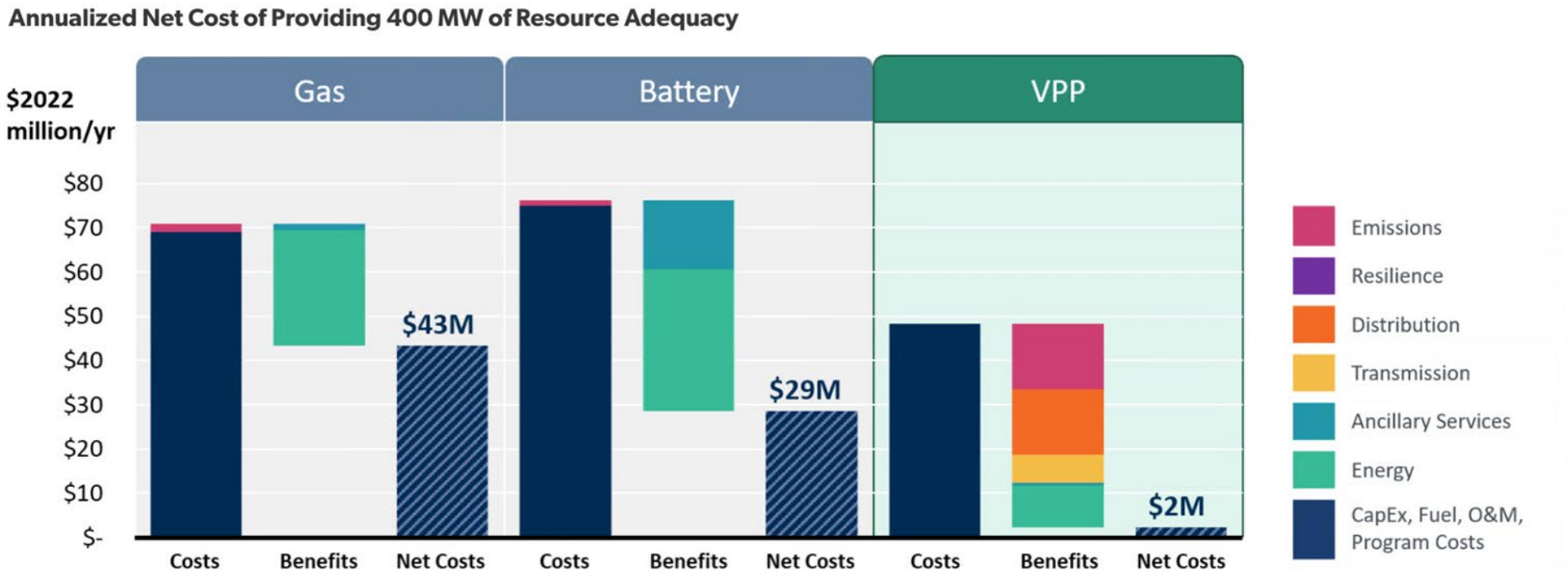
Source: Pathways to Commercial Liftoff - Virtual Power Plants (U.S. Department of Energy, 2023)

They are the cheapest resource to maintain a reliable grid

https://www.brattle.com/real-reliability/

Resource Adequacy... For Cheap

The VPP provides the same resource adequacy at a significant cost discount relative to the alternatives.

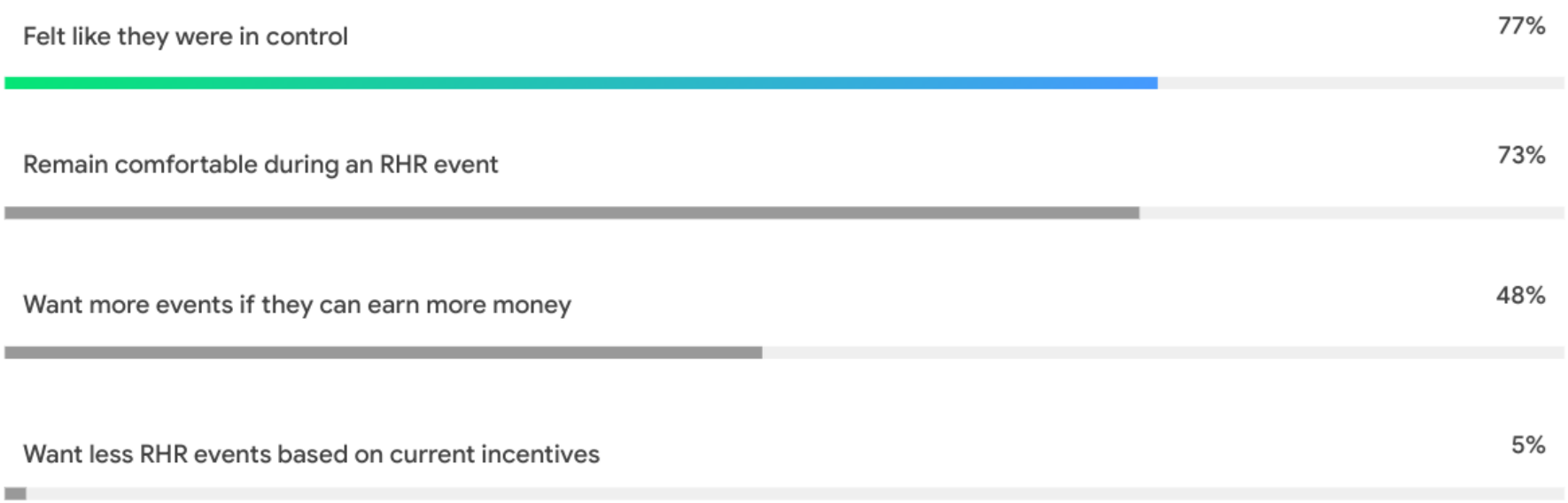


Source: Brattle Group. "Real Reliability: The Value of Virtual Power" - 2023

And customers want to participate

Customers love RHR! Rush Hour Rewards customers reported 41 NPS compared to ~32 for non participants.

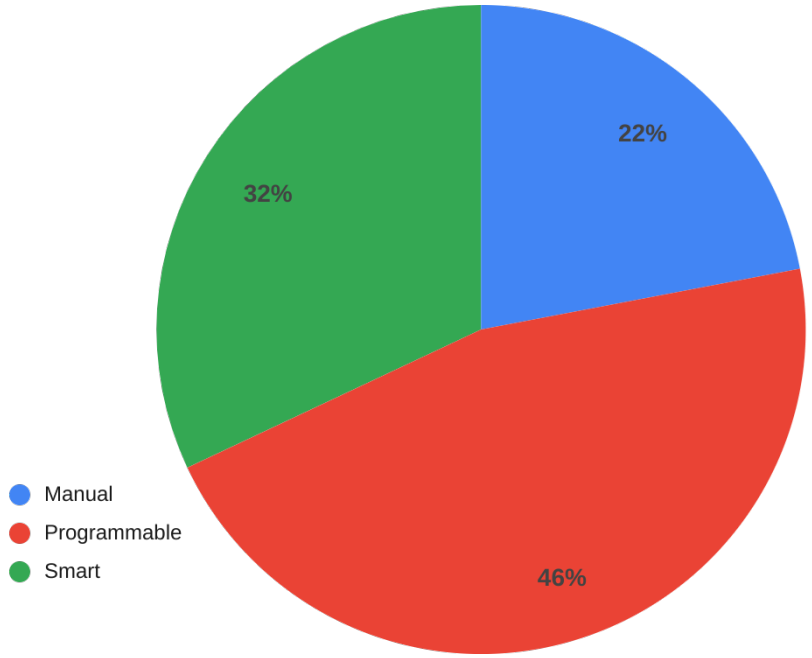
Top 3 reasons customers are enrolling in RHR: Reduce high energy demand, help environment, earn money!



Source: Nest survey data

But most thermostats sold today are not VPP-ready

More than ⅔ of the market today can't support Automated Demand Response or TOU



Estimated USA residential thermostat market, by thermostat type, 2021, volume %*

Type	% Sold	CAGR
Manual	22%	-7%
Programmable	46%	+6%
Smart	32%	+12%
Total		+5.4%

(and will be on the wall for a very long time)

*BSRIA USA residential thermostats market 2021:trends in professional channels, Study completed for Google Nest July 2022

Good news: Smart thermostats are an eligible IRA Measure

Recommendation for SEOs: As part of new heat pump programs, require a smart thermostat with heat pump installation

Goal: Ensure those customers have the opportunity to enroll in VPP programs and grid operators have the levers to cost effectively balance the new load electrification that we will add to the grid

CASE STUDY

Increasing access and equity

Arizona residents get paid to beat the heat

Arizona Public Service, Salt River Project, and Tucson Electric Power offer incentive programs to help customers save money, support the grid

(Arizona) August 31, 2023 – Arizona is experiencing record high temperatures, lasting not just days but weeks, forcing many to crank up their air conditioners with the unintended effect of straining the region's electrical grid. This summer and fall, Arizonans have the opportunity to join demand response programs that support the grid and receive substantial compensation for participating, including cash and free or discounted smart thermostats.

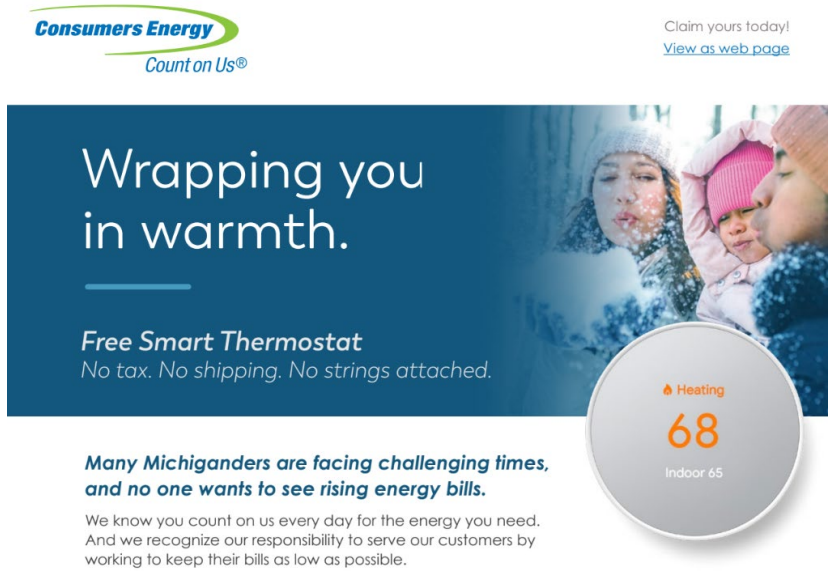
CASE STUDY

Increasing access and equity

Consumers Energy Winter Care Campaign

The challenge

Utility customers faced enormous economic pressures at the end of 2022, from rising inflation across the economy, to significantly higher energy costs, primarily from the rising cost of natural gas. Consumers Energy forecasted that their customers' average monthly residential bills would increase by 10.6% for natural gas and 14.2% for electricity.



The results

The Winter Care Campaign began in early December 2022 and concluded at the end of March 2023, capturing the majority of heating season in Michigan. It was a huge success. Together we successfully engaged over 37,000 Michigan households with Nest Thermostats that will deliver energy and cost savings this year and for years to come.

37,000
Nest Thermostats delivered to customers

44 MW
DR potential from those new thermostats

$7.4 M
Dollars saved / economic impact to those households

Thank you

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Head of Energy Marketplace Partnerships
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Nest

Thank you for joining today!

Upcoming Webinars:

- **Monday, December 18th** ADER Valuation
- **Monday, January 8th** Compensation Options for ADER Services

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Appendix: Grid Services Definitions

Terminology

FERC Order 2222 Definitions

- **DER** is "any resource located on the distribution system, any subsystem thereof or behind a customer meter… [that] may include, but are not limited to … electric storage resources, intermittent generation, distributed generation, demand response, energy efficiency, thermal storage, and electric vehicles and their supply equipment…." (Order No. 2222 at P 114)
- **Aggregated DER** (ADER) [aka DER Aggregation – DERA, Virtual Power Plant – VPP, or Distributed Energy Aggregated Resources – DEAR] is one or more DERs participating together in the wholesale markets, "which acts as a single resource" (Id.at P 180)
- **DER Aggregator** is "the entity that aggregates one or more distributed energy resources for purposes of participation in the capacity, energy and/or ancillary service markets of the regional transmission organizations and/or independent system operators." (Id.at P 118)

Bulk Power System		
Service & Definition	**Performance Attributes**	**Source**
Energy		
The generation or use of electric power by a device over a period of time, expressed in kilowatt-hours (kWh), megawatt-hours (MWh), or gigawatt-hours (GWh) as transported across a transmission system.	Requirements may vary based on the required level of availability and reliability.	Service Definition: EIA
Regulating Reserves		
Regulation Service provides for the management of the minute-to-minute differences between load and resources and to correct for unintended fluctuations in generator output to comply with NERC's Real-Power Balancing Control Performance Standards (BAL-001-1, BAL-001-2)	Allow continuous energy balance over the next 1 minute, and 20 to 30 minutes time interval due to the variability in resources and load that can be called upon in response to operator dispatch.	**Service Definition:** NERC EPRI: Ancillary Services in the United States **Performance Attribute:** HECO: Grid Needs Assessment & Solution Evaluation Methodology
Frequency Response		
The ability of a system or elements of the system to react or respond to a change in system frequency for maintaining scheduled Interconnection frequency at sixty cycles per second (60 Hz).	Specific requirements for each type of frequency response are provided below.	**Service Definition:** NERC

Source: DOE Grid Services Definitions paper

Inertial Response		
Inertial response injects stored kinetic or battery energy into the system, slowing down the decline in frequency to provide time for other reserve products (including primary frequency response (PFR), which is the next stage of reserve deployment) to detect those changes and respond accordingly.	Response time in cycles.	**Service Definition:** NREL: An Introduction to Grid Services EPRI: Ancillary Services in the United States **Performance Attribute:** NERC
Primary Frequency Response (PFR)		
Automatic and autonomous response to frequency variations through a generator's droop parameter and governor response or energy injection by grid following inverters, or response by load.	Operate a governor or equivalent with a maximum 5 percent droop and ±0.036 Hz dead band and for the droop characteristic to be based on the nameplate capacity. Response time in seconds to tens of seconds.	**Service Definition:** HECO: Grid Needs Assessment & Solution Evaluation Methodology **Performance Attribute:** FERC Order No. 842 PNNL: Grid Architecture Power System Glossary]
Fast Frequency Response (FFR)		
Fast frequency response combines characteristics of inertia and primary frequency response. It is essentially an energy injection that is provided almost immediately following a frequency deviation, that provides support by reducing the rate of change of frequency thereby increasing the minimum frequency, and reducing the steady-state frequency deviation due to a more continuous injection.	Response time in fractions of seconds (but not instantaneously like inertia) after an event.	**Service Definition & Performance Attribute:** EPRI: Ancillary Services in the United States

Source: DOE Grid Services Definitions paper

Secondary Frequency Response		
To maintain grid frequency, and to honor scheduled energy flows between different Balancing Authorities BA). It is measured through NERC CPS1, CPS2 (retired), and the new BAAL (balancing authority area control error limit) score requirements.	Response time in 5-15 minutes.	**Service Definition & Performance Attribute:** PNNL: Grid Architecture Power System Glossary] NERC
Tertiary Frequency Response		
Maintain scheduled energy flows between different BAs, to maintain the BA generation-load balance (load-following reserve), or maintain grid reliability under N-1 contingencies (spinning and non-spinning reserve). Tertiary balancing service is provided by the spinning and non-spinning reserve units.	Response time from 5-15 minutes to 30 minutes or longer if replacement is through market response.	**Service Definition & Performance Attribute:** PNNL: Grid Architecture Power System Glossary]
Operating Reserves		
The active power capacity above firm system demand required to provide for regulation, load forecasting error, equipment forced and scheduled outages and local area protection. It consists of spinning and non-spinning reserve.	The speed of response is also a characteristic in the type of operating reserve as described below.	**Service Definition:** NERC EPRI: Ancillary Services in the United States **Performance Attribute:** EPRI: Ancillary Services in the United States

Source: DOE Grid Services Definitions paper

Operating Reserves (Spinning)		
Spinning Reserve is the capability of resources synchronized to the system and fully available to serve load within the Disturbance Recovery Period following the contingency event; or Load fully removable from the system within the Disturbance Recovery Period following the contingency event.	All ISOs require the response time to be ten minutes to allow for five minutes to account for communication time. On any particular resource, the capability for secondary contingency reserves is typically limited by 10-minutes of ramp rate from the set point of a spinning unit up to its maximum operating level, or in the case of non-spinning reserve, how much it can provide when starting up and synchronizing within 10 minutes. The response time is based on NERC Standard BAL-002, the contingency event recovery period, which requires that Area Control Error (ACE) be returned to its pre-disturbance value within fifteen minutes.	**Service Definition & Performance Attribute:** EPRI: Ancillary Services in the United States
Operating Reserves (Non-Spinning)		
Non-spinning reserves are energy producing resources that that are off-line but that can respond to dispatch instructions.	Generation and responsive load that is off - line but can be fully responsive within 30 minutes and load that can respond to dispatch in time-frames that exceed 10 minutes.	**Service Definition & Performance Attribute:** PNNL: Grid Architecture Power System Glossary]
Operating Reserves (Tertiary)		
Tertiary or contingency reserve is used after Spinning and Non-spinning reserves are employed in the case of a contingency. It is procured to replace reserve capacity prior to a second contingency event to ensure operating reserves are restored to the required amount soon after the contingency.	Resources, including offline units and load, with the ability to respond to dispatch instructions in 30-60 minutes.	**Service Definition & Performance Attribute:** PNNL: Grid Architecture Power System Glossary] EPRI: Ancillary Services in the United States

Source: DOE Grid Services Definitions paper

Reactive Power & Voltage Support		
The ability to control leading and lagging reactive power on the system to maintain appropriate voltage levels and acceptable voltage bandwidths, to maximize efficient transfer of real power to the load under normal and contingency conditions, and provide for operational flexibility under normal and abnormal conditions.	Reactive Power & Voltage support is location-specific and requires the injection and absorption of reactive power from generating units and transmission assets (e.g., capacitor banks, static VAR compensators, etc.). Voltage must be kept generally within 5 or 10% of their nominal levels.	**Service Definition:** EPRI: Ancillary Services in the United States **Performance attribute:** NERC
Ramping		
The ability of a resource to ramp active power upward or downward in a certain amount of time. It is typically measured on a MW/min basis.	Upward and downward flexible capacity to support 15-minute and 5-minute markets. Sufficient ramping capacity is needed to meet the needs of both the upcoming 15-minute market runs and the three 5-minute market runs within that 15-minute interval. Procurement in the 5-minute market is aimed at ensuring that enough ramping capacity is available to manage differences between consecutive 5-minute market intervals.	**Service Definition:** NERC **Performance Attribute:** CAISO: Flexible Ramping Product Uncertainty – Calculation and Implementation Issues
Energy Imbalance		
Energy Imbalance Service is provided when a difference occurs between the scheduled and the actual delivery of energy to a load located within a Control Area over a single hour.	Response time within 60 minutes.	**Service Definition:** FERC Sched. 4
Black Start		
The ability to energize a bus, meeting the Transmission Operator's restoration plan needs for Real and Reactive Power capability,	Capability to meet:	**Service Definition:** NERC

Source: DOE Grid Services Definitions paper

frequency and voltage control, and that has been included in the Transmission Operator's restoration plan.	• Real and Reactive Power requirements of the Cranking Paths and the dynamic capability to supply initial Loads. • Location and magnitude of Loads required to control voltages and frequency within acceptable operating limits. • Required to control voltages and frequency within acceptable operating limits.	**Performance attribute:** NERC
Transmission Capacity		
A non-transmission alternative (NTA) supply and/or a load modifying service that provides as required via reduction or increase of power or load that is capable of reliably and consistently reducing net loading on desired transmission infrastructure.	Requirements are situation specific.	**Service Definition:** HECO: Grid Needs Assessment & Solution Evaluation Methodology

Distribution System		
Distribution Voltage-Reactive Power		
The ability to control leading and lagging reactive power on the system to maintain appropriate voltage levels and acceptable voltage bandwidths (ANSI C84.1), to maximize efficient transfer of real power to the load under normal and contingency conditions, and provide for operational flexibility under normal and abnormal conditions.	Remain on standby, ready and able to detect when the distribution voltage drops rapidly, and act instantly and autonomously by rapidly adjusting net load in the form of its reactive and/or real power components within ~1 second (less is preferred).	**Service Definition & Performance Attribute:** DOE: Grid Services from DER Device Fleet

Source: DOE Grid Services Definitions paper

Distribution Capacity		
A supply and/or a load modifying service that provides as required via reduction or increase of power or load that is capable of reliably and consistently reducing net loading on desired distribution infrastructure.	Distribution capacity service can be provided by a single resource and/or an aggregated set of resources that reduce the net loading on a specific infrastructure location coincident with the identified operational need in response to a control signal from the utility	**Service Definition:** HECO: Non-Wires Opportunity: Evaluation Methodology HECO: Grid Needs Assessment & Solution Evaluation Methodology
Power Quality		
Services that satisfy power quality requirements regarding flicker and harmonics should be within acceptable levels.	Response time in cycles.	**Service Definition & Performance Attribute:** PNNL: Grid Architecture Power System Glossary]
Resilience		
Supply-based services capable of improving local distribution resiliency and reliability within a microgrid. This service may also involve fast reconnection and availability of excess reserves to reduce demand when restoring customers from abnormal configurations.	Reconnection response time, if applicable, is sub-second to less than 30 seconds. Minimum of 24 consecutive hours of energy. Ability to maintain acceptable service voltage (ANSI C84.1) and frequency (nominally 60Hz) bandwidths.	**Service Definition & Performance Attribute:** CPUC: Competitive Solicitation Framework and Utility Regulatory Incentive Pilot CPUC: Community Microgrid Incentive Program p.21
Energy		
The production or use of electric power by a device over a period of time, expressed in kilowatt-hours (kWh), or megawatt-hours (MWh) as transported within a distribution system.	Requirements may vary based on the required level of availability and reliability.	**Service Definition:** EIA (adapted)

Source: DOE Grid Services Definitions paper

Edge		
Energy		
The production or use of electric current by a device over a period of time, expressed in kilowatt-hours (kWh) or megawatt-hours (MWh) as transported behind a metered grid connection point or behind a microgrid islanding point within a community microgrid boundary.	Requirements may vary based on the required level of availability and reliability.	**Service Definition:** EIA (adapted)
Distribution Voltage-Reactive Power		
The ability to dynamically control leading and lagging reactive power on the distribution system to maintain appropriate voltage levels and acceptable voltage bandwidths (ANSI C84.1), to maximize efficient transfer of real power to the load under normal and contingency conditions.	Response time within 1 second or less.	**Service Definition & Performance Attribute:** DOE: Grid Services from DER Device Fleet
Power Quality		
Services that satisfy electric service power quality requirements, including flicker and harmonics within acceptable levels.	Response time in cycles.	**Service Definition & Performance Attribute:** PNNL: Grid Architecture Power System Glossary]
Resilience		
Energy based service to supply connected net customer loads as determined by a typical load profile within the microgrid boundary during island mode when disconnected from the power grid at the islanding point.	Reconnection response time, if applicable, is sub-second to less than 30 seconds. Minimum of 24 consecutive hours of energy. Ability to maintain acceptable service voltage (ANSI C84.1) and frequency (nominally 60Hz) bandwidths.	**Service Definition:** CPUC: Community Microgrid Incentive Program p.21

Source: DOE Grid Services Definitions paper

Massachusetts Department of Energy Resources

Appendix: Specific Program Details and Links to Program Materials

How do They Work? Residential

Performance Incentive	For Eversource, National Grid and the Cape Light Compact Customers: $275 per kW
Discharge Events per Season	30 to 60
Months Discharge Events Can Occur	June through September
Time Discharge Events Can Occur	3 p.m. to 8 p.m.
5-year incentive lock	Yes
• Customers can apply for a 0% HEAT Loan for the cost of the battery system with no down payment and a $25,000 lifetime cap per account number. • Customers with battery inverter capacity of 50kW or less are eligible for the incentives in this table. Larger systems should enroll in the Daily Dispatch program. • The incentive rates listed here changed as of January 2023. The new incentives will be applied starting the summer of 2023.	

The above chart is for small batteries. Residential DLC is deployed for 15 events for $50 up front and $20 for performance at the end of the season.

Source: Program Materials for Connected Solutions Small-Scale Batteries. Source material includes additional detail.

DOER
Massachusetts Department of Energy Resources

How do They Work? Commercial

	Targeted Dispatch	Daily Dispatch
Number of Events per Season	1 to 8 per Summer	30 to 60 per Summer
Incentive	$35/kW-Summer +10/kW-Summer Weekend Bonus[1]	$200/kW-Summer
Battery Incentive Lock	None	5 Years
Length of Events	3 Hours	2 to 3 Hours
Time of Day	Between 3pm and 8pm	Between 3pm and 8pm
Weekend/Weekday	Any Day, with a Weekend Bonus	Any Day
Events on Holidays	No	Yes
Day-Ahead Notification	Yes	Yes
Months	June – September	June – September

Source: C&I DR Program Materials June 2022. Source material includes additional detail.