Energy System Planning for a Modern Electric Grid

Lisa Schwartz, Lawrence Berkeley National Laboratory

National Governors Association Energy Policy Institute
August 25, 2020

This work was funded by the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

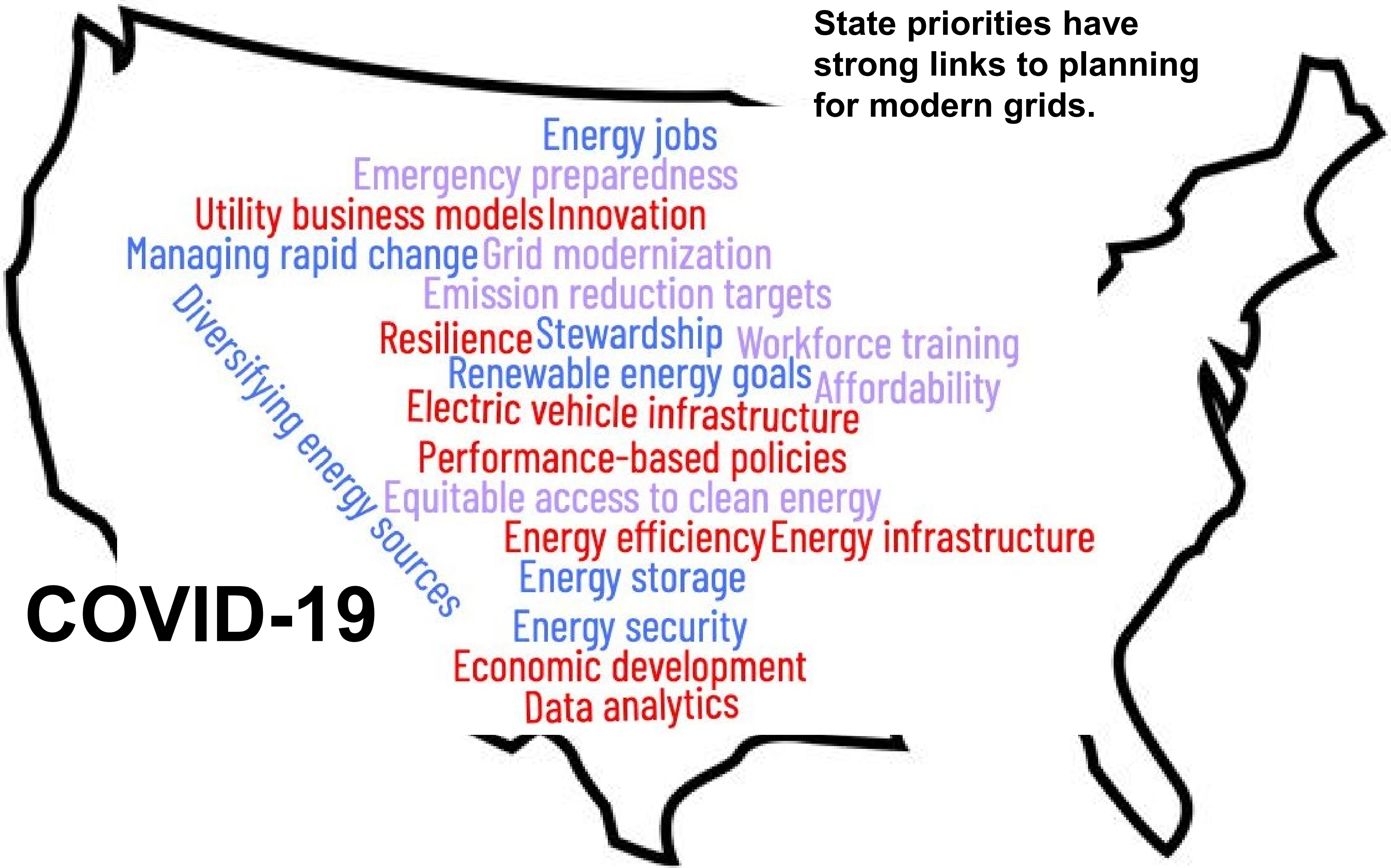
In this presentation

- ► Context: State energy-related priorities and potential state roles
- ► Electricity systems and modern grids
- ► State policies, grid challenges and opportunities
- ► Electricity system planning: activities, technologies and considerations
- ► Extra slides
  - ■ Example state objectives for distribution planning
  - ■ Example state requirements for distribution planning
  - ■ Resources for more information

Snapshot of energy-related priorities

From Day 1 of NGA Energy Policy Institute

State priorities have strong links to planning for modern grids.



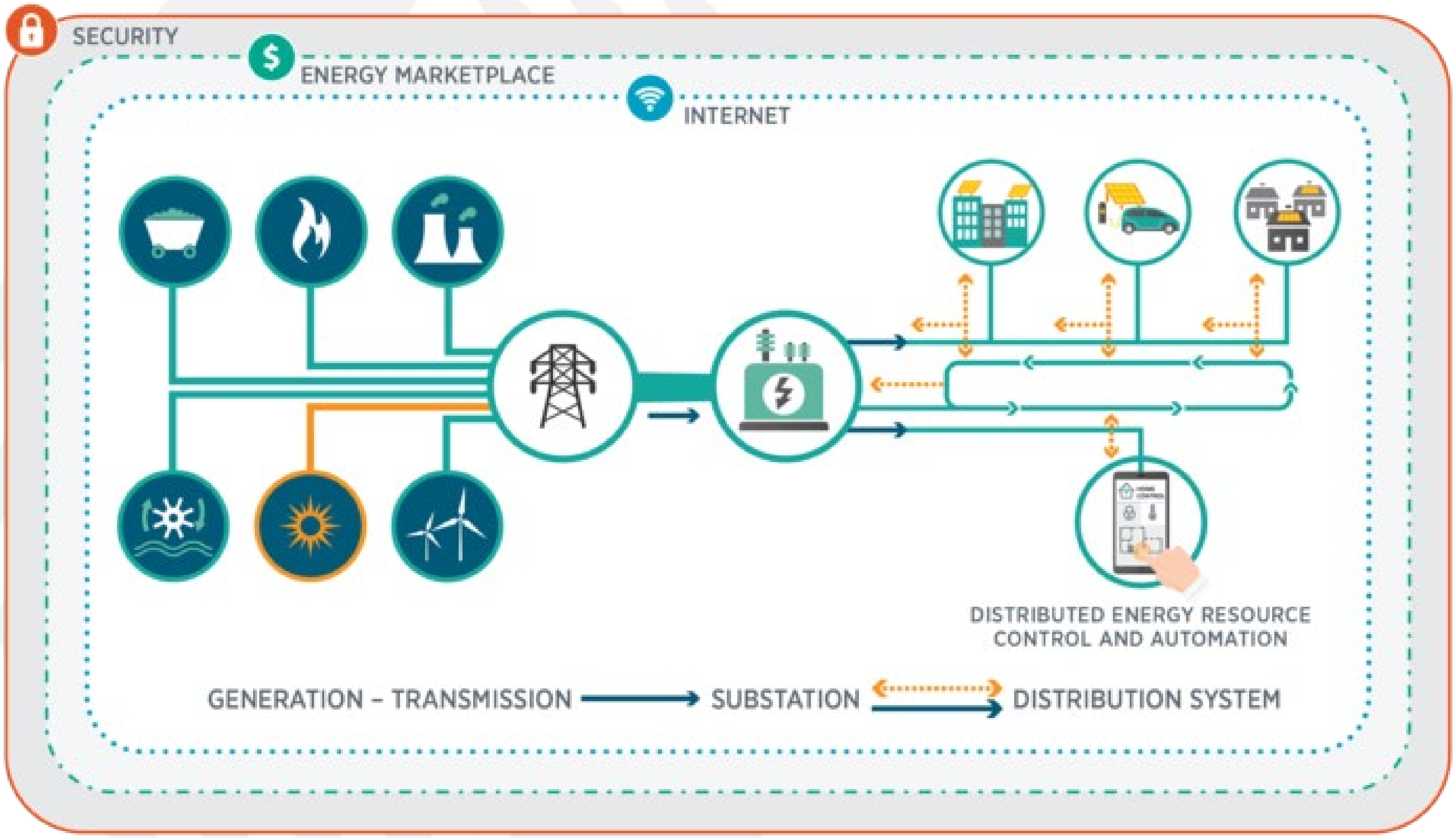
Potential state roles in planning modern grids

GRID MODERNIZATION LABORATORY CONSORTIUM
U.S. Department of Energy

- Lead by example
  - Statewide energy planning
  - Studies and pilots in publicly owned buildings
- Standards and protocols
  - Data access, privacy, interoperability, cybersecurity
- Requirements or guidance for state-regulated utilities
  - Value to customers
  - Enhanced analytical methods and practices
  - Identify barriers and solutions
- Executive branch initiatives
- Legislative action

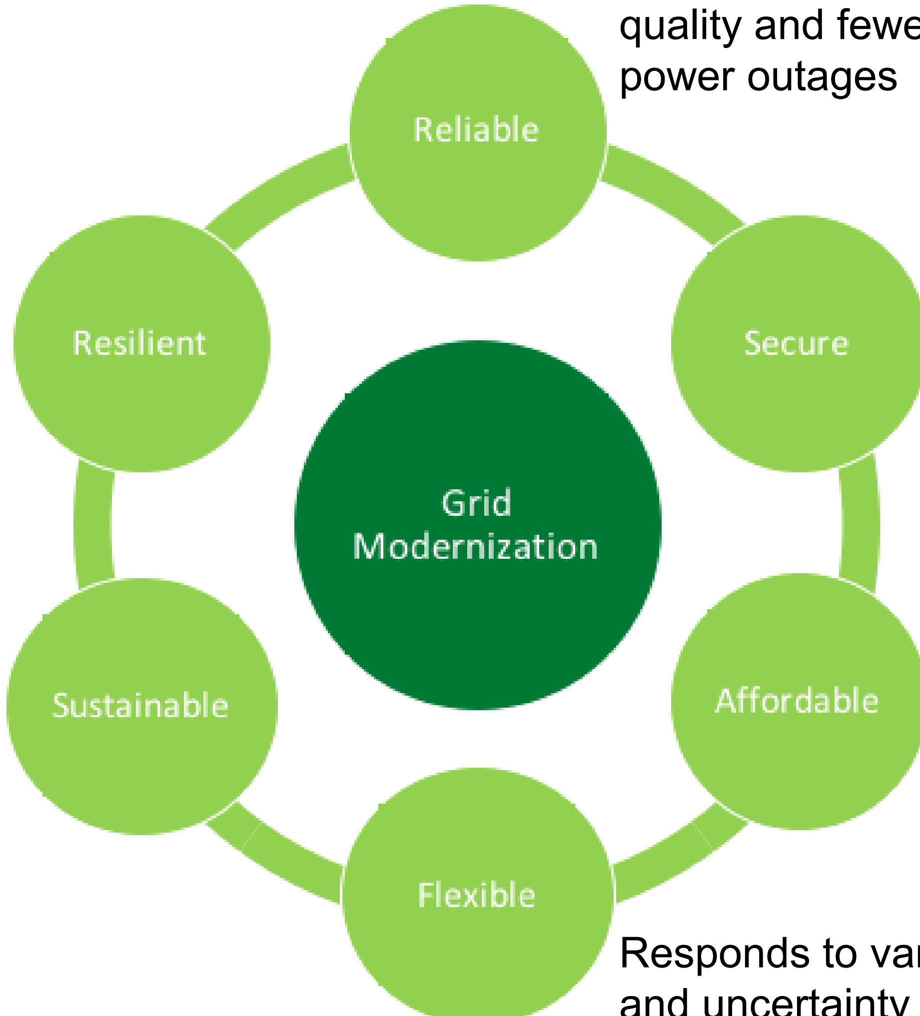
Source: National Governors Association

Electricity systems



Source: U.S. Department of Energy

What is a modern grid?



Improves power quality and fewer power outages

Increases protection of critical infrastructure

Maintains reasonable costs to consumers

Responds to variability and uncertainty of conditions

Facilitates broader deployment of clean generation and efficient end-use technologies

Quick recovery from any situation or power outage

Source: U.S. Department of Energy's *Grid Modernization Multi-Year Program Plan*

Example grid modernization principles: Hawaii

GRID MODERNIZATION LABORATORY CONSORTIUM
U.S. Department of Energy

HRS § 269-145.5(b) – *In advancing the public interest, the commission shall balance technical, economic, environmental, and cultural considerations associated with modernization of the electric grid, based on principles that include but are not limited to* **[emphasis added]**:

- *Enabling a **diverse portfolio of renewable energy resources**;*
- ***Expanding options for customers** to manage their energy use;*
- ***Maximizing interconnection of distributed generation** to the State's electric grids on a cost-effective basis at non-discriminatory terms and at just and reasonable rates, while maintaining the reliability of the State's electric grids, and allowing such access and rates through applicable rules, orders, and tariffs as reviewed and approved by the commission;*
- ***Determining fair compensation for electric grid services** and other benefits provided to customers and for electric grid services and other benefits provided by distributed generation customers and other non-utility service providers; and*
- ***Maintaining or enhancing grid reliability and safety** through modernization of the electric grids.*

Order 32491 – The Commission adopted additional principles related to:

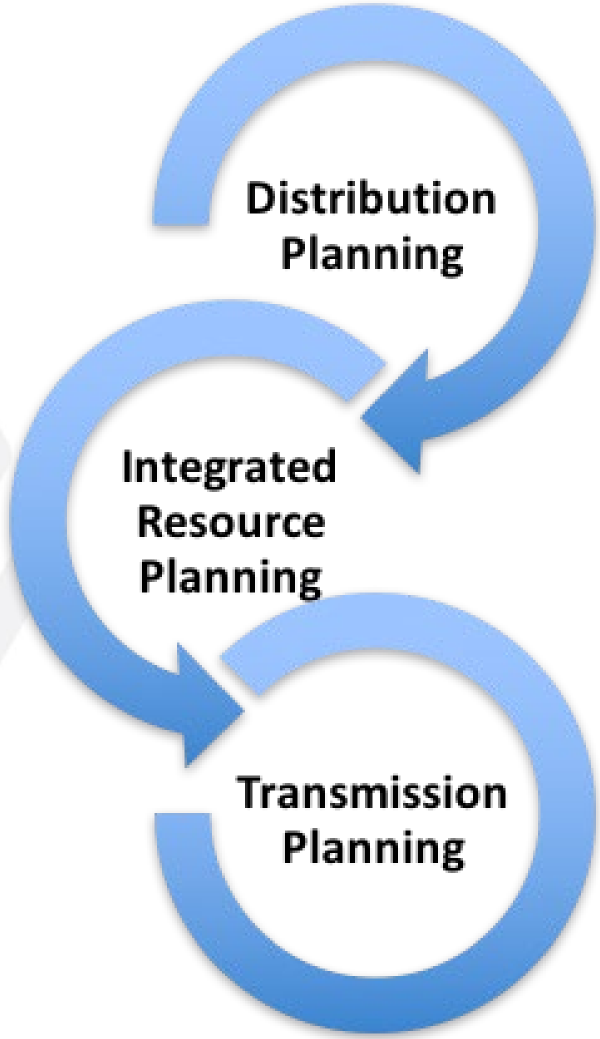
- **Grid platforms** for new products, services, opportunities for distributed energy resources (DERs)
- **Optimization of grid assets** and resources to minimize total system costs
- Greater **customer engagement** and options for consuming and providing energy services
- Enhancing **safety, security, reliability, and resilience** at fair and reasonable costs
- **Comprehensive, transparent and integrated distribution system planning**

State policies, grid challenges and opportunities

- State policies
  - Efficiency (30 states) and renewable energy targets (29 states)
  - Clean energy targets (12 states)
  - Storage policies (>15 states; also see PNNL policy database)
  - Electrification plans—e.g., CA, MA, MN, NY, VT
  - Greenhouse gas reduction goals (at least 15 states)
- Challenges
  - Growth in peak demand
  - Infrastructure constraints for transmission and distribution systems
  - Increase in variable generation—utility-scale and DERs
  - Cybersecurity
  - Maintaining affordability of essential electricity services
- Opportunities
  - Lower technology costs and improved functionality
  - Engaging consumers
  - Business practices and strategies—utilities, vendors and service providers
  - State lead by example
  - Utility, state, and local pilots and programs
  - *Improved planning processes*

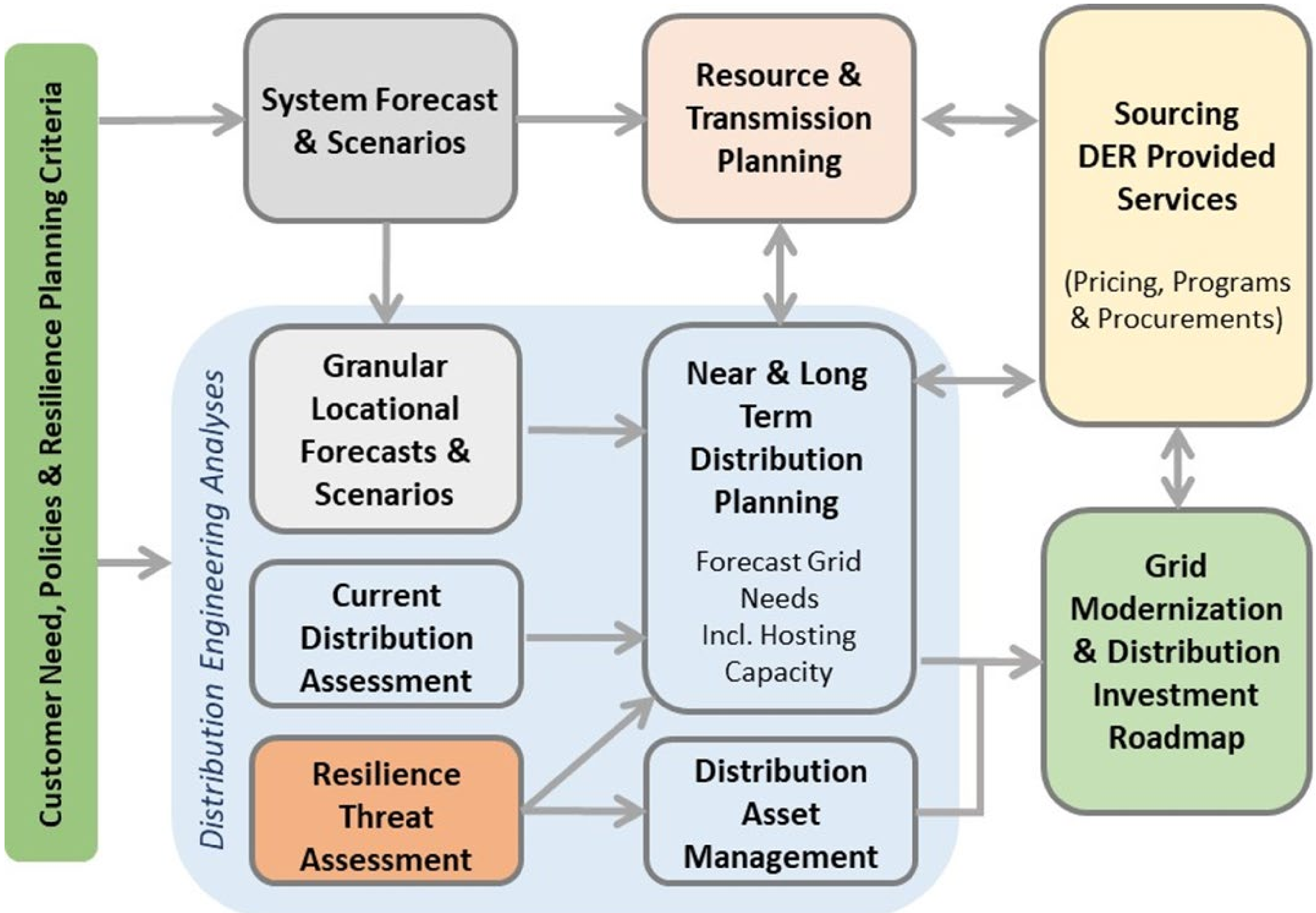
Electricity planning activities

- **Distribution planning** - Assess needed physical and operational changes to local grid
  - Annual distribution planning process
    - Identify and define distribution system needs
    - Identify and assess possible solutions
    - Select projects to meet system needs
  - Long-term utility capital plan
    - Includes solutions and cost estimates, typically over a 5- to 10-year period, updated every 1 to 3 years
- **Integrated resource planning** - Identify future investments to meet bulk power system reliability and public policy objectives at a reasonable cost
  - Can consider scenarios for loads and distributed energy resources and impacts on need for, and timing of, utility resource investments
  - *For states with vertically integrated utilities*
- **Transmission planning** – Identify future transmission expansion needs and options



Also: energy efficiency, demand-side management, and electrification plans

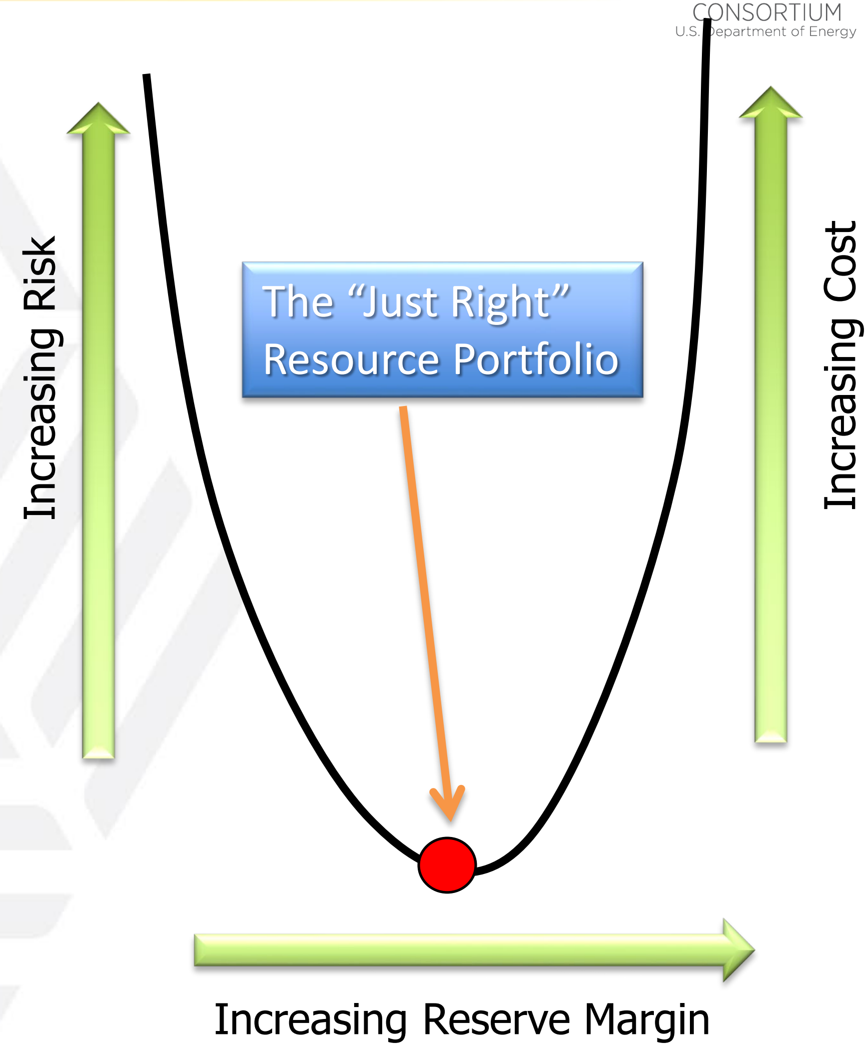
Integrated grid planning



Adapted from P. De Martini, *Integrated Distribution Planning*, ICF

See [DOE's Modern Distribution Grid initiative]

Planning in the face of uncertainty

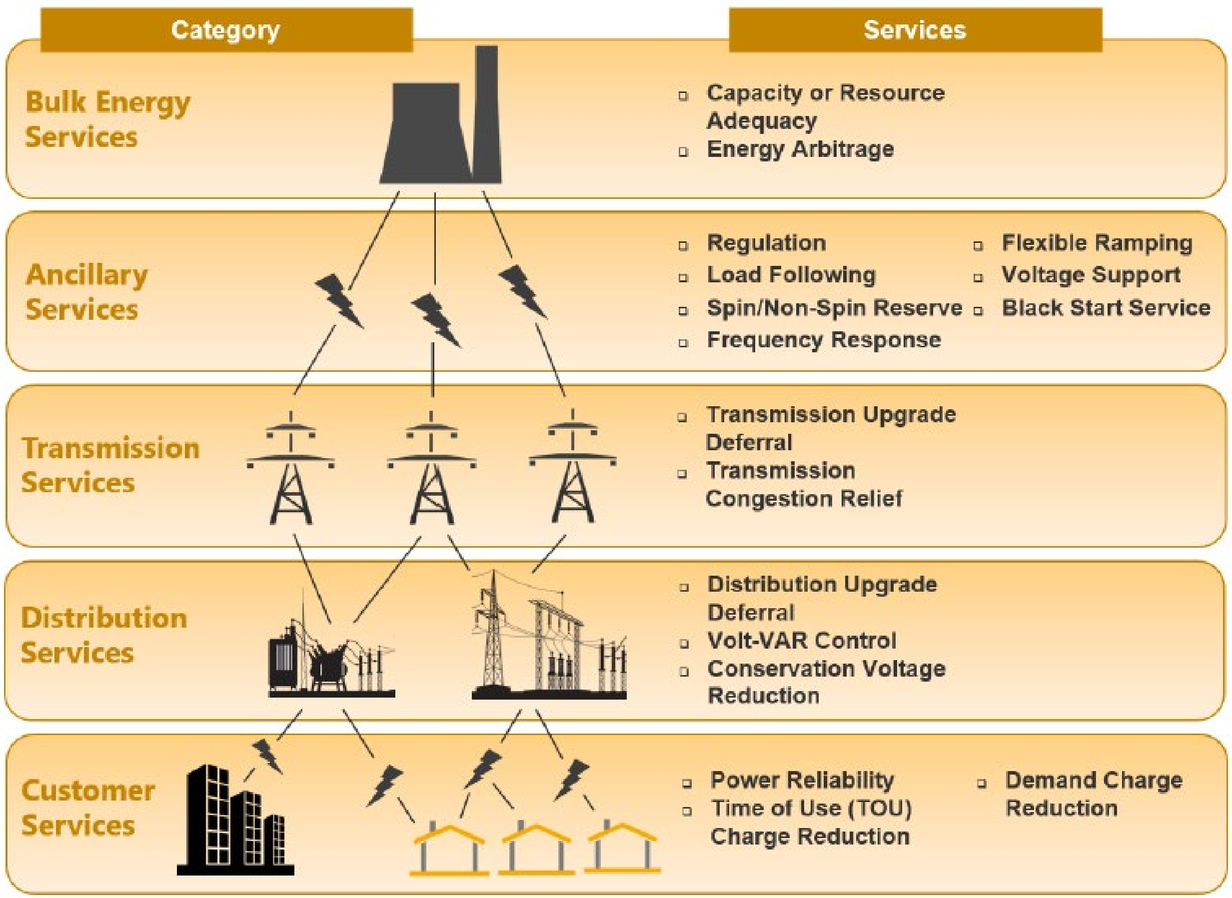


Source: Tom Eckman, Berkeley Lab

Planning with new technologies (1)

GRID MODERNIZATION LABORATORY CONSORTIUM
U.S. Department of Energy

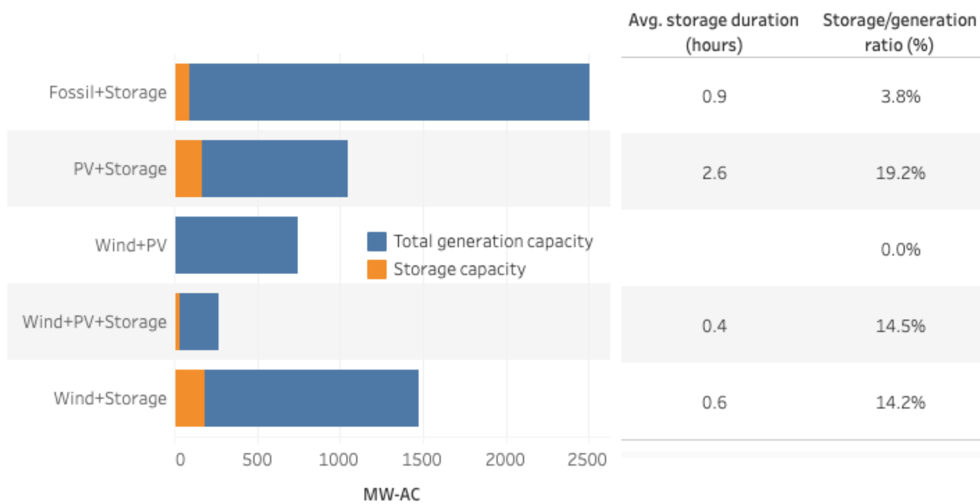
- Energy storage can provide grid services throughout the electricity system.



Source: Patrick Balducci, "Fundamentals of Energy Storage Valuation" (2020)

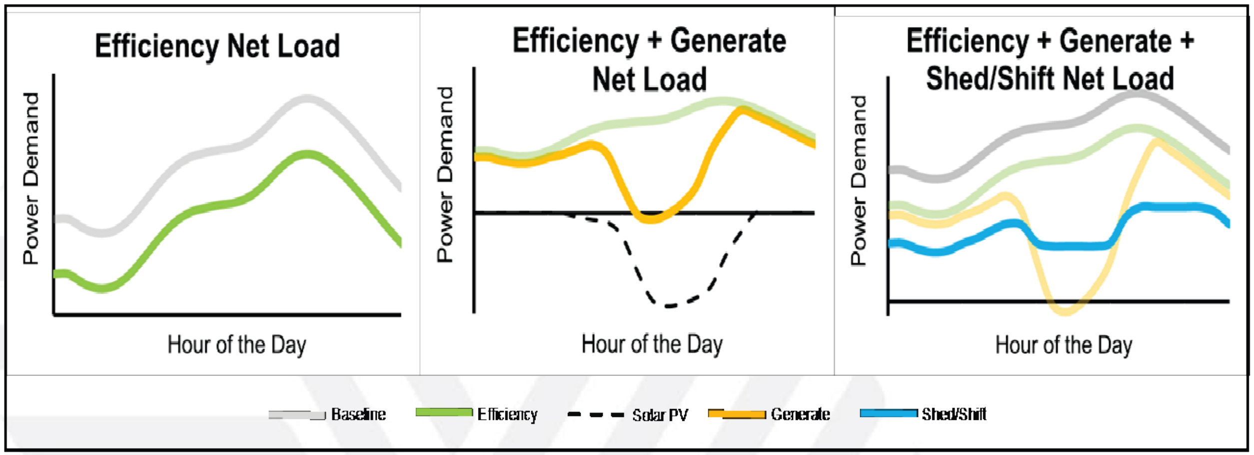
Planning with new technologies (2)

- [Hybrid power plants](#)
  - Fossil, solar, or wind *plus storage*
- Distributed energy resources
  - Resources sited close to customers that can provide some or all of their power needs; can reduce demand or provide supply to satisfy grid needs
  - Distributed generation, storage, energy efficiency and demand response



Source: Berkeley Lab

Planning with new technologies (3)



Source: Neukomm et al. 2019

- Grid-interactive efficient buildings use smart technologies and DERs to provide demand flexibility while co-optimizing for energy cost, grid services, and occupant needs and preferences in a continuous and integrated way
  - *Smart technologies* to manage DERs - advanced controls, sensors, models, and analytics
  - *Demand flexibility* - Capability of DERs to adjust a building's load profile across different timescales, including:
    - *Load shed*: Reduce electricity use for a short time and typically on short notice
    - *Load shift*: Change timing of electricity use
- Distribution system technologies—Geographic Information System, Outage Management System, Distribution Automation, Volt-var Optimization, and Advanced Distribution Management System that can integrate these components, plus Advanced Metering Infrastructure and DER Management Systems

Valuing demand flexibility in planning

► Value of a single “unit” (e.g., kW, kWh) of grid service provided by demand flexibility is a function of:

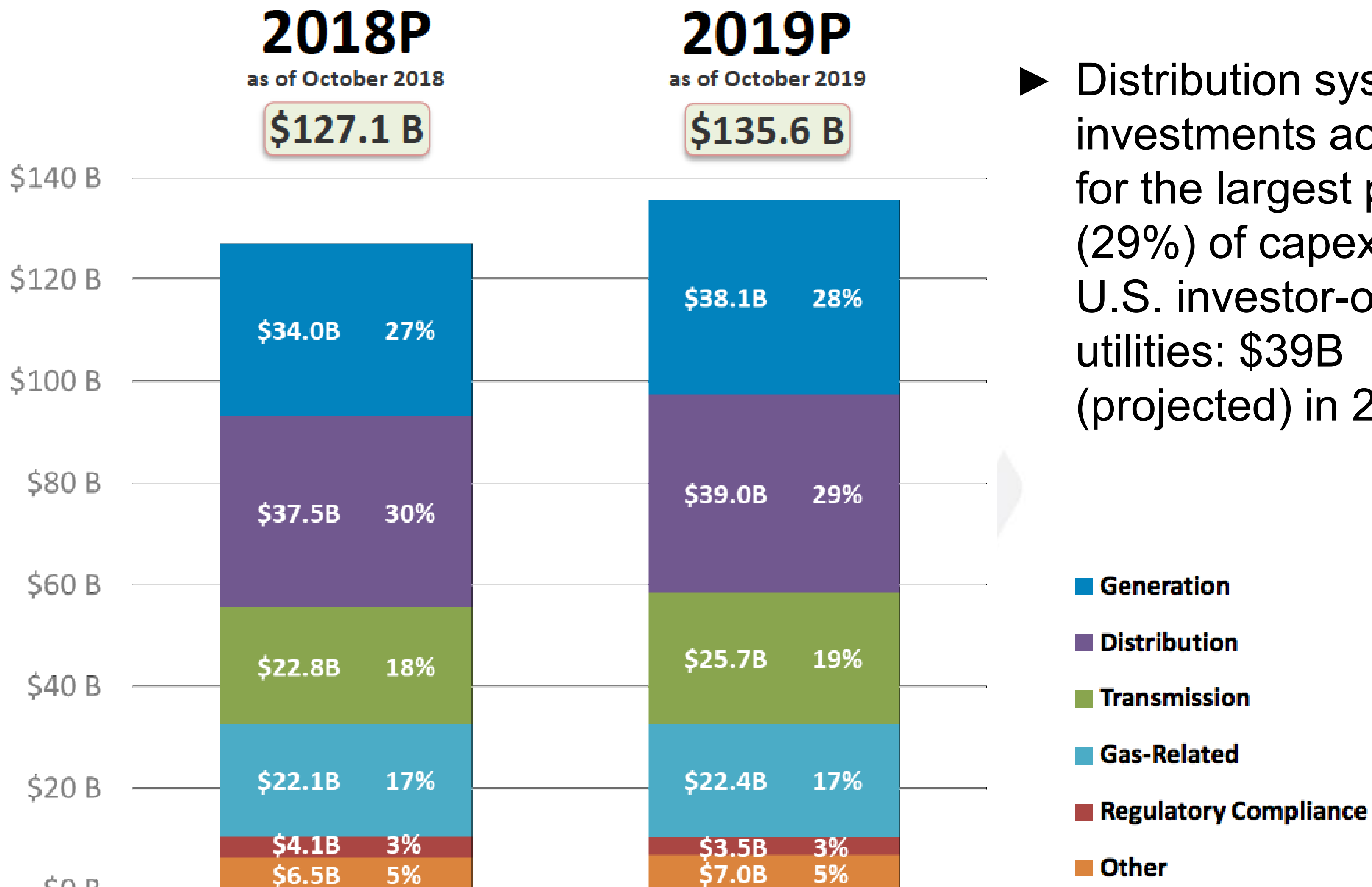
- *timing* of the impact on load profiles – sub-hourly, daily, monthly, and seasonally
- *location*
- *grid services* provided
- *expected service life* (persistence)
- *avoided cost of least expensive alternative* providing comparable grid service

Enhanced valuation methods to account for:	Distribution System Planning			Generation Planning		Transmission Planning	
	Hosting Capacity (for distributed generation capacity)	Energy Analysis (loss estimation)	Thermal Capacity (peak capacity)	Capacity Expansion Modeling	Market-Based Mechanisms	Capacity Expansion Modeling	Congestion Pricing Analysis
1. All electric utility system economic impacts resulting from demand flexibility	●	●	●	●	●	●	●
2. Variations in value based on when demand flexibility occurs	●	●	●	●	●	●	●
3. Impact of distribution system savings on transmission and generation system value	◔	●	◑	◑	◑	◑	◑
4. Variations in value at specific locations on the grid	●	●	◔	◔	◔	●	●
5. Variations in value due to interactions between DERs providing demand flexibility	●	◕	●	◕	◕	◕	◕
6. Benefits across the full expected useful lives of the resources	◑	◑	●	◑	◑	●	●
7. Variations in value due to interactions between DERs and other system resources	◕	◑	●	●	●	●	●

● most applicable, ◔ least applicable

[Determining Utility System Value of Demand Flexibility From Grid-interactive Efficient Buildings]

Why may states be interested in distribution planning?



- Distribution system investments account for the largest portion (29%) of capex for U.S. investor-owned utilities: $39B (projected) in 2019

Source: Edison Electric Institute

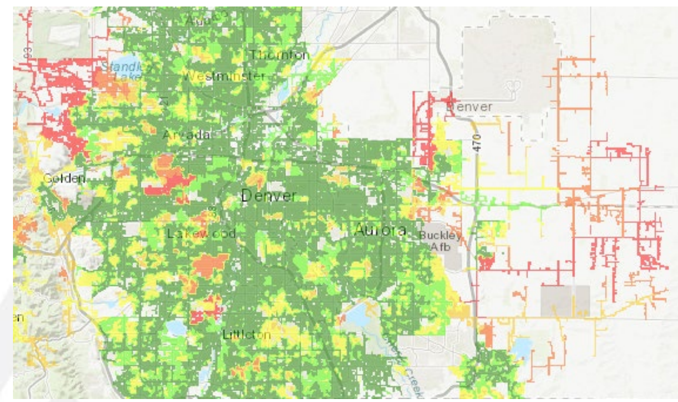
States are responding to a variety of drivers for distribution planning.

- More DERs deployed — costs down, policies, new business models, consumer interest
- Resilience and reliability (e.g., storage, microgrids)
- More data and better tools to analyze data
- Aging grid infrastructure and utility proposals for grid investments
- Need for greater grid flexibility in areas with high levels of wind and solar
- Interest in conservation voltage reduction and volt/VAR optimization
- Non-wires alternatives to traditional solutions may provide net benefits to customers

Elements of distribution plans considering DERs

GRID
MODERNIZATION
LABORATORY
CONSORTIUM
U.S. Department of Energy

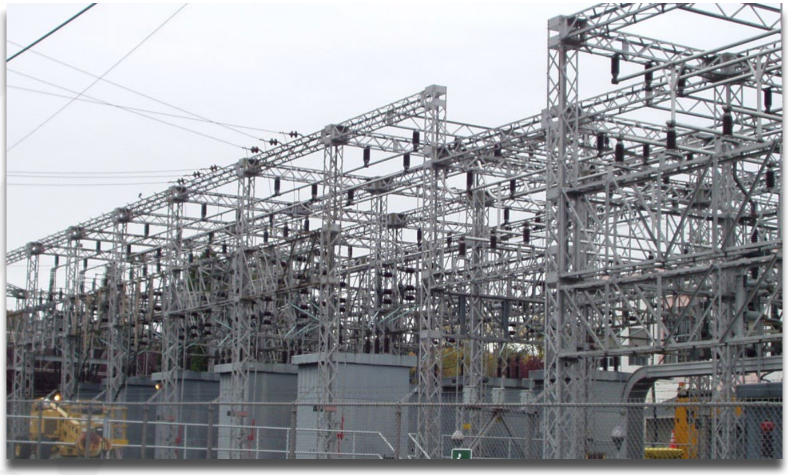
- Baseline information on current state of distribution system
  - System statistics, reliability performance, equipment condition, historical spending by category
- Description of planning process
  - Load forecast—peak demand for feeders and substations
  - Risk analysis for overloads and mitigation plans
  - Budget for planned capacity projects



- Distribution operations—vegetation and event management
- DER forecast—Types and amounts
- Hosting capacity analysis—the amount of DERs (typically solar PV) that can be interconnected to the distribution system without adversely impacting power quality or reliability under existing control and protection systems and without infrastructure upgrades
- Non-wires alternatives analysis (*next slide*)
- Grid modernization strategy—may include request for certification for major investments
- Action plan
- Additional elements may include coordination with integrated resource planning, stakeholder and customer engagement, and proposals for pilots

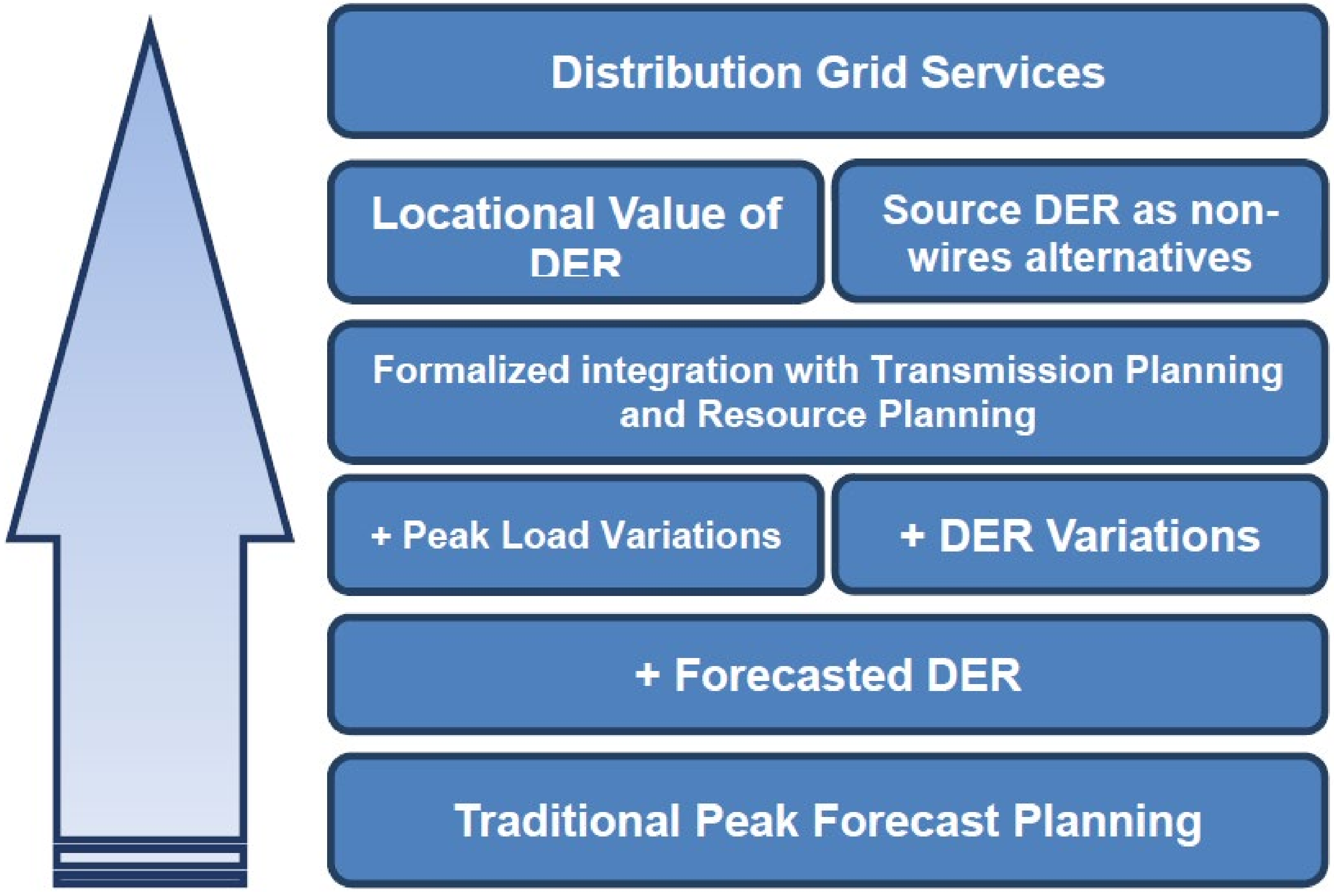
Considering non-wires alternatives

- Non-wires alternatives (NWA) are options for meeting distribution (and transmission) system needs related to load growth, reliability and resilience.
  - Single large DER (e.g., battery) or portfolio of DERs that can meet the specified need
- Objectives: Provide load relief, address voltage issues, reduce interruptions, enhance resilience, or meet generation needs
- Potential to reduce utility costs
  - Defer or avoid infrastructure upgrades
  - Implement solutions *incrementally,* offering a flexible approach to uncertainty in load growth and potentially avoiding large upfront costs for load that may not show up



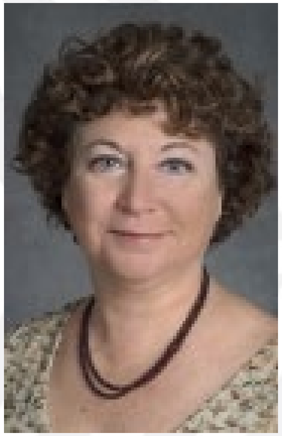
- Typically, the utility issues a competitive solicitation for NWA for specific distribution system needs and compares these bids to planned traditional grid investments (e.g., distribution substation transformer) to determine the lowest reasonable cost solution.
- DERs must be in the right place and operate at the right time to meet grid needs. The value of DERs for the distribution system depends on location.

Evolution in distribution planning practices



Source: Xcel Energy, *Integrated Distribution Plan*, Nov. 1, 2019

Contact



Lisa Schwartz, Deputy Leader
Electricity Markets and Policy Department
Berkeley Lab
(510) 486-6315; lcschwartz@lbl.gov
https://emp.lbl.gov/

Click here to stay up to date on our publications, webinars and other events and follow us @BerkeleyLabEMP

Extra Slides

Example state objectives for distribution planning

- **Michigan**: Safety, reliability and resiliency, cost-effectiveness and affordability, and accessibility (order in U17990 and U-18014 dockets)
- **Nevada**: "reductions or increases in local generation capacity needs, avoided or increased investments in distribution infrastructure, safety benefits, reliability benefits and any other savings the distributed resources provide to the electricity grid for this State or costs to customers of the electric utility or utilities." (SB 146)
- **Minnesota** Stat. §216B.2425: "…enhancing reliability, improving security against cyber and physical threats, and by increasing energy conservation opportunities by facilitating communication between the utility and its customers through the use of two-way meters, control technologies, energy storage and microgrids, technologies to enable demand response, and other innovative technologies."
  - Public utility commission objectives (8/30/18 order in Docket 18-251):
    - Maintain and enhance the safety, security, reliability, and resilience of the electricity grid, at fair and reasonable costs, consistent with the state's energy policies.
    - Enable greater customer engagement, empowerment, and options for energy services.
    - Move toward the creation of efficient, cost-effective, accessible grid platforms for new products and services, with opportunities for adoption of new distributed technologies.
    - Ensure optimized use of electricity grid assets and resources to minimize total system costs.

Example state requirements*

- ▶ Distribution system plans

  California, Delaware, Indiana, Hawaii, Maine, Maryland, Michigan, Minnesota, Nevada, New York, Rhode Island, Virginia

- ▶ Grid modernization plans

  California, Hawaii, Oregon, Massachusetts, Minnesota, Ohio

  - Utilities in several other states have filed grid modernization plans even absent requirements (GA, NC, SC, TX).

- ▶ Hosting capacity analysis

  California, Minnesota, Nevada, New York, Hawaii

- ▶ Non-wires alternatives

  CA, CO, DC, HI, MD, ME, MN, NV, NY, RI

- ▶ Benefit-cost handbook or guidance

  Maryland, Nevada, New York, Rhode Island

*This list is growing and not all-inclusive.

Resources for more information

U.S. Department of Energy's (DOE) Modern Distribution Grid guides

Integrated Distribution Planning: Utility Practices in Hosting Capacity Analysis and Locational Value Assessment, by ICF for DOE, 2018

Alan Cooke, Juliet Homer, Lisa Schwartz, *Distribution System Planning – State Examples by Topic*, Pacific Northwest National Laboratory and Berkeley Lab, 2018

Juliet Homer, Alan Cooke, Lisa Schwartz, Greg Leventis, Francisco Flores-Espino and Michael Coddington, *State Engagement in Electric Distribution Planning*, Pacific Northwest National Laboratory, Berkeley Lab and National Renewable Energy Laboratory, 2017

Tom Eckman, Lisa Schwartz and Greg Leventis, *Determining Utility System Value of Demand Flexibility From Grid-interactive Efficient Buildings*, Berkeley Lab, 2020

T. Woolf, B. Havumaki, D. Bhandari, M. Whited and L. Schwartz. *Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments: Trends, Challenges and Considerations*. Lawrence Berkeley National Laboratory (forthcoming — email me to request the draft)

Berkeley Lab's Future Electric Utility Regulation reports, including:

> *Utility Investments in Resilience of Electricity Systems*, *The Future of Transportation Electrification*, *Regulatory Incentives and Disincentives for Utility Investments in Grid Modernization*, *The Future of Electricity Resource Planning*, *Performance-Based Regulation in a High DER Future*

More from Berkeley Lab:

- Reliability and resilience
- Renewable energy
- Energy efficiency
- Time- and locational-sensitive value of DERs