

Time to Grow Up: Advancing Demand Flexibility Maturity in an Era of Surging Load

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Webinar overview

- Welcome and Housekeeping
- Current State of Demand Flexibility (DF)
- Demand Flexibility Maturity Model Overview
- Example DF Capability Maturity Assessment
- Considerations for Adapting the DF Maturity Model
- Example Applications
- Summary



Moving Beyond Direct Load Control: A Maturity Model for Realizing the Promise of Demand Flexibility

January 2025

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Report is available at
<https://emp.lbl.gov/publications/moving-beyond-direct-load-control>



Housekeeping

- All participants are muted.
- If you have a comment or question, please use the Q&A box.
- The webinar is being recorded.
- The report is available on Berkeley Lab's website. The recording and slides will be posted there in 2-3 days. <https://emp.lbl.gov/publications/moving-beyond-direct-load-control>
- When it is available, we will send the link to the recording and slides to everyone registered for the webinar.

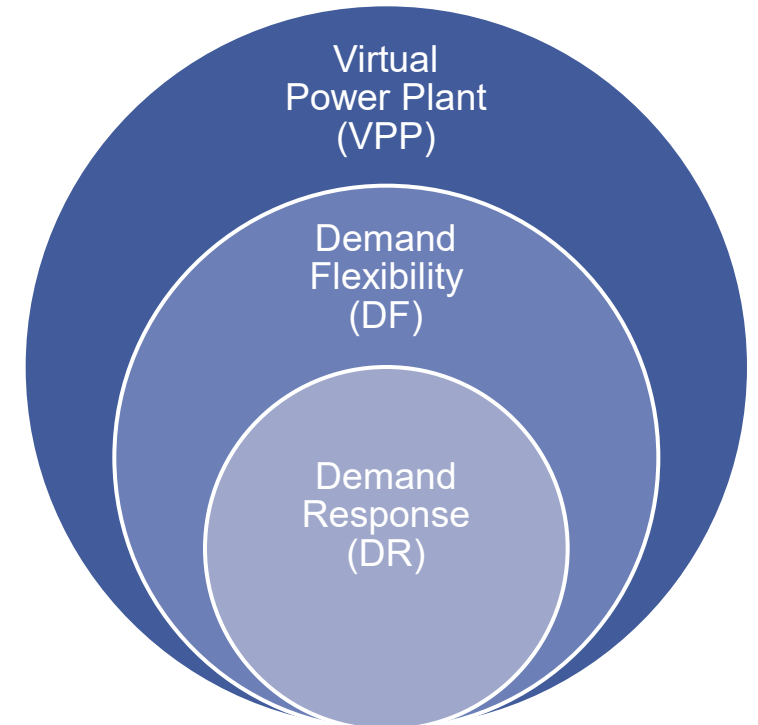


Current State of Demand Flexibility

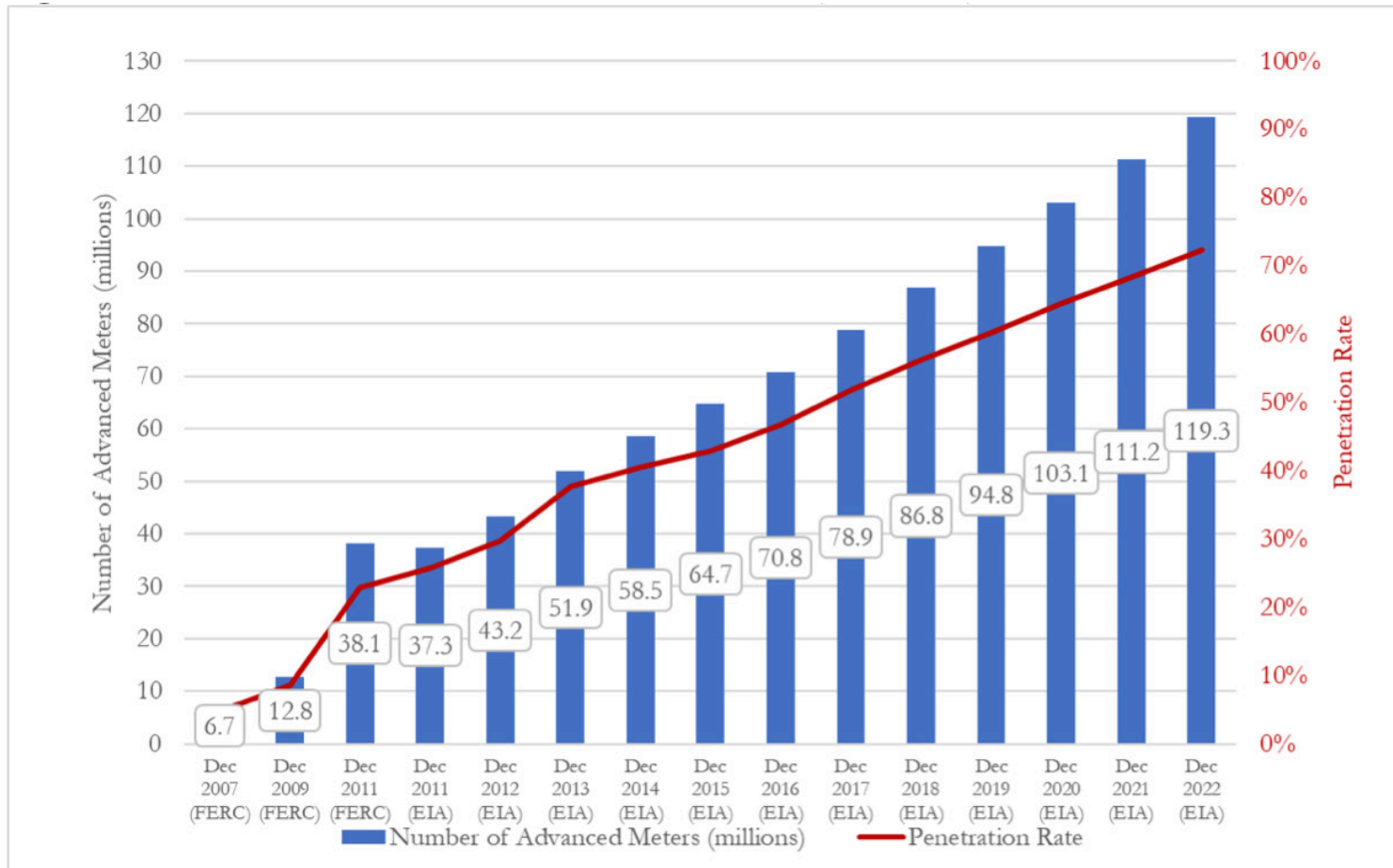


What is demand flexibility?

- ❑ **Demand flexibility (DF):** “the capability provided by on-site Distributed Energy Resources (DERs) to reduce, shed, shift, modulate, or generate electricity” ([DOE 2021](#))
- ❑ DF includes any type of flexible **behind-the-meter DER**, including solar, storage, electric vehicles, and traditional demand response (DR)
- ❑ DR and DF are used interchangeably in this presentation for assessing progress, though DF can offer a **broader range of grid services**
- ❑ Virtual Power Plants (VPPs) are DER aggregations that provide a broad range of grid services, and may include **front-of-the-meter DER** ([DOE 2025](#))



Advanced meter penetration in the United States has increased from about 5% in 2007 to 72% in 2022, with over 119 million meters nationwide



Source: [FERC \(2024\)](#)

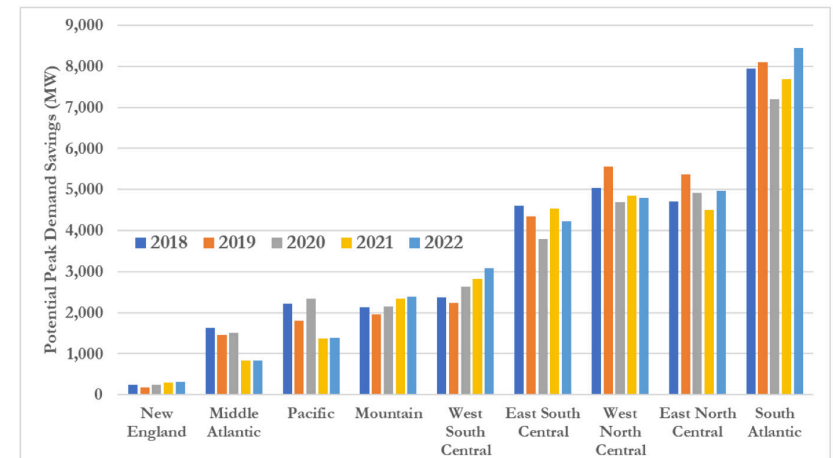
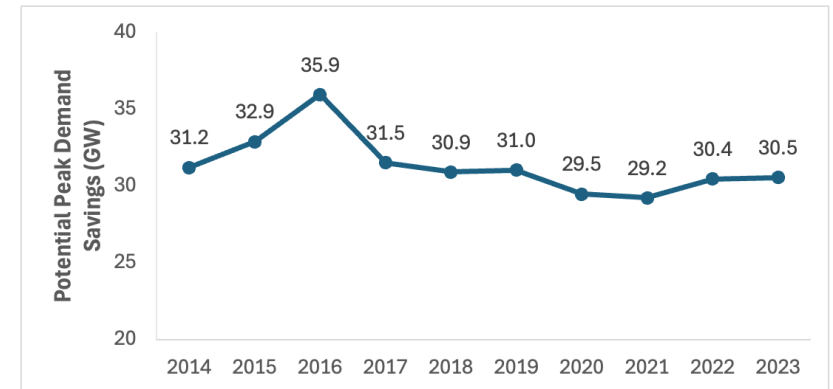
- Prior to this growth, [FERC estimated](#) in 2006 that the total potential resource contribution from all existing DR programs and rates nationwide was **37.5 GW**
- 2006 FERC study also found:
 - ▣ Interest in DR programs was growing
 - ▣ Results from recent programs and pilots were encouraging
 - ▣ Based on responses from 3,365 organizations in all 50 states representing every aspect of the electric delivery industry



DR programs have not grown substantially, even though *potential* has increased with the adoption of advanced meters and connected devices

- U.S. Energy Information Administration (EIA) data shows retail DR program capacity is at **~31 GW** – the same as 10 years ago
 - ▣ EIA started collecting retail DR program data from utilities via [Form EIA-861](#) in 2013
 - ▣ Potential peak demand savings estimates do not include dynamic pricing programs, also known as time-based rates
- Annual increase in retail DR program potential peak demand savings in seven of the nine census divisions in 2022, but consistent multi-year growth is not evident in any region
- Based on an in-depth review of 148 programs, [Murphy et al. \(2024\)](#) finds that most DR efforts focus on reducing demand during summer peaks driven by air conditioning

Retail DR Program Potential Peak Demand Savings in the United States



Source: [EIA \(2023\)](#) and [FERC \(2024\)](#), based on Form EIA-861 data

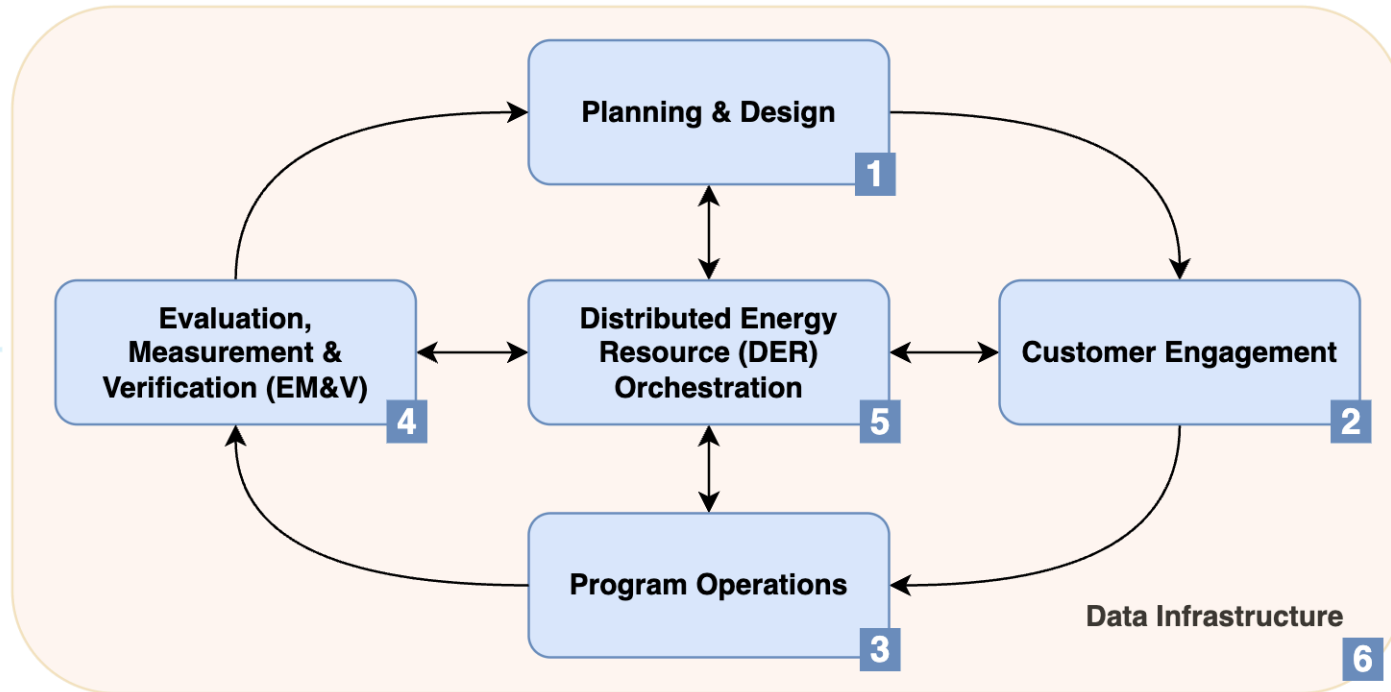


Demand Flexibility Maturity Model Overview



States and utilities are seeking novel approaches for driving DF progress

Berkeley Lab Demand Flexibility Maturity Model Overview



- With surging load from data centers, manufacturing facilities, buildings and transportation, DF is needed to mitigate capacity constraints
- Berkeley Lab developed the DF maturity model, based on well-documented industry best practices for utility administered DF programs
- Serves as framework for assessing current capabilities and developing a plan for improvement, similar to utility capability maturity models for:
 - ▣ Wildfire mitigation ([OEIS 2020](#))
 - ▣ Cybersecurity ([DOE 2022](#))
 - ▣ Smart grid ([Carnegie Mellon 2018](#))

Maturity model drives DF programs in the following direction

Low Maturity

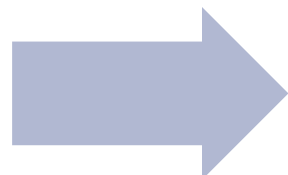
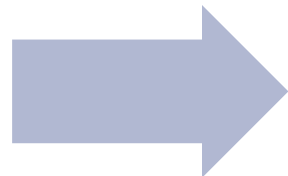
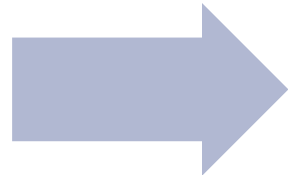
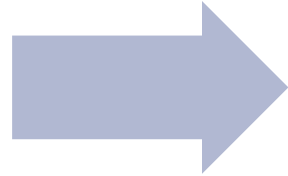
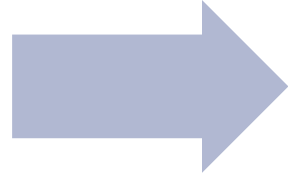
Inflexible and uninformed by grid needs and data

Limited understanding of performance

Infrequent, reactive testing and iteration

Enrollment as the primary success metric

New pilots and initiatives that do not scale efficiently



High Maturity

Highly flexible and driven by grid needs and accurate, granular data

Frequent, ongoing performance assessment that proactively identifies scaling constraints and continuous improvements

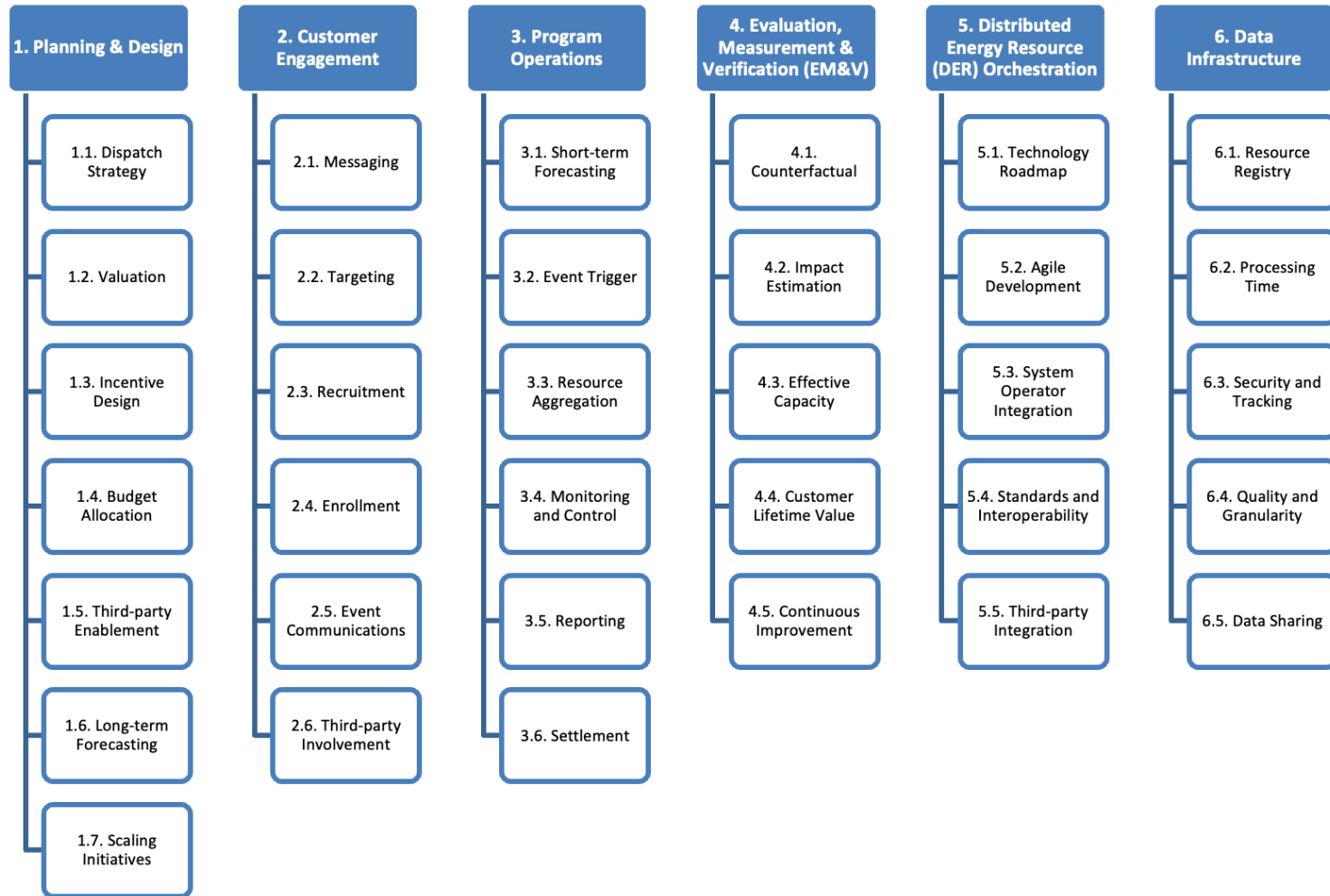
Proactive testing and monitoring of key leading indicators, leading to rapid iteration including “failing fast” when necessary

Customer-specific expected DF value based on projected net benefits

Driving value at scale, with close integration of DF program planning, operations, and external parties, including system operators and third parties as needed to scale efficiently



By measuring maturity across 34 DF capabilities, states and utilities can prioritize investment, identify gaps, and drive continuous improvement



- Each DF capability is scored at one of five levels of maturity:
 1. Below expectations
 2. Meets minimum expectations
 3. Beyond minimum expectations, but not consistent with best practice
 4. Consistent with best practice
 5. Improvement over best practice
- Industry literature, conference presentations, and reviewer feedback have informed maturity levels, including best practices and reasonable expectations of utility capabilities



Given increased interest in third-party DF, the maturity model draws from recent key learnings and challenges with third-party participation

Challenges of DR Auction Mechanism (DRAM) in California

- **2015:** DRAM begins with the promise that, "For the first time, aggregations of customer-sited resources of at least 100 kW will have access to the state's electricity markets" ([Walton 2015](#))
- **2022:** First independent evaluation report could not affirmatively find that DRAM met success criteria, particularly in the areas of performance and reliability ([Schellenberg et al. 2022](#))
 - Lack of availability during critical hours, such as the Aug. 2020 heatwave
 - Administrative burden, data errors and reporting inconsistencies, leading to over-compensation and a lack of confidence and transparency
- **2024:** After \$100M+ allocated to the statewide DRAM procurement budget, the CPUC decides to close the program, citing evaluation report's findings



Applying key learnings from DRAM to the DF Maturity Model

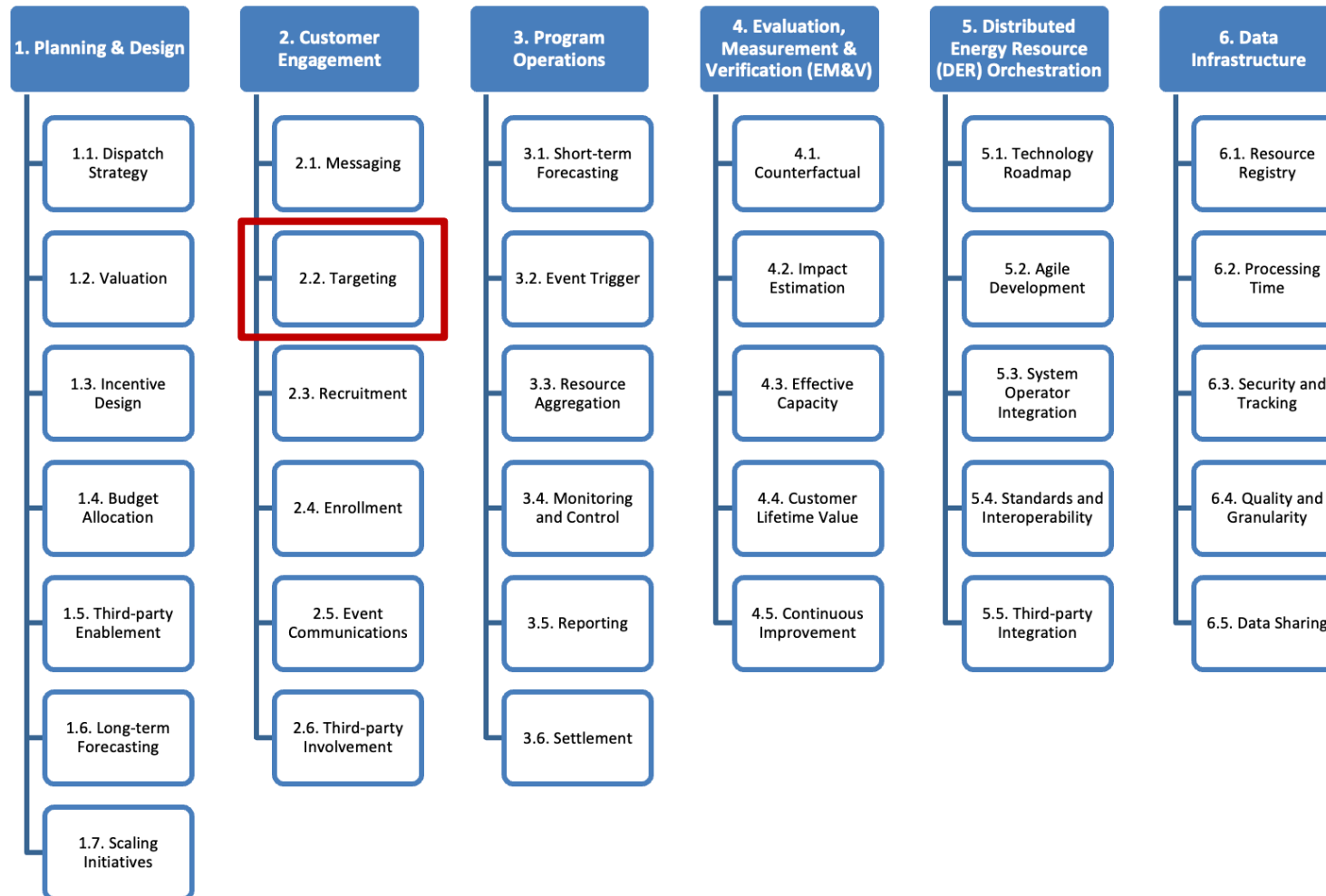
- Emphasis on close monitoring of performance and availability during critical hours, ensuring that avoided costs are tied to demonstrably offsetting grid investments
- Standalone categories for DER orchestration and data infrastructure to highlight the importance of data accuracy and reducing administrative burden for all parties involved
- Proactive testing and identification of key leading indicators, leading to rapid iteration including "failing fast" when necessary



Example DF Capability Maturity Assessment



Assessing Targeting capability within the Customer Engagement category



Assessing Targeting capability within the Customer Engagement category

2. Category: Customer Engagement

2.2. Capability: Targeting – Process of identifying and focusing efforts on high value customers

Maturity Indicator	Maturity Level				
	1 Below expectations	2 Meets minimum expectations	3 Beyond minimum expectations	4 Consistent with best practice	5 Improvement over best practice
Basis of targeting	No customer targeting	Propensity to enroll in the DF program, regardless of customer-specific potential to deliver load impacts	Propensity to enroll in the DF program, with rudimentary screening criteria based on overall usage and customers that are known to have eligible devices	Propensity to enroll, customers that are known to have eligible devices and hourly interval data to estimate customer-specific expected DF value	Same as level 4, with sub-hourly interval data to estimate customer-specific expected DF value, using randomized groups to inform propensity model for different program options
Customer segments		Marketing personas based on predefined groups, regardless of outcomes related to DF program enrollment and usage	Same as level 2, with minor adjustments based on DF program enrollment and usage	Marketing personas based on DF program enrollment propensity, hourly usage profiles, and target segments (such as low income customers)	Customers are individually ranked based on estimates of customer-specific expected DF value, aligning with grid needs
Device adoption	<div style="background-color: #4a7ebb; color: white; padding: 10px; border-radius: 5px;"> One example of 34 capabilities in appendix of report: https://emp.lbl.gov/publications/moving-beyond-direct-load-control </div>			Analyze hourly interval data and other customer characteristics to estimate device adoption likelihood (such as the percent chance of a customer having an EV or central AC)	Same as level 4, with the support of third-party data (e.g., DMV or dealer lists for EVs)



Assessing Targeting capability within the Customer Engagement category

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Capability definition

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Areas in which capability maturity is assessed



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Many capabilities have no requirements for maturity level 1



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Device adoption	Must meet all indicators to achieve a higher maturity level			Analyze hourly interval data and other customer characteristics to estimate device adoption likelihood (such as the percent chance of a customer having an EV or central AC)	Same as level 4, with the support of third-party data (e.g., DMV or dealer lists for EVs)

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Device adoption		Maturity may build from the prior level		Analyze hourly interval data and other customer characteristics to estimate device adoption likelihood (such as the percent chance of a customer having an EV or central AC)	Same as level 4, with the support of third-party data (e.g., DMV or dealer lists for EVs)

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Device adoption		<p>Levels 4 and 5 can be a high bar, given that achieving or improving over best practice is meant to be a stretch goal</p> 		Analyze hourly interval data and other customer characteristics to estimate device adoption likelihood (such as the percent chance of a customer having an EV or central AC)	<u>Same as level 4</u> , with the support of third-party data (e.g., DMV or dealer lists for EVs)



Considerations for Adapting the DF Maturity Model



States and utilities can adapt the DF maturity model as needed

- Maturity levels are generalized, with limited use of terms specific to certain jurisdictions or technologies, so that the maturity model can apply to varying regulatory environments and market structures
 - ▣ “Device makers” may include everything from a smart thermostat to an electric vehicle
 - ▣ “DER orchestration platform” may include DER Management Systems, or DERMS, or other orchestration platforms
- DF maturity model is not necessarily a progression with a higher level clearly being more appropriate than a lower level for every jurisdiction
 - ▣ States and utilities can skip levels or stay at current maturity if that is what is cost-effective based on grid needs, market conditions, and the relative cost of meeting or exceeding best practices
 - ▣ It also may be cost-effective to have a mix of maturity levels within a DF portfolio, such as a legacy air-conditioning direct load control (DLC) program that focuses on load shedding along with battery storage aggregations that deliver a wider range of grid services
- Remainder of this section summarizes the six DF maturity model categories, including how each jurisdiction can apply (and adapt) the model to their region



Planning & Design (1) overview and considerations

Focus

- Create DF programs that are operationally effective, economically justified, and adaptable over time
- Includes involvement of third-party DER aggregators and device makers

Goal

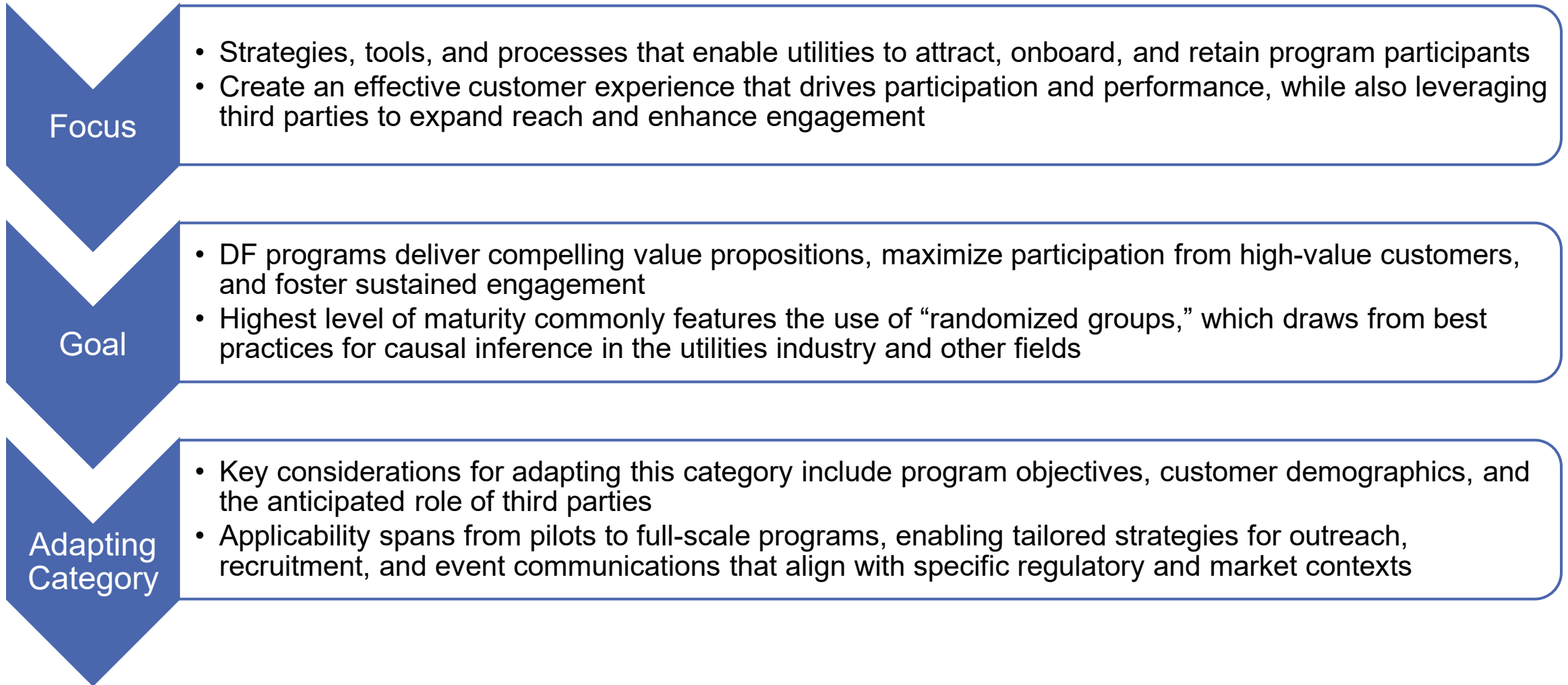
- DF programs are well-positioned to support grid needs, strategic goals, and regulatory requirements
- Cost-effective DF resources that demonstrably offset other types of grid investments

Adapting Category

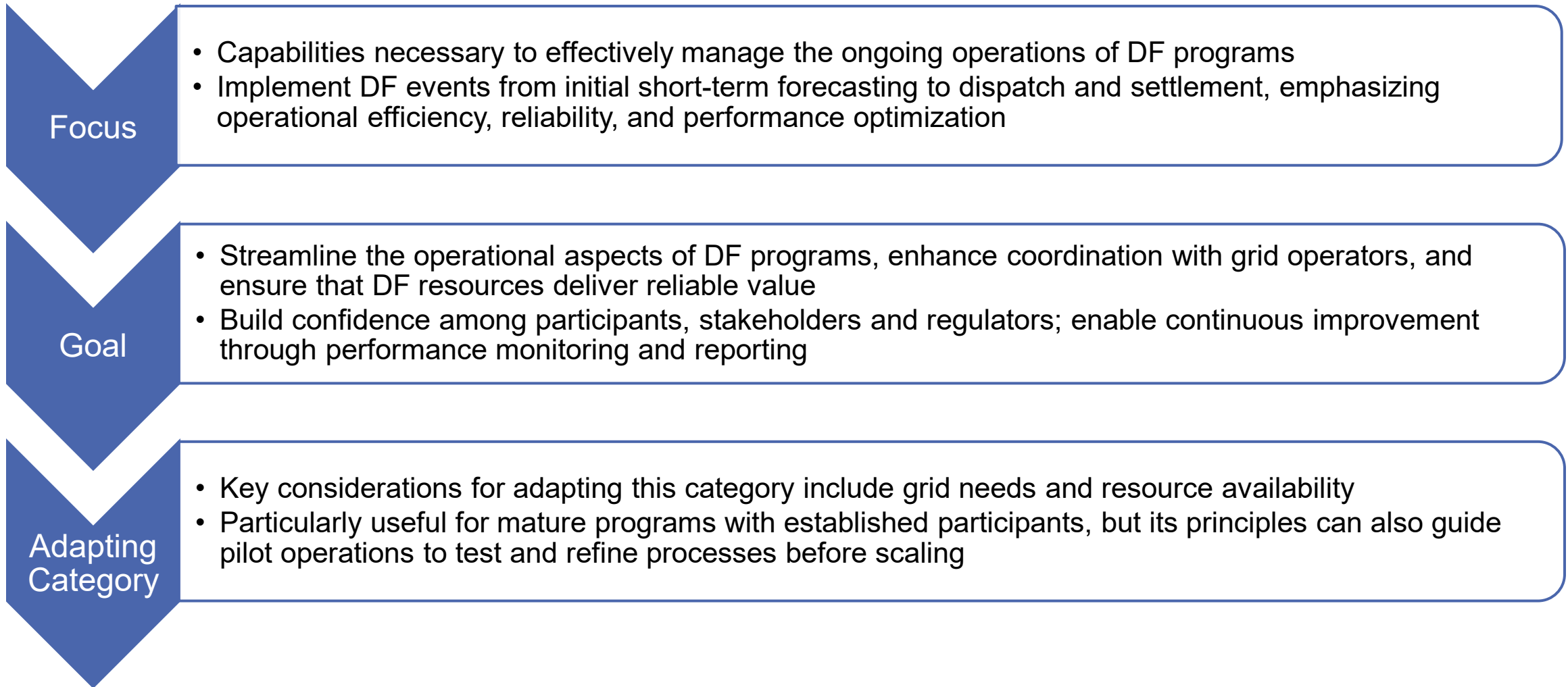
- Key considerations for adapting this category include projected grid needs, expected role of third parties, and state objectives, priorities and valuation frameworks
- Can be adapted and applied on its own for new initiatives, including pilots and new programs



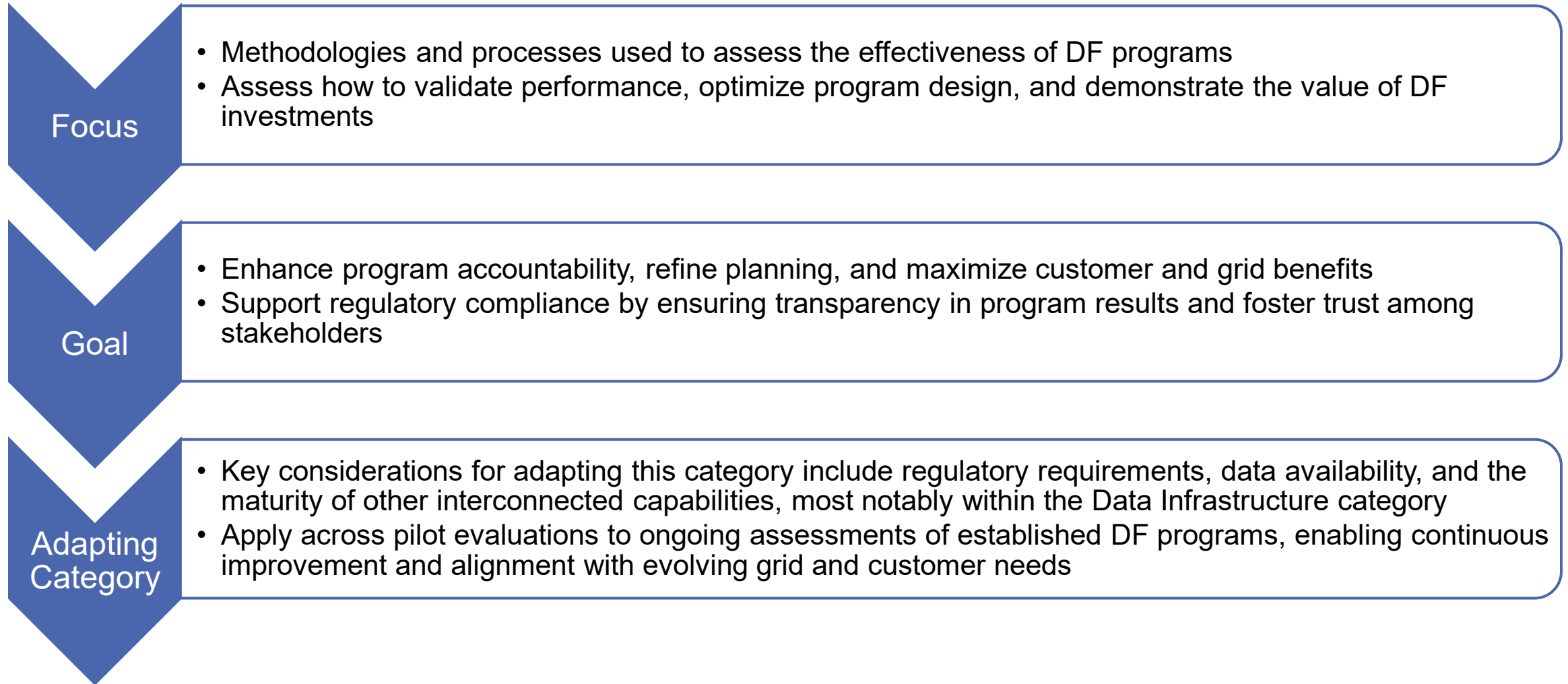
Customer Engagement (2) overview and considerations



Program Operations (3) overview and considerations



Evaluation, Measurement & Verification (4) overview and considerations



DER Orchestration (5) overview and considerations

Focus

- Develop the technological frameworks necessary to enable coordination among utilities, system operators, and DER aggregators
- Ensure that DF resources can be effectively monitored, dispatched and controlled to meet grid needs

Goal

- Integrate a robust DER orchestration platform into the DF program portfolio, supporting real-time operations, enhancing grid reliability, and maximizing the value of DERs
- Ensure that utilities integrate the software required to scale DF resources efficiently while maintaining adaptability to new technologies and evolving requirements

Adapting Category

- Key considerations for adapting this category include status of existing technologies, scale required to meet grid needs, and the expected number and type of DF programs, third parties, and devices
- Particularly useful for jurisdictions that expect to scale multiple DF programs and technologies



Data Infrastructure (6) overview and considerations

Focus

- Systems and processes needed to collect, manage, and share high-quality, secure, and detailed data about DF resources and performance
- Ensures that utilities and third parties can efficiently exchange validated information, enabling effective program management and decision-making

Goal

- Build reliable, secure, and scalable data systems that support accurate dispatch, robust analysis, and third-party integration
- Forms backbone of successful DF programs

Adapting Category

- Key considerations for adapting this category include status of existing technologies, scale required to meet grid needs, and the expected number and type of DF programs, third parties, and devices
- Particularly useful for jurisdictions that expect to scale multiple DF programs and technologies (though mature Data Infrastructure is important to ensure transparency and accountability for any DF program)



Example Applications



Considerations for applying the DF maturity model

- Maturity model primarily applies to retail DF programs run by utilities, with involvement of third-party technology providers and DER aggregators
 - Could also apply to many aspects of dispatchable time-varying pricing programs (e.g., Critical Peak Pricing)
 - Though it does not include all pricing-related capabilities such as rate design
- In combination with other metrics, states can also use the maturity levels as indicators of DF progress as part of utility financial incentives
- Any utility, including municipal and cooperatives, can also use the DF maturity model to conduct a self-evaluation, which is how the Cybersecurity Capability Maturity Model ([DOE 2022](#)) and Smart Grid Capability Maturity Model ([Carnegie Mellon 2018](#)) are implemented
- This section includes two example maturity model applications, though there are many more potential applications, such as minimum filing requirements and DF roadmap development



Selecting DF maturity model capabilities to use as metrics for a utility Performance Incentive Mechanism (PIM)

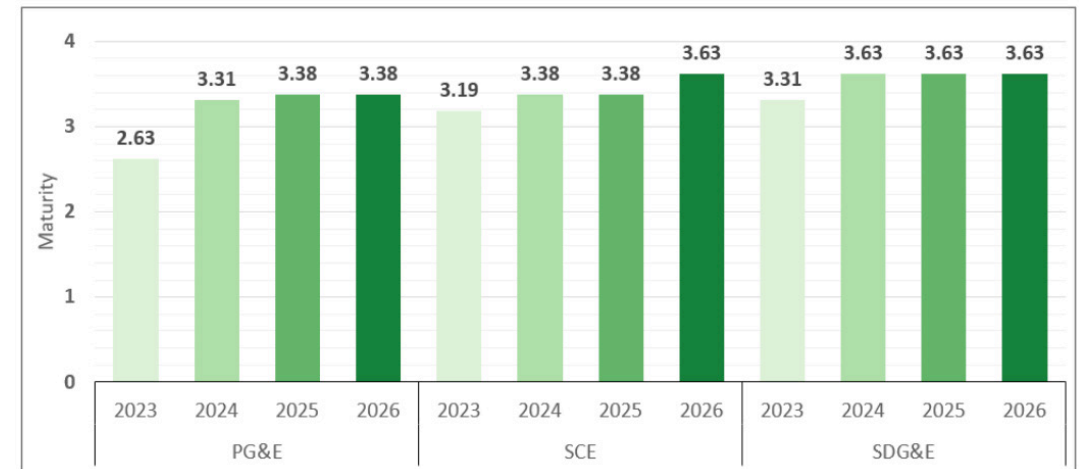
- For example, consider a utility's Dispatch Strategy capability within the Planning & Design category
 - ▣ Low maturity: Lack of alignment with system needs (inflexible resources that are rarely dispatched)
 - ▣ High maturity: Close alignment with the needs of the distribution and bulk power systems (highly flexible resources that are frequently dispatched, both locally for a subset of DF program participants and for all DF program participants)
- PIM associated with the DF portfolio could have metrics that initially focus on Planning & Design capabilities and then evolve over time
- As the utility achieves a higher level of maturity for Dispatch Strategy and other capabilities in the Planning & Design category, the metric weighting could change to emphasize a different category (e.g., Program Operations or DER Orchestration), including third-party provider integration
- Metrics could also start to emphasize outcome-based performance tied to shedding, shifting and shaping load



Using a maturity model to benchmark capabilities

- Wildfire Mitigation Maturity Model benchmarks three California utilities – within the vegetation management and inspections category in this example
- By assessing underlying capabilities within vegetation management and inspections, each utility identifies how to improve and can prioritize changes accordingly
- Using the DF maturity model, utilities can also benchmark capabilities to identify improvements
 - For example, three utilities may find that they have widely varying average maturity levels within Program Operations
 - Digging deeper, the utility with relatively low maturity may find that its low score for the Monitoring and Control capability is driving down its overall Program Operations score
 - Reviewing the capability maturity indicators and levels, the utility can identify specific improvements

Comparison across Utilities for Vegetation Management and Inspections Category



Source: [Office of Energy Infrastructure Safety \(2023\)](#)



Summary



Advancing DF maturity in an era of surging load

- Despite the widespread adoption of advanced meters and connected devices, utilities have generally not moved beyond traditional direct load control (DLC) programs
- With surging load from data centers, manufacturing facilities, buildings and transportation, DF is urgently needed to mitigate capacity constraints and power interruptions
- *Vast potential* remains for existing BTM technology to alleviate grid constraints at a low cost
- Berkeley Lab has developed the DF maturity model, based on well-documented industry best practices and barriers to broader DF adoption
 - By measuring maturity levels across 34 DF capabilities, states and utilities can prioritize investment, identify gaps, and drive continuous improvement
 - This detailed, practical guidance based on a wide range of lessons learned fills a gap in the literature by providing an extensive tool to help utilities and regulators realize the promise DF and move beyond DLC



Resources

Utility Capability Maturity Models

- Carnegie Mellon (2018). [Smart Grid Capability Maturity Model Compass Assessment Survey](#).
- DOE (2022). [Cybersecurity Capability Maturity Model \(C2M2\)](#).
- OEIS (2020). [Utility Wildfire Mitigation Maturity Model](#).

Best Practices and Barriers to Adoption

- Delurey, Dan (2013). [Demand Response: The Road Ahead](#).
- DOE (2021). [A National Roadmap for Grid-Interactive Efficient Buildings](#).
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- Schellenberg et al. (2022). [Demand Response Auction Mechanism Evaluation](#).

State of Demand Flexibility

- NARUC (2023). [Demand Flexibility within a Performance-Based Regulatory Framework](#).
- Murphy, Sean, Cesca Miller, Jeff Deason, Diana Dombrowski, and Portia Awuah (2024). [The State of Demand Flexibility Programs and Rates](#).



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