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

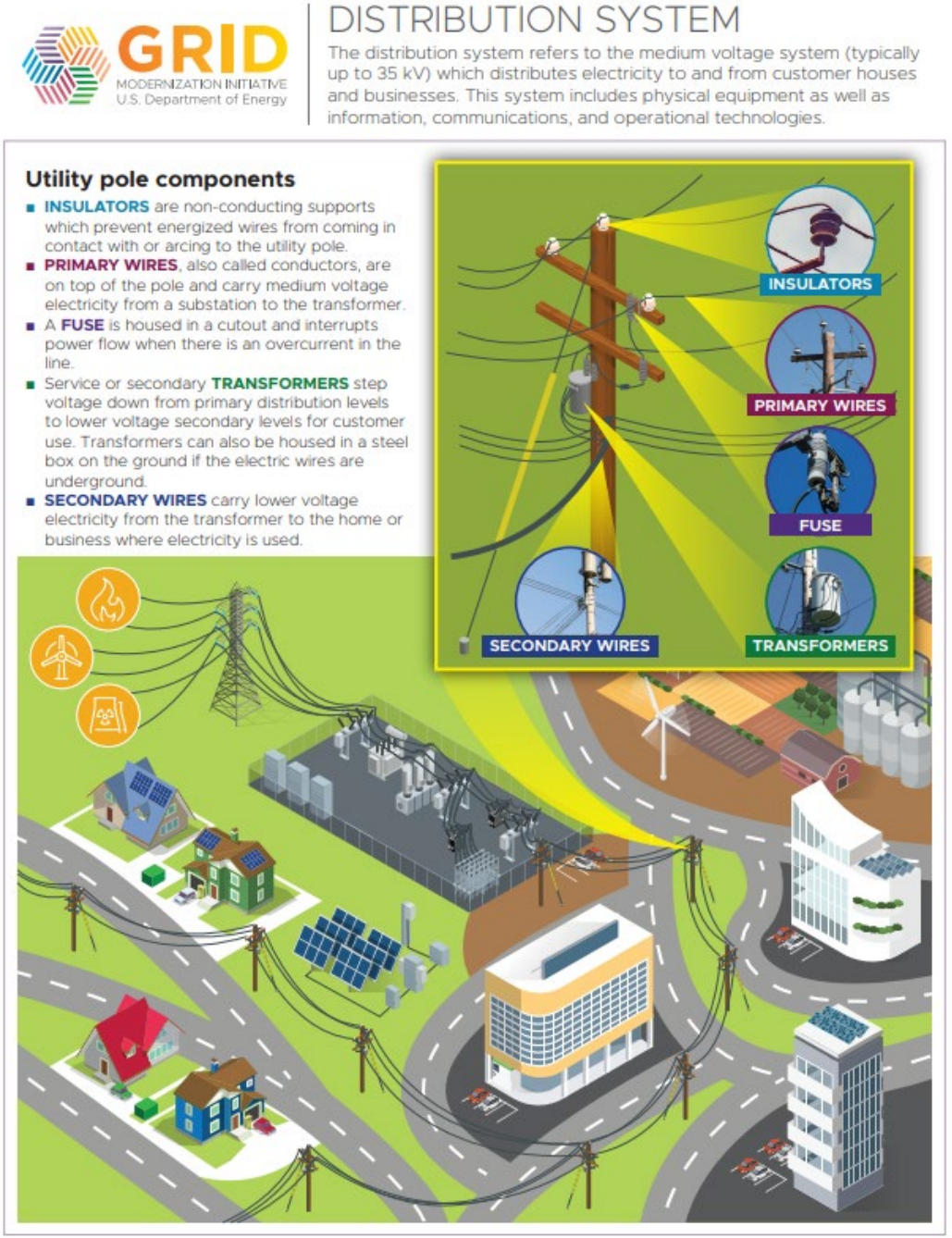


Figure: PNNL

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

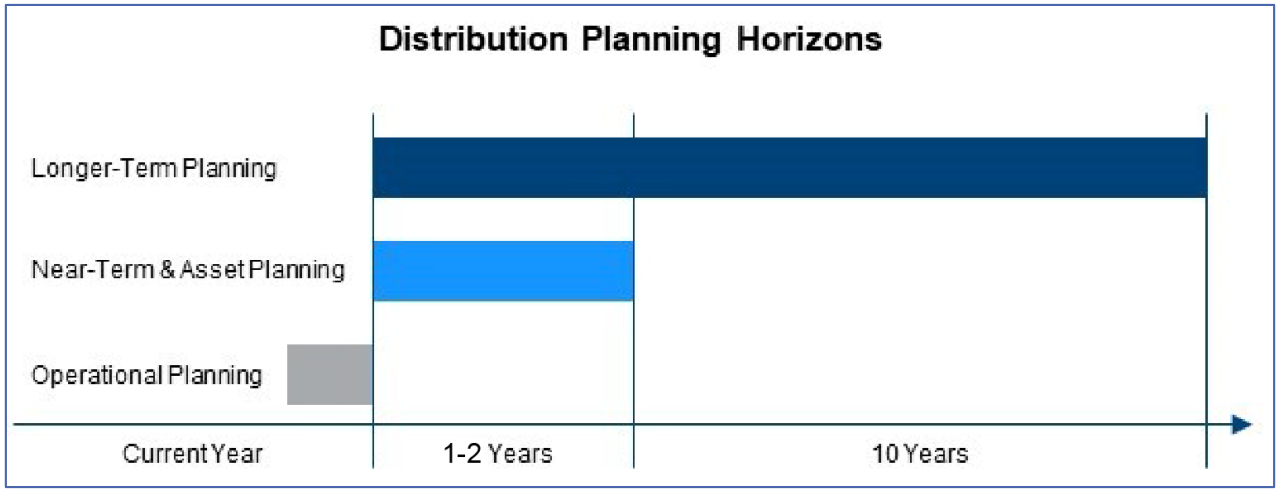
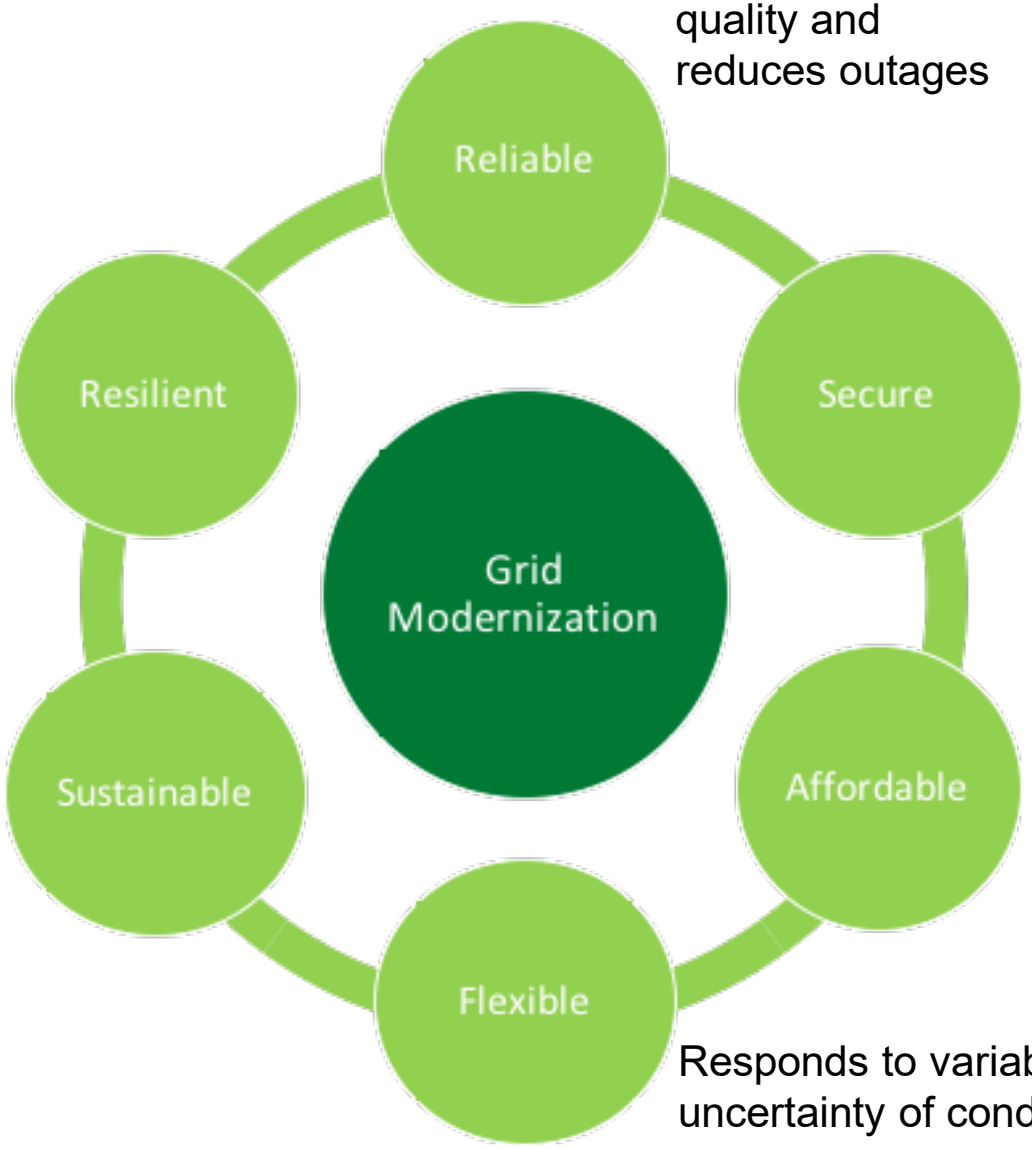


Figure: DOE 2020

What is a modern grid?



Improves power quality and reduces outages

Increases protection of critical infrastructure

Maintains reasonable costs to consumers

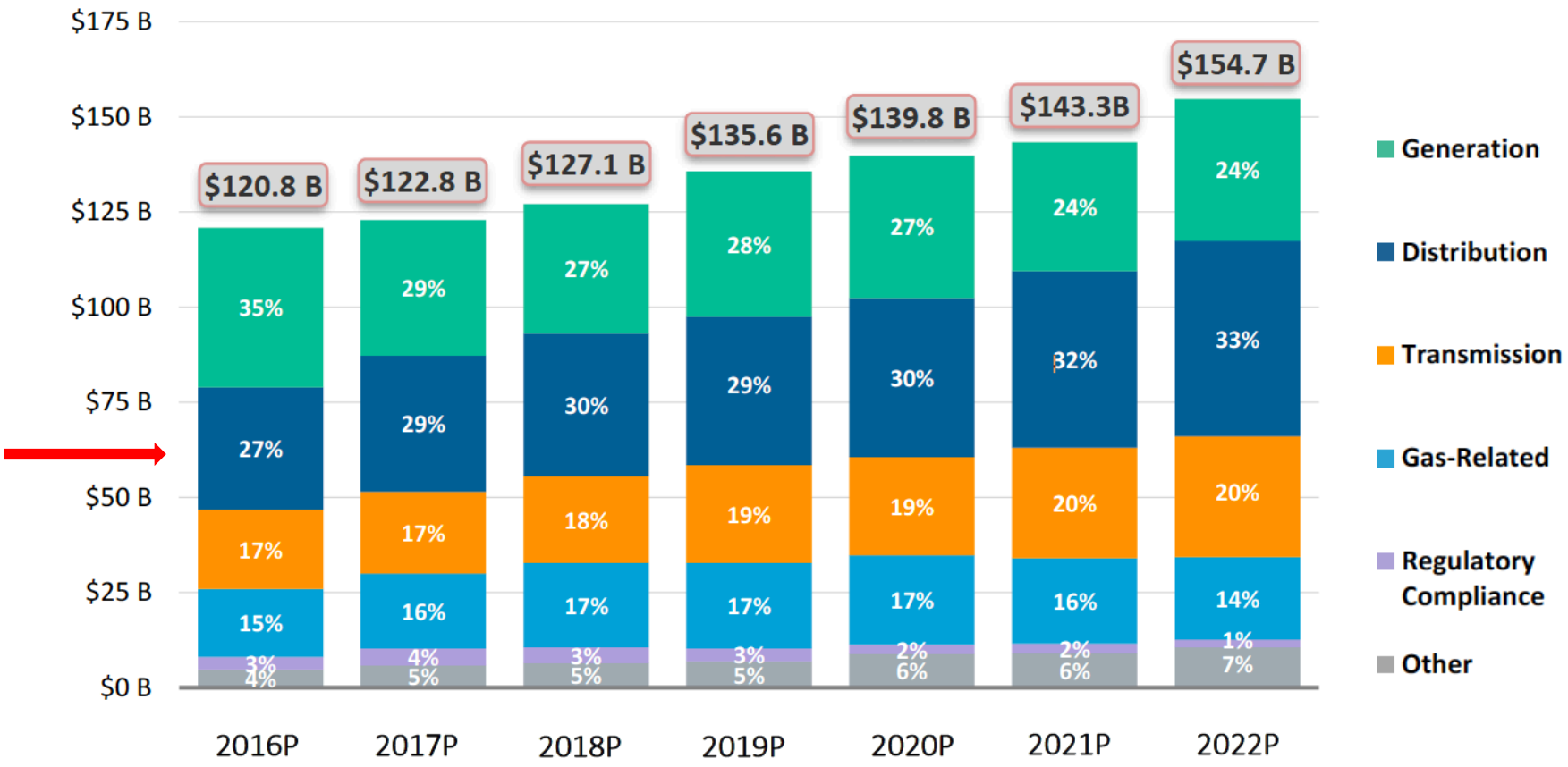
Responds to variability and uncertainty of conditions

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

Quick recovery from disruptions

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

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.

Source: Edison Electric Institute

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 3rd 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

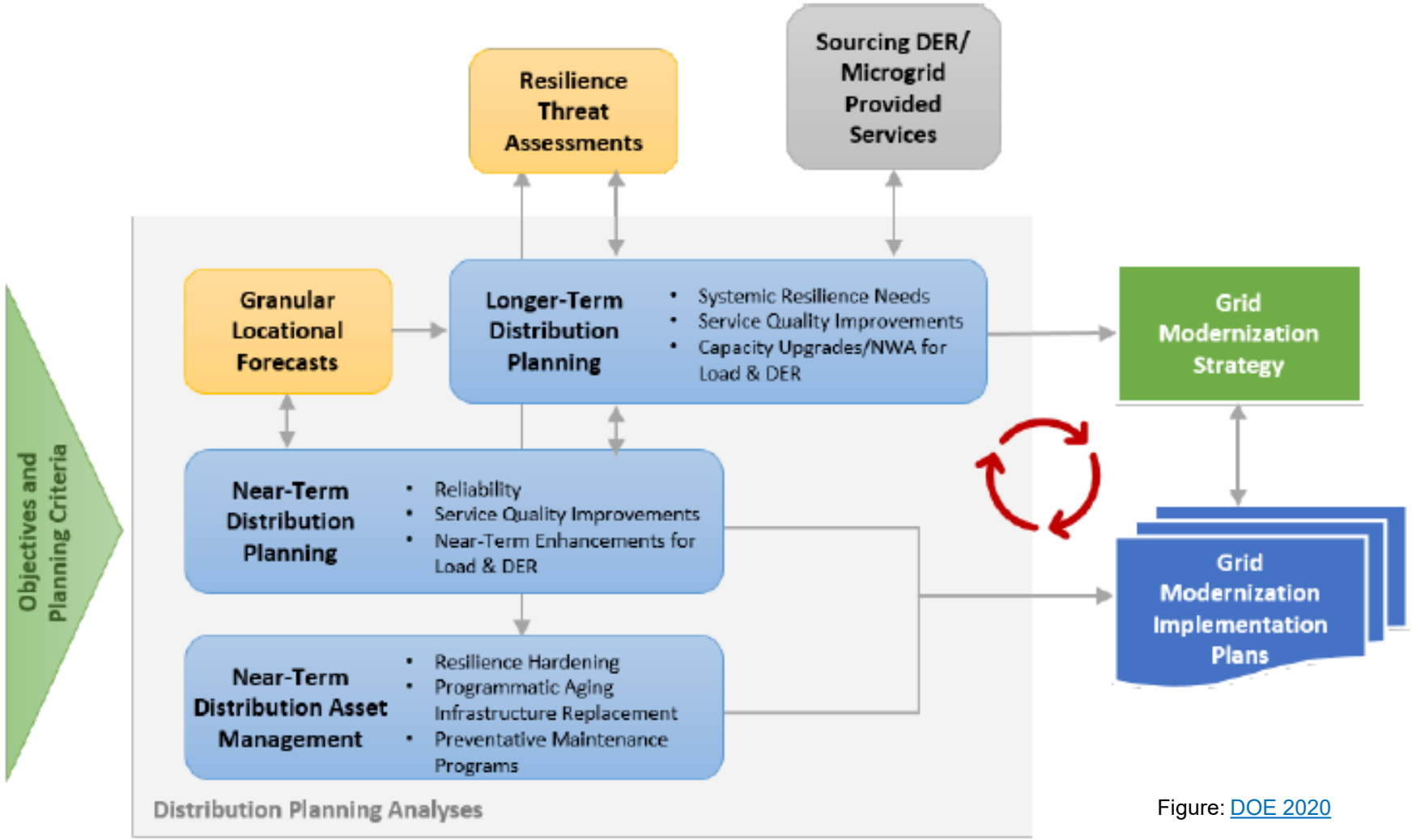
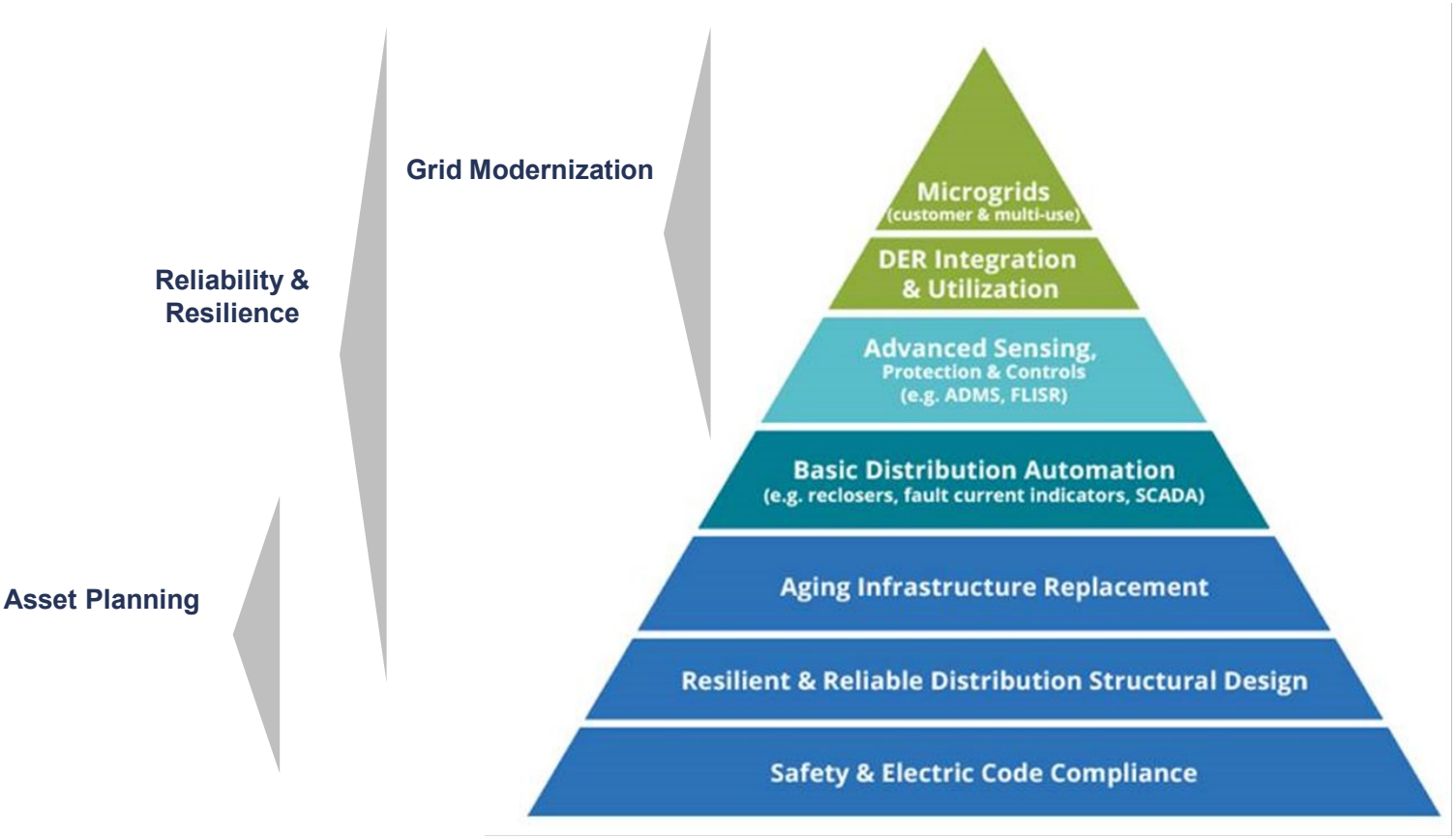


Figure: DOE 2020

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

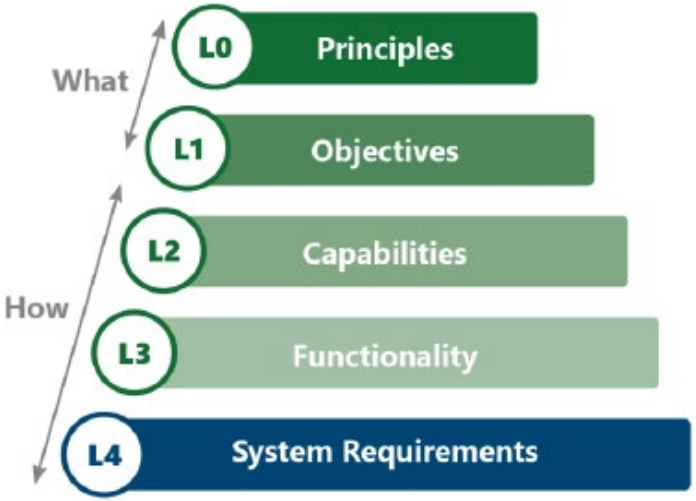
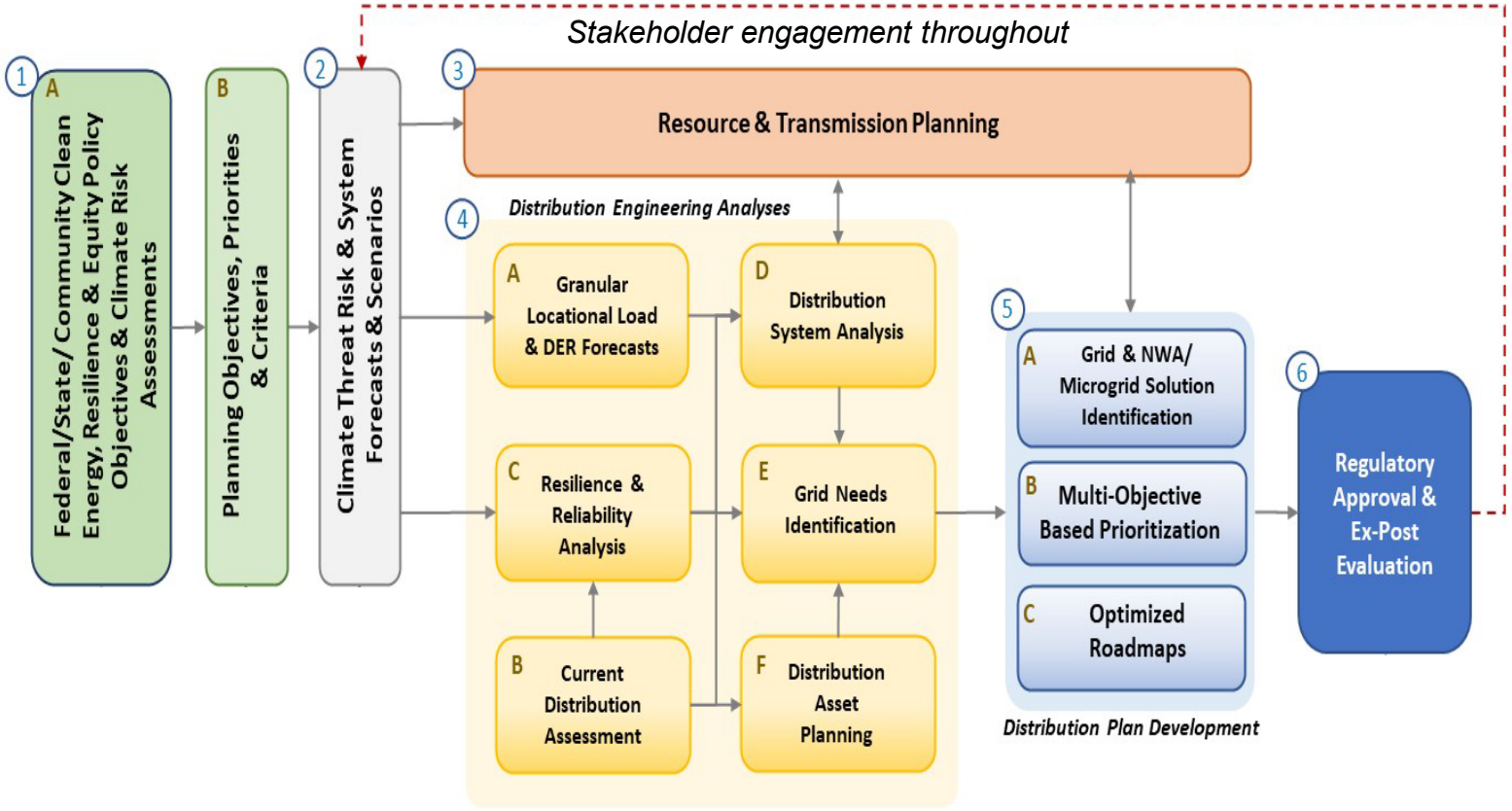


Figure: DOE 2020

New Mexico grid modernization law (HB 233, 2020)

- 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

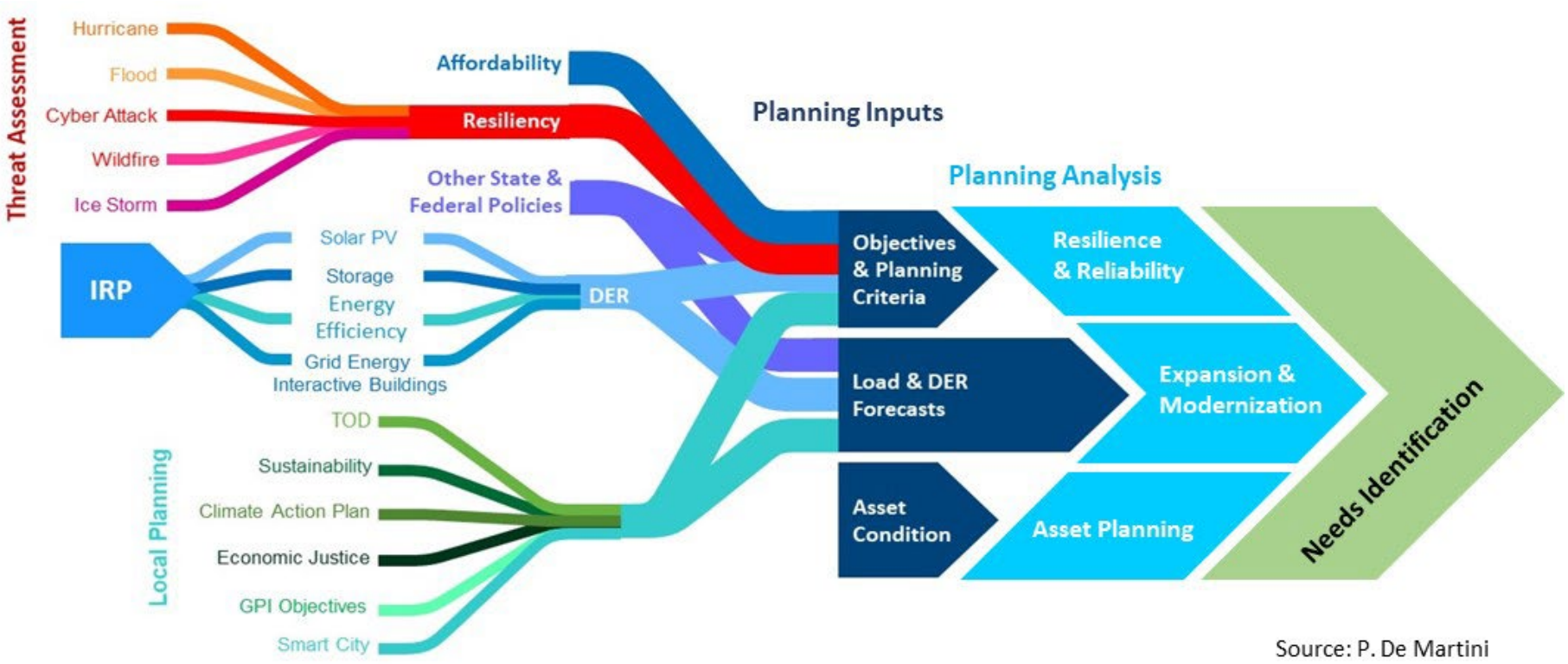


1. Planning Objectives, Priorities and Criteria
2. Extreme Weather Threats and System Forecasts
3. Resource & Transmission Planning
4. Distribution Engineering Analyses
5. Solution Identification, Evaluation and Prioritization
6. Regulatory Review & Ex Post Evaluation

Source: Paul De Martini, Newport Consulting, for DOE

Emerging distribution system planning inputs

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



Source: P. De Martini

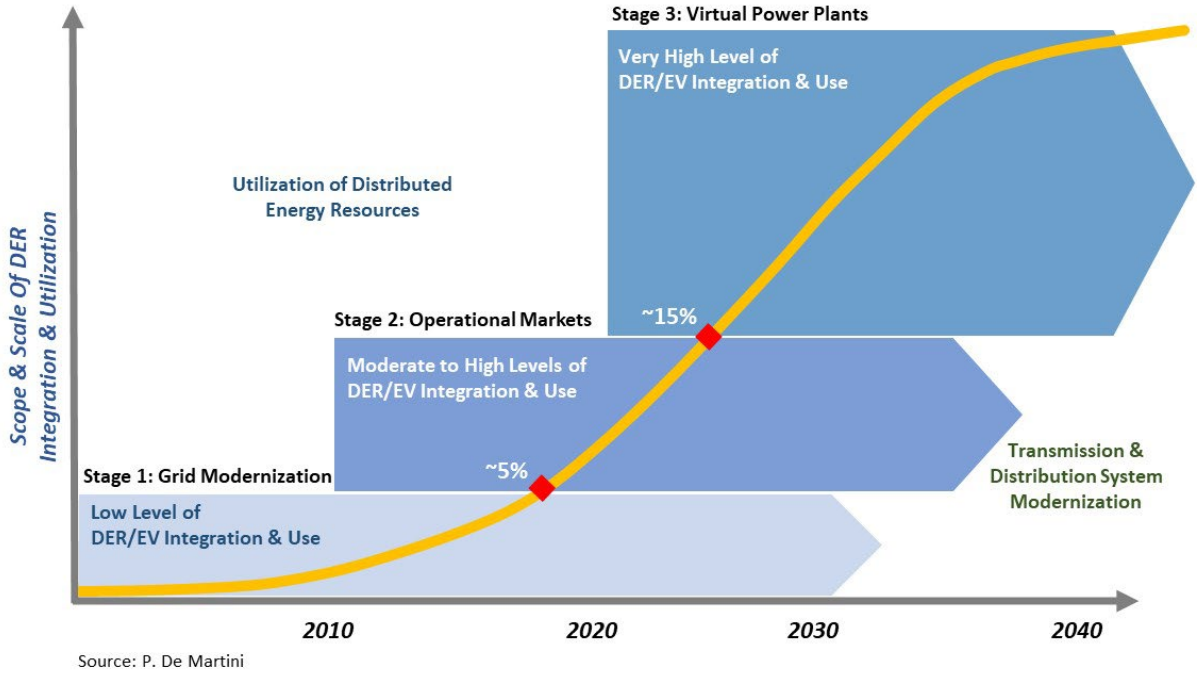
Evolutionary framework for distribution systems

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

% are rough approximations for threshold levels requiring significant institutional, business and grid changes

Resources

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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