

## Integrated distribution planning and grid modernization

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# What is the distribution system?

- Portion of electric system composed of medium voltage lines, substations, feeders and related equipment
- Transports electricity to and from homes and businesses
- Connects to high-voltage transmission system that carries electricity long distances from large power plants
- Includes physical equipment as well as information, communications, and operations technologies



## DISTRIBUTION SYSTEM

The distribution system refers to the medium voltage system (typically up to 35 kV) which distributes electricity to and from customer houses and businesses. This system includes physical equipment as well as information, communications, and operational technologies.

### Utility pole components

- **INSULATORS** are non-conducting supports which prevent energized wires from coming in contact with or arcing to the utility pole.
- **PRIMARY WIRES**, also called conductors, are on top of the pole and carry medium voltage electricity from a substation to the transformer.
- A **FUSE** is housed in a cutout and interrupts power flow when there is an overcurrent in the line.
- Service or secondary **TRANSFORMERS** step voltage down from primary distribution levels to lower voltage secondary levels for customer use. Transformers can also be housed in a steel box on the ground if the electric wires are underground.
- **SECONDARY WIRES** carry lower voltage electricity from the transformer to the home or business where electricity is used.

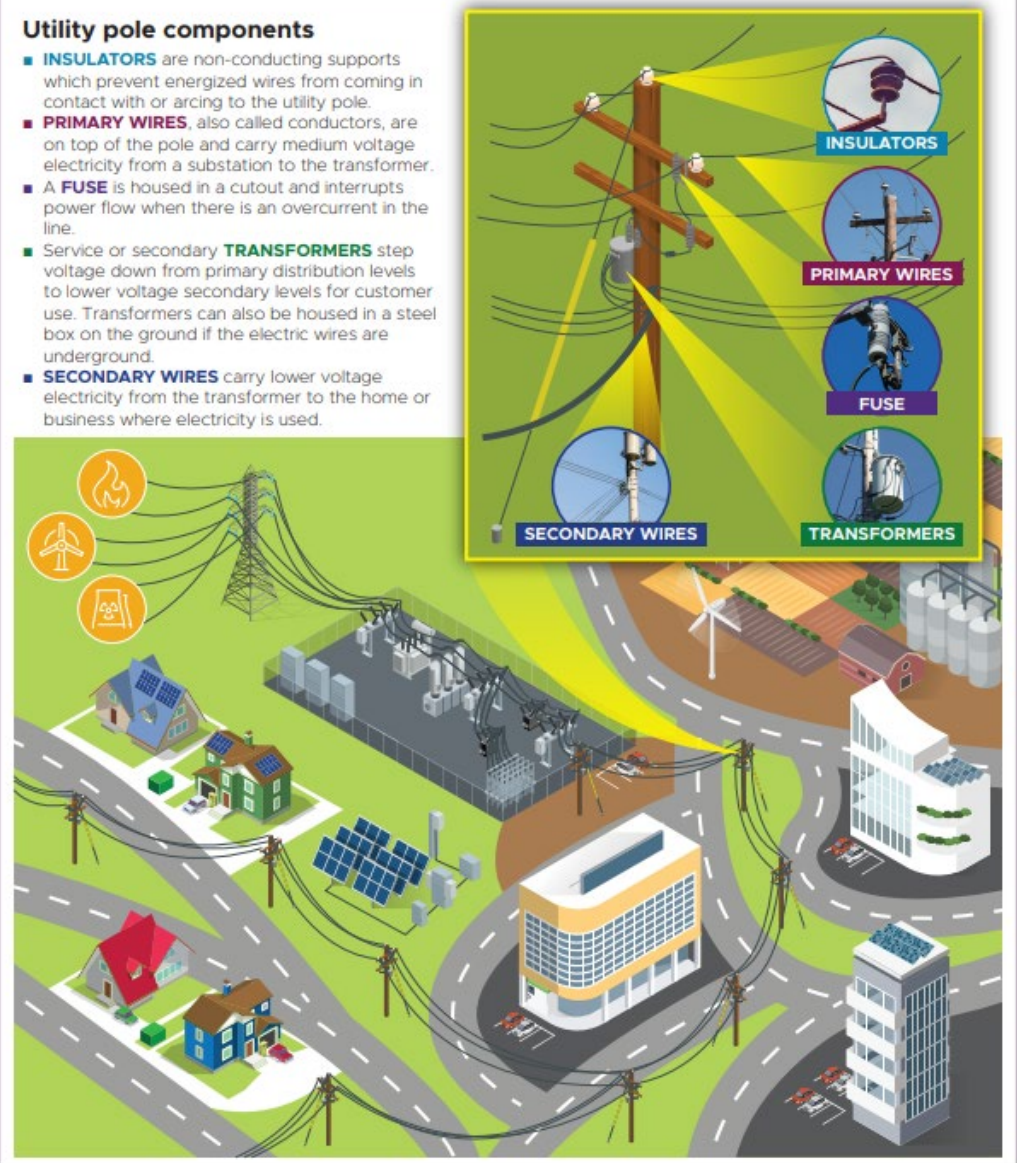


Figure: [PNNL](#)

# What is distribution system planning?

- Assesses needed physical and operational changes for the local grid
  - ▣ Annual planning for distribution system spending for next year or two
  - ▣ Longer-term utility capital plan over 5–10 year planning horizon
    - Solutions and cost estimates updated every 1 to 3 years

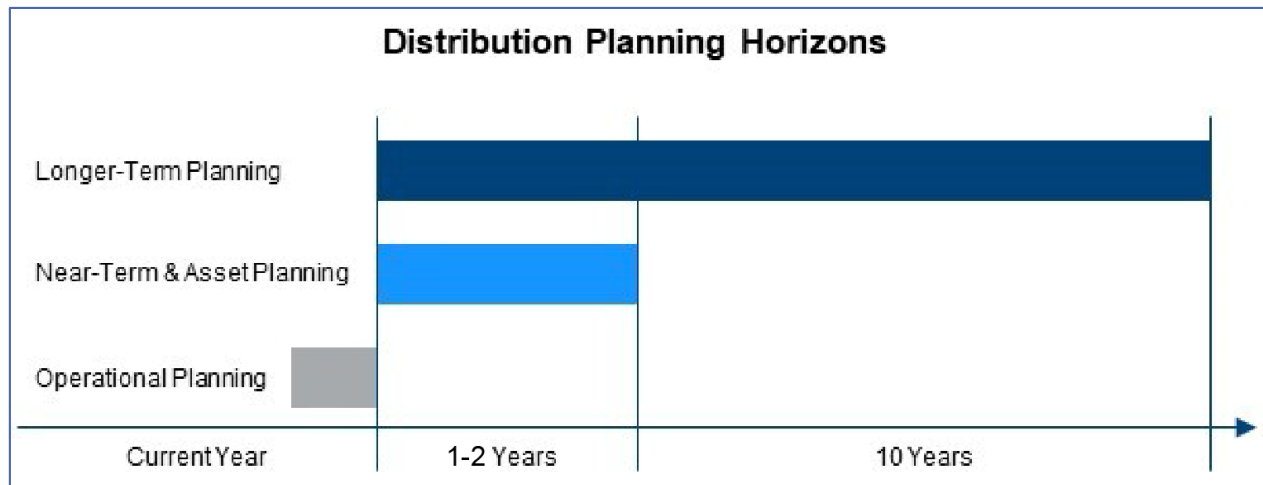
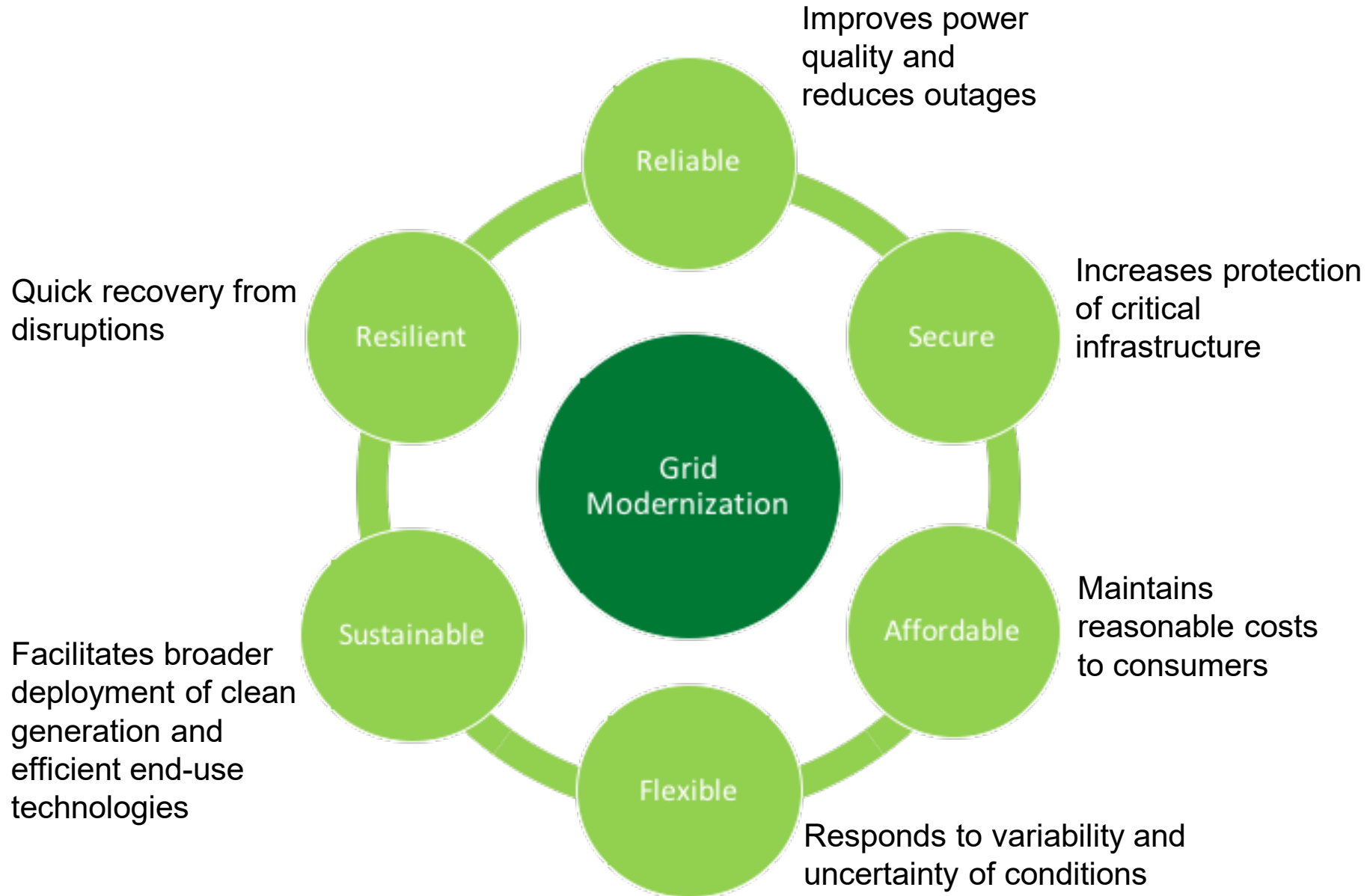


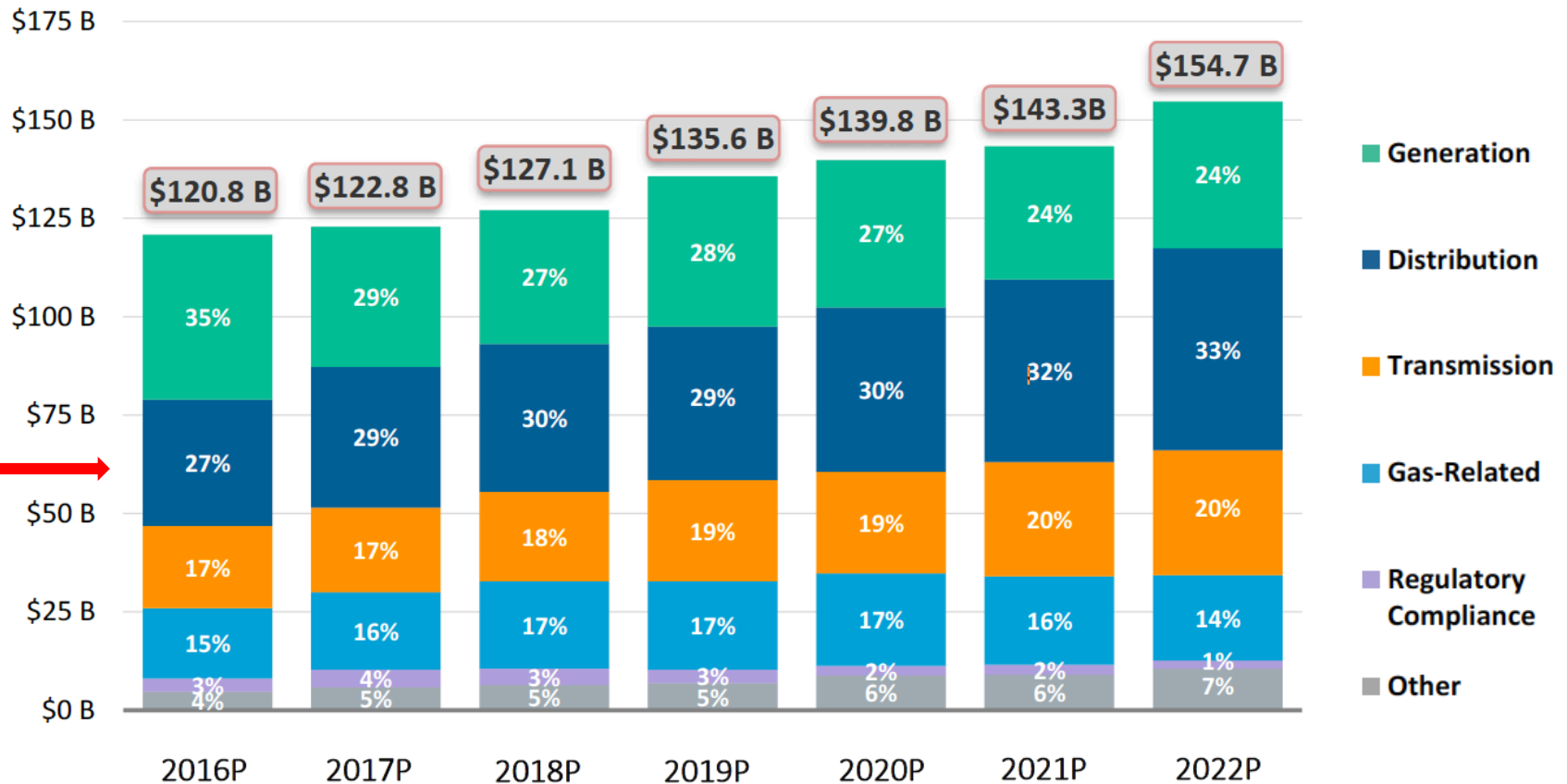
Figure: [DOE 2020](#)



# What is a modern grid?



# Why are states increasingly interested in distribution system planning?



*Distribution system investments account for the largest portion of capex for U.S. investor-owned utilities: 33% — \$51.3B (projected) — in 2022.*



# What are the potential benefits from improved distribution planning processes?

- ❑ Makes transparent utility plans for distribution system investments in a holistic manner, before showing up individually in general rate cases
- ❑ Provides opportunities for meaningful regulatory and stakeholder engagement to improve outcomes
- ❑ Considers uncertainties under a range of possible futures (scenarios)
- ❑ Considers all solutions for least cost/risk (including DERs)
- ❑ Enables consumers and 3<sup>rd</sup> party providers to propose grid solutions and participate in providing grid services



Source: Con Edison



# Relationship of grid modernization planning to integrated distribution system planning

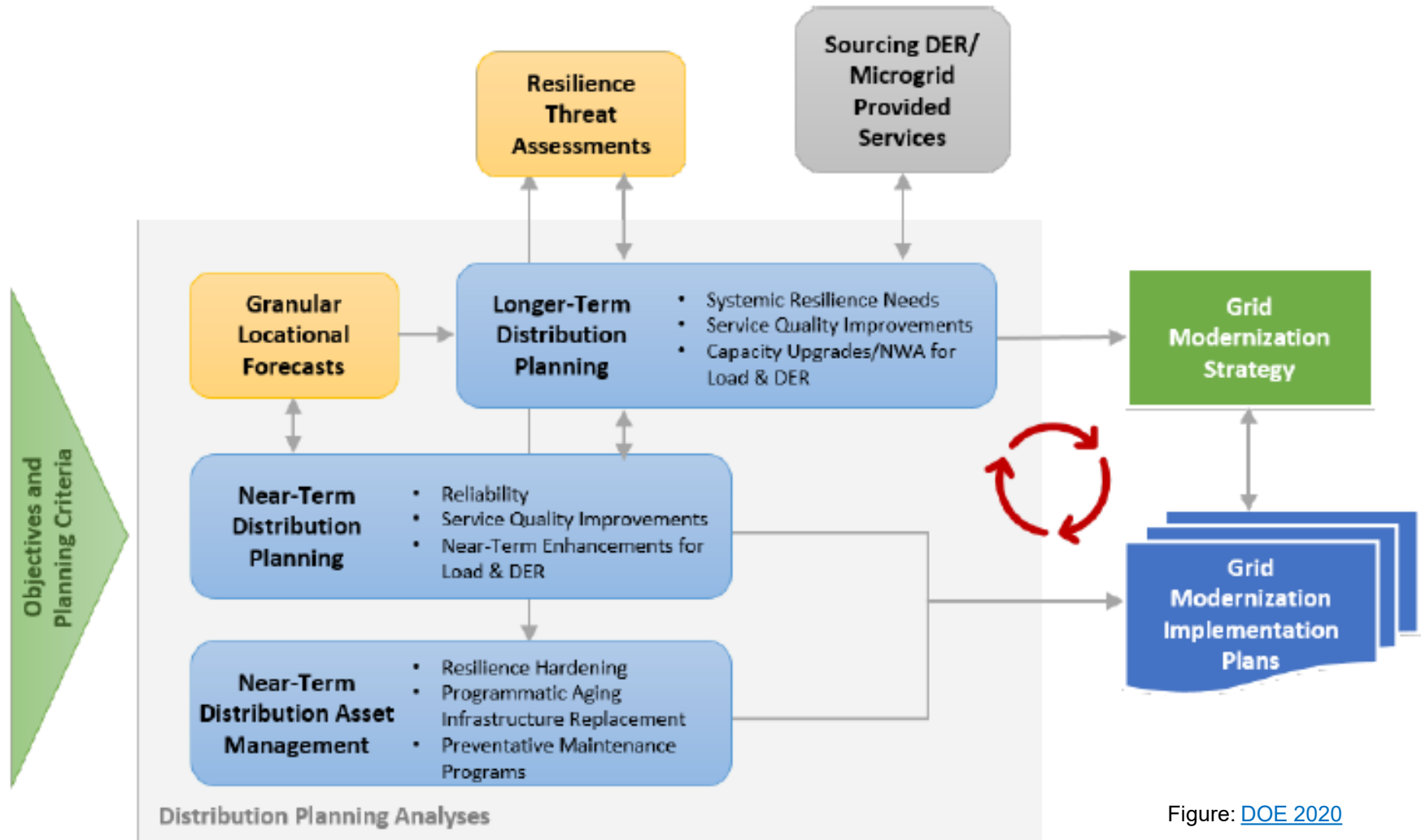
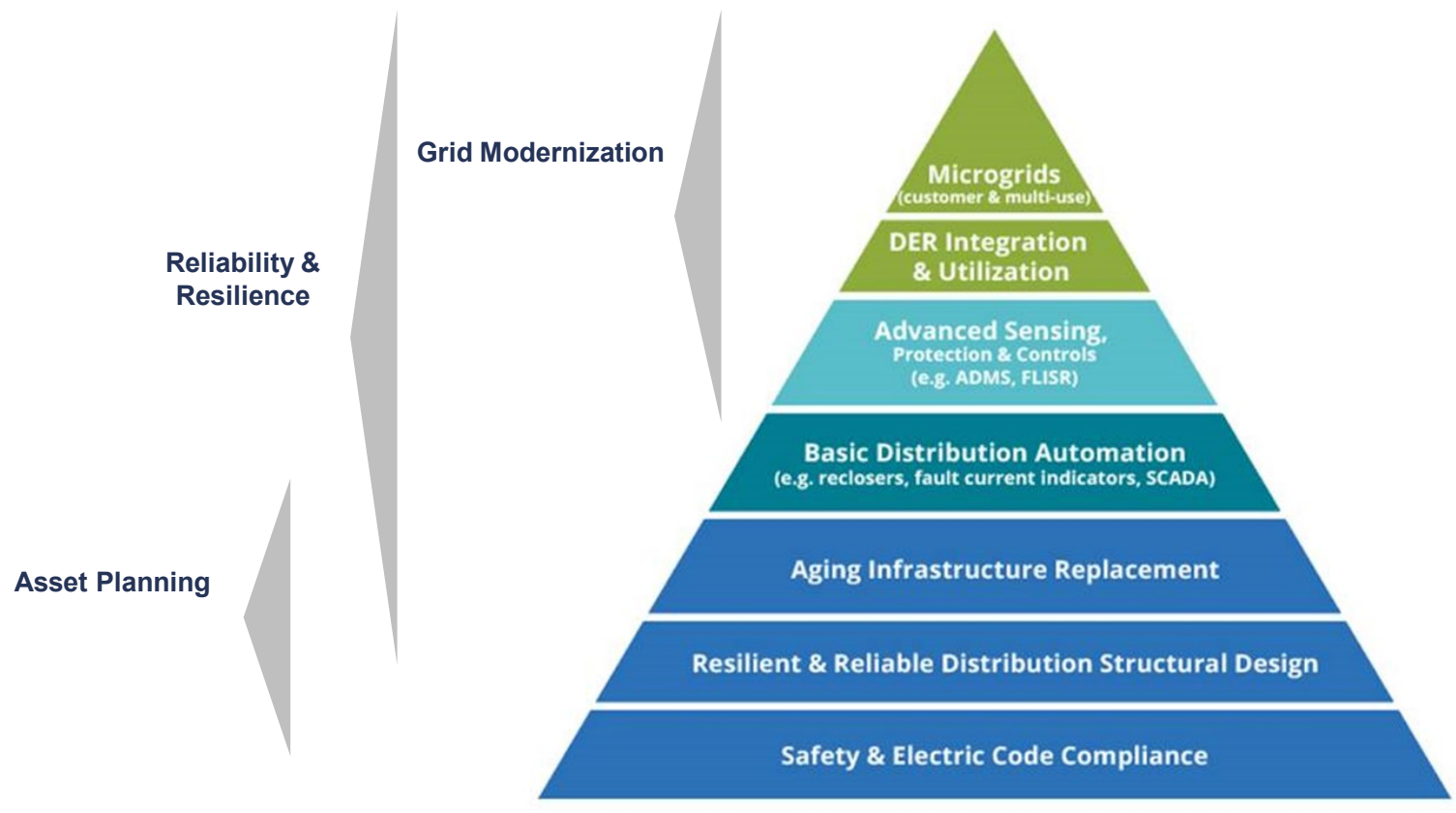


Figure: [DOE 2020](#)



# Distribution & Modernization Investment Categories

Grid modernization layers on top of —  
and integrates with — foundational grid infrastructure.



Source: De Martini



# Start with principles and objectives instead of picking technologies

- Grid modernization planning starts with the state's principles and objectives and the capabilities needed to achieve them. That determines functionality and system requirements.
- Holistic, long-term planning for grid modernization in the context of distribution system planning:
  - Supports state goals
  - Addresses interdependent and foundational technologies and systems
    - Core components — e.g., Advanced Distribution Management System, Geographic Information System, Outage Management System
    - Applications to support other grid modernization projects — e.g., smart meters, DER management
  - Considers proactive grid upgrades to facilitate customer choice

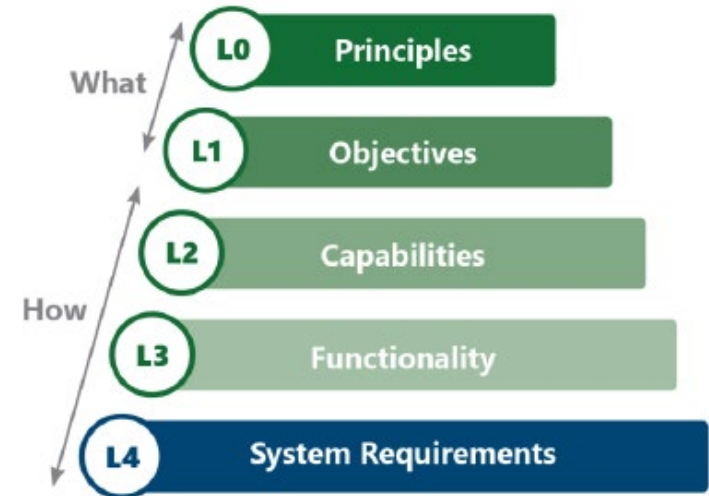


Figure: [DOE 2020](#)

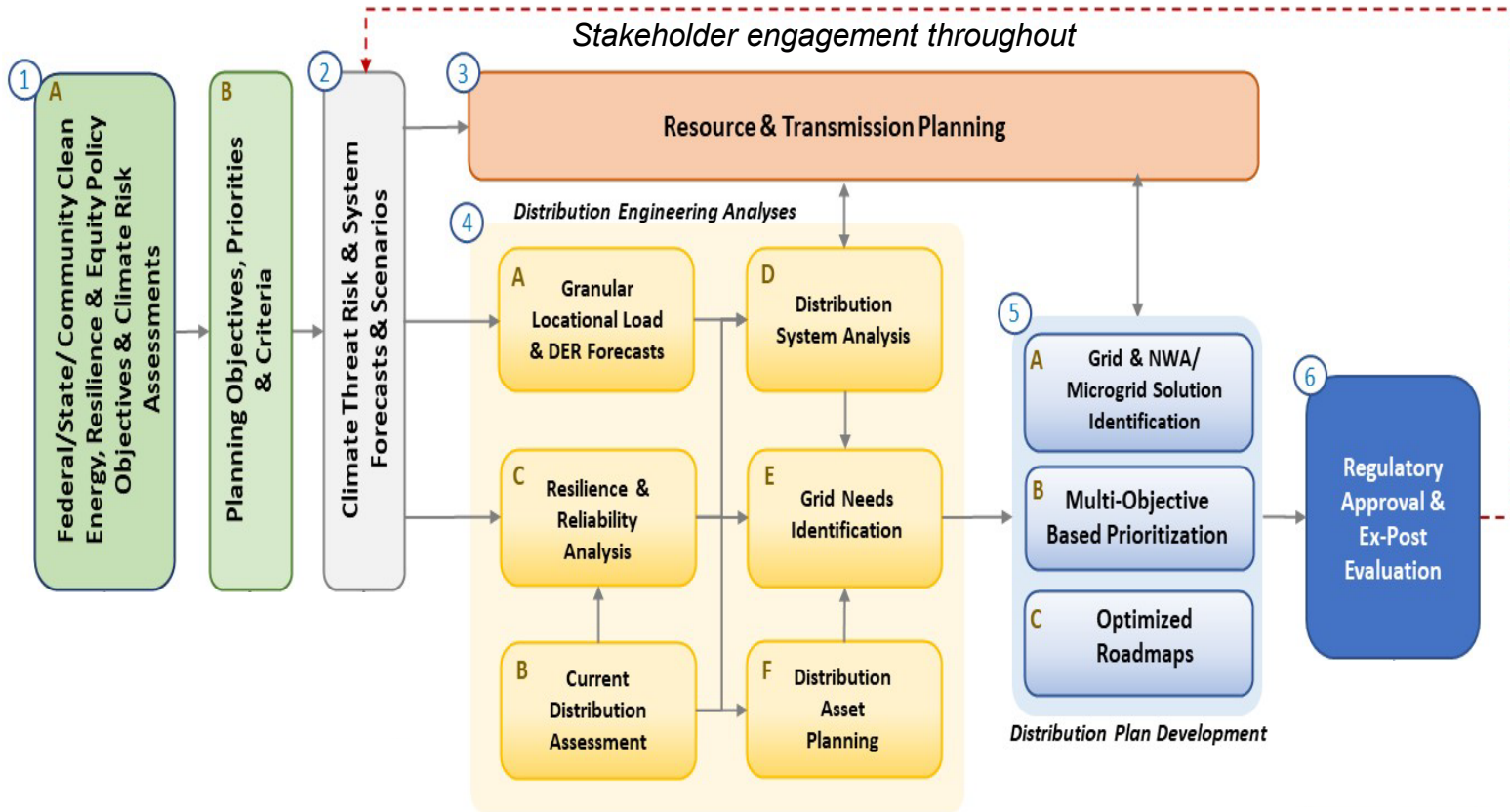
# New Mexico grid modernization law ([HB 233](#), 2020)

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- Grid modernization should facilitate:
  - Integration of renewable electric generation
  - Enhanced reliability, security, demand response capability, customer service, efficiency/conservation
- Technologies and systems specifically included:
  - Advanced metering infrastructure
  - Intelligent grid devices for real time system and asset information
  - Communications networks for service meters
  - Distribution system hardening projects for circuits and substations
  - Physical and cyber security measures
  - Energy storage systems and microgrids for reliability, resiliency and power quality
  - Facilities and infrastructure to support EV charging systems
  - New customer information platforms
  - Greater service options and expanded access to energy usage information
- ***Integrated distribution system planning can consider all of these things in the context of a holistic assessment of grid needs and potential investments.***



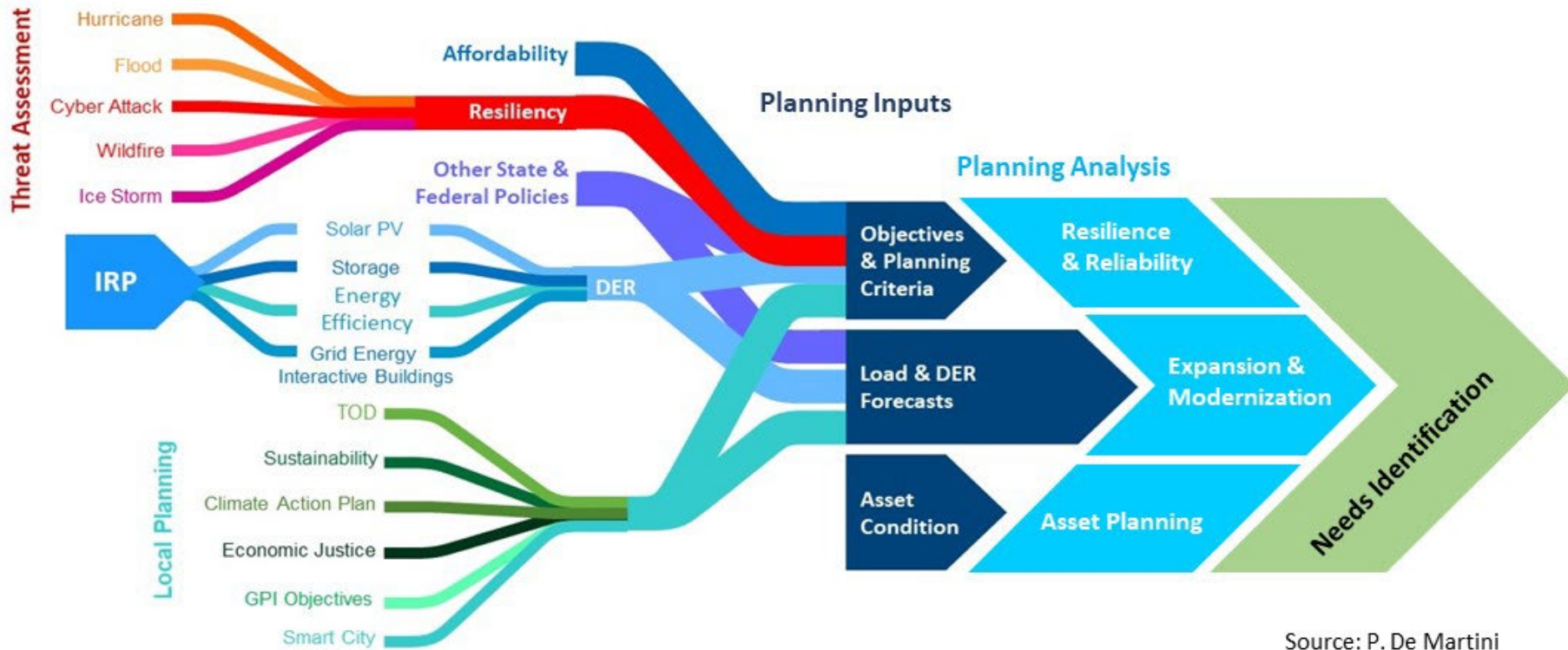
# Integrated distribution planning elements



1. Planning Objectives, Priorities and Criteria
2. Extreme Weather Threats and System Forecasts
3. Resource & Transmission Planning
4. Distribution Engineering Analyses
5. Solution Identification, Evaluation and Prioritization
6. Regulatory Review & Ex Post Evaluation

# Emerging distribution system planning inputs

Distribution planning is increasingly dependent on resilience plans, bulk power system planning, local planning, and use of DERs.



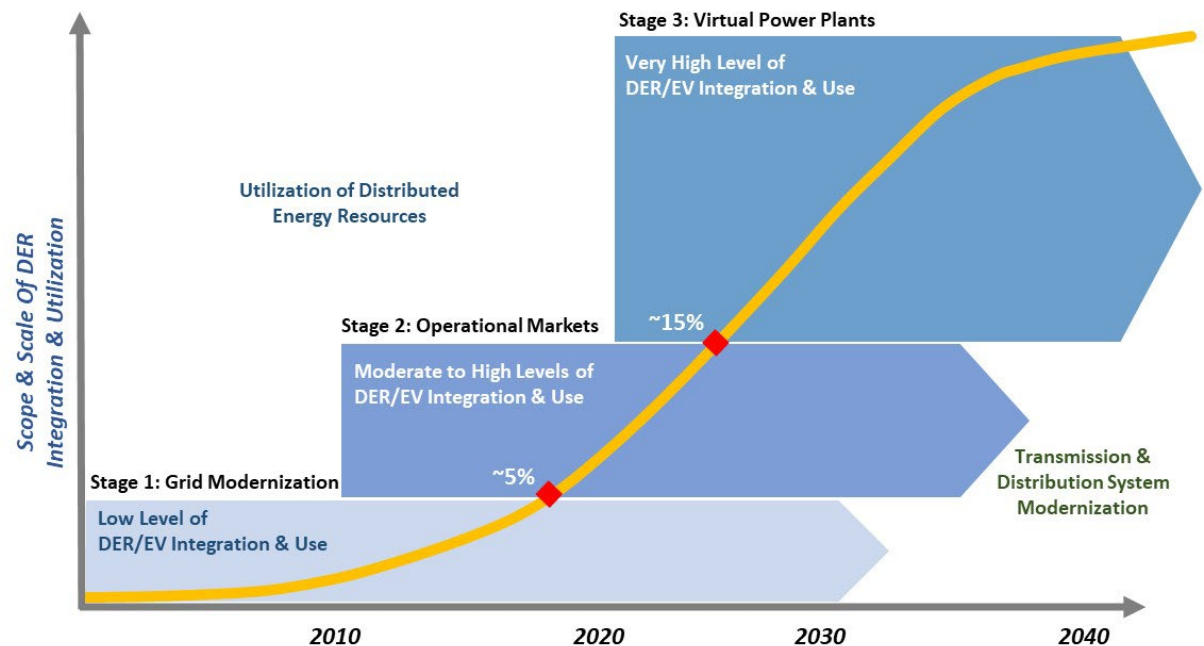
# Evolutionary framework for distribution systems

**Stage 1.** DERs <5% of distribution peak can be accommodated without material changes to infrastructure, planning and operations. *Grid modernization* focuses on replacing aging infrastructure and deploying advanced technologies for reliability, resilience, safety, and operational efficiency that also enable integration and utilization of higher DER levels in stages 2 and 3.

**Stage 2.** DERs 5%-15% of distribution peak, with pockets of high customer adoption of solar and EVs. Individual and aggregated DERs are increasingly used as load-modifying resources for both distribution system and bulk power system services. *Grid modernization* enables real-time observability and operational use of DERs.

**Stage 3.** DERs >15% of distribution system peak

- Individual DERs and DER aggregations are optimized to provide grid services.
- Multi-use/community microgrids help support local energy supply and resilience.
- Ultimately, distribution system-level energy transactions are enabled.
- *Grid modernization* includes dynamic managing of distribution system hosting capacity with high levels of solar PV, storage and electrification.



Source: P. De Martini

# Resources

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Berkeley Lab's integrated distribution system planning [website](#)

U.S. Department of Energy, [Modern Distribution Grid](#)

Berkeley Lab and Pacific Northwest National Lab, [Peer-Sharing Webinars](#) for Public Utility Commissions on Integrated Distribution System Planning with NARUC, 2023

L. Schwartz and N. M. Frick, Berkeley Lab, "[State regulatory approaches for distribution planning](#)," Presentation for New England Conference of Public Utility Commissioners," June 16, 2022

N. Frick, S. Price, L. Schwartz, N. Hanus and B. Shapiro, [Locational Value of Distributed Energy Resources](#), Berkeley Lab, 2021



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