Using Grid Edge Resources to Provide Distribution-level Services

NASEO-NARUC GEB Working Group

Paul De Martini

July 2025

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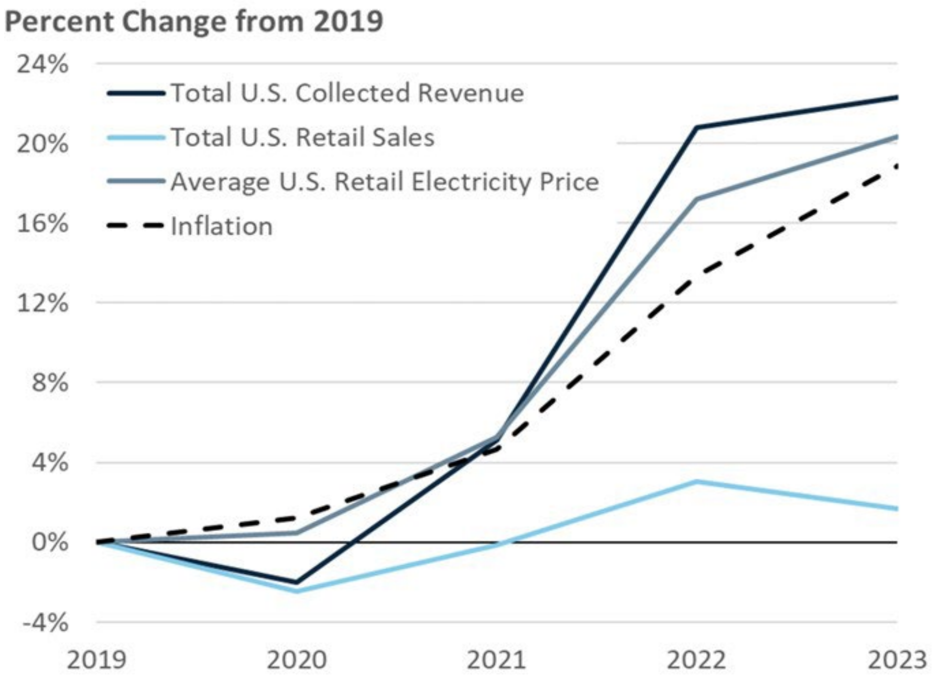
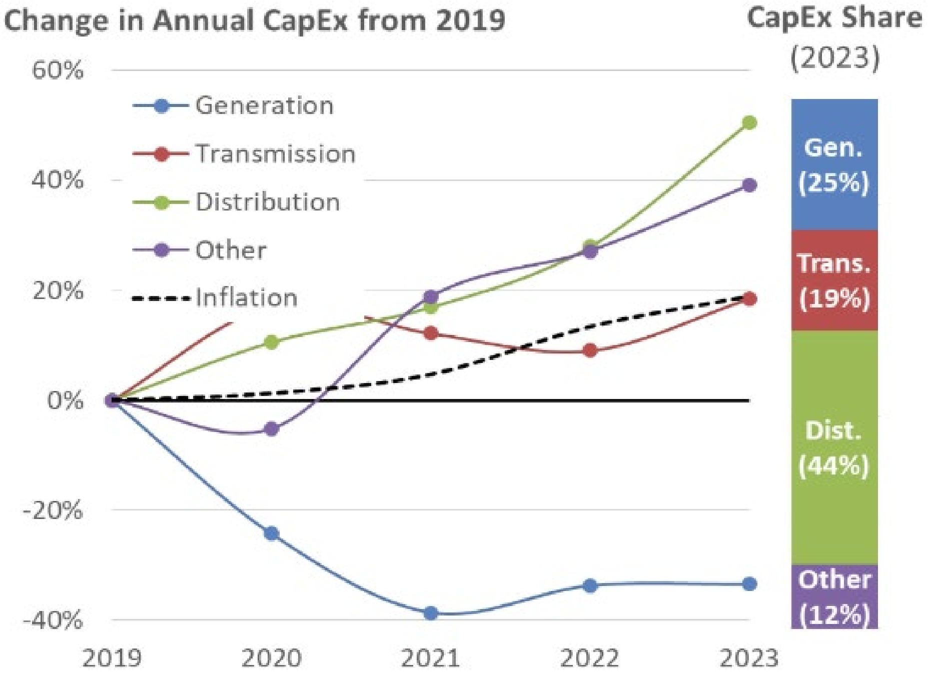
Distribution Costs Have Risen Dramatically Impacting Rates

Managing distribution costs has become a key objective for customers, policy makers, regulators and utilities





Source: Retail Electricity Price and Cost Trends: 2024 Update, Berkeley Lab

Spending on Adaptation, Hardening, and Resilience (AHR) **37%**, Aging Asset Replacement **28%**, Capacity Expansion **28%**, and Other **7%** (EEI)

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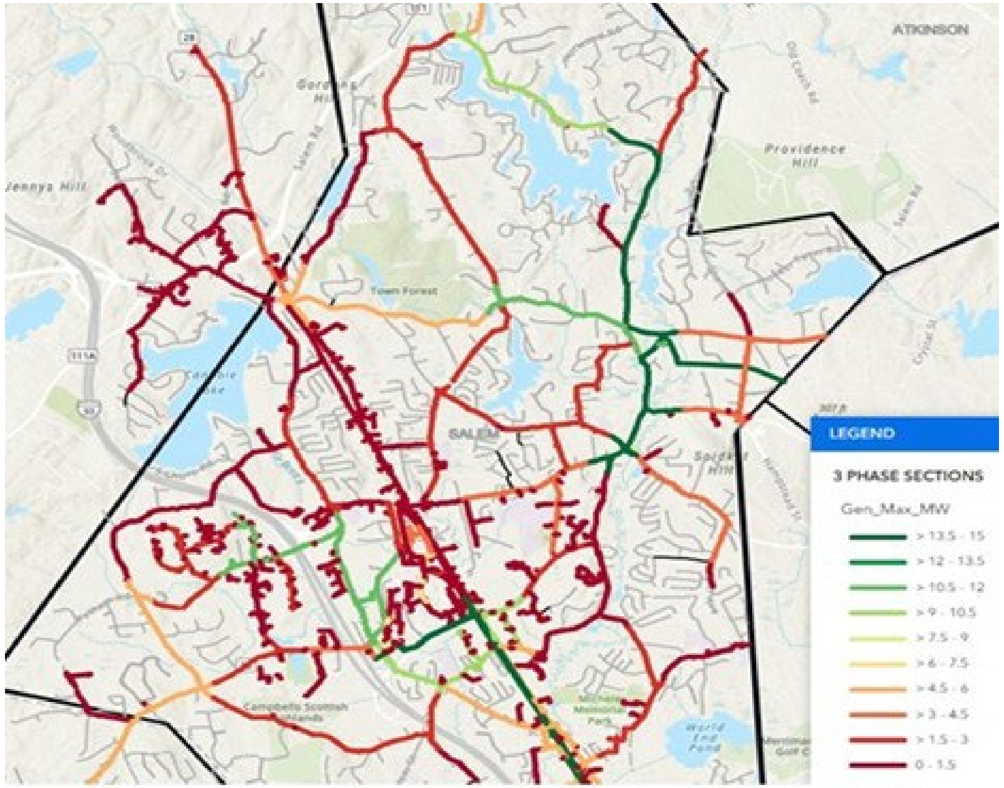
Distribution Operational Constraints

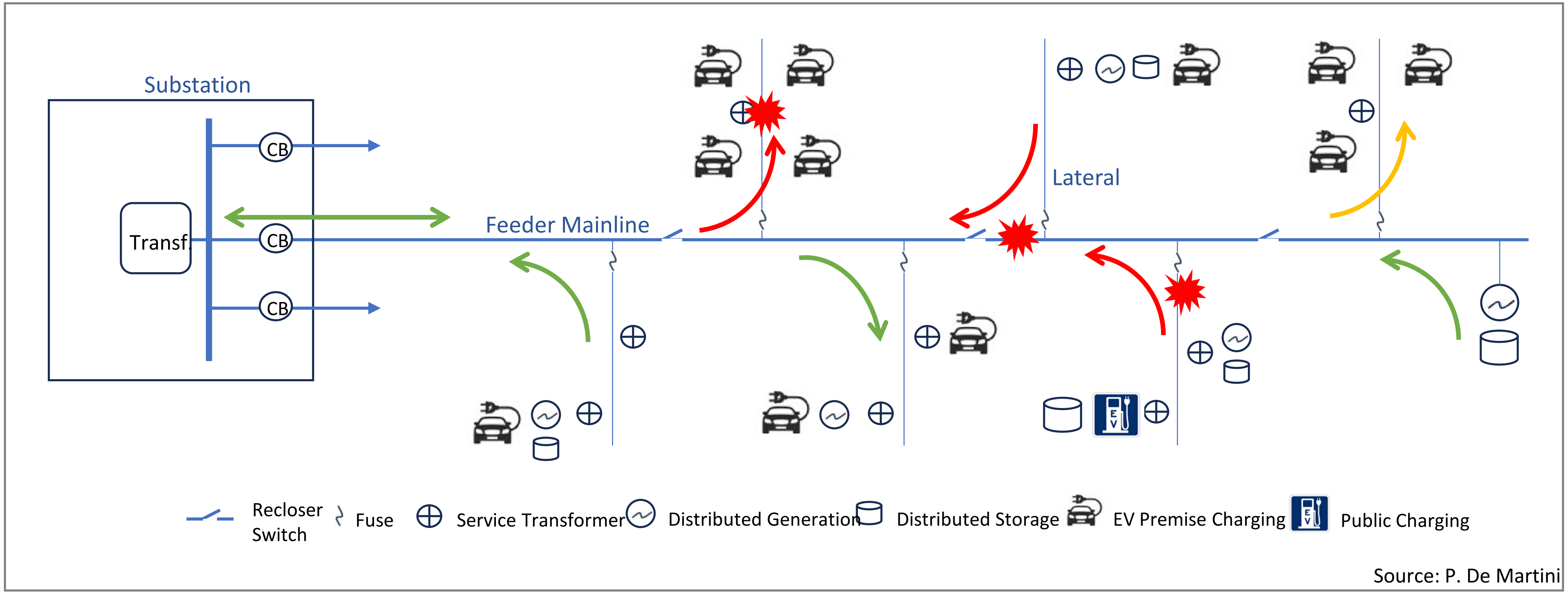
- Hosting Capacity maps highlight feeders and line segments that have limited capacity for additional interconnection.
- This was originally focused on solar PV impacts. However, distribution constraints can emerge from the operation of various DER/EVs.
- Due to the source of the flows, individual constraints can occur in several locations on a single feeder and may occur at non-coincident times.
- Non-coincident refers to individual distribution line segments and equipment that experience peak loading within the same feeder at different times. For example, an individual service transformer may experience peak loading from EV charging while the feeder mainline may not be at a peak.
- These non-coincident constraints also nest with one another depending on the power flow directions, creating further complexity to manage.



Source: Liberty Utilities

Distribution Feeder Zones for Managing Power Flows within Operating Limits

Power flow constraints at any point may occur at different times due to the nature of the flows, depending on the direction and magnitude of the power flows



Notes:

- The red, yellow, and green arrows in the figure indicate the direction of power flow and whether the flow exceeds an operating limit (red), nears a limit (yellow), or is reliably within a limit (green).
- Each service transformer and associated secondary conductor are also constraints to consider although not illustrated

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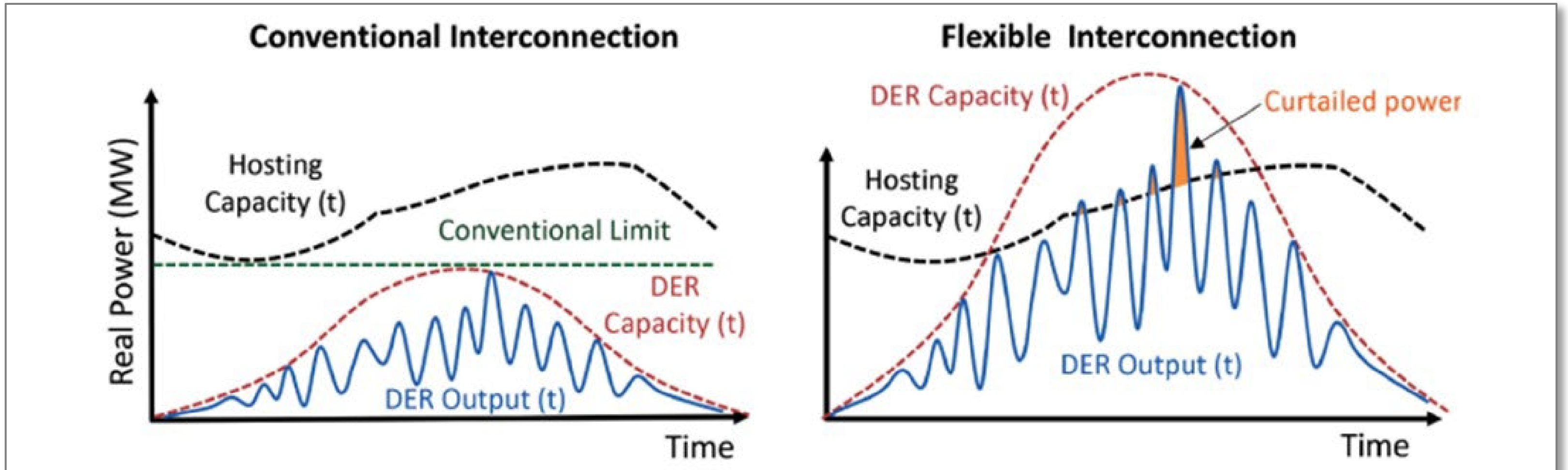
Flexible GER & EV Charging Connections

Flexible Distribution Connections

- Flexible connections are methods to improve distribution system utilization allowing more GER interconnections and service connections for EV charging while lowering the cost of integration.
- Flexible connection strategies involve shaping GER and EV charging exports and imports to remain within distribution system operating parameters (e.g., capacity limits, voltage limits) during periods when distribution systems are constrained



Source: EPRI

The potential benefits of flexible connections include facilitating the development of GER and EV charging facilities & other large loads, lowering connection costs, and/or deferring infrastructure upgrades.

R. Yu and P. De Martini, Flexible DER & EV Connections, US Dept. of Electricity, 2024.

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Flexible Planning and Operating Parameters

Traditional vs Flexible Connection Studies:

- Interconnection studies and hosting capacity analysis have traditionally used static analyses of worst-case operating conditions for both grid conditions and GER and loads.
- Conversely, analyses for flexible connections involve identifying granular locational and temporal (e.g., 8760 hours) distribution grid constraints over an annual or shorter (e.g., seasonal, day-ahead) horizon.
- ***Dynamic operating envelope*** methods reflect a more granular, time-sensitive representation of grid conditions. Dynamic operating envelopes offer a more effective understanding of distribution capacity availability due to variations in export energy, customer demand, and grid conditions (including circuit reconfigurations).
- A dynamic operating envelope establishes the upper and lower bounds (operating parameters) for a given time interval for allowable import or export power at a point of interconnection/service connection. These upper and lower bounds can change from one time interval to the next, based on distribution conditions and anticipated constraints.
- Operating envelopes for distribution systems in the US are currently forecasted hourly over a year. This results in seasonal, monthly, or daily time-specific operating limits for GER/Large Loads based on available distribution capacity at each time interval. These variable operating limits for GER export and large load demand define the dynamic operating envelope.

Flexible Interconnections/Service Connection Approaches

Customer Controlled Solutions

- **Advanced Inverter Settings:** Advanced inverters can provide the capability to modulate power output dynamically. These inverters can adjust the electricity export and import for distributed generation and battery storage based on grid conditions, ensuring that DER systems operate within safe and allowable system parameters.
- **Export/Import Limits:** Customers can utilize dynamic operating envelope export/import limits to manage the flow of electricity between their DER systems and the grid. By adhering to variable limits that reflect the grid's capacity at different times, customers can ensure that their energy exports and imports are optimized to avoid overloading the grid.

CPUC Flexible GER Interconnection Example

An example of customer-controlled export limits for solar and battery storage is California's Limited Generation Profiles (LGP). LGP is a dynamic operating envelope that specifies the maximum amount of electric generation a system will export to the grid at different times throughout the year, ensuring that the project is responsive to fluctuating grid constraints at different times." Under LGP, a customer will alter their grid injections by selecting one of three options to respond to grid conditions.

SCE Flexible EV Fleet Charging/Large Load Service Connections

Southern California Edison (SCE) has implemented a two-year Automated LCMS Pilot, designed to allow customers to receive electrical service connections based on the currently available grid capacity, rather than delaying the customer's EV charging interconnection until required grid upgrades are completed to support full-capacity charging. The customer's LCMS can reduce charging levels, disconnect specific devices, or stop charging at specific chargers to remain within distribution grid operating limits. Customers are responsible for purchasing, installing, and operating their LCMS.

Flexible Interconnections/Service Connection Approaches

Utility Direct Control Solutions

- Utility-controlled flexible GER interconnection and EV/Large Load flexible service connections involve the use of utility operational system analytics and control capability to interface with customers' smart inverters, PCS systems, EV telematics, smart chargers, or facility energy management systems to initiate curtailment based on specific grid operating limits.
- **Curtailment Allocation**: For utility-controlled approaches, this requires the utility to determine how much reduction is needed and from which GER/Load that is under utility control. There are several allocation methods in development - most common curtailment decision methods employed today are Last-in-First-Out (LIFO) and Pro Rata.

  The LIFO method refers to the first GER interconnection/load service connection is curtailed last. The Pro Rata method involves all GER or large loads under a utility's flexible control in a constrained area experiencing a proportionate reduction in their grid export/demand.

Commonwealth Edison's (ComEd) Mendota Demonstration

ComEd has implemented a utility-controlled solution in its Mendota demonstration to enable flexible GER interconnection. This utility-controlled solution leveraged ComEd's DERMS and ADMS to assess grid conditions and dispatch DER for real and/or reactive power control. Smart inverter dispatches are coordinated with ComEd's existing Volt-Var Optimization (VVO) implementation.

National Grid EV Charge Smart Plan

National Grid's program employs both active and passive managed charging strategies. Active managed charging involves real-time utility control over charging activities, while passive managed charging relies on time-of-use rates and customer behavior to shift charging to off-peak periods. The actively managed charging approach uses the telematics from EV manufacturers and networked Electric Vehicle Supply Equipment (EVSE) to provide real-time data and control over EV charging activities.

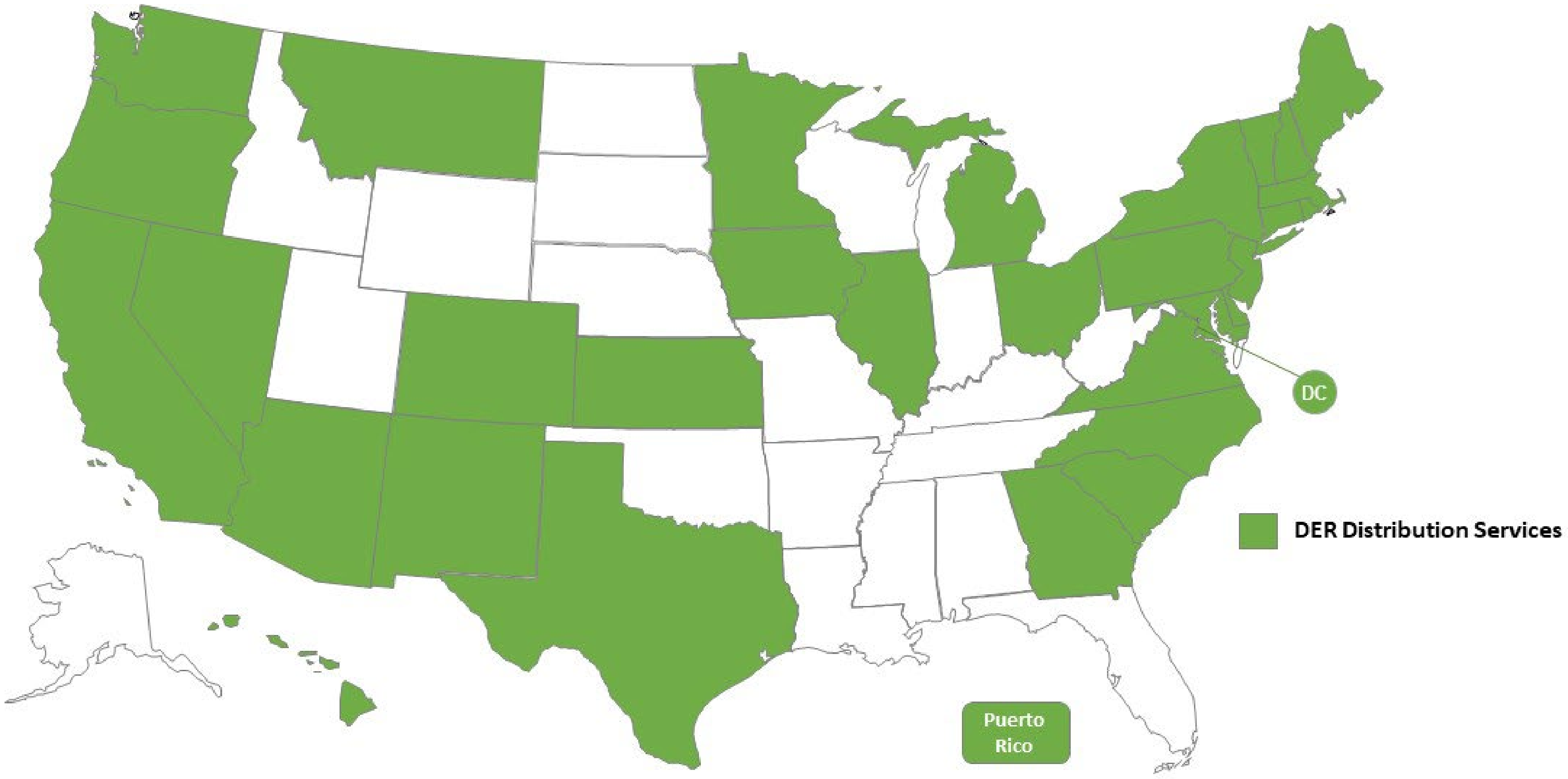
Key Considerations

- **Policy & Regulatory:**
    - Establishing clear policy and guidelines for the adoption of flexible connection methods, including customer–controlled and utility-controlled approaches
    - Curtailment allocation methods require stakeholder engagement to determine an acceptable approach. Any approach selected will require ongoing monitoring and assessment of non-discriminatory implementation.
    - Determining the role that flexible connections play within a broader flexibility services strategy for mitigating distribution capacity investments
- **Customer Engagement:**
    - Educating and empowering customers to participate in managed charging and energy export schemes to optimize their flexible connection for improved grid utilization.
- **Data and Forecasting:**
    - Detailed grid data and forecasting analytics are required to determine dynamic operating envelopes for distribution systems at a granular location and temporal detail.
- **Technology Integration:**
    - Technologies like ADMS, Grid DERMS, smart inverters, and related interoperability standards may be required depending on the flexible approach used. The cost, performance, and other implementation considerations should be evaluated.

Distribution Flexibility Services from GER

Distribution Grid Flexibility Services

State Policy, Regulation & Utility Pursuit of GER Services* for Distribution Grid Needs

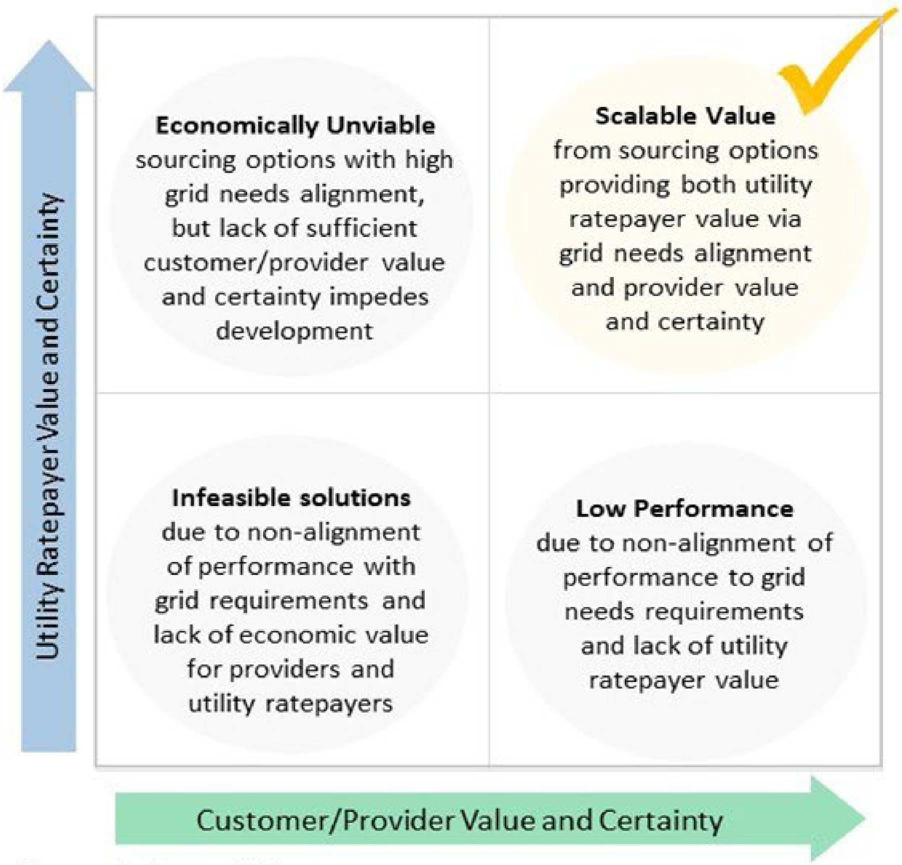


Sources: Newport Consulting and North Carolina DSIRE Program

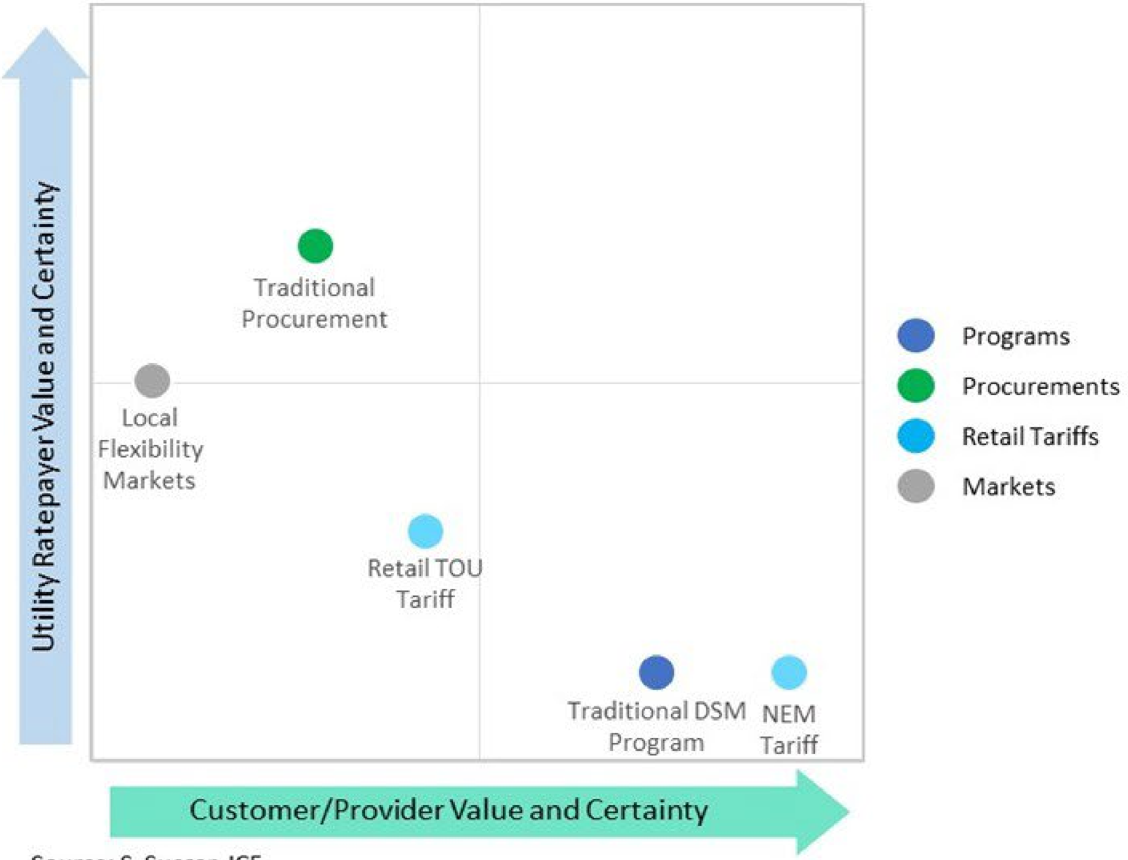
*Includes utility geotargeted DSM programs, NWS procurements, and utility-owned grid storage

Sourcing Methods for Distribution Grid Services

Current Application of Pricing, Programs, Procurements & Markets for Distribution Needs



Source: S. Succar, ICF



Source: S. Succar, ICF

Reference:
P. De Martini, S. Succar, and P. Cook, Evolution of Sourcing Distribution Grid Services, U.S. DOE, December 2024

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Sourcing Methods Have Different Incremental Costs for Ratepayers

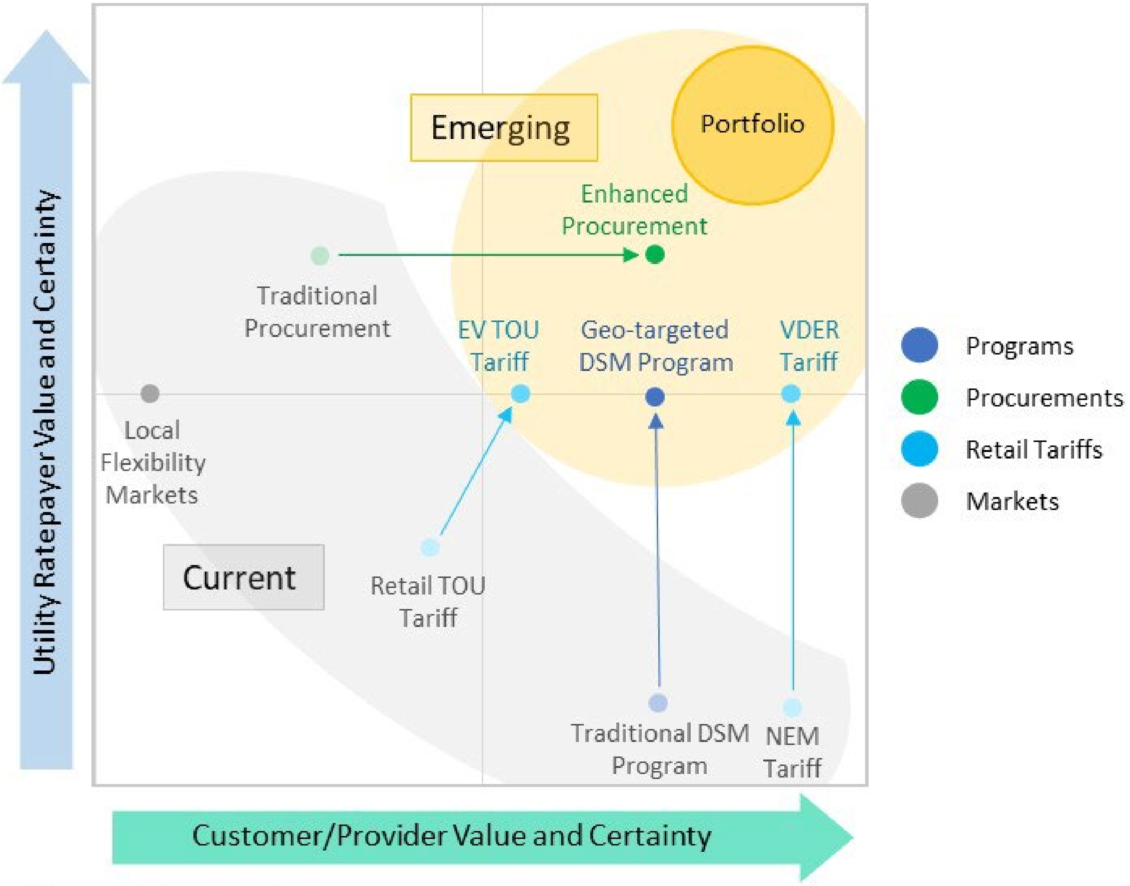
- The incremental cost of adding an EV TOU rate is relatively low if a general TOU rate is in place. Also, DER tariff rates, such as the value of DER tariffs that align pricing to avoided costs, could have minimal cost impacts on customer rates.
- Similarly, realigning existing DSM budgets to include geo-targeted programs may not involve incremental costs to ratepayers.
- By contrast, flexibility services procurements add material incremental costs for ratepayers regarding the specific NWA evaluation and procurement processes and the compensation for the service(s) provided.
- Additionally, the cost recovery mechanism employed for NWA services compensation (e.g., utility operating expense) can have a greater near-term rate impact than the avoided utility distribution capital expense typically amortized over the asset's life.

Sourcing Method	Incremental Ratepayer Cost
Tariffs/Price Signal (DER, TOU)	Relatively low cost for billing changes and customer communications
DSM/Demand Flexibility Programs (Geo-targeted and temporal)[62]	None if the existing authorized program funding is redirected to geo-targeted /temporal needs
Procurement/Bi-lateral Contract	Cost is based on competitive proposals but typically capped at the deferred/avoided distribution value.
Local Flexibility Market	Market implementation cost + cost of purchased flexibility service at market prices

Evolution Needed in Sourcing Methods for Distribution Services

No sourcing method alone can address the evolving distribution grid – a portfolio is needed

- Evolving distribution grid needs necessitate evolving sourcing methods toward the top-right quadrant of high alignment and scalability.
- DER solutions must reliably meet the variability and hyper-locality of emerging distribution constraints. Note: Average distribution reliability is 99.86%
- This means moving "up" toward a greater alignment with distribution grid needs and improving DER service provider financial and value certainty that moves toward the "right."
- To find options in the top-right quadrant of these alignment-scalability axes, we can explore a two-fold evolution in DER sourcing that involves:
  - Improving DER sourcing options toward distribution needs alignment and sustained viability for providers, and
  - Combining sourcing options into integrated portfolios that consider each option's relative contributions and cost to address distribution grid needs.



Source: S. Succar, ICF

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Utility Distribution NWA - Flexible DER/DSM Case Example:

CASE STUDY

Our client's journey on realizing DERs operational flexibility

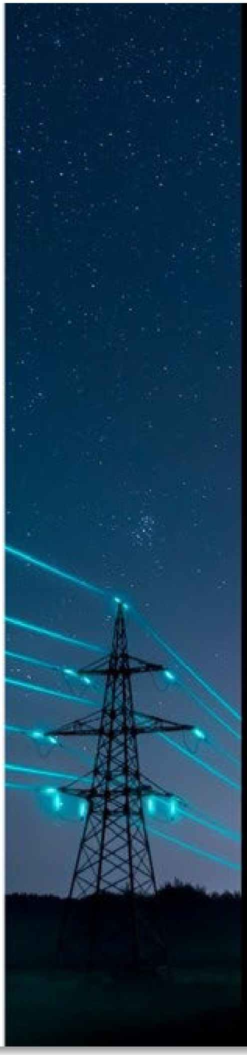
$6.9 Million

Distribution Operations identified a 2.3 MVA overage on a substation and proposed an upgrade to raise firm capacity for $6.9 Million.

$1,787/kWyr

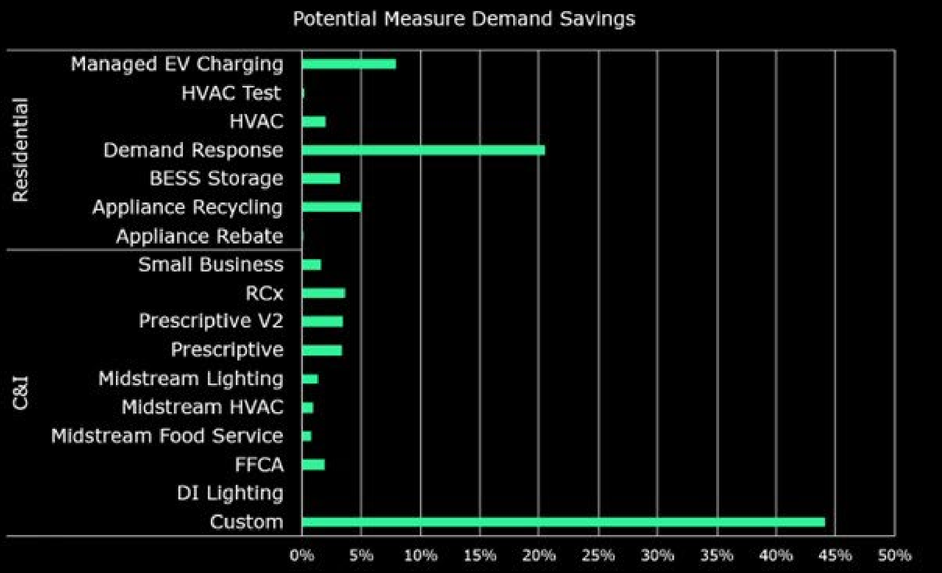
Tracking towards a deferral benefit* of $1,787/kWyr, the possibilities of cheaper DER savings were very high.

**including bulk system benefits*



A bottom-up analysis for localized potential savings (substation-level), which was informed by:

- ✓ Localized Customer Building Energy Models
- ✓ Distribution System Needs
- ✓ Customer Program Needs



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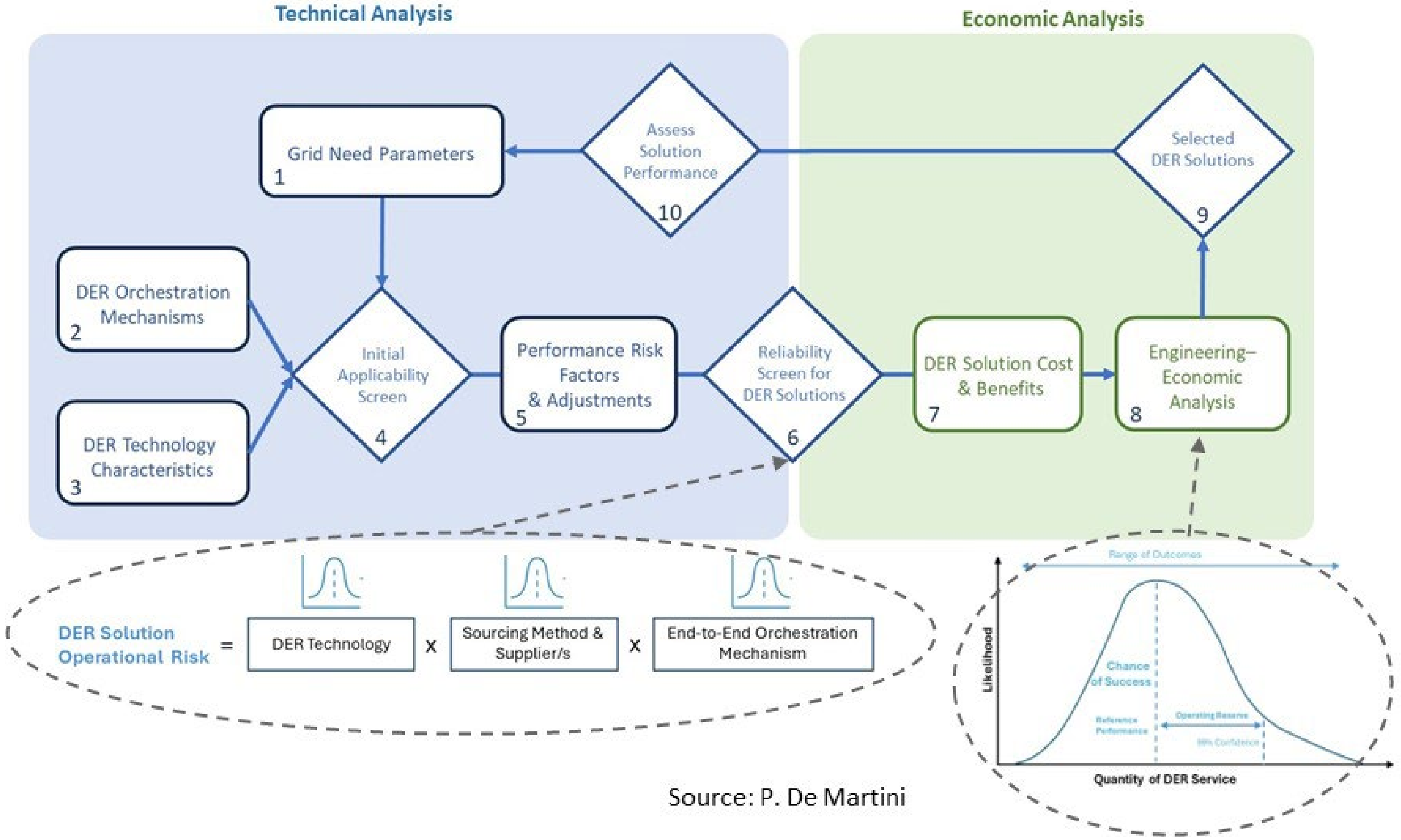
Techno-Econometric Model to Evaluate Flexibility Service Provision

A gap exists between distribution flexibility services' value potential & Distribution Operator confidence

- A reliability risk-based methodology for systematically evaluating DER solutions individually and in a portfolio against distribution grid performance requirements.
- Employing a value-at-risk type analytic methodology for determining the appropriate level of distribution operating reserves to achieve a desired level of confidence in operational performance from a portfolio of DER solutions
- Incorporate a techno-econometric methodology into planning tools for use by utilities to develop DER distribution services sourcing strategies required in a growing number of states as part of Integrated Distribution System Planning.

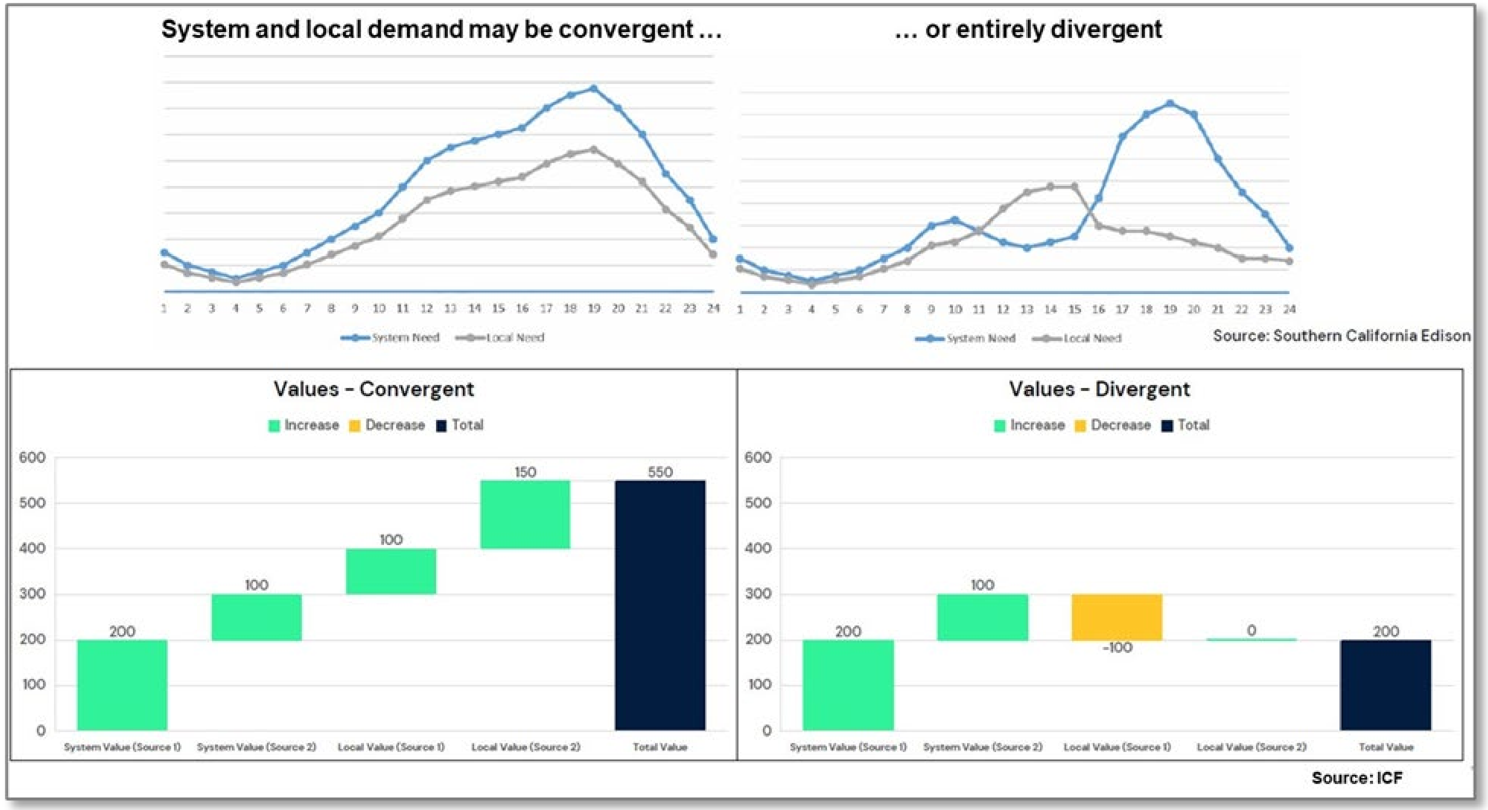
DER Orchestration
Techno-Econometric Decision Model



Source: P. De Martini

BPS & Distribution Needs Are Not Always Aligned

Existing policies and practices often prioritize BPS needs independent of distribution impact – need for coordination



Ensure GER services & DSM programs are coordinated to avoid them canceling each other out or creating worse outcomes

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Key Considerations: Flexibility Services

- Integrate flexibility sourcing approaches to holistically consider the use of flexible connection, pricing, programs, and procurements:
  - Explore integration/coordination of regulatory dockets to examine retail rate designs, geo-targeted/temporal demand flexibility programs, and NWA procurement processes that may yield more effective utilization of flexibility services for distribution.
  - Consider flexible connections as part of a holistic flexible services portfolio and roadmap, including development of a flexibility resource stack and consideration of a preferred order of GER/flexible connection dispatch.
  - Examine geo-targeting GER/DSM programs to address distribution needs by considering temporal and locational needs, including performance requirements, to provide cost-effective grid solutions.
- Revisit NWA procurement approaches to consider enhancements that address service provider cost and risk factors to improve participation and viability.
- Consider a bottom-up approach to assess GER optimization first at the distribution level before use for bulk power systems to better assess the convergent and divergent values.
- Consider employing a techno-econometric planning and portfolio development methodology for reliable distribution flexibility services.

Thank you

Paul De Martini
paul@newportcg.com

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