A Framework for Integrated Distribution System Planning

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Presentation for NASUCA Annual Meeting

November 12, 2024

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Berkeley Lab's activities in integrated distribution planning

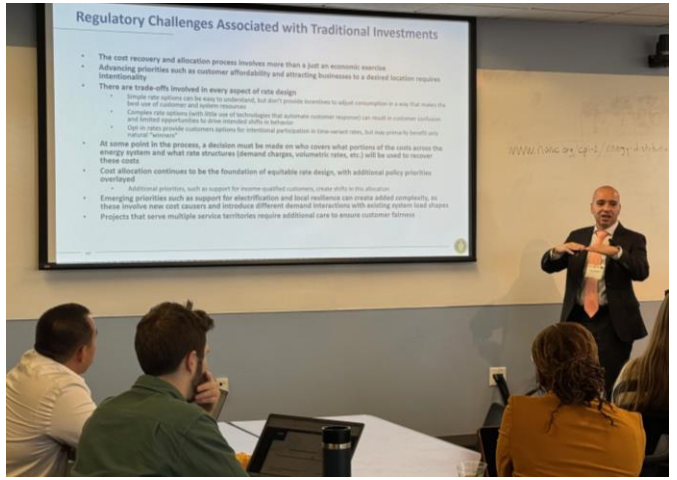
In partnership with NARUC, NASEO, NASUCA, and other national and regional organizations, Berkeley Lab conducts training, technical assistance, and research and develops tools to advance integrated distribution system planning (IDSP).

Training	Technical Assistance	Research & Tools
We **offer educational opportunities** that provide foundational information, address cutting-edge issues, disseminate advanced planning practices and new DOE-funded research, and facilitate peer-sharing.	We **provide unbiased technical expertise and research-based information** to help states address key institutional issues related to advancing distribution system technologies, investing in grid infrastructure, and applying robust planning methods and processes.	We conduct research and provide tools focused on three areas: **1. Current practices and gaps** **2. Emerging best practices** **3. Planning guidance**

Website: https://emp.lbl.gov/projects/integrated-distribution-system-planning

In-person training on Integrated Distribution System Planning 2.0: Planning for Electrification and Distributed Energy Resources

- Hosted by NARUC, NASEO and Berkeley Lab, funded by USDOE
  - **Limited travel stipends are available for utility consumer advocates**
    - Reach out before making travel arrangements: Jessica Diaz (jdiaz@naruc.org)
- All new curriculum! Participants will learn:
  - Best practices across the U.S. for planning distribution systems
  - How to incorporate electrification and DERs in local grid planning
  - How to design stakeholder-informed planning processes to achieve state goals
  - Challenges and potential solutions
  - Questions to ask utilities
- Office hours with trainers
- Half-day State Action Planning Workshop facilitated by RMI
  - Apply learning to develop plans for advancing distribution planning in your state
  - Engage in interactive discussions and peer exchange to support implementation

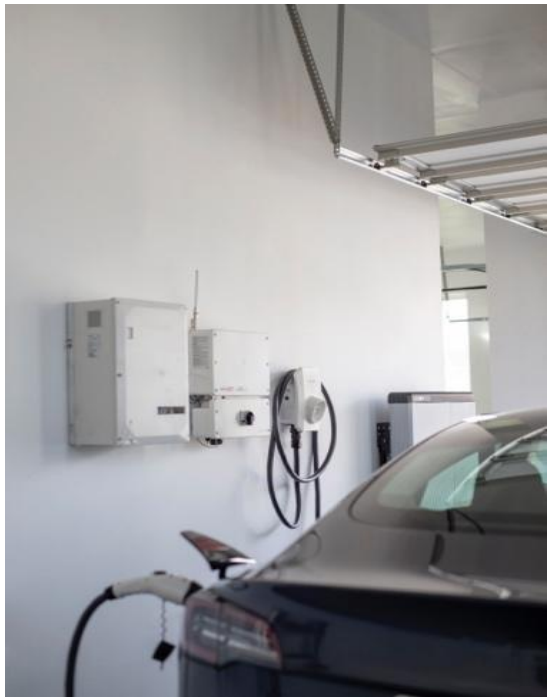


- ***Charlotte, December 11-12* - Register now!***
- ***Detroit, March 11-12 - Register now!***
- ***Salt Lake City, April 23-24 -*** Register soon

**Tour EPRI Power Delivery and Utilization Lab in Charlotte on Dec. 13*

What is integrated distribution system planning?

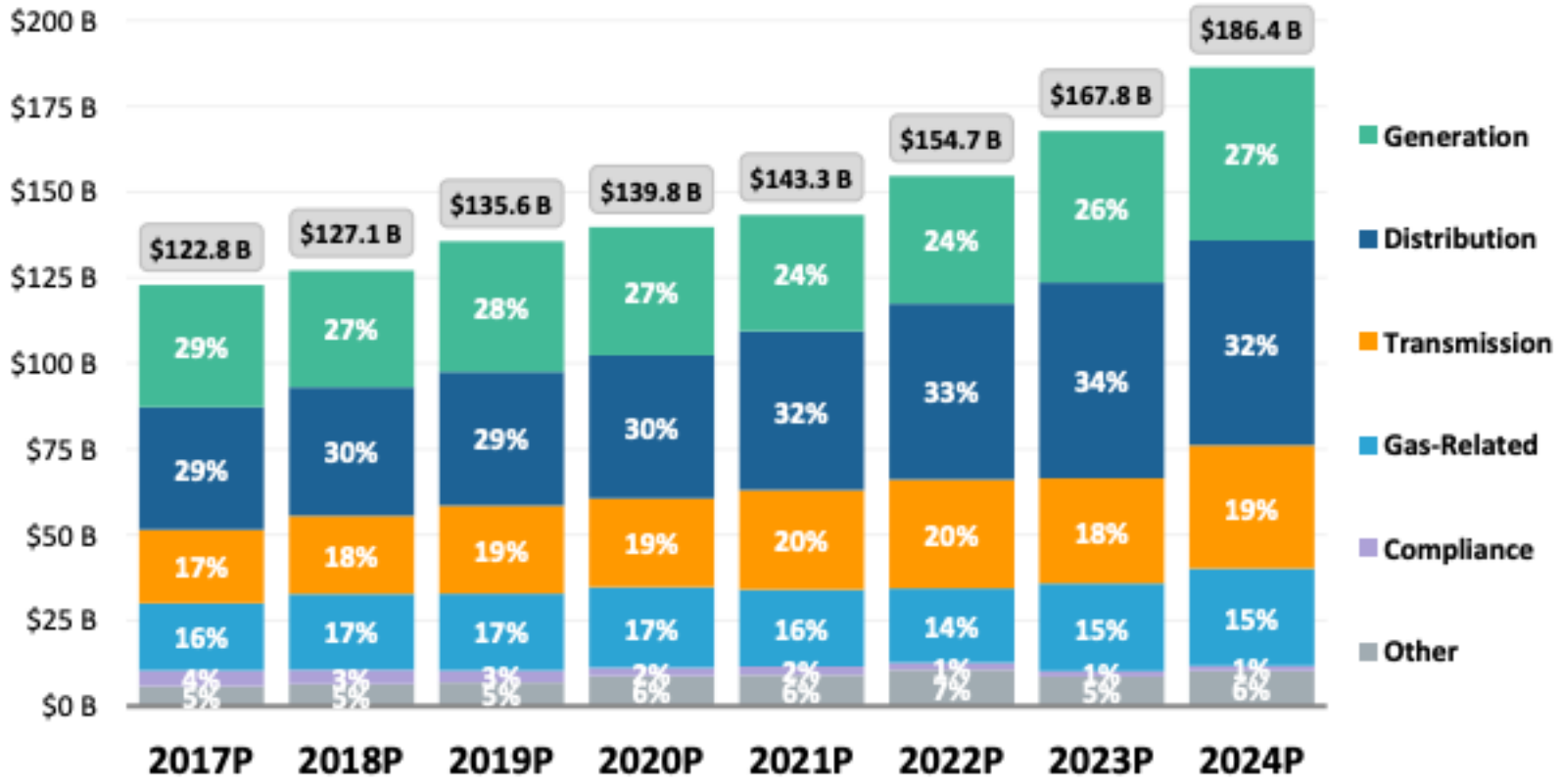
- IDSP provides a **decision framework to enable the formulation of long-term grid investment strategies** that address state and local policy goals, objectives, and priorities, consumers' needs, and evolution at the grid edge.
- States set goals, objectives, and priorities that define **long-term, high-level outcomes** for grid planning. Goals for grid planning include:
  - **Traditional regulatory aims** — e.g., safety, reliability, and affordability
  - **Newer policy goals** — e.g., transportation electrification, more renewable resources, and emissions reductions
  - **Related outcomes** — e.g., greater asset utilization and improved integration and utilization of DERs
- Grid planning objectives also reflect the importance of **transparency and stakeholder engagement**.
- A **shared understanding across stakeholders of strategies** for addressing goals, objectives and priorities is essential.



Source: Sunrun

Why are states increasingly interested in distribution system planning?

Distribution system investments account for the largest portion of capex — 32% in 2024 (projected $59.7B) — for U.S. investor-owned utilities.



Source: EEI 2024

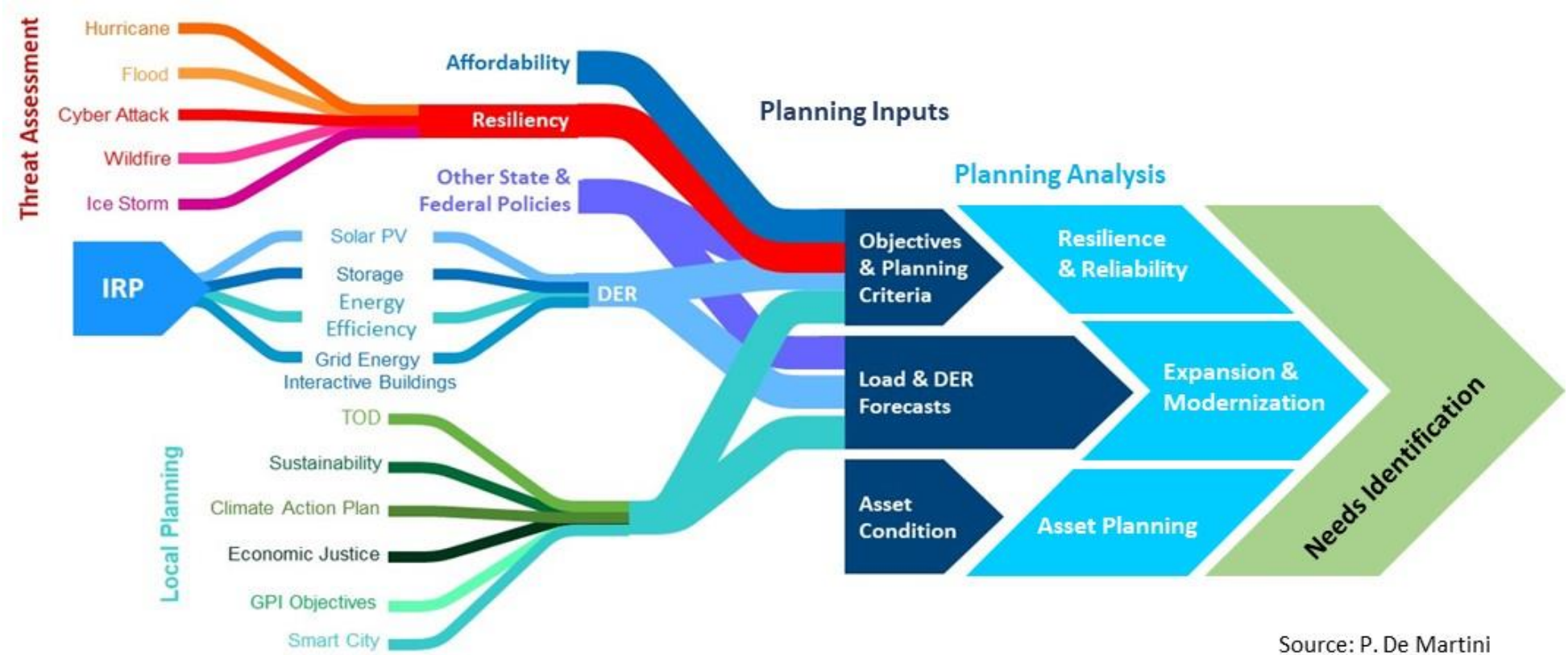
What are the potential benefits from an improved planning process?

- Better oversee utility expenditures
- Make transparent utility plans for distribution system investments in a holistic manner, before showing up individually in rate cases
- Provide opportunities for meaningful engagement with stakeholders and regulators to improve outcomes
- Consider uncertainties under a range of possible futures (scenarios)
- Consider all solutions for least cost/risk (including DERs)
- Enable consumers and third-party providers to propose grid solutions and participate in providing grid services (e.g., grid-interactive efficient buildings)

Source: Con Edison

How is distribution planning changing?

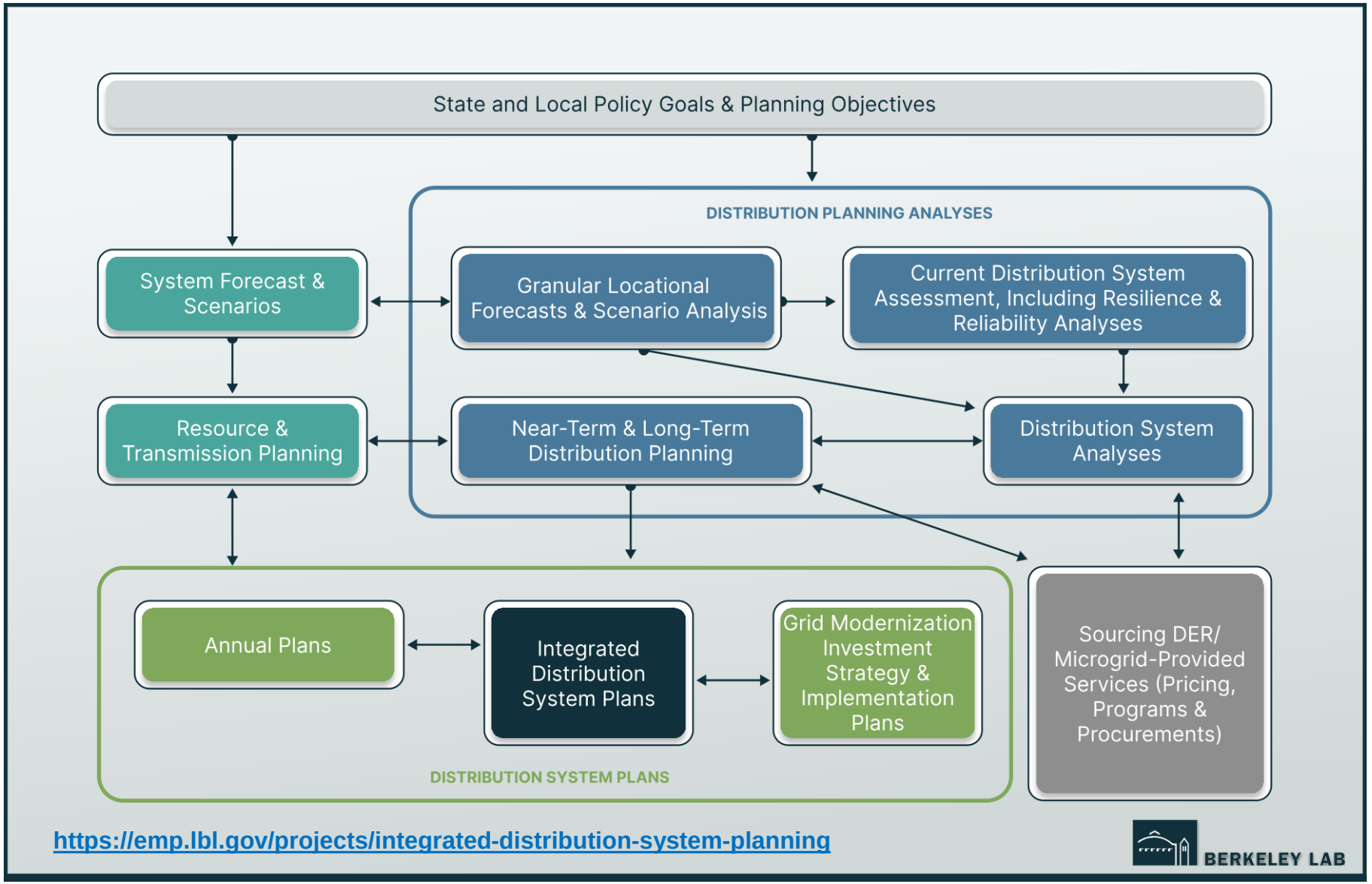
Distribution planning is increasingly dependent on resilience planning, bulk power system planning, local planning, and DER planning.



Source: P. De Martini

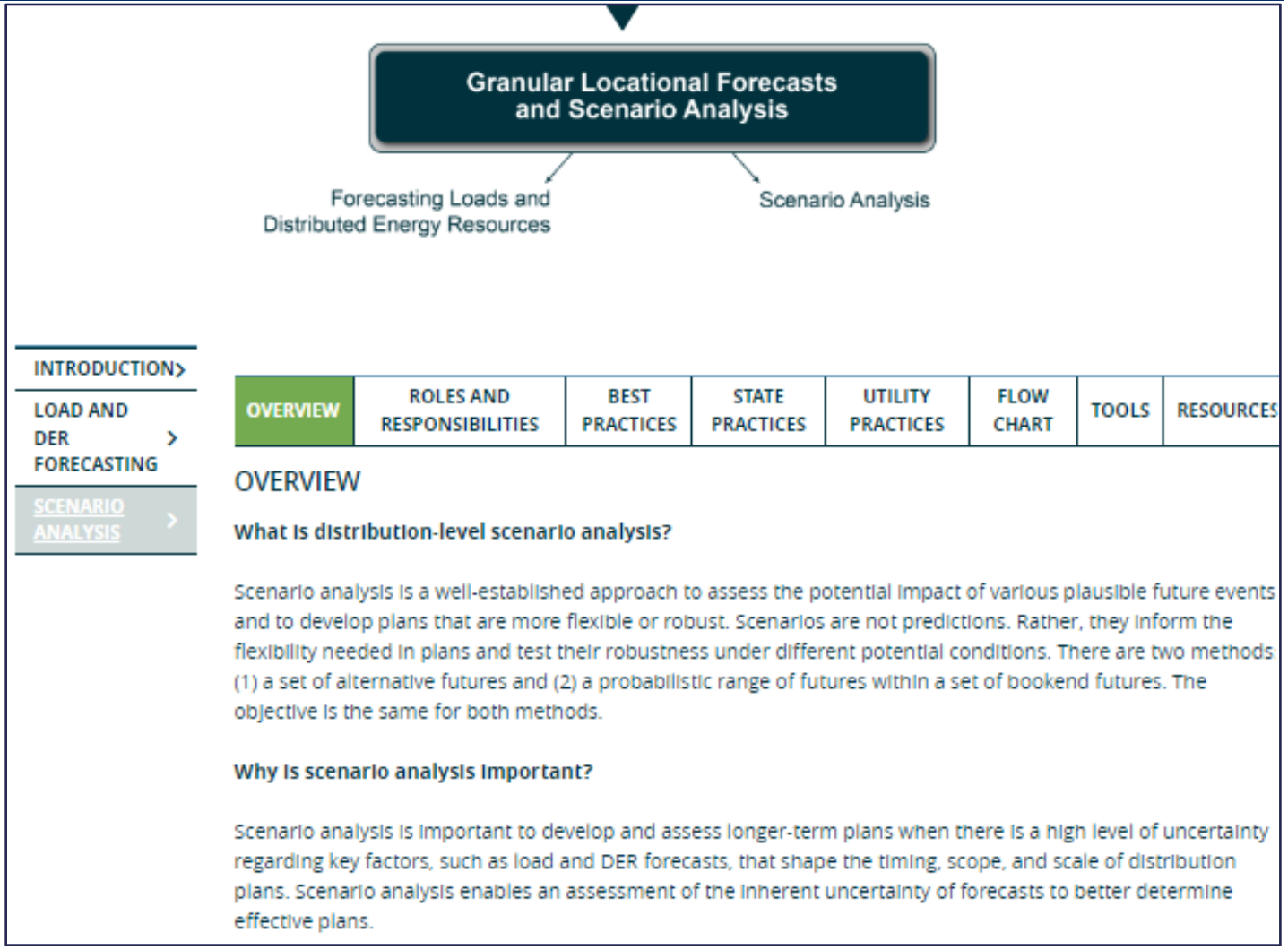
New Berkeley Lab Interactive Planning Framework

New Interactive Decision Framework for Integrated Distribution System Planning



What's included?

- Overview
  - What is it?
  - Why is it important?
  - Key questions (Q&A)
- Roles and Responsibilities
- Best Practices
- State Practices
- Utility Practices
- Flow Chart (e.g., inputs/outputs)
- Tools
- Annotated Resources List



What topics are covered?

1. Stakeholder Engagement
2. Equity Considerations
3. Forecasting Loads and DERs
4. Scenario Analysis
5. Threat-Based Risk Assessment
6. Worst-Performing Circuits Analysis
7. Asset Management Strategy
8. Cost-Effectiveness Framework for Investments
9. Multi-Objective Decision-making
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11. Hosting Capacity Analysis
12. Value of DERs
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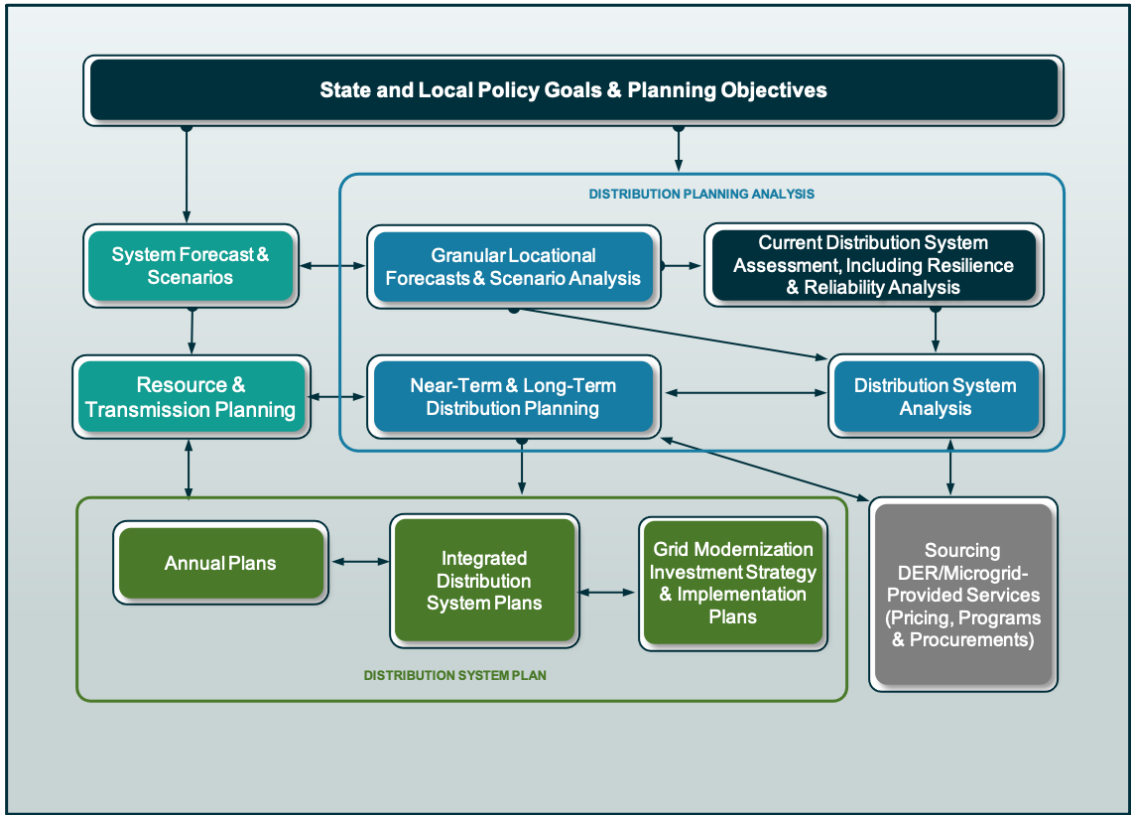
15. Functional Requirements Analysis
16. Geotargeting Programs
17. Procurements



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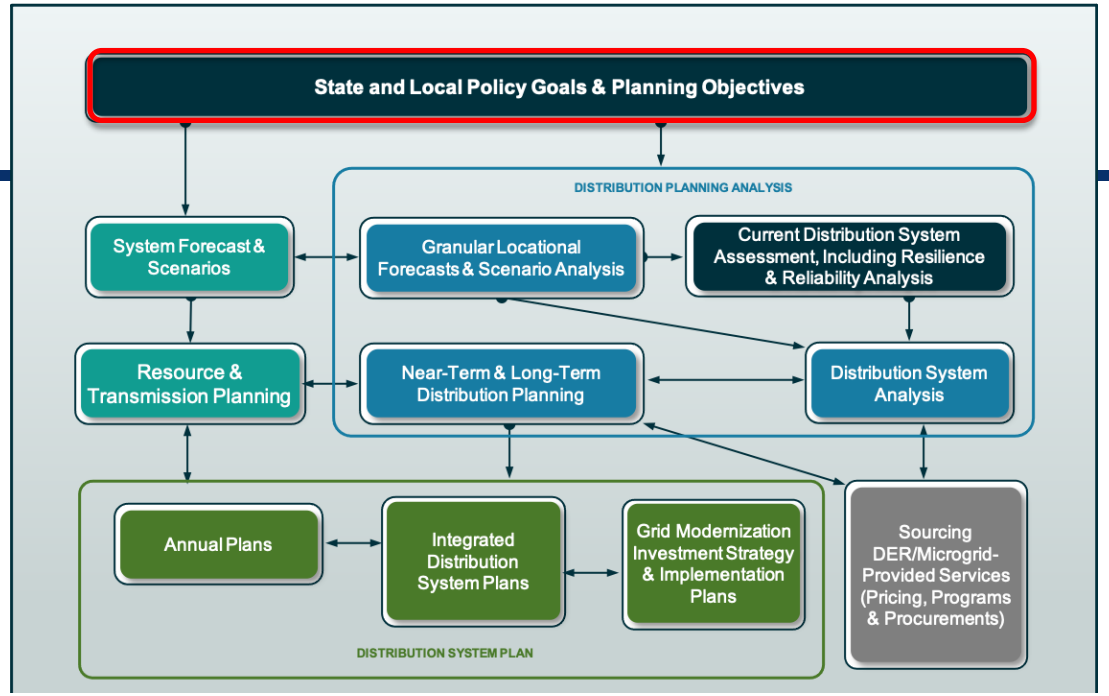

State and local policy goals and planning objectives are key IDSP inputs. Planning objectives and priorities originate from these goals, as well as input from communities and stakeholders.

- **Stakeholder engagement** involves participation by a wide variety of interested or concerned parties to provide feedback on planning objectives, inputs, methods, scenarios, and priority investments.
- **Equity considerations** aim to fairly distribute the benefits and burdens of grid investments across different customer groups.

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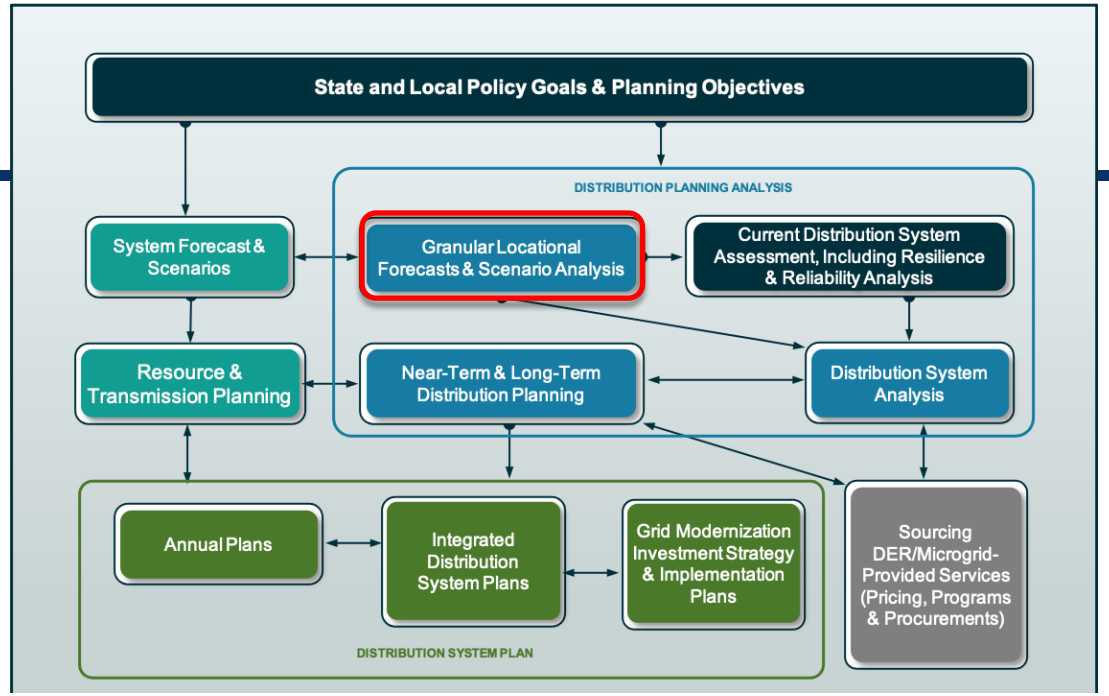

- **Granular locational forecasts** are projections of loads and DERs at the distribution substation and feeder levels that provide locational and temporal information to inform the type and timing of distribution system investments needed. The forecasting process considers potential changes to loads due to load modifiers such as various types of DERs.
- **Scenario analysis** assesses the potential impact of various plausible future events to inform the flexibility needed in grid plans and test their robustness under different potential conditions.

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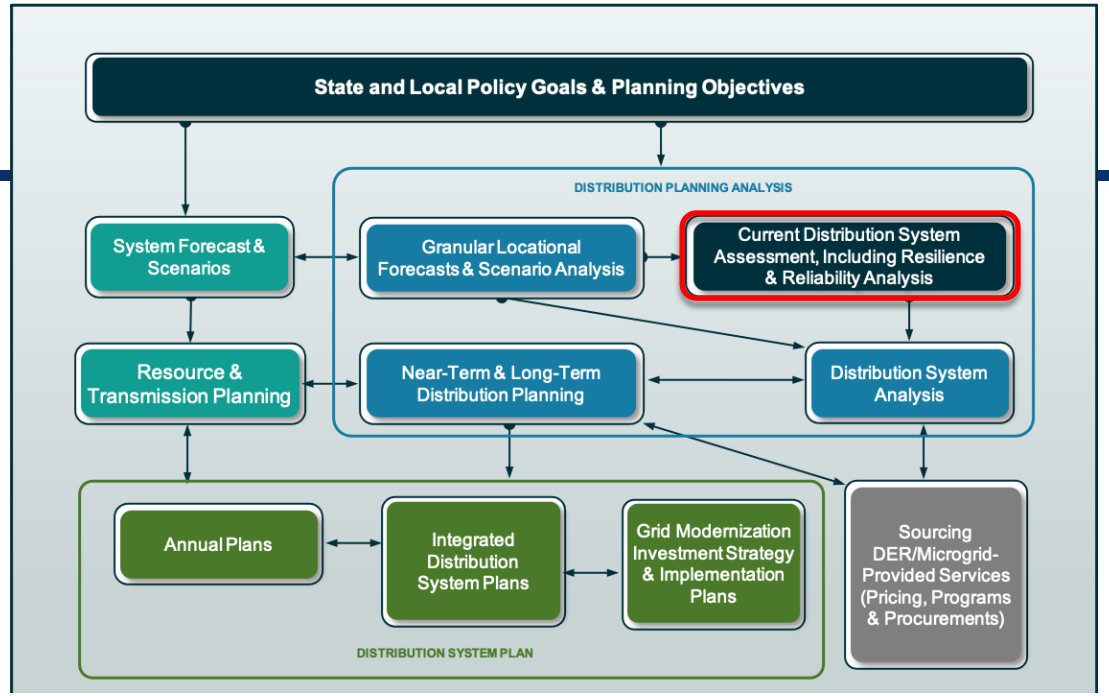
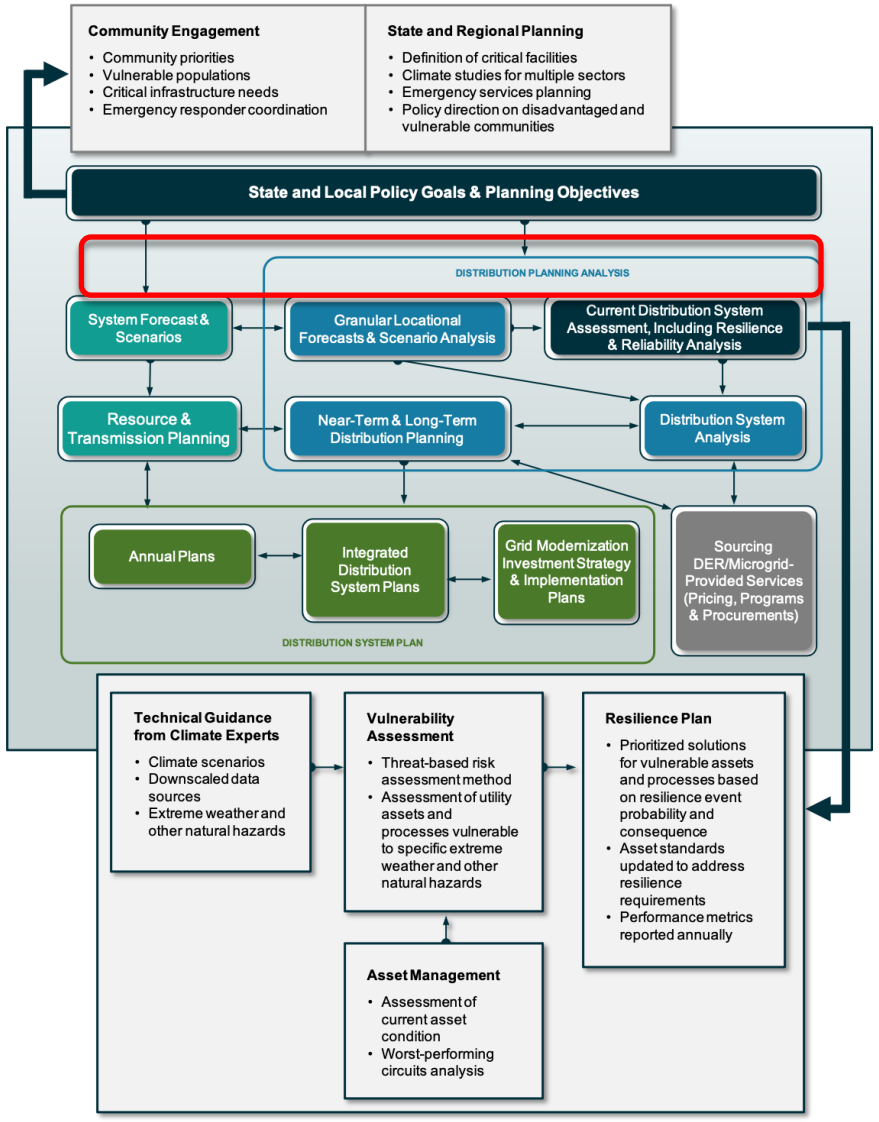


Current distribution system assessment evaluates asset condition and operational performance with respect to planning criteria and service standards, *including for reliability and resilience*.

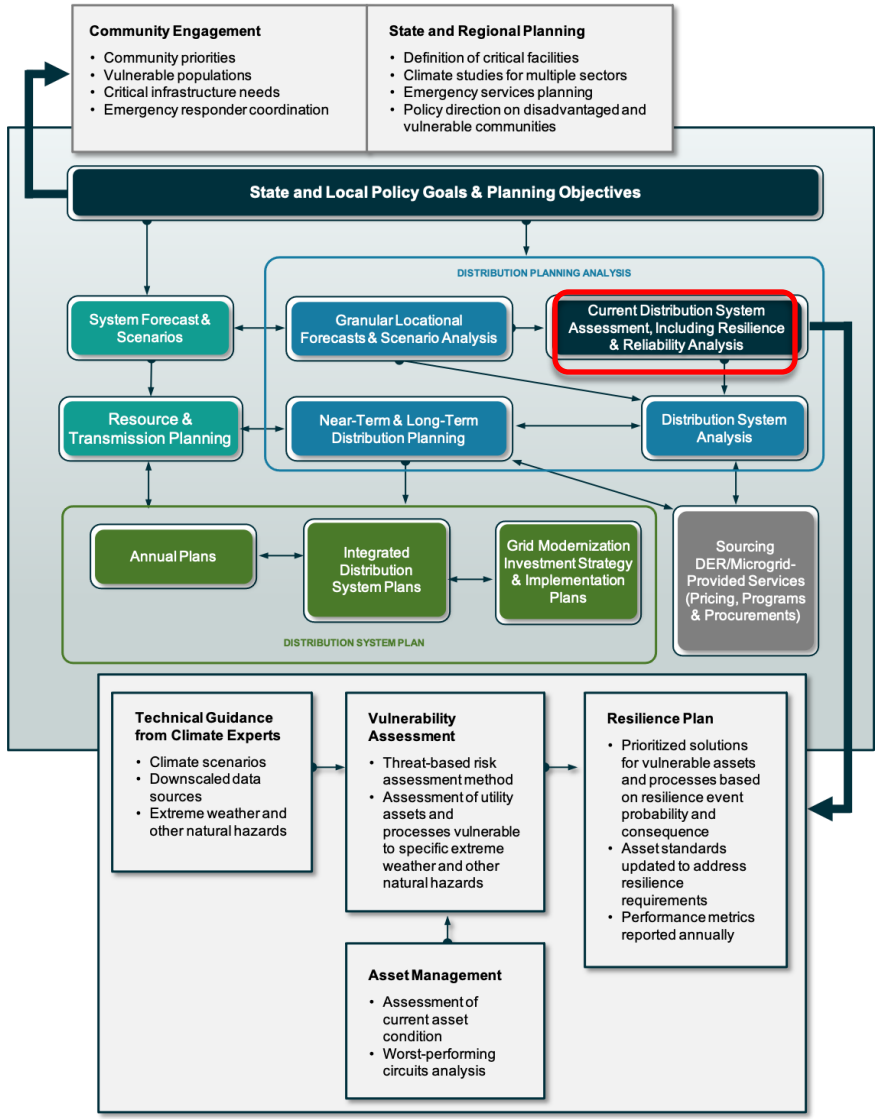
- **Asset management strategy** is the process of managing physical infrastructure for delivering electric service, including a systematic analysis of the condition and performance of physical grid assets.
- **Worst-performing circuits analysis** examines outage data to develop a list of circuits with the worst reliability performance and assess potential root causes to develop a remediation plan to reduce the duration and/or frequency of interruptions.
- **Threat-based risk assessment** identifies specific threats to assets and processes and categorizes vulnerability levels based on consequences (e.g., customer interruptions, grid damage).

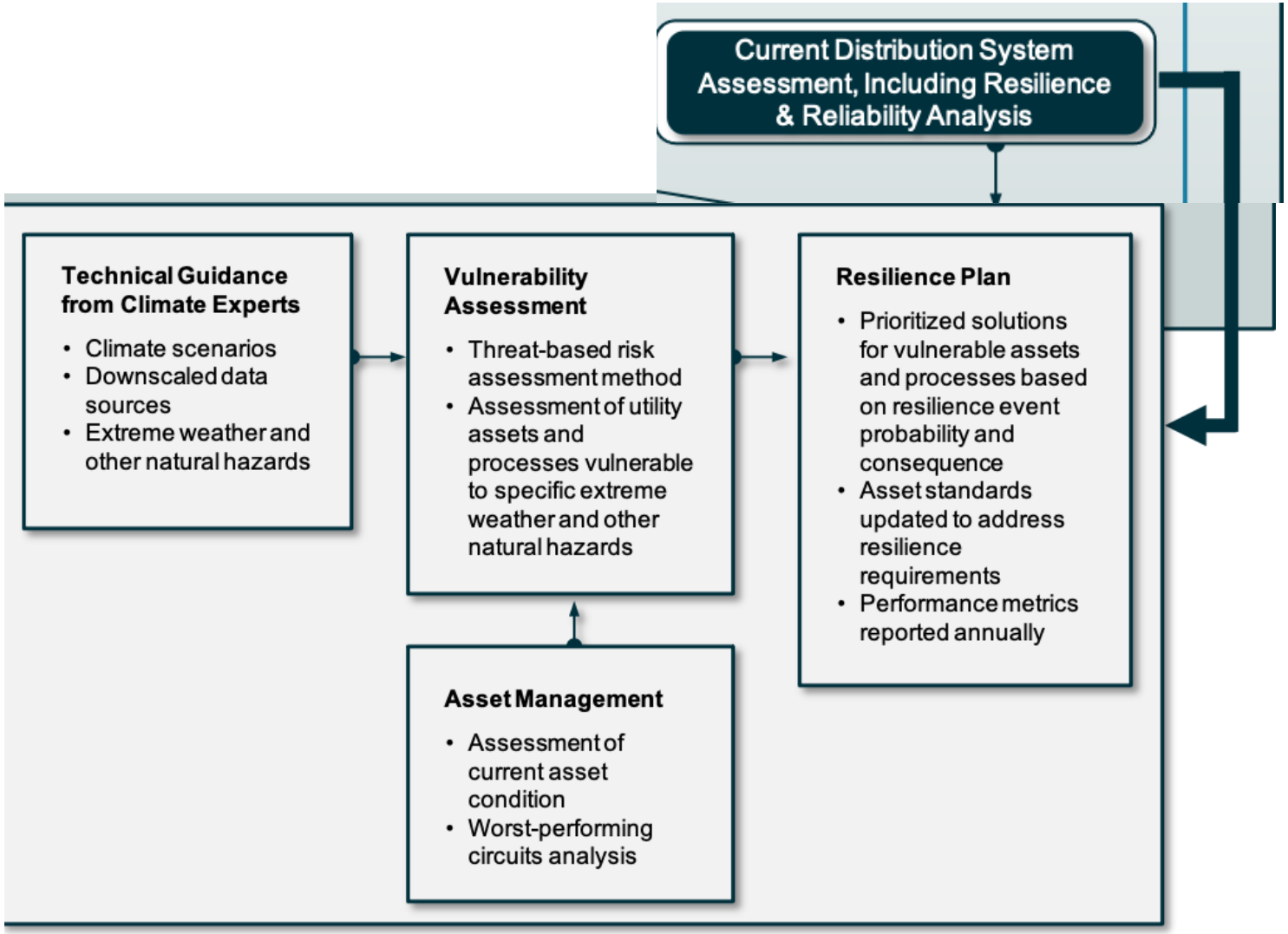
Integrating resilience planning and distribution planning (1)



Source: Berkeley Lab, *Grid Resilience Planning: State Requirements, Utility Practices, and Utility Plan Template*

Integrating resilience planning and distribution planning (2)





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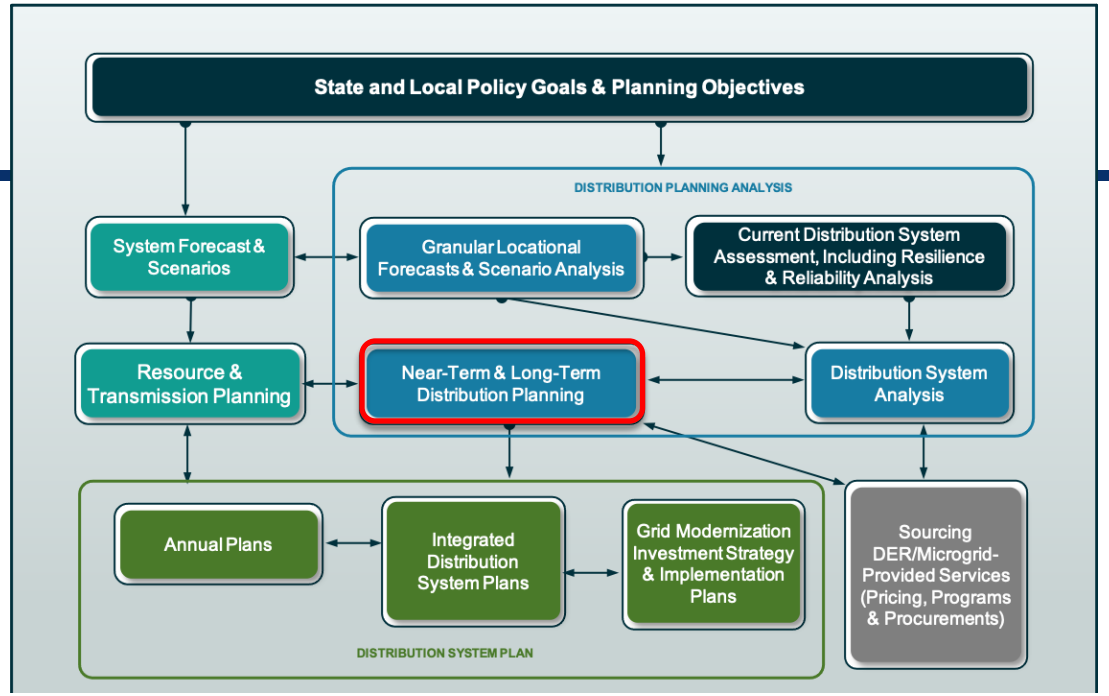

Long-term plans establish the utility's strategy for capital investments and other expenditures to address identified grid needs, typically over a 10-year period. **Near-term plans** identify expenditures with greater specificity over the next 3–5 years.

- **Cost-effectiveness evaluation** assesses benefits and costs of grid investments and qualitative factors to determine an optimal course of action to meet identified grid needs.
- **Multi-objective decision-making** is a set of methods to prioritize expenditures that provide the greatest value for meeting state goals, customer needs, regulatory requirements, and utility criteria.
- **Coordinated planning** harmonizes outputs from traditionally siloed planning processes (e.g., transmission and distribution planning) by enhancing consistency in assumptions and methods. **Integrated planning** unifies processes to streamline analyses, mitigate misalignment, and increase resource efficiency.

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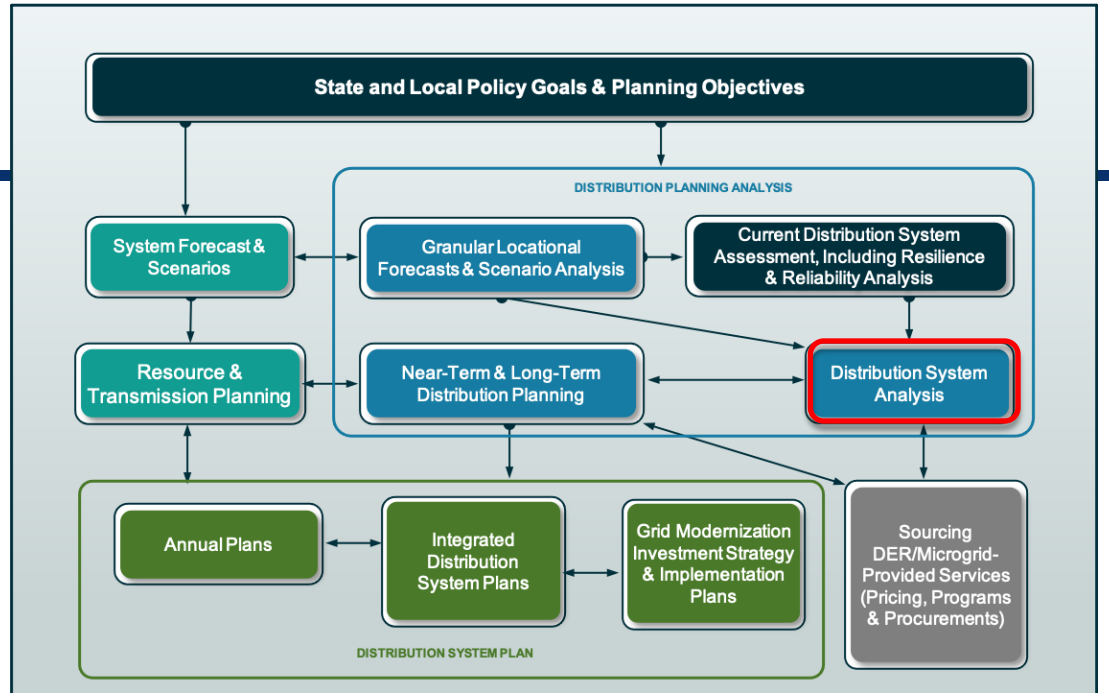

Distribution system analyses include engineering, economic, and other technical studies necessary for an effective planning process for local grids.

- **Hosting capacity analysis** identifies the amount of DERs that can be interconnected without adversely impacting power quality or reliability under existing control and protection systems and without infrastructure upgrades.
- **Value of DERs** derives from their capability to provide load relief, reduce power interruptions, address voltage issues, enhance resilience, or meet local energy needs. The potential value depends on capability to provide needed grid services at specific locations and times.
- **Interconnection** is the result of adding a DER to a distribution system. The term may refer to the technical, procedural, and legal requirements of the interconnection process or the physical location at which the DER provides certain electrical and interoperability capabilities.

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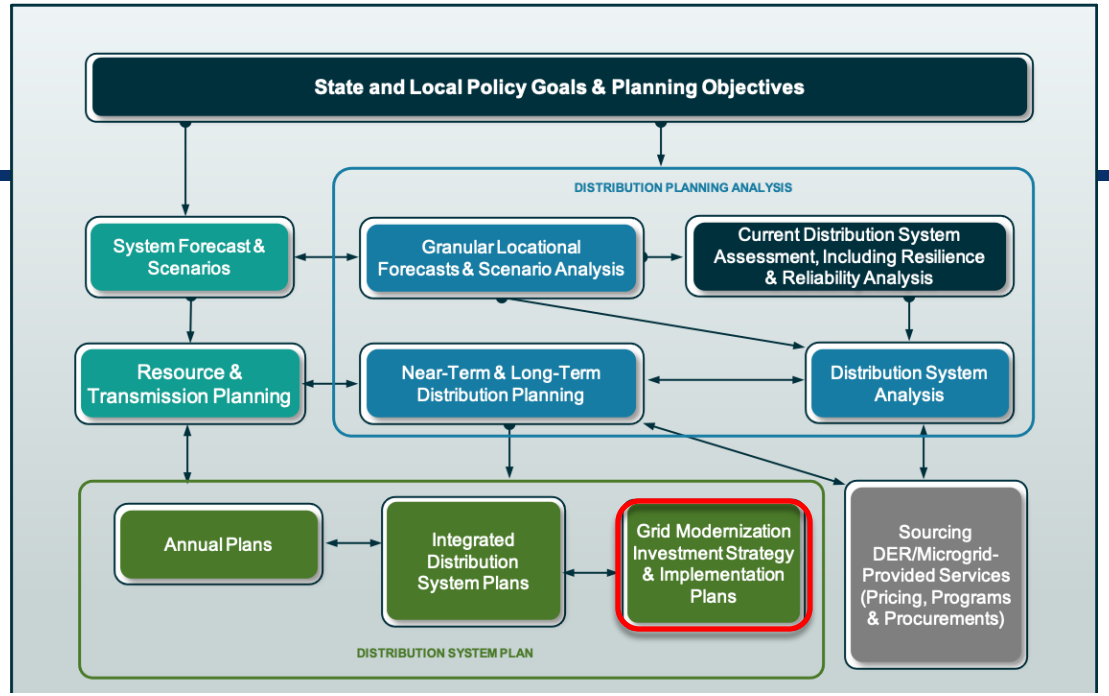

Grid modernization strategy & implementation plans establish a technology roadmap for capital investments, programs, and other expenditures. Grid modernization plans are informed by the IDSP and, ideally, are filed together.

- The **distribution investment strategy and implementation plan** provides the utility's roadmap for meeting multiple planning objectives in an affordable way over the planning horizon. It demonstrates how the utility translates planning objectives into expenditure decisions and describes near-term needs in the context of long-term goals.
- **Functional requirements analysis** is a business process that identifies potential changes to utility organizational activities involving people, processes, and technologies to address specific grid needs.

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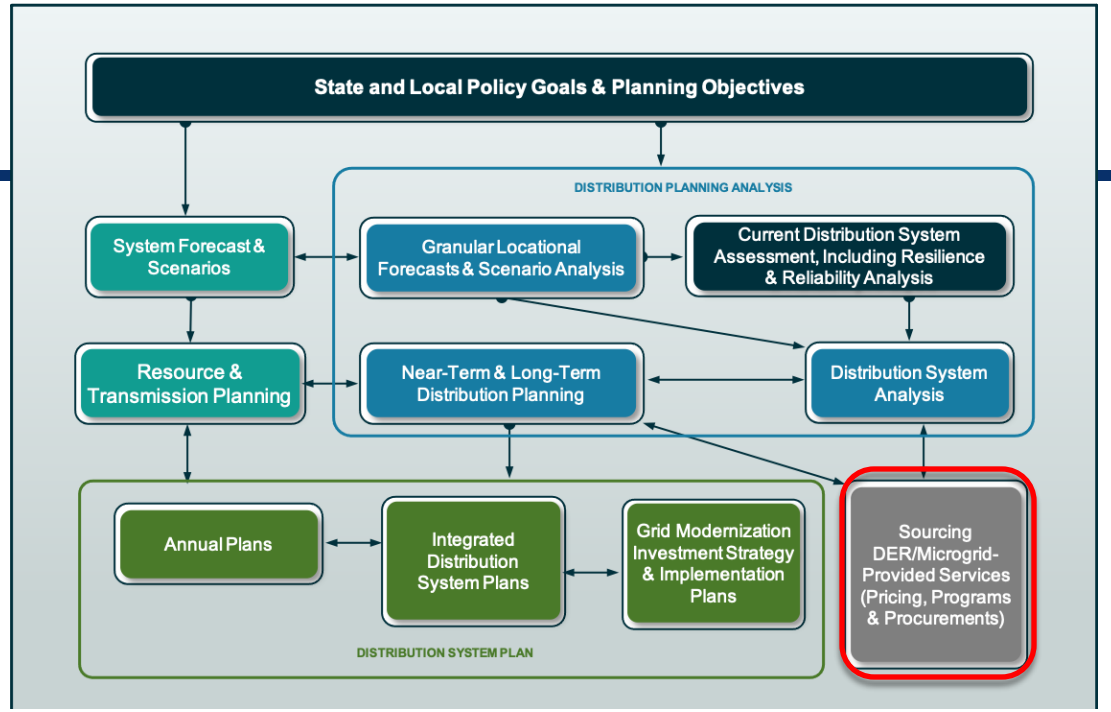
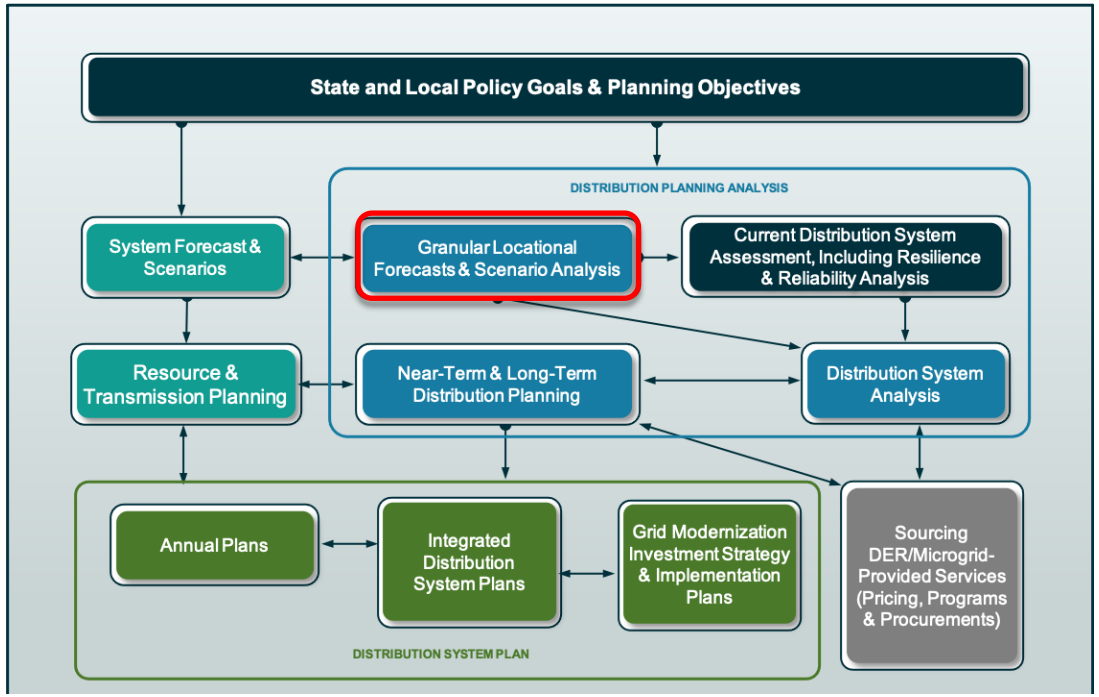


Sourcing DER/microgrid-provided services includes programs, procurements, and pricing to meet some distribution system needs with DERs.

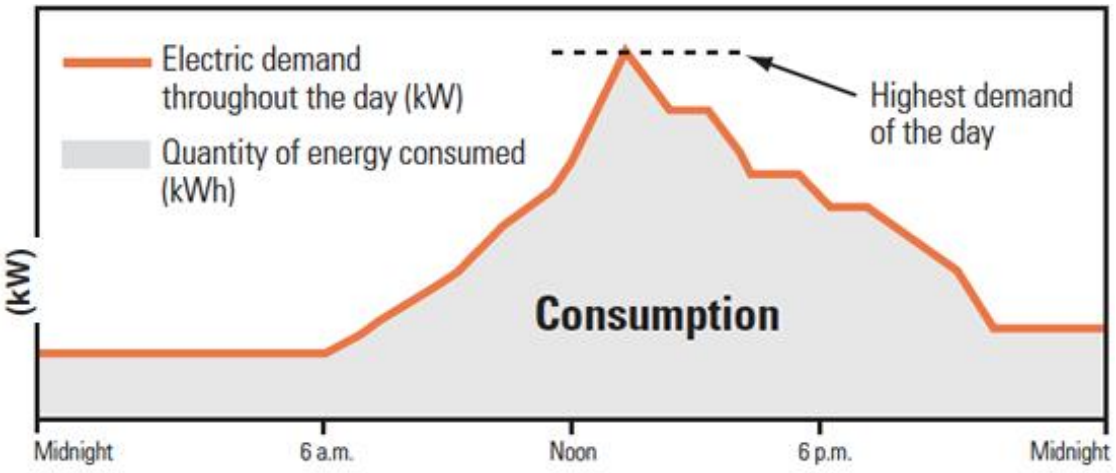
- **Geotargeting programs** includes focusing incentives by grid location or providing higher incentives to address a specific locational grid need through DERs.
- **Procurements** are solicitations for non-wires alternatives to defer traditional distribution system investments, such as feeder and substation upgrades, by acquiring DERs to provide specific grid needs — e.g., to provide load relief, reduce power interruptions, or improve resilience.
- ***Pricing*** *includes designing new or adapting existing tariffs for utility customers to include location- and time-sensitive distribution system benefits of DERs. See Carvallo and Schwartz 2023.*

Example Section: Load and DER Forecasting

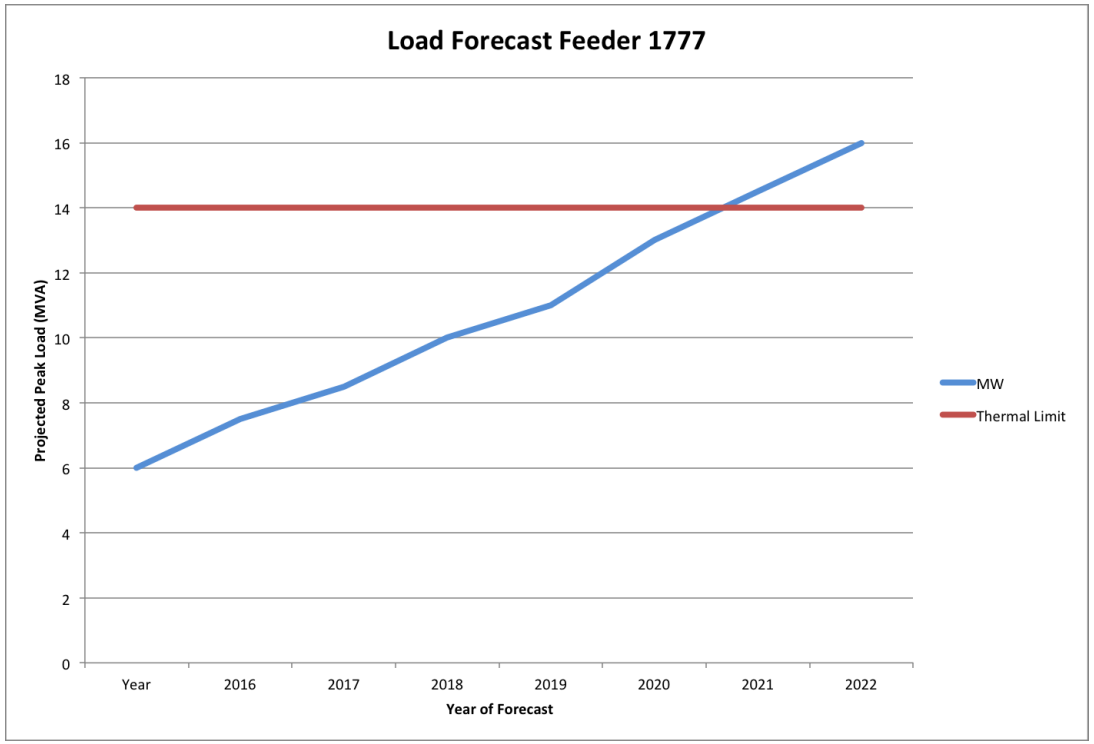


Why is load and DER forecasting important?

- Projecting peak demand at specific locations on the distribution system informs the timing, need, and type of investments.
  - For example, to address capacity shortfalls, power factor and voltage issues, thermal overloads

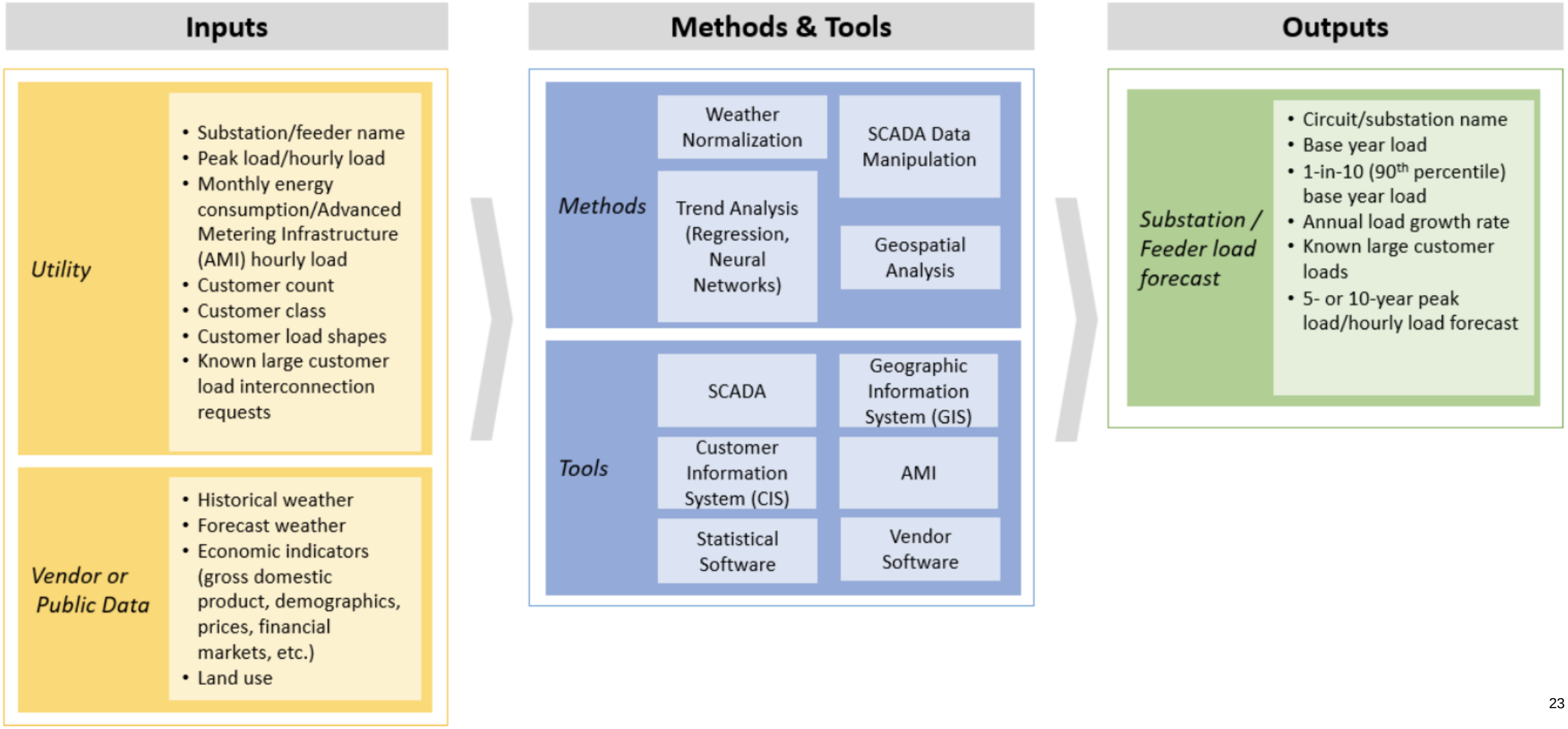


Source: We Energies

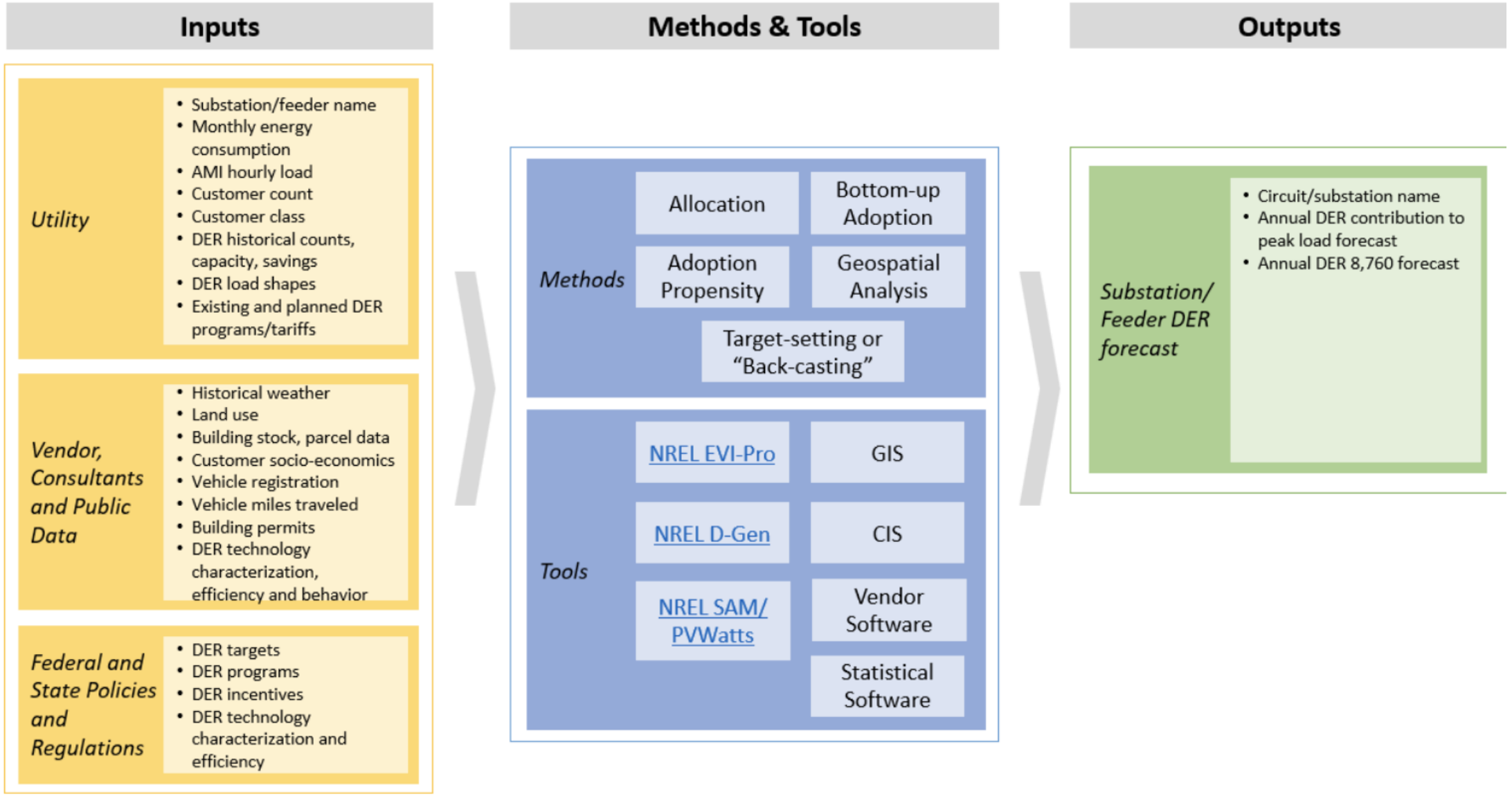


Source: Distribution System Planning 101

Load forecasting process



DER forecasting process



Roles and responsibilities

Public utility commissions

- ☐ Provide guidance to regulated utilities on developing forecasting scenarios consistent with state policies.
- ☐ Require reporting on forecast error metrics and forecast improvements to avoid utility over- or under-investment to meet loads.

Utilities

- ☐ Develop spatial load forecasts annually for distribution substations and circuits.
- ☐ Revise forecasts continually based on error metrics and emerging load drivers.

State energy offices, utility consumer advocates and other stakeholders

- ☐ Participate in technical meetings and regulatory proceedings to provide feedback on forecasting inputs, methods, DER adoption propensity models, and scenarios to meet state and local policies and priorities.

Best practices

- ☐ Adopt **scenario or probabilistic forecasting techniques** to better capture uncertainty and manage risk — and update decision-making processes to use these inputs.
- ☐ Incorporate **risk analysis**, including to account for forecast bias.
- ☐ **Revise forecasts to address errors** in key data sources and **add information** not included in the original forecast.
- ☐ Choose the right type of function for **load-temperature relationships**.
- ☐ Consider **price elasticity** to electricity rates.
- ☐ Conduct **sensitivity analysis** to understand how economic forecast errors translate into load forecast errors.
- ☐ Adopt **hourly forecasts**, such as 8,760 (every hour of the year) or 576 (one 24-hour weekend day and one weekday for each month of the year).
- ☐ Adopt **longer-term forecasting horizons** (>15 years) that align with policy goals.
- ☐ Incorporate **adoption propensity models** for DERs and electrification.
- ☐ Create **spatial load forecasts** with customer-level resolution.
- ☐ **Align forecasts** across utility departments.
- ☐ **Reconcile forecasts** — distribution-level, bottom-up forecast and corporate.

Example state practices

- **California** - Energy Commission (state energy office) develops system-level, demand-side forecasts
  - Baseline demand, BTM distributed generation, transportation, additional achievable energy efficiency, additional achievable fuel substitution, and long-term demand scenarios (see Demand Side Modeling web page)
- **Hawaii** - The Public Utilities Commission (PUC) directed Hawaiian Electric Companies to convene stakeholder groups to discuss development of integrated grid plans.
  - Topics addressed by the Distribution Planning Working Group include circuit-level forecasts and forecasting tools.
- **Colorado** - The PUC requires utilities to develop forecasts under at least two load scenarios: load growth associated with existing state policy and a "high" growth scenario
- **Vermont** - The Department of Public Service requires that load forecasts account for levels of building and transportation electrification that result from compliance with state climate policy.
  - Requirements also specify that utilities forecast peaks for both summer and winter and springtime minimum load.
- Some states require load forecasts to account for DER growth (e.g., **CA, CO, MI, MN, NV, VT**).
- Some states require load forecasts to include new building and transportation electrification loads (e.g., **CO, HI, MN, NY, NV, VT**).

Example utility practices

- **Duke Energy (SC)** - Utility developed "Morecast" in-house for its Integrated System Operations Plan
  - 10-year, hourly distribution system forecast at the circuit level
  - Describes aggregate load at the beginning of the primary voltage feeder
  - Forecasts for load, EVs, DERs, and customer programs are used to build circuit-level net load forecasts
- **Hawaiian Electric Companies** - Utility convenes a Forecast Assumptions Working Group for its Integrated Grid Planning stakeholder engagement process
- **Eversource Energy (MA)** - Forecasting and Electric Demand Assessment Methodology describes how forecasting fits into the utility's overall distribution planning process

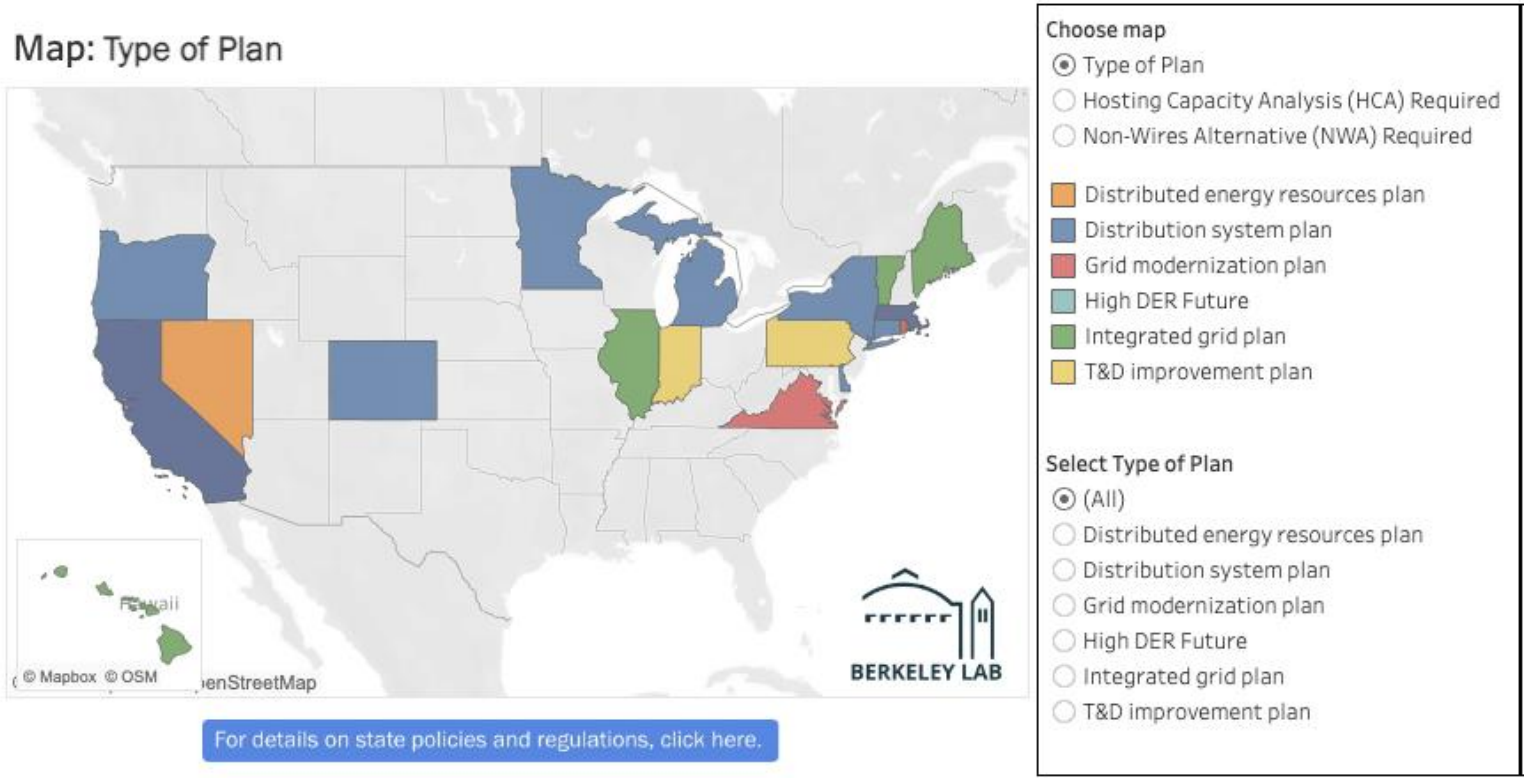
Tools

- LoadSeer - Scenario management, load growth, and capacity analysis
- Kevala's platform - Load and DER forecasting and DER adoption propensity modeling
- ITRON's forecasting analytics website includes MetrixIDR (short-term automated forecasting), MetrixND (statistical modeling), and MetrixLT (load shape modeling)
- SAS Energy Forecasting
- Eviews - Econometric analysis, forecasting, and simulation
- Clean Power Research PowerClerk Analytics - DER adoption scenarios and PV production
- AdopDER - Portland General Electric used this tool to estimate technical, economic, and achievable potential for more than 50 DER technologies and program measures
- NREL's Distributed Generation Market Demand (dGen™) model - Customer adoption of DERs
  NREL's TEMPO model - Long-term scenarios for transportation
- NREL's EVI-X Modeling Suite - EV charging infrastructure needs
- NREL's End-Use Load Profiles for the U.S. Building Stock - Represents all major end uses, building types, and climate regions in the U.S. commercial and residential building stock. Berkeley Lab and NREL published practical guidance on using the database.
- EPRI's Load Shape Library - Publicly-available dataset of end-use building load profiles
- Energetics' EV Watts - Data and analysis on vehicle electrification

Other Resources

State requirements for distribution planning

- Online catalog and data visualization
  - Update in early 2025
- **Interactive interface**
  - Types of distribution plans filed
  - Filing frequency
  - Planning horizon
  - Non-wires alternatives
  - Hosting capacity analyses
- Details by state
  - Proceedings, orders
  - Filed utility plans
  - Type of regulatory action
  - State goals and objectives
  - Term of action plan
  - Stakeholder engagement and equity provisions



Forthcoming companion report

- State goals and objectives
- Procedural requirements
- Stakeholder engagement
- Forecasting loads and DERs
- Hosting capacity analysis
- Baseline information requirements
- Grid modernization strategy
- Grid needs assessment
- Non-wires solutions
- Reliability and resilience analyses
- Equity
- Pilots
- Coordination with other planning processes

Reviews state requirements and utility approaches and offers best practices

Includes links to legislation, regulatory requirements, proceedings, orders, and filed utility plans

Grid resilience plans: Report and template

- Overview of state requirements and emerging best utility practices for resilience planning
- Template that utilities and states can adapt
- Key template elements
  - A vulnerability assessment
  - Description of proposed resilience programs
  - Projected costs and rate impacts

https://emp.lbl.gov/publications/grid-resilience-plans-state

Forthcoming distribution planning resources

- Distribution planning data, metrics & analyses that states can ask for
- Resilience planning data, metrics and analyses states can ask for
- Cost-effectiveness evaluation for grid modernization investments
- Cost recovery challenges for grid modernization investments
- Interactive resource for best practices for grid codes

Source: EPRI

More resources

- Berkeley Lab's integrated distribution system planning website
- DOE's Distribution Grid Transformation website
- U.S. Department of Energy, *Modern Distribution Grid* guidebooks
- S. Murphy, L. Schwartz, C. Reed, M. Gold, and K. Verclas, *State Energy Offices' Engagement in Electric Distribution Planning to Meet State Policy Goals*, National Association of State Energy Officials, 2023
- J. Carvallo and L. Schwartz, *The use of price-based demand response as a resource in electricity system planning*, Berkeley Lab, 2023
- J. Keen, E. Pohl, N. Mims Frick, J.P. Carvallo and L. Schwartz, *Duke Energy's Integrated System and Operations Planning: A comparative analysis of integrated planning practices*, Grid Modernization Laboratory Consortium, 2023
- Berkeley Lab, Pacific Northwest National Lab and NARUC, Peer-Sharing Webinars for Public Utility Commissions on Integrated Distribution System Planning, 2023
- N. Frick, S. Price, L. Schwartz, N. Hanus and B. Shapiro, *Locational Value of Distributed Energy Resources*, Berkeley Lab, 2021

In-person training on Integrated Distribution System Planning 2.0: Planning for Electrification and Distributed Energy Resources

- Hosted by NARUC, NASEO and Berkeley Lab, funded by USDOE
  - **Limited travel stipends are available for utility consumer advocates**
    - Reach out before making travel arrangements: Jessica Diaz (jdiaz@naruc.org)
- All new curriculum! Participants will learn:
  - Best practices across the U.S. for planning distribution systems
  - How to incorporate electrification and DERs in local grid planning
  - How to design stakeholder-informed planning processes to achieve state goals
  - Challenges and potential solutions
  - Questions to ask utilities
- Office hours with trainers
- Half-day State Action Planning Workshop facilitated by RMI
  - Apply learning to develop plans for advancing distribution planning in your state
  - Engage in interactive discussions and peer exchange to support implementation

- ***Charlotte, December 11-12* - Register now!***
- ***Detroit, March 11-12 - Register now!***
- ***Salt Lake City, April 23-24 -*** Register soon

**Tour EPRI Power Delivery and Utilization Lab in Charlotte on Dec. 13*

ENERGY MARKETS & POLICY

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