# Integrated distribution planning overview

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New Mexico Public Regulation Commission
Grid Modernization Webinar Series
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GRID MODERNIZATION LABORATORY CONSORTIUM
U.S. Department of Energy

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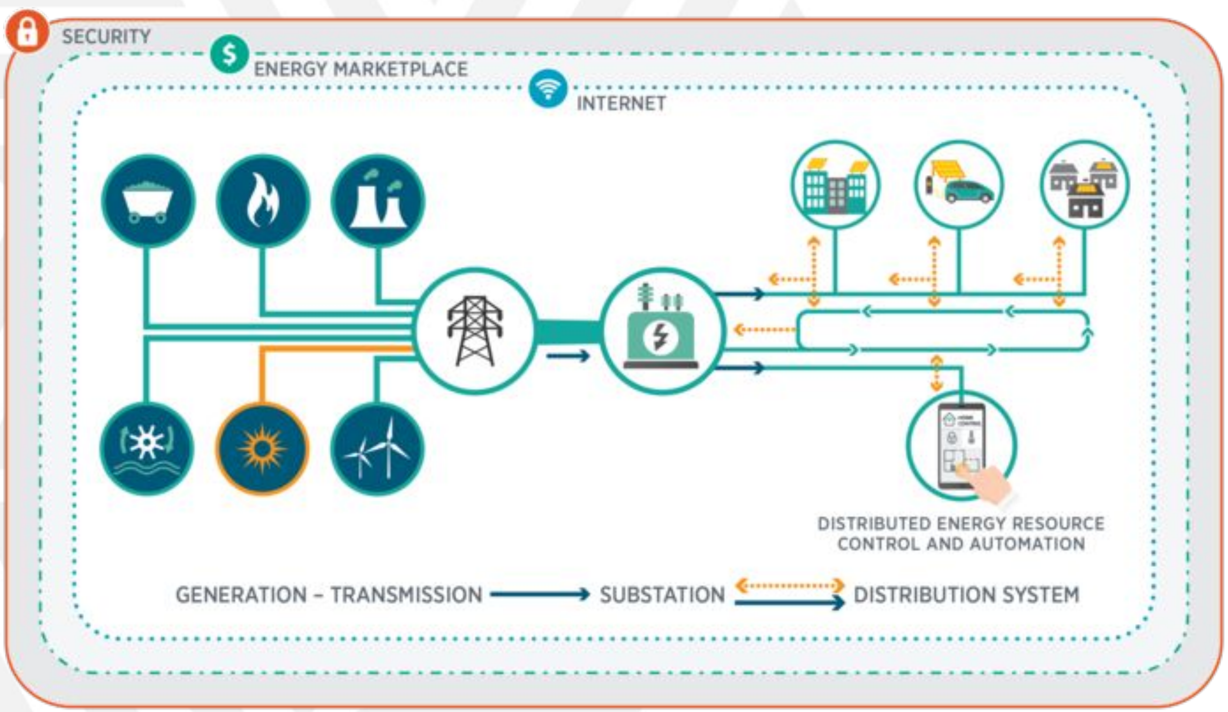
# Evolution of power grids

# From one-way to bidirectional flow

- The grid was designed for power to flow from large generators to geographically distant uses (loads).
- The grid is evolving to accommodate bidirectional flow, with significant penetration of solar PV, energy storage and other distributed energy resources (DERs), and to enable grid-interactive demand response.



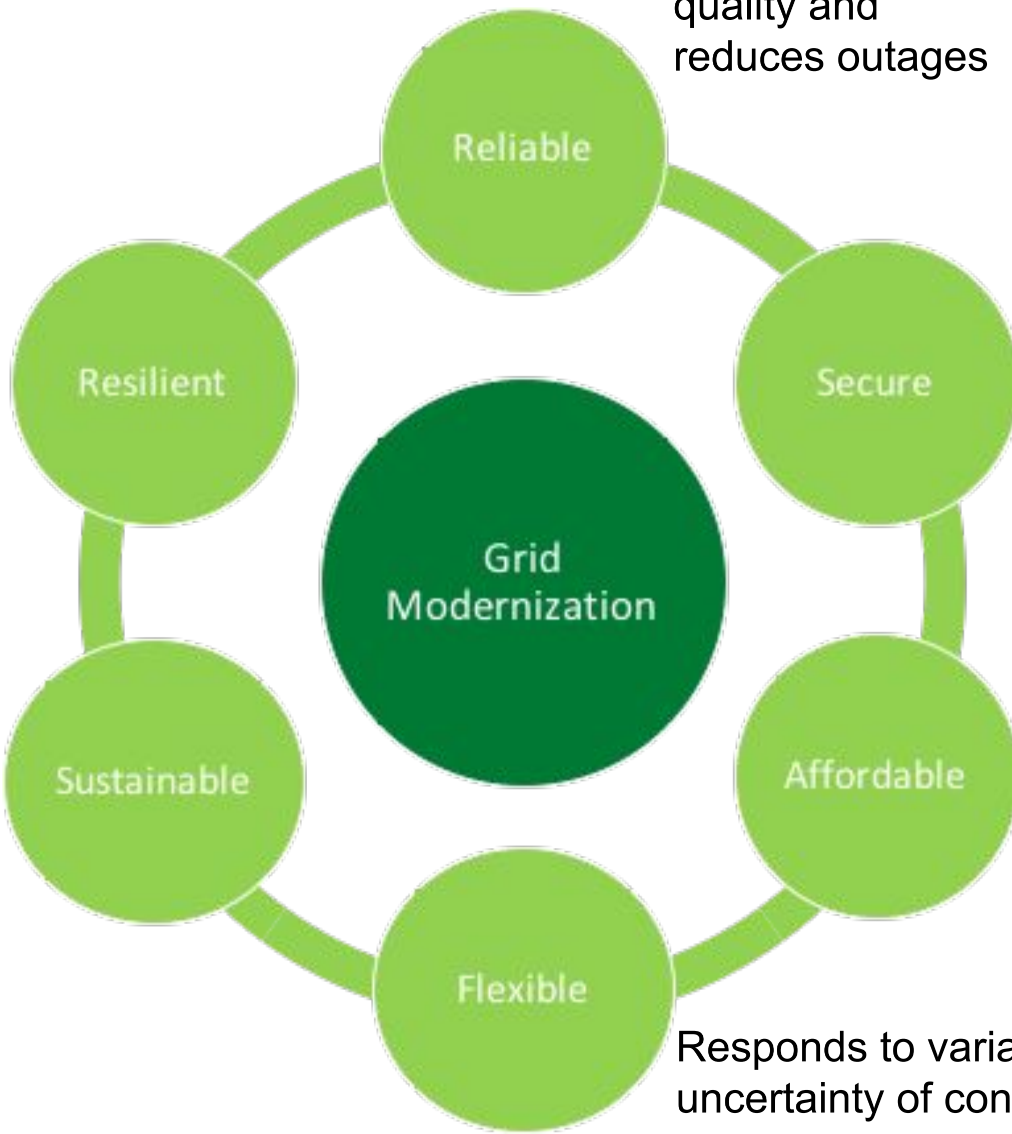

Source: U.S. Department of Energy

# What is a modern grid (1)?

Improves power quality and reduces outages

Quick recovery from disruptions

Increases protection of critical infrastructure




Maintains reasonable costs to consumers

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

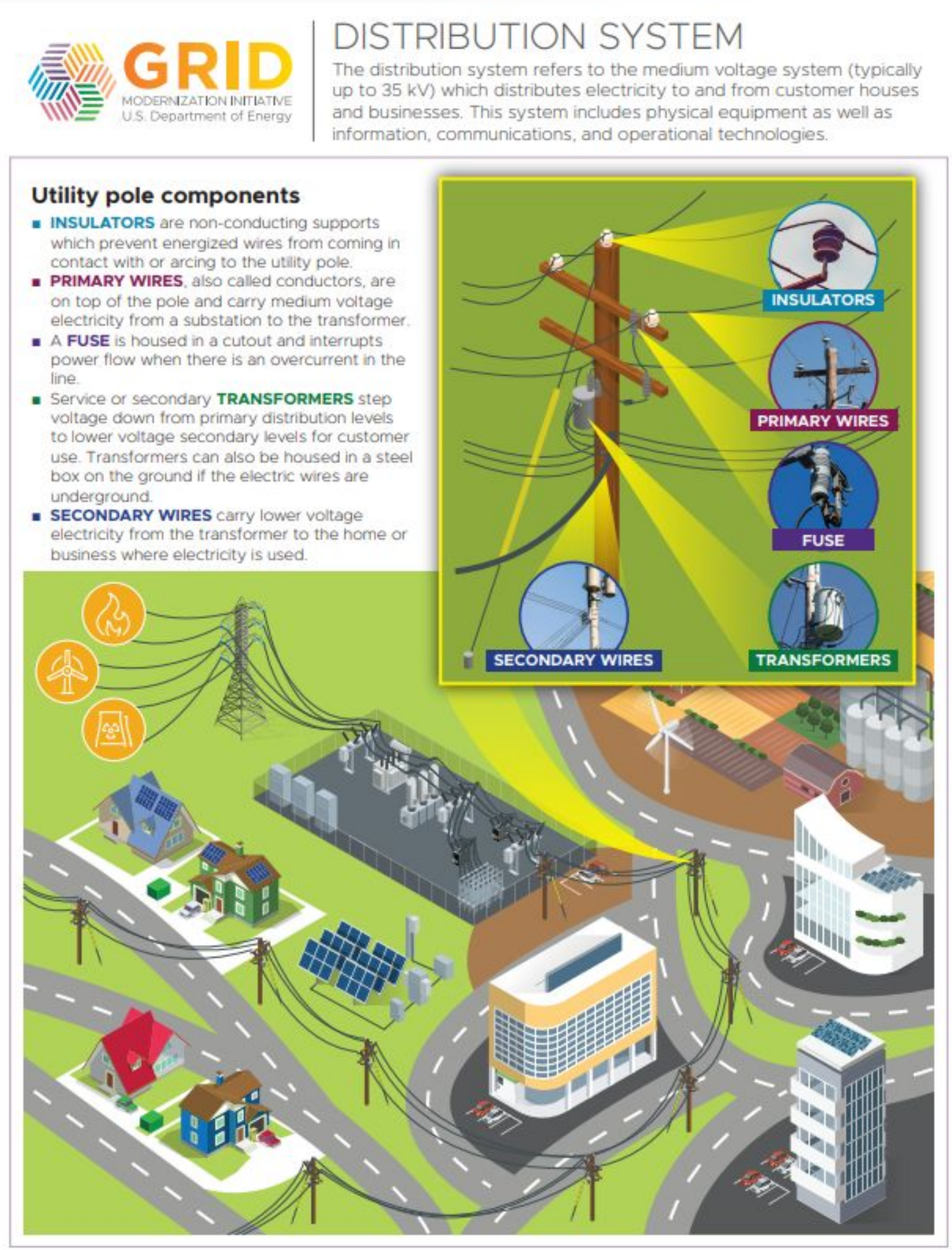
Responds to variability and uncertainty of conditions

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

# What is a modern grid (2)?

- Fundamental technical characteristics
  - Information exchange using digital communications
  - System management using programmable controls
  - Real-time situational awareness using sensors and computer-based analytics
- Many utilities have taken steps toward grid modernization — for example:
  - Advanced metering infrastructure (AMI)
  - Distribution automation
  - Adopting a standards-based approach to communications across all functional areas — customer interface, distribution, transmission, generation, control center and corporate information systems

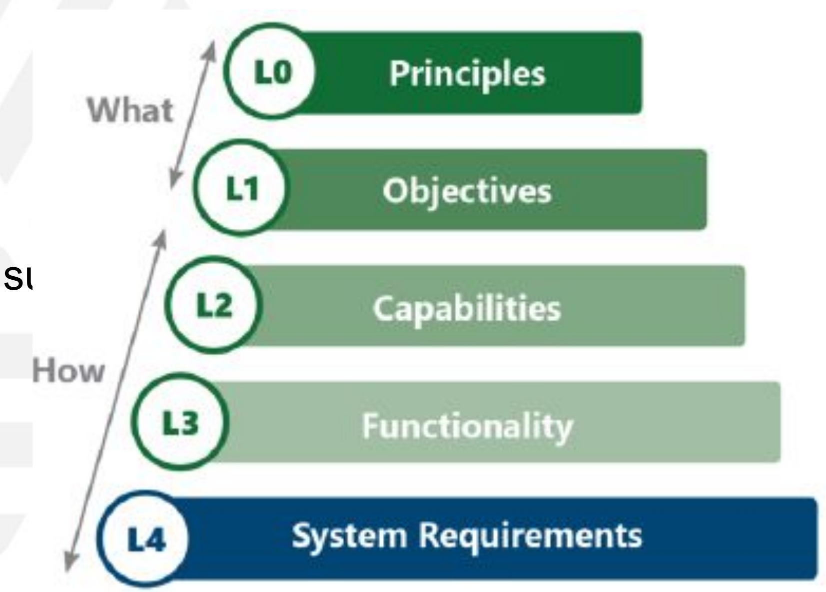
# Grid modernization and integrated distribution planning




Infographic by PNNL

# Putting the pieces together (1)

- Grid modernization planning starts with principles, objectives and capabilities needed. They determine functionality and system requirements.
- Holistic, long-term planning for grid modernization is needed to:
  - Support state goals, including reliability, resilience, affordability, clean energy resources, climate and electrification (e.g., AMI for time-varying rates that provide demand flexibility to integrate more wind and solar)
  - Address interdependent technologies and systems, including "platform" components (e.g., Advanced Distribution Management Systems, Geographic Information System, Outage Management System) needed to enable or su modernization projects
  - Consider proactive grid upgrades to facilitate customer choice (e.g., improve hosting capacity* for DER interconnection)




*Hosting capacity analysis determines the additional amount of DER that can be easily managed on a given feeder and relative interconnection costs (high/low) by location.

# Putting the pieces together (2)

- Under New Mexico HB 233 (2020), grid modernization should facilitate:
  - Integration of renewable electric generation
  - Enhanced reliability, security, demand response capability, customer service, efficiency/conservation
  - Technologies specifically included:
    - AMI
    - 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
- All of these technologies should be considered in distribution planning.
- Other plans may feed into the distribution planning process—for example:
  - Electrification plan informs grid needs for EV charging
  - Cybersecurity plan identifies resilience threats that distribution planning can consider
  - Demand-side management plan specifies capabilities that distribution technologies and systems should provide to achieve multi-year targets for demand response, energy efficiency and conservation

# How one state put together the pieces: Minnesota (1)

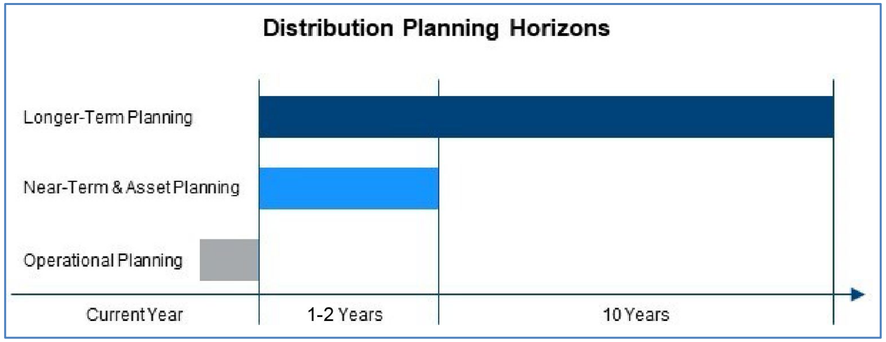
- Minn. Stat. §216B.2425 (2015) requires the largest utility (Xcel Energy) to submit biennial transmission and distribution plans to the PUC
  - To *"identify … investments that it considers necessary to* ***modernize the transmission and distribution system by enhancing reliability, improving security against cyber and physical threats, and by increasing energy conservation opportunities*** *…."*
  - May ask Commission to **certify priority projects and approve costs through a rider** — a finding that the project is consistent with requirements of this statute, not a prudency determination
  - Analyze hosting capacity for *small-scale distributed generation resources* and to *identify necessary distribution upgrades to support [their] continued development*

- Xcel Energy filed its 1st grid modernization report in 2015 (Docket 15-962) and 2nd grid modernization report in 2017 (Docket 17-776)
- The Commission certified investments in:
  - Advanced Distribution Management System (ADMS)
  - Residential Time of Use Pilot using AMI
  - Field Area Network (FAN)

# How one state put together the pieces: Minnesota (2)

- The PUC initiated an inquiry on Electric Utility Grid Modernization with a focus on distribution planning (Docket CI-15-556)
  - Series of stakeholder meetings
  - Questionnaire to utilities on utility planning practices plus stakeholder comments
    - How do Minnesota utilities currently plan their distribution systems?
    - What is the status of each utility's current plan?
    - How could the utility's planning processes be improved or augmented?
  - Staff Report on Grid Modernization defined grid modernization for Minnesota, proposed a phased approach, and identified principles to guide it.
- The Commission set Integrated Distribution Planning requirements for Xcel Energy (Docket 18-251) and smaller regulated utilities (Dockets 18-253, 18-254 and 18-252).
- Xcel Energy filed the 1st DSP in 2018 (Docket 18-251), a 2nd IDP in 2019 (Docket 19-666), and a 3rd IDP in 2021 (Docket 21-694).
  - **Grid modernization report now filed *with* IDP filing**

# Electricity planning activities

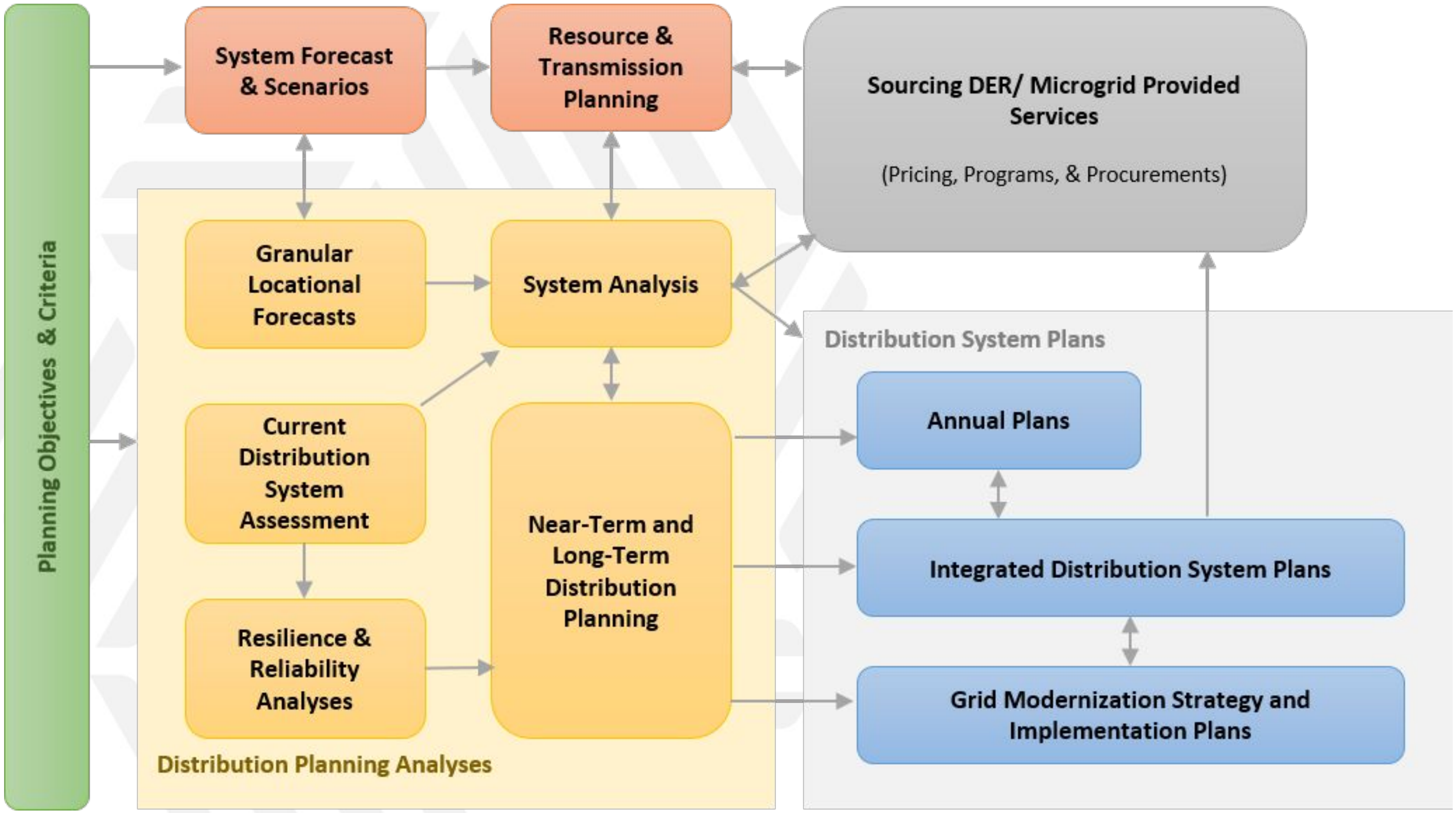



- Distribution planning - Assess needed physical and operational changes to the local grid
  - Annual process, with 1–2 year planning horizon*
    - Identify and define distribution system needs
    - Identify and assess possible solutions
    - Select projects to meet system needs
  - Longer-term utility capital plan
    - Includes solutions and cost estimates, typically over a 5- to 10-year period, updated every 1 to 3 years
- Integrated resource planning (IRP)* - Identify future investments to meet bulk power system reliability and public policy objectives at a reasonable cost
  - Consider scenarios for loads and distributed resources; impacts on need for, and timing of, utility investments
- Transmission planning – Identify future transmission expansion needs and options


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

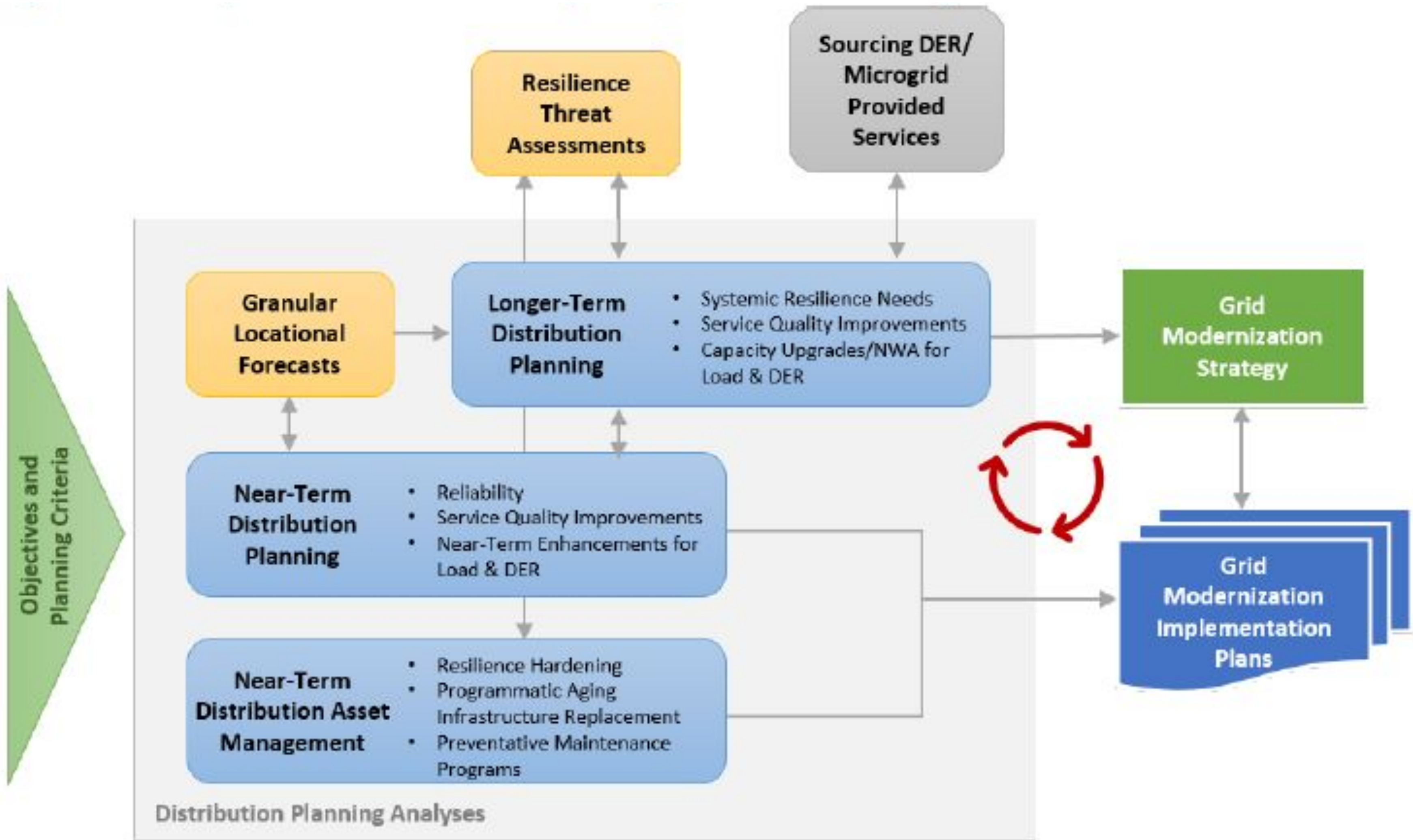
*Operational planning addresses immediate concerns (intraday through the current year)

# Integrated planning processes




Source: DOE 2021

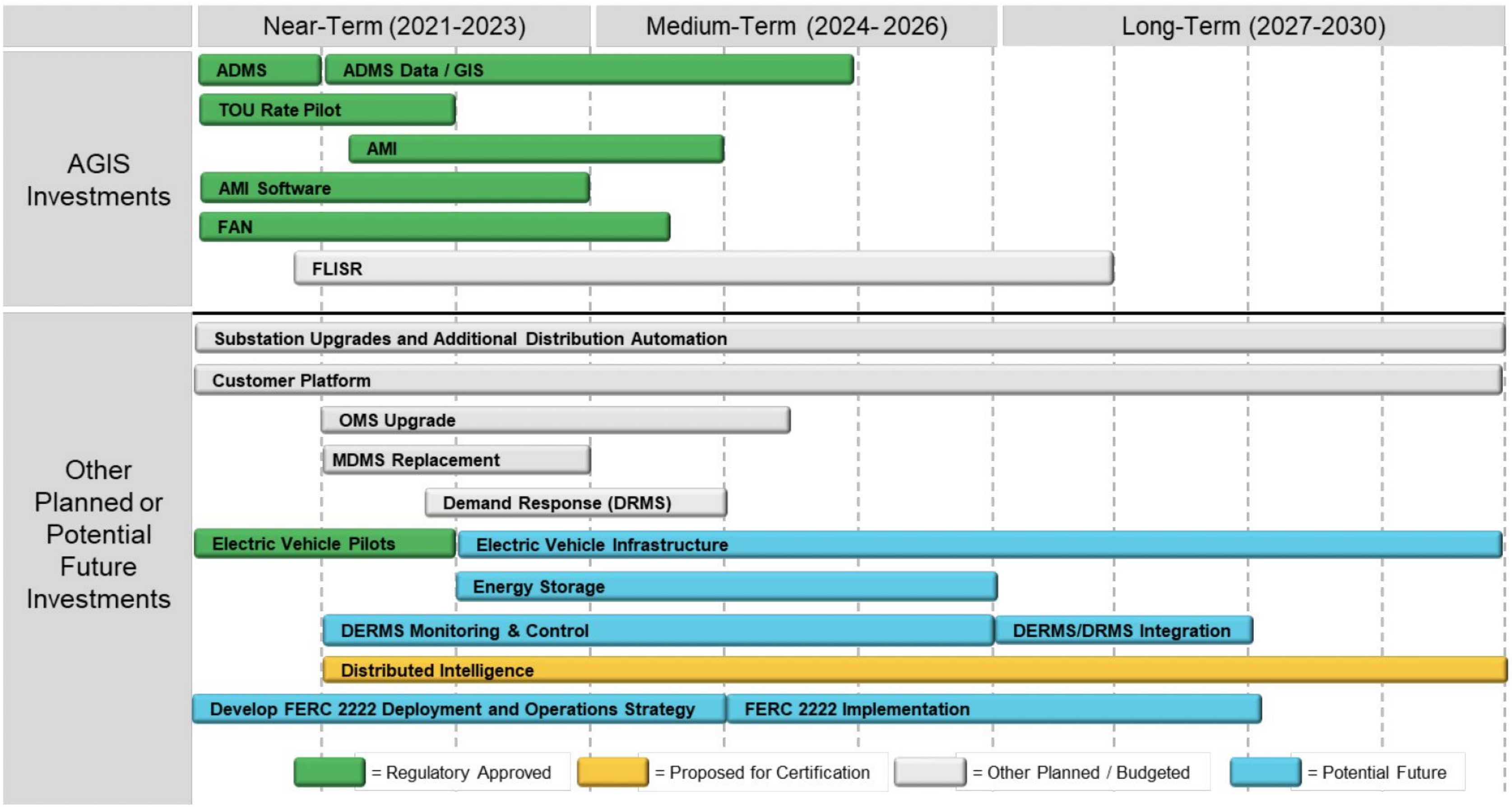
# Relationship of grid modernization planning to integrated distribution planning




Source: DOE 2021

# Investments in the context of planning

Distribution modernization investments are made in the context of distribution system planning and state policies. Distribution system planning reveals the most effective grid modernization strategies to achieve the state's policy objectives.




Source: Xcel Energy 2021. The Advanced Grid Intelligence and Security (AGIS) initiative is the utility's long-term strategic plan to transform its distribution system to update technologies and capabilities. For other definitions, see DOE 2021.

# Evaluating grid modernization costs and risks

| | |
|---|---|
| **Whole vs. Parts** | Grid modernization ideally is supported by a holistic vision and investment strategy. At the same time, component investments may support different objectives and use different evaluation methods. |
| **Resources vs. Grid** | Some grid modernization investments may support bulk power resources as well as the distribution grid. Resource and grid investments often have different evaluation methods. |
| **Joint & Inter-dependent Benefits** | Grid modernization investments often have benefits that are hard to isolate and depend on other investments. |
| **Uncertainty** | Grid modernization technologies are subject to significant uncertainty — e.g., costs, timing of need, technology maturity, deployment challenges. |

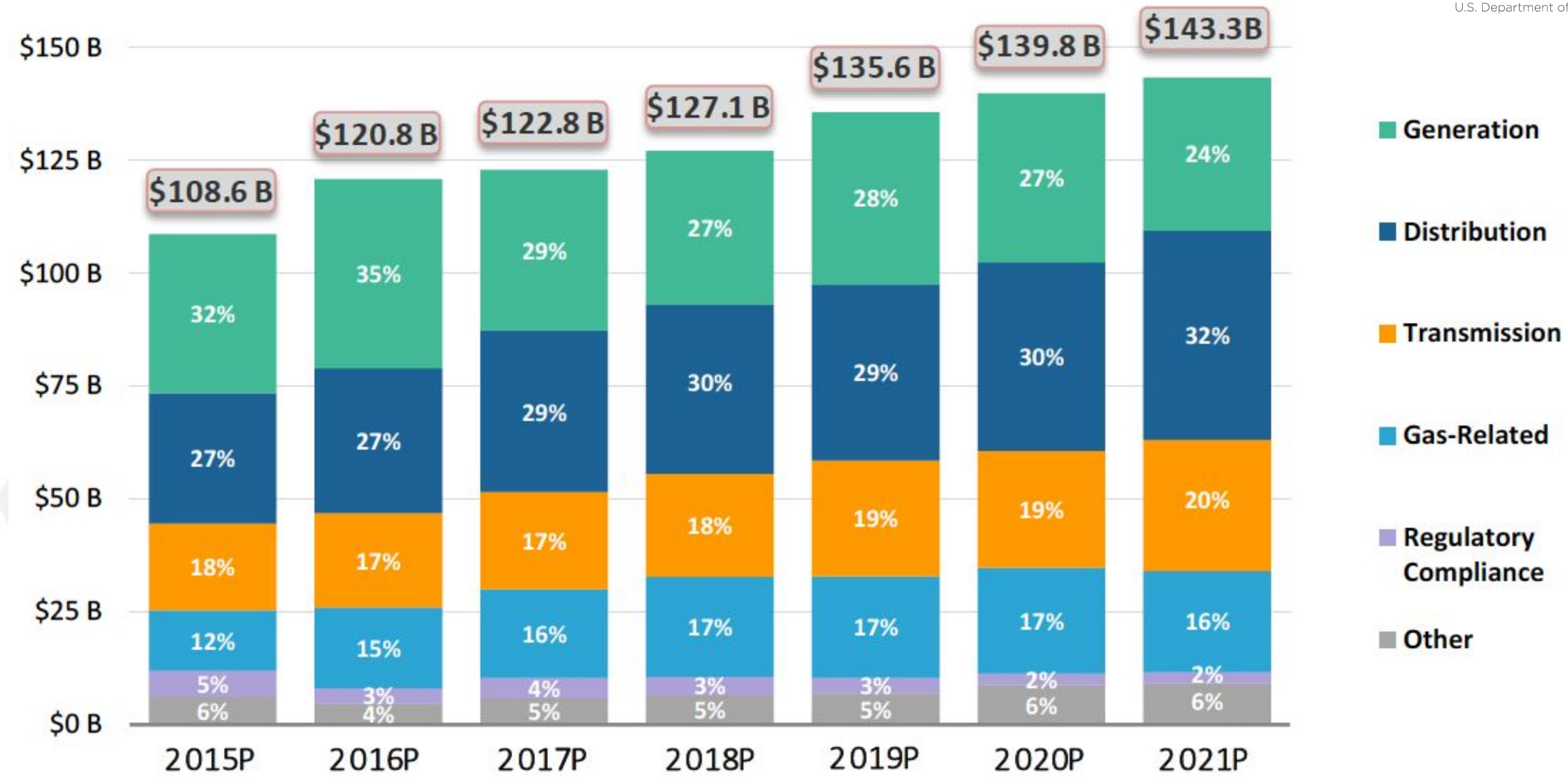
Source: Adapted from Fredrich Kahrl, 3rdRail, for Berkeley Lab

# Distribution planning: State drivers and benefits

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

- More DERs deployed — cost reductions, 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

# One reason states are increasingly interested in distribution planning

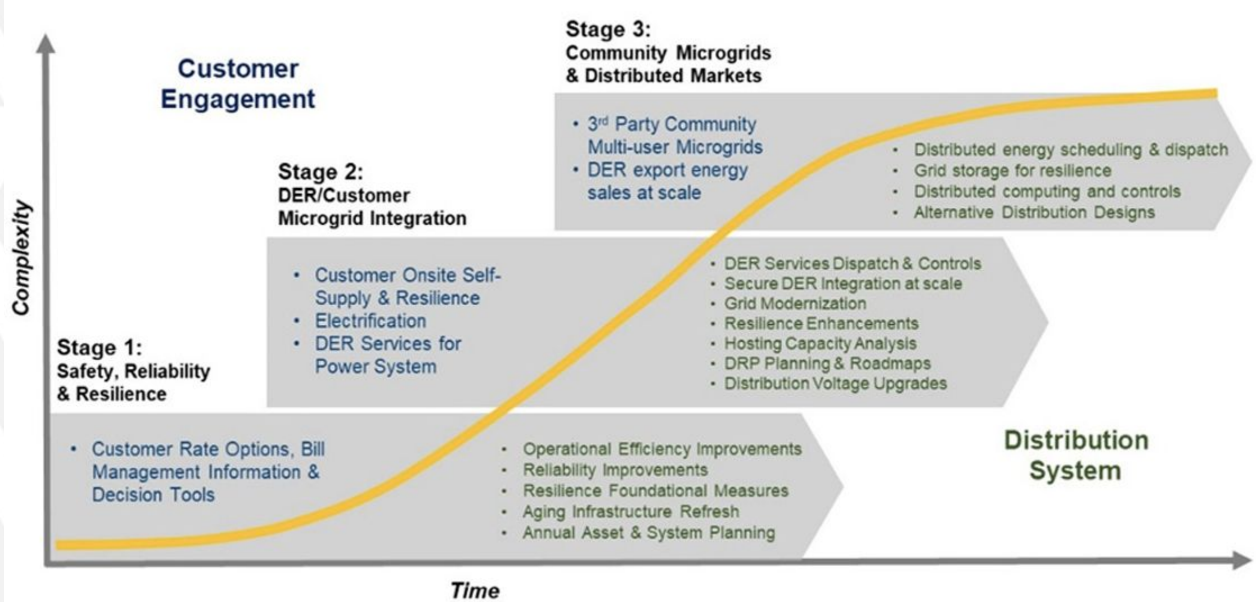



Distribution system investments account for the largest portion (32%) of capex for U.S. investor-owned utilities: $46.4B (projected) in 2021.

Source: Edison Electric Institute

# Other potential benefits from improved distribution planning processes

- ► Makes transparent utility plans for distribution system investments holistically, before showing up individually in a rider or rate case
- ► Provides opportunities for meaningful PUC and stakeholder engagement
  - ■ Can improve outcomes — more data, community input, review
- ► Considers uncertainties under a range of possible futures
- ► Considers all solutions for least cost/risk
- ► Motivates utility to choose least cost/risk solutions
- ► Enables consumers and 3rd party providers to propose grid solutions and participate in providing grid services




Source: DOE 2021

# State requirements and elements

# States with distribution planning requirements

| | California | Colorado | Delaware | District of Columbia | Florida | Hawaii | Illinois | Indiana | Maine | Maryland | Massachusetts | Michigan | Minnesota | Nevada | New Hampshire | New Jersey | New York | Ohio | Oregon | Pennsylvania | Rhode Island | Texas | Utah | Vermont | Virginia | Washington |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Distribution system plan requirement | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | | ● | | ● | | | | ● | |
| Grid modernization plan requirement | ● | | | | | ● | | | | | ● | | ● | | ● | | ● | ● | | | | | | | | |
| Hosting capacity analysis/mapping requirement | ● | | | ● | | ● | | | | | ● | ● | ● | ● | ● | | ● | | | | | | | | | |
| Non-wires alternatives / locational value requirements | ● | ● | ● | ● | | ● | | | ● | | | ● | ● | ● | ● | | ● | | | | ● | | | | | |
| Storage Mandates or Targets | ● | | | | | | | | | | ● | | | ● | | ● | ● | | ● | | | | | | ● | |
| Benefit-Cost Methodology / Guidance | ● | | | | | | | | ● | | | | | ● | ● | | ● | | | | ● | | | | | |
| Storm hardening requirements | | | | | ● | | | | | ● | | | | | | | | | | | | | | | ● | |
| Required reporting on poor-performing circuits and improvement plans | | ● | ● | | ● | | ● | | | ● | ● | | ● | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● |

*Grid modernization plans may be filed in combination with integrated distribution plans.*

# Example state requirements*

- Distribution system plans

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

- Grid modernization plans

  California, Hawaii, Massachusetts Minnesota, Ohio

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

- Hosting capacity analysis/maps
  California, Colorado, Hawaii, Michigan, Minnesota, Nevada, New York

- NWA/locational value
  CA, CO, DE, DC, HI, ME, MI, MN, NV, NH, NY, RI

- Benefit-cost handbook or guidance
  California, Maryland, Nevada, New York, Rhode Island

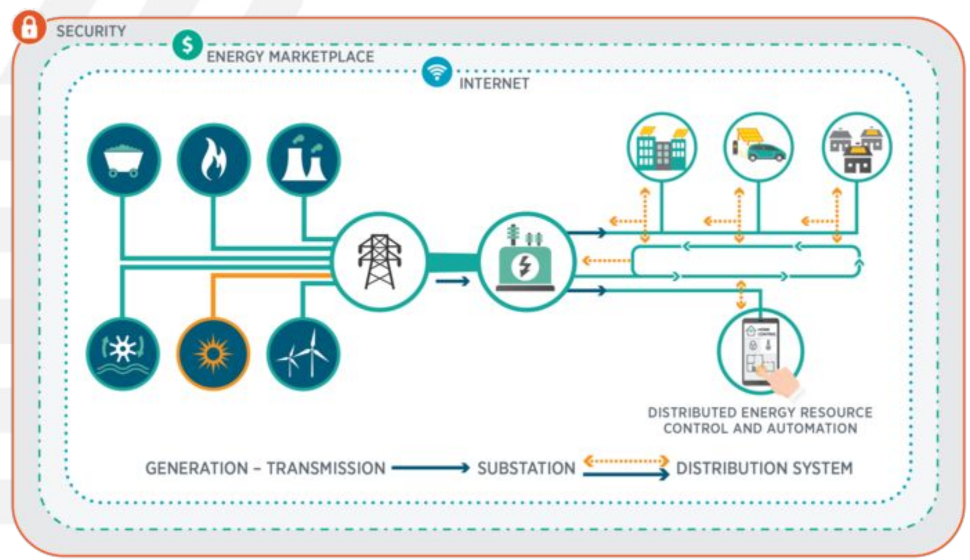
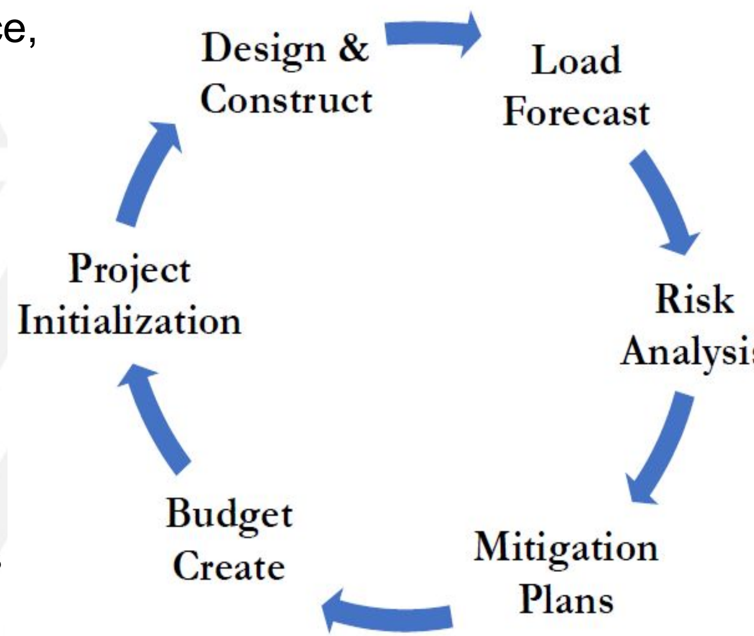



Figure: U.S. Department of Energy

***This list is *not* all-inclusive.**

# Substantive elements (1)

- Baseline information on current state of distribution system
  - Such as system statistics, reliability performance, equipment condition, historical spending by category
- Description of planning process
  - Load forecast – projected peak demand for feeders and substations
  - Risk analysis for overloads and mitigation plans
  - Budget for planned capacity projects
    - Asset health analysis and system reinforcements
    - Upgrades needed for capacity, reliability, power quality
    - New systems and technologies
    - Ranking criteria (e.g., safety, reliability, compliance, financial)
- Distribution operations — vegetation management and event management




Source: Xcel Energy, 2021

# Substantive elements (2)

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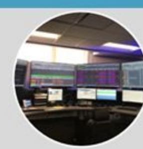
- DER forecast
  - Types, amounts and locations
- Hosting capacity analysis
  - Including maps
- Grid needs assessment and NWA analysis to identify:
  - Existing and anticipated capacity deficiencies and constraints
  - Traditional utility mitigation projects
  - A subset of these projects that may be suitable for non-wires alternatives (NWA) to defer or avoid infrastructure upgrades for load relief, voltage, reducing interruptions, resilience
    - Portfolio of DERs or single large DER (e.g., battery) — typically through competitive solicitations
    - Locational net benefits analysis systematically analyzes costs and benefits of NWAs providing specific grid services to determine net benefits for a given area of the distribution system
    - Can implement NWA incrementally, offering a flexible approach to uncertain load growth and potentially avoiding large upfront costs for load that may not show up
    - NWAs leverage customer and third-party capital investments

# Substantive elements (3)

- Grid modernization strategy
  - Includes financial forecasts associated with grid modernization plans
  - May include request for certification for major investments
- Action plan
- Additional elements
  - Long-term utility vision and objectives
  - Ways distribution planning is coordinated with integrated resource planning
  - Customer engagement strategy
  - Summary of stakeholder engagement
  - Proposals for pilots

| GRID VISIBILITY AND CONTROLS | | Network | Meters |
|---|---|---|---|
| Advanced Distribution Management System (ADMS) | Fault Location, Isolation and Service Restoration (FLISR) | Field Area Network (FAN) & Home Area Network (HAN) | Advanced Metering Infrastructure (AMI) |
|  |  |  |  |
| • Advanced centralized software or the "brains," enhances the operation of the distribution grid<br>• Enables improved reliability, management of DERs, and improved efficiency when operating the grid<br>• Enables enhanced visibility and control of field devices (including customer meters via AMI) | • ADMS provides fault location prediction and the automatic operation of intelligent grid devices<br>• Reduces outage durations and the number of customers impacted by an outage<br>• Enabled by intelligent field devices, FAN, and ADMS | • Two-way communications network<br>• Connects intelligent grid devices and smart meters with software<br>• Enables enhanced remote monitoring and control of intelligent field devices and advanced meters | • Focused on the deployment of smart meters and software<br>• Provides near real-time communication between software and meters<br>• Data and AMI functionality enable new products and services and improves customer experience |

Source: Xcel Energy 2021

# Procedural elements (1)

- **Frequency of filing**
  - Typically annual or biennial
  - Every 3 years (e.g., NV)
  - *Considerations:* alignment with utility distribution capital planning, IRP filing cycle, workload, making and tracking progress on goals and objectives

- **Planning horizon**
  - 2-4 year action plan – OR (+ 5-10 year roadmap for investments, tools and activities)
  - 3 year action plan — NV (+ 6-yr forecasts), DE (+ 10-yr long-range plan)
  - 5 years – NY, CA (+ 10-yr grid modernization vision), HI (+ plan to 2045), MI (+ 10-15 yr outlooks), MN (+ 10-yr Modernization & Infrastructure Investment Plan)
  - 5-7 years – Indiana
  - *Considerations:* short- and long-term investments, coordination with IRP, granularity of distribution planning

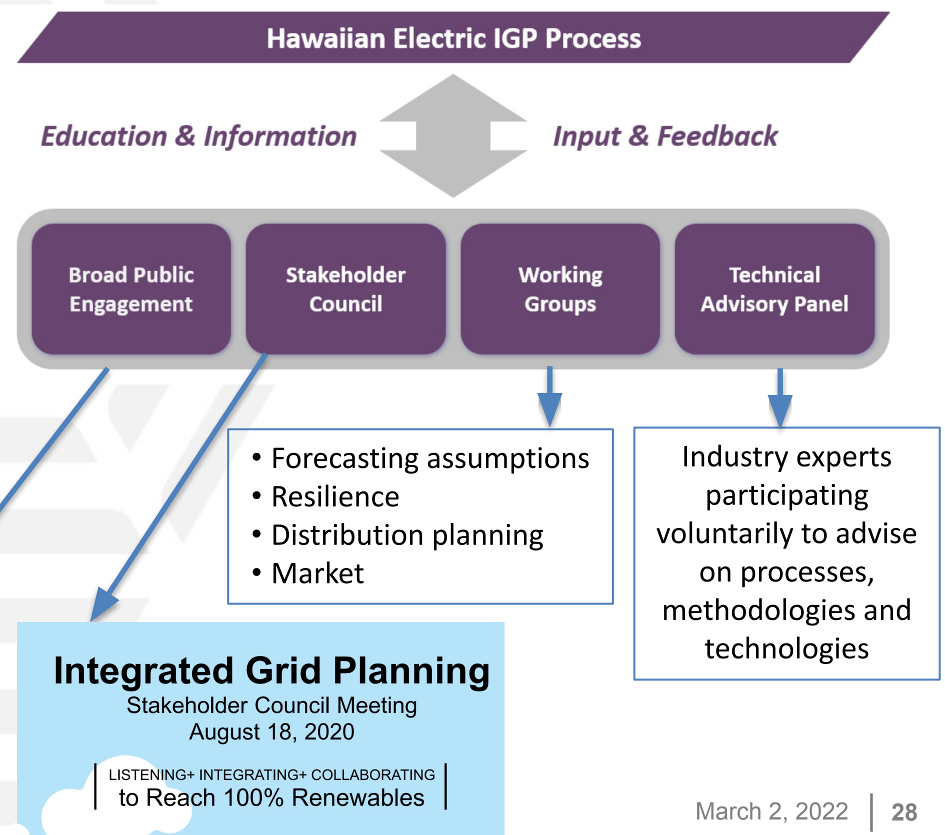
# Procedural elements (2)

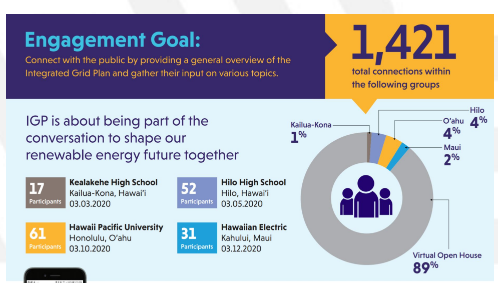
- Stakeholder engagement
  - *Before plan is filed:* Requirements vary from one timely meeting (MN) to significant input through working groups (e.g., CA, DC, HI, MI, NH, NY) and ongoing stakeholder engagement.
  - Examples - HI (see graphic)

NH – A stakeholder group recommends assumptions and metrics, load/DER forecasting methodology, and approaches for hosting capacity, interconnection and locational value.

OR's staged approach initially requires 4 public stakeholder meetings and consultation with CBOs* before plan filing, plus a community engagement plan. It evolves to active collaboration with CBOs and EJ communities so community needs (energy burden, customer choice, resilience) inform DSP projects.

- *After plan is filed:* Stakeholders can file comments; utility provides periodic updates

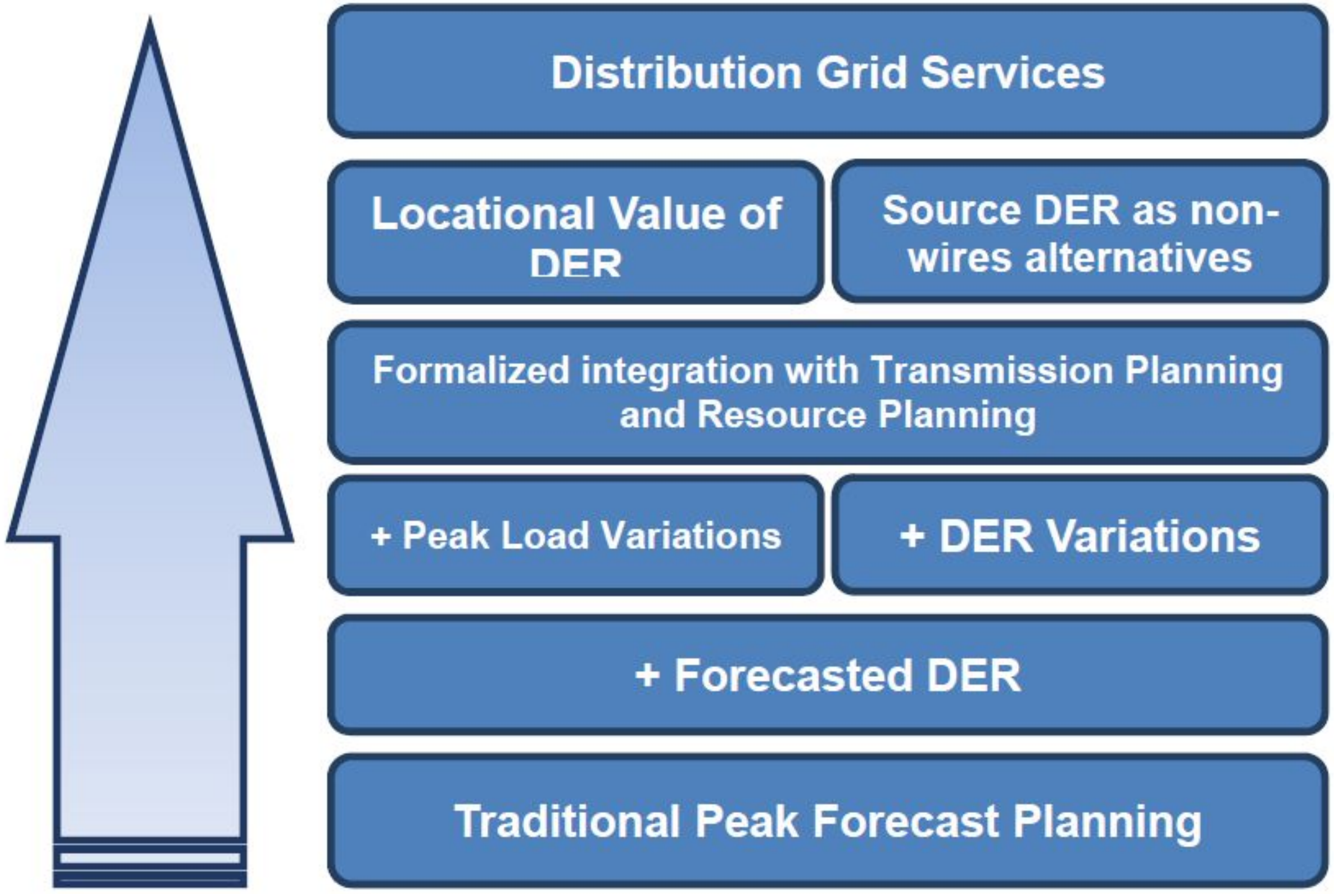



*Community-based organizations

See Confidentiality provisions in Extra Slides

# Evolution in distribution planning practices




Source: Xcel Energy, *2020-2029 Integrated Distribution Plan*, Nov. 1, 2019

# Resources for more information

U.S. Department of Energy's (DOE) Modern Distribution Grid, Vol. IV, 2021

National energy lab distribution planning trainings: https://emp.lbl.gov/projects/integrated-distribution-system-planning

Berkeley Lab's research on time- and locational-sensitive value of DERs

Xcel Energy, *2022-2031 Integrated Distribution Plan*, 2021

N. Frick, S. Price, L. Schwartz, N. Hanus and B. Shapiro, *Locational Value of Distributed Energy Resources*, Berkeley Lab, 2021

T. Woolf, B. Havumaki, D. Bhandari, M. Whited and L. Schwartz, *Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments: Trends, Challenges and Considerations*, Berkeley Lab, 2021

T. Eckman, L. Schwartz and G. Leventis, *Determining Utility System Value of Demand Flexibility From Grid-interactive Efficient Buildings*, Berkeley Lab, 2020

J.S. Homer, Y. Tang, J.D. Taft, D. Lew, D. Narang, M. Coddington, M. Ingram, A. Hoke, *Electric Distribution System Planning with DERs — Tools and Methods*, Pacific Northwest National Laboratory and National Renewable Energy Laboratory, 2020

Smart Electric Power Alliance, *Integrated Distribution Planning: A Framework for the Future*, 2020

ICF (prepared for DOE), *Integrated Distribution Planning: Utility Practices in Hosting Capacity Analysis and Locational Value Assessment*, 2018

A. Cooke, J. Homer, L. Schwartz, *Distribution System Planning – State Examples by Topic*, Pacific Northwest National Laboratory and Berkeley Lab, 2018

J. Homer, A. Cooke, L. Schwartz, G. Leventis, F. Flores-Espino and M. Coddington, *State Engagement in Electric Distribution Planning*, Pacific Northwest National Laboratory, Berkeley Lab and National Renewable Energy Laboratory, 2017

Y. Tang, J.S. Homer, T.E. McDermott, M. Coddington, B. Sigrin, B. Mather, *Summary of Electric Distribution System Analyses with a Focus on DERs*, Pacific Northwest National Laboratory and National Renewable Energy Laboratory, 2017

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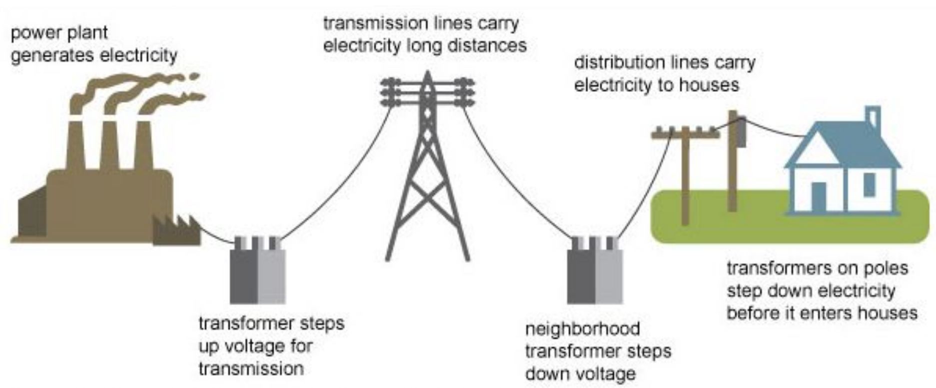
# What is the distribution system?

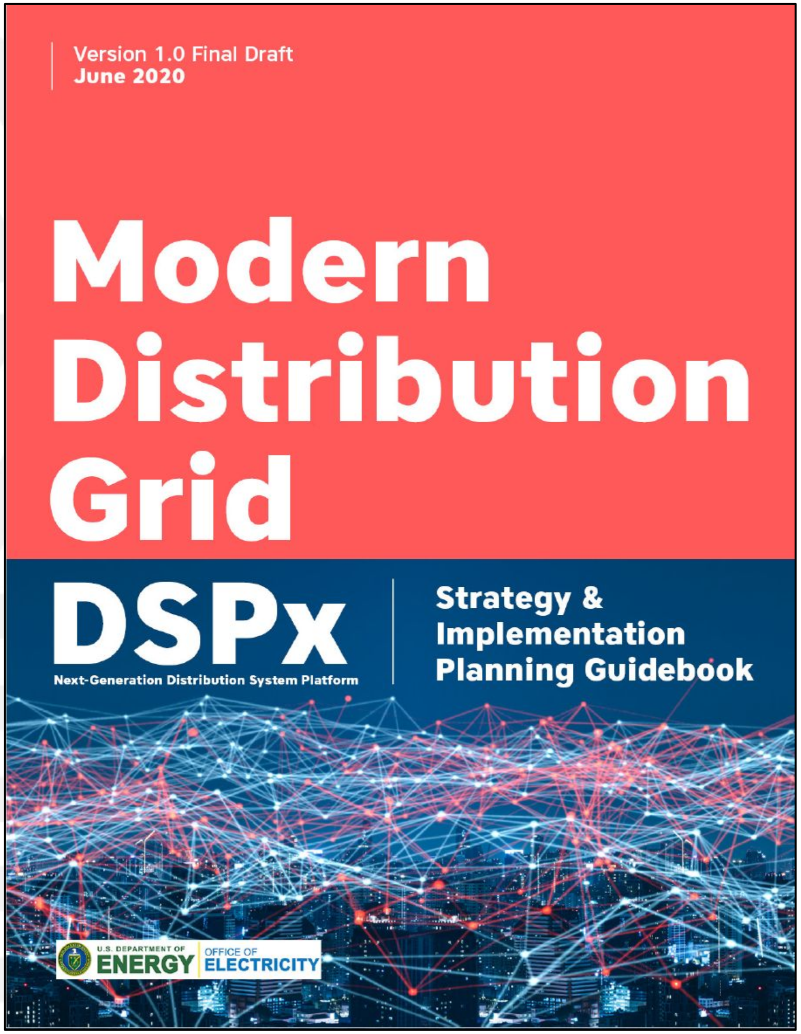



- Portion of electric system composed of medium voltage (up to 69 kV) lines, substations, feeders and related equipment
- Transports electricity to and from homes and businesses and links customers to high-voltage transmission system
- Physical infrastructure (transformers, wires, switches and other equipment) and cyber components (information, telecommunication and operational technologies needed to support reliable operation)

Graphic source: https://www.eia.gov/energyexplained/index.cfm?page=electricity_delivery

# DOE's Modern Distribution Grid guides

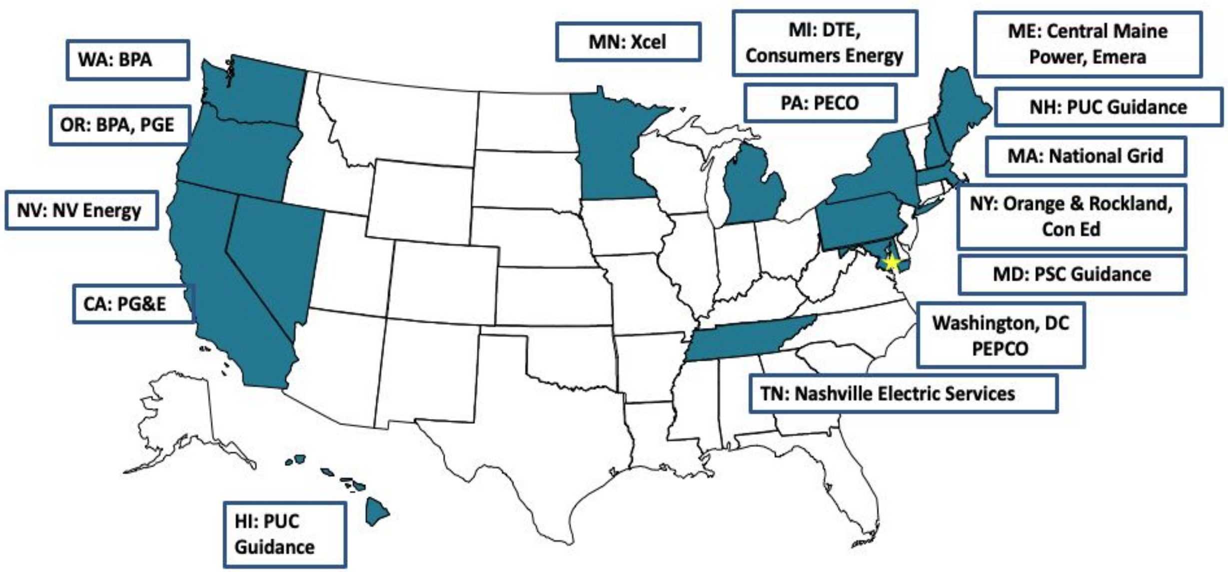
- Volume IV includes an economic evaluation framework for grid modernization investments
- Aims to inform approaches to evaluating economics and managing costs and risks of grid modernization investments




U.S. Department of Energy. *Modern Distribution Grid Volume IV*, 2021

# Considering non-wires alternatives

- Jurisdictions that require consideration of NWAs include CA, CO, DE, DC, HI, ME, MI, MN, NV, NH, NY and RI.
- Several additional states have related proceedings, pilots or studies underway.




Case studies featured in Berkeley Lab report, *Locational Value of Distributed Energy Resources*

# Procedural elements (3)

- Confidentiality for security or trade secrets — for example:
  - Level of specificity for hosting capacity maps
  - Peak demand/capacity by feeder
  - Values for reliability metrics
  - Contractual cost terms
  - Bidder responses to NWA RFPs
  - Proprietary model information