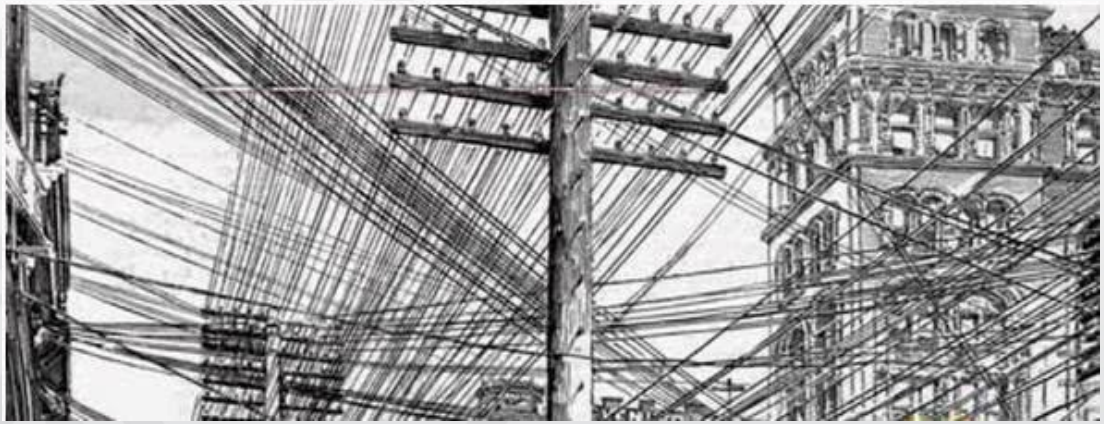


PUC Distribution Planning Practices

Lisa Schwartz, Lawrence Berkeley National Laboratory

Distribution Systems and Planning Training for Southeast Region
March 11-12, 2020

In this presentation

- Electricity planning and state interests, drivers and activities
- Ways states are engaging in distribution system planning
  - Many flavors
  - Example state regulatory process
- Non-wires alternatives and procurement strategies
- Hosting capacity analysis
- Possible places to start
- For further reading:
  - Resources for more information
  - Extra slides: Variety of other state approaches

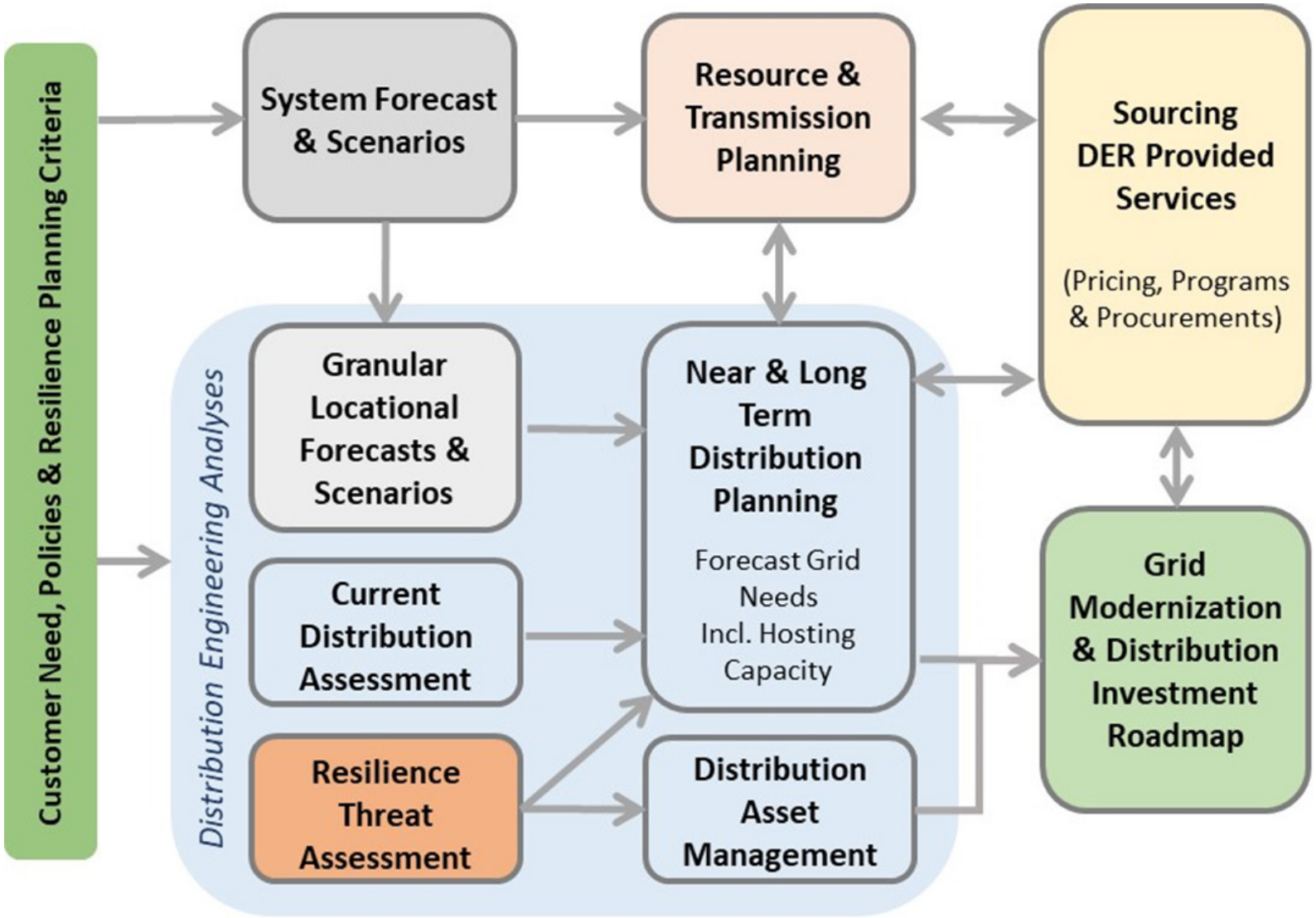
Thanks to Juliet Homer (PNNL) and Greg Leventis and Natalie Mims Frick (Berkeley Lab) for contributions to these slides.

Electricity planning and state interests, drivers and activities

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 (IRP) - 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 (DERs) and impacts on need for, and timing of, utility resource investments
- Transmission planning – Identify future transmission expansion needs and options for meeting those needs

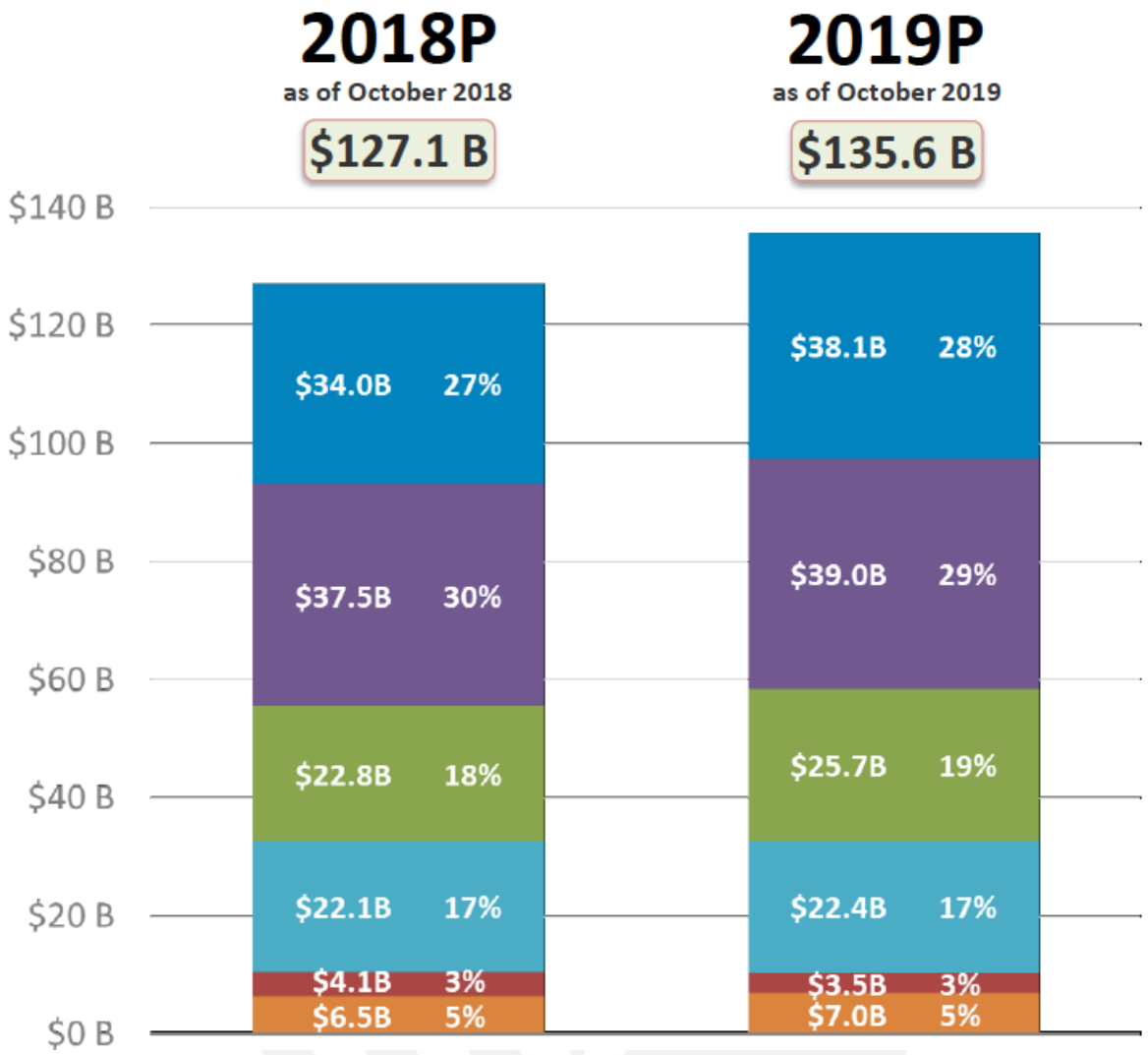
Integrated distribution planning



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

See [DOE's Modern Distribution Grid initiative]

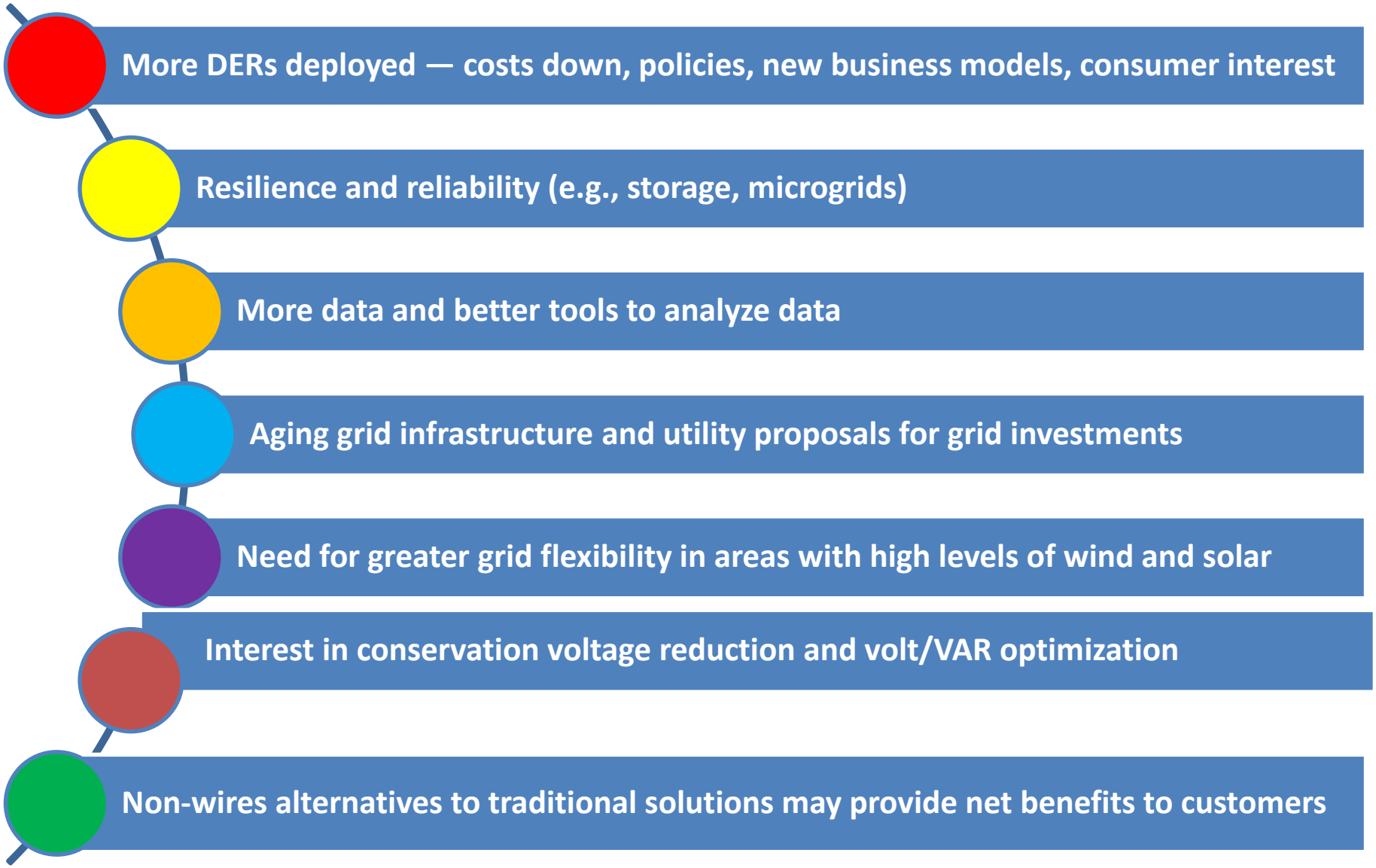
Why may states be interested in distribution planning?



- 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 improved distribution planning.



Other potential benefits from improved distribution planning

- 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
- 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 third-party providers to propose grid solutions and participate in providing grid services

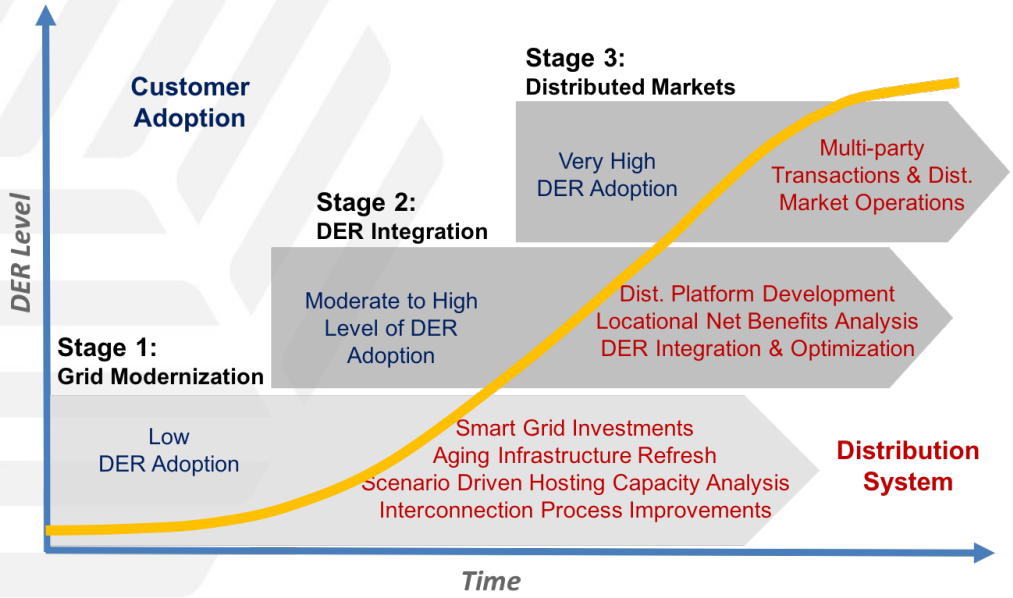
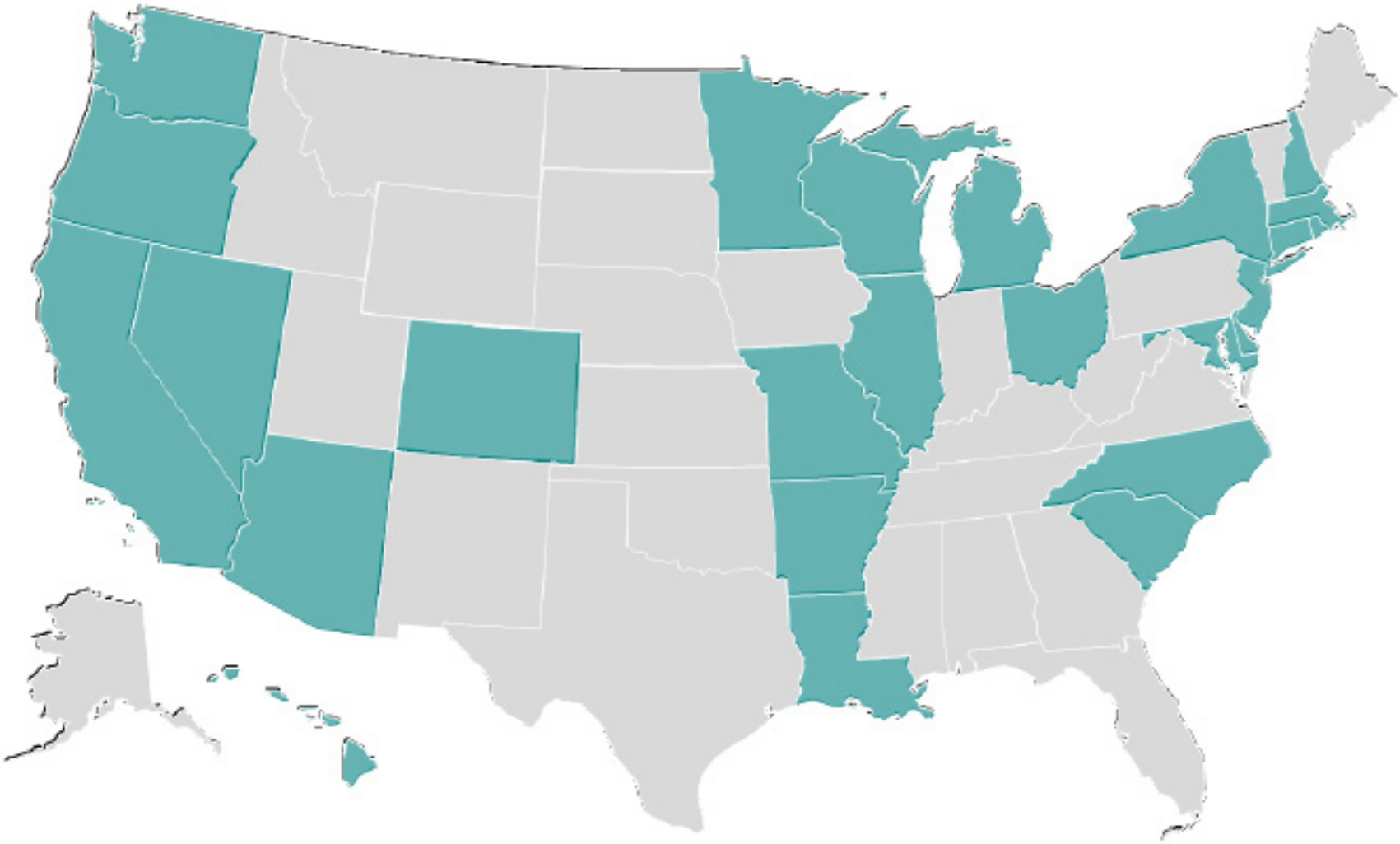


Figure from De Martini and Kristov, for Berkeley Lab

State legislative and regulatory activities (1)



Distribution system planning activities in 25 states

Source: EPRI, *Modernizing Distribution Planning: Benchmarking Practices and Processes as They Evolve*. November 2019

State legislative and regulatory activities (2)

Common Components	Range of Requirements
Data Sharing and Transparency	Share a broad range of data including feeders, substations, operating voltages/ratings, load assumptions/forecasts, etc.
Hosting Capacity	Defining methods and tools, sharing maps, leveraging in planning and interconnection analysis. The granularity requested varies from requiring a node-level to feeder-level analysis. The frequency of updates ranges from monthly to annually.
Non-Wires Alternatives (NWAs)	Develop screening processes or criteria that can be used to identify when a grid need should be reviewed as a potential for NWAs. The consideration and assessment of NWAs in the investment plans varies by state – from being required to evaluate a NWA on every infrastructure investment to infrastructure projects of $1 million or greater.
Distribution System Plan Requirements	Provide annual documentation of the planning process and outline their distribution system investment plans to provide the scale of grid needs over a 5-year period. Some utilities are also required to define changes to the planning process in order to better incorporate DER.
Locational Value	Discussions are still in the early stages on this as is a longer-term component of the overall efforts. Some states like CA and NY are beginning to develop methods to assess locational value.

Source: EPRI, *Modernizing Distribution Planning: Benchmarking Practices and Processes as They Evolve*, November 2019

Some considerations for establishing a regulatory process for distribution planning

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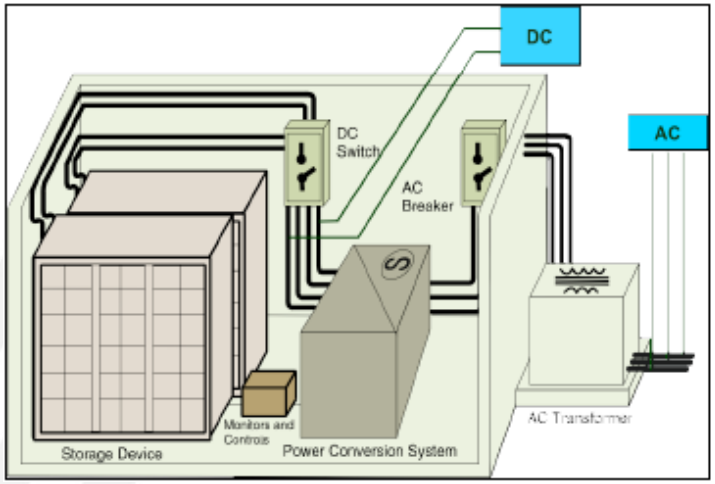
U.S. Department of Energy

- Statutory requirements, regulatory precedents
- Priorities, phasing, related proceedings
- What's worked elsewhere, tailored to your state
- Recognize differences across utilities
- Regulatory clarity with flexibility built-in
- Quick wins, early benefits for consumers
- Long-term, cohesive view to achieve goals
- Pilots vs. full-scale approaches (including economy of scale, rate impacts)



Battery storage. Source: Sandia National Laboratories

Examples of state engagement in distribution system planning

States are engaging in distribution system planning in a variety of ways. Here are some *examples*.*

- Requirements for utilities to file distribution system or grid modernization plans (CA, CO, DC, HI, IN, MA, MD, ME, MI, MN, NV, NY, OH, PA, RI, VA, WA)
  - Utilities in several other states also are filing grid modernization plans (GA, NC, SC, TX, VA)
- Storage studies or proceedings on storage investments (AL, AR, FL, KY, GA, LA, MA, MD, ME, MN, NC, NJ, NV, NY, SC, TX, VA, VT)
- Requirements to conduct hosting capacity analysis (CA, HI, MN, NY)
- Requirements to consider non-wires alternatives (CA, CO, DC, HI, MD, ME, MN, NV, NY, RI)
- Utility infrastructure hardening and/or undergrounding requirements (FL, MD, NY)
- Requirements for utilities to file distribution reliability reports and develop improvement plans (many states — e.g., FL, IL, OH, PA, RI)

**This list is growing and not all-inclusive. See "Example Filing Requirements" in Extra Slides.*

Example state regulatory process: Minnesota (1)*

- Minn. Stat. §216B.2425 (2015) requires largest utility to submit biennial transmission and distribution (T&D) plans to PUC
  - *"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** 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."*
  - 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)
- To date, Commission has certified investments in:
  - Advanced Distribution Management System (ADMS)
  - Residential Time of Use Pilot using advanced metering infrastructure (AMI)
  - Field Area Network (FAN)

See other state approaches in "Extra Slides" at the back of this deck.

Example state regulatory process: Minnesota (2)

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U.S. Department of Energy

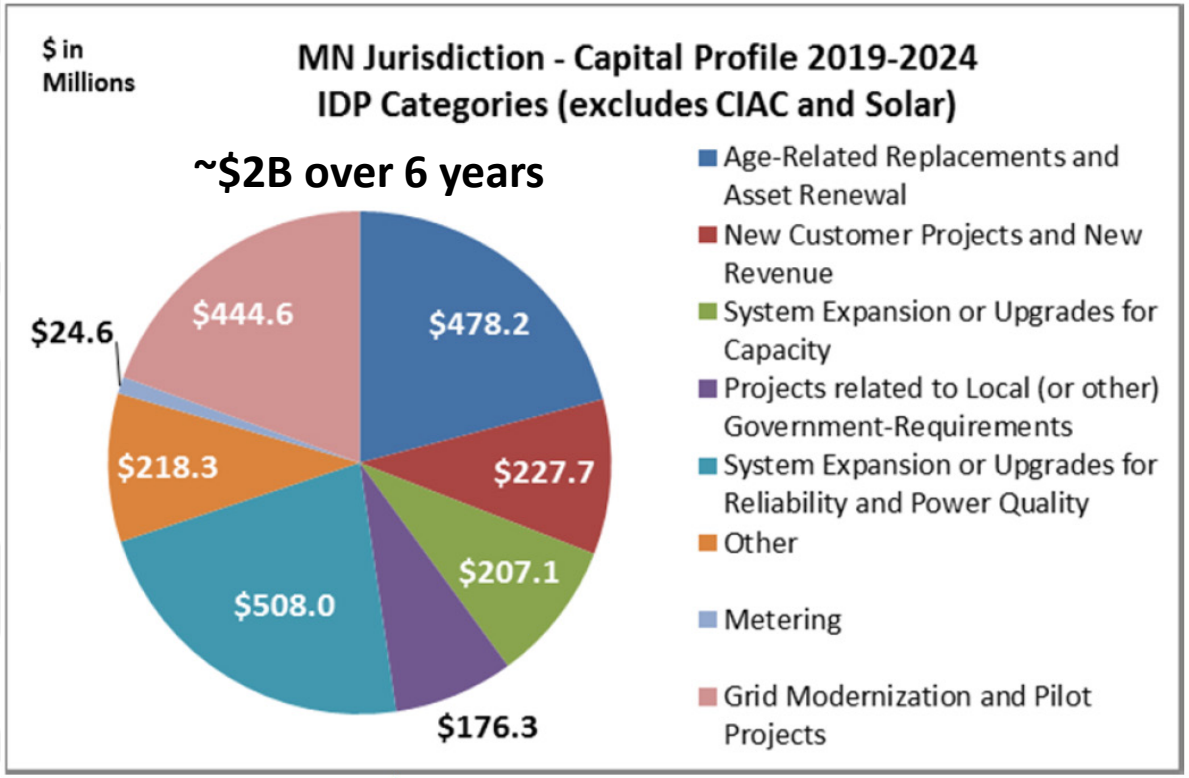
- PUC initiated inquiry on Electric Utility Grid Modernization in 2015 with a focus on distribution planning (Docket No. CI-15-556)
  - Series of stakeholder meetings
  - Questionnaire to utilities on utility planning practices with stakeholder comments
    - How do Minnesota utilities currently plan their distribution systems?
    - What is the status of each utility's current plan?
    - Ways to improve or augment utility planning processes?
  - Staff Report on Grid Modernization defined grid modernization for Minnesota, proposed a phased approach, and identified principles to guide it:
    - *Maintain and enhance safety, security, reliability, and resilience of electricity grid, at fair and reasonable costs, consistent with state's energy policies*
    - *Enable greater customer engagement, empowerment, and options for energy services*
    - *Move toward creation of efficient, cost-effective, accessible grid platforms for new products, new services, and opportunities for adoption of new distributed technologies*
    - *Ensure optimized use of grid assets and resources to minimize total system costs*
    - *Facilitate comprehensive, coordinated, transparent, integrated distribution system planning*

Example state regulatory process: Minnesota (3)

- In 2018, the Commission set Integrated Distribution Planning requirements for Xcel Energy (Docket No. 18-251) and requirements for smaller regulated utilities
  - Docket Nos. 18-253 (Otter Tail), 18-254 (Minnesota Power), 18-252 (Dakota Electric)
- Most requirements are the same across utilities, but diverge in two ways:
  - Filing cycle – annual vs. biennial
  - Hosting capacity – For smaller utilities, spreadsheet analysis by feeder, daytime min. load data
- Fundamental provisions
  - 10-year Distribution System Modernization and Infrastructure Investment Plan
    - Including a 5-year action plan, based on internal business plans and DER future scenarios
      - Base case, medium and high — specifying methods and assumptions
  - Coordination with Integrated Resource Planning (except for Dakota Electric, a distribution coop)
  - Utility holds at least one "timely" meeting prior to filing; PUC staff can convene a stakeholder meeting during public comment period
  - Data specified for filing - Baseline distribution system, financial data, DER deployment
  - For projects >$2M, analyze how non-wires alternatives (NWAs) compare with traditional grid solutions in terms of viability, price and long-term value
    - Specify project types (e.g., for load relief or reliability), timelines and cost thresholds

Example state regulatory process: Minnesota (4)

- Xcel Energy filed its 1st DSP Nov. 1, 2018 (Docket 18-251), and 2nd IDP Nov. 1, 2019 (Docket 19-666)
  - Grid modernization report required by statute now filed in combination with IDP filing
  - Includes certification request for Advanced Grid Intelligence and Security (AGIS) and an Advanced Distribution Planning Tool. AGIS includes AMI, FAN, Fault Location and Isolation Service Restoration, and Integrated Volt/Var Optimization.
- Filings by other regulated utilities
  - MN Power (19-684)
  - Dakota Electric Association (19-674)
  - Otter Tail Power Co. (19-693)



Note: excludes non-investment/CIAC amounts.

Non-wires alternatives and procurement strategies

Considering non-wires alternatives in distribution system planning

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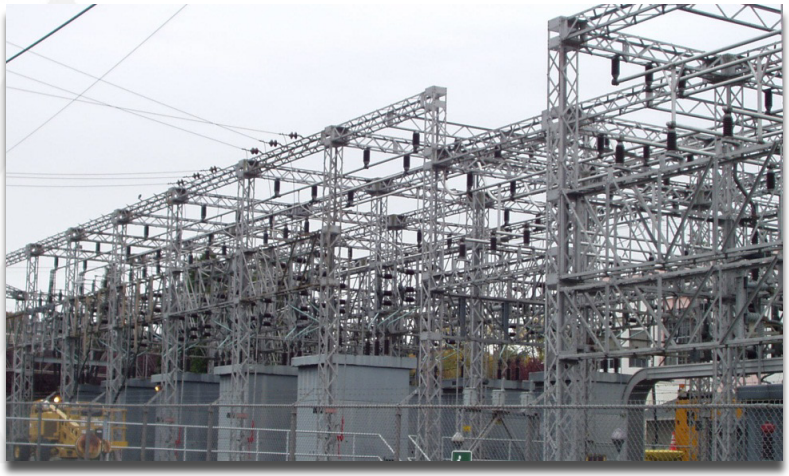
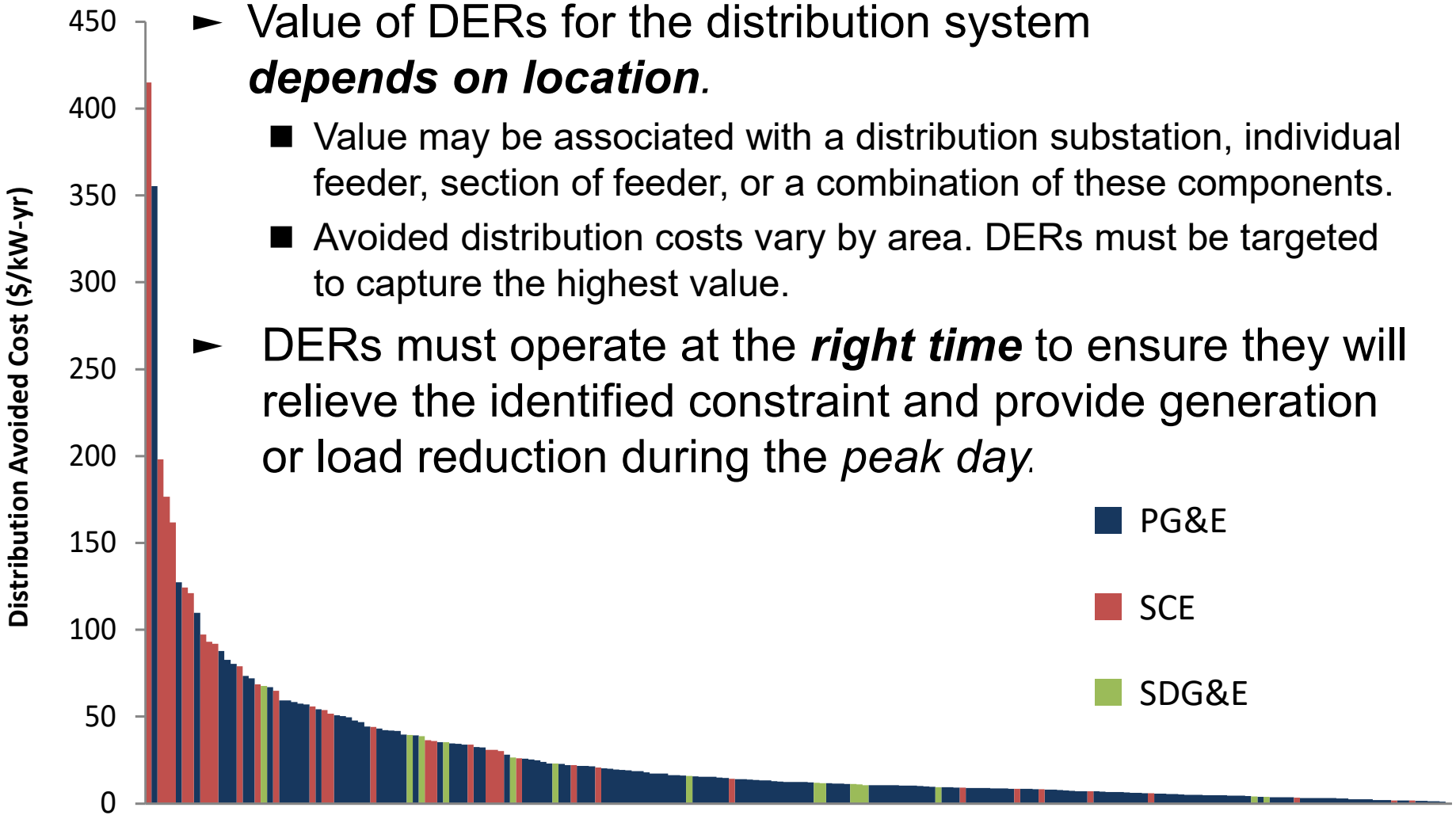
U.S. Department of Energy

- Non-wires alternatives (NWA) are options for meeting distribution (and transmission) system needs related to load growth, reliability and resilience.
  - Large DER (e.g., storage) or portfolio of DERs that can meet the specified need
- Objectives: Provide load relief, address over- or under-voltage, 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, 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, including implementation and operational risk assessment.

DERs must be in the right place and operate at the right time to meet grid needs.

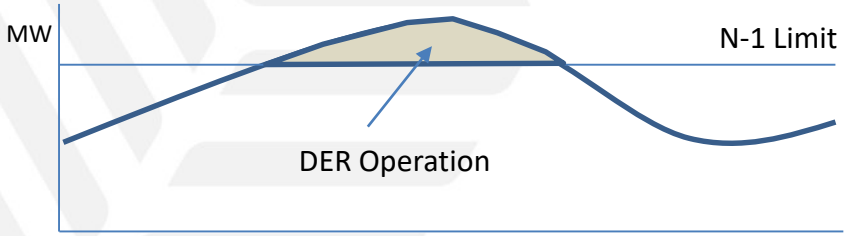


- Value of DERs for the distribution system ***depends on location***.
  - Value may be associated with a distribution substation, individual feeder, section of feeder, or a combination of these components.
  - Avoided distribution costs vary by area. DERs must be targeted to capture the highest value.
- DERs must operate at the ***right time*** to ensure they will relieve the identified constraint and provide generation or load reduction during the *peak day*.

E3 study for California using utility distribution planning information

Valuation of DERs as non-wires solutions began several decades ago.

- Utilities have been targeting, evaluating, and deploying DERs for deferring or avoiding distribution capacity since the 1990s. Transmission providers (e.g., Bonneville Power Administration) also have considered non-wires solutions for some projects.
- Lessons learned
  - ***Value.*** Value of DERs for avoiding or deferring capital upgrades may not be large for areas with high load growth where significant capacity is needed. *The highest value opportunities for deferral are where low load growth is driving the utility towards large capital investments, and there is significant value per kilowatt of peak load relief.*
  - ***Timing.*** Sufficient time is required to implement non-wires solutions, to make sure they are online before the constraint occurs and to verify reliable operation at the time needed.



Source: Adapted from E3, prepared for Berkeley Lab

DER procurement strategies: New York (1)

- Utilities must routinely identify candidate projects (load relief, reliability) for non-wires alternatives, post information to websites, and issue RFPs
- Joint Utilities (ConEd, O&R Utilities and Central Hudson) provided suitability criteria for NWA projects in March 2017 and described how criteria will be applied to projects in their capital plans in a filing in May 2017

Criteria	Potential Elements Addressed	
Project Type Suitability	Project types include Load Relief and Reliability*. Other categories currently have minimal suitability and will be reviewed as suitability changes due to State policy or technological changes.	
Timeline Suitability	**Large Project**	36 to 60 months
	Small Project	18 to 24 months
Cost Suitability	**Large Project**	≥ $1M
	Small Project	≥ $300k

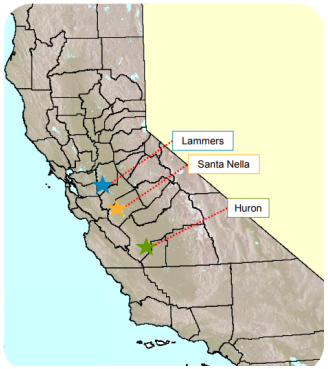
DER procurement strategies: New York (2)

- May 2017 supplemental filing describes procurement process to award contracts; also see Joint Utilities NWA process
- RFP response requirements include:
  - Proposed solution description
  - Project schedule and acquisition plan
  - Detailed costs associated with proposed solution
  - Risks, challenges and community impacts
  - Professional background and experience
- All NWA opportunities on REV Connect website
  - Example NWA: Rochester Gas & Electric plans to use targeted efficiency near Station 51 to reduce peak demand that would otherwise be met with traditional upgrades

DER procurement strategies: California

- Distribution Investment Deferral Framework decision (Feb. 2018)
  - Annual process for DERs to defer or avoid traditional capital investments
  - "The central objective … is to identify and capture opportunities for DERs to cost-effectively defer or avoid traditional IOU investments that are planned to mitigate forecasted deficiencies of the distribution system."
  - Utilities file two reports annually:
    1) Grid Needs Assessment (example GNA filing) main driver for Distribution Resources Plan
    2) Distribution Deferral Opportunity Report (DDOR)
  - Recommend deferral projects for competitive annual solicitations—e.g., SCE, PG&E, SDG&E
  - May 2019 update modifies requirements
    - GNA and DDOR in consolidated filing with specific $/MWh and locational net benefit analysis values for prioritizing projects
    - Additional requirements for GNA narrative and datasets
    - Additional project-specific data required for planned investments and candidate deferral project shortlist

2019 DIDF Project Locations



	Candidate Deferral	In-Service Date	Deficiency (MW)
★	New Lammers Feeder	6/1/2021	1.5
★	Huron Bank 1	4/1/2021	3.7
★	Santa Nella Bank 1 and New Feeder	5/1/2022	5.4
	Subtotal		*10.6*

Figure: PG&E presentation on 2019 RFO for support of local distribution capacity relief in three 3 areas in central Calif.

DER procurement strategies: Hawaii

- Hawaiian Electric Companies (HECO) Integrated Grid Planning (IGP) incorporates procurement *into planning itself*, not after planning*
- Integrated Grid Planning process (Order 35569)
  1. Develop forecasts and assumptions that will drive planning
  2. Collectively identify needs - resources, T&D
  3. Identify solutions - resource, T&D that can be achieved through procurement, pricing and program options
  4. Evaluate and optimize resource and T&D solutions, submit 5-year plan to PUC with proposed investments, pricing and programs

- 2nd DER grid services RFP for fast frequency response (ancillary service) (Docket 2017-0352, HECO RFP website), following on successful RFP in 2018
- IGP "soft launch" RFP for capital deferral for a new housing/commercial development and emergency overloads at a substation recently cancelled due to insufficient response to MW and duration requirements
- HPUC approved (March 2019) a 25-year power purchase agreement for solar (≤30 MW) + storage (120 MWh) project, to be dispatched by HECO
  - Lump sum payments based on net energy potential and availability, not delivered energy
  - Costs recovered through Purchased Power Adjustment (if not in rate base)

*See Hawaii process diagram in "Extra Slides"

Hosting capacity analysis

What is hosting capacity analysis?

- Amount of DERs that can be interconnected without adversely impacting power quality or reliability under existing control and protection systems and without infrastructure upgrades
- Some states require regulated utilities to do it
  - CA, HI, MN, NY
- Utilities can decide to do it on their own
  - e.g., Pepco

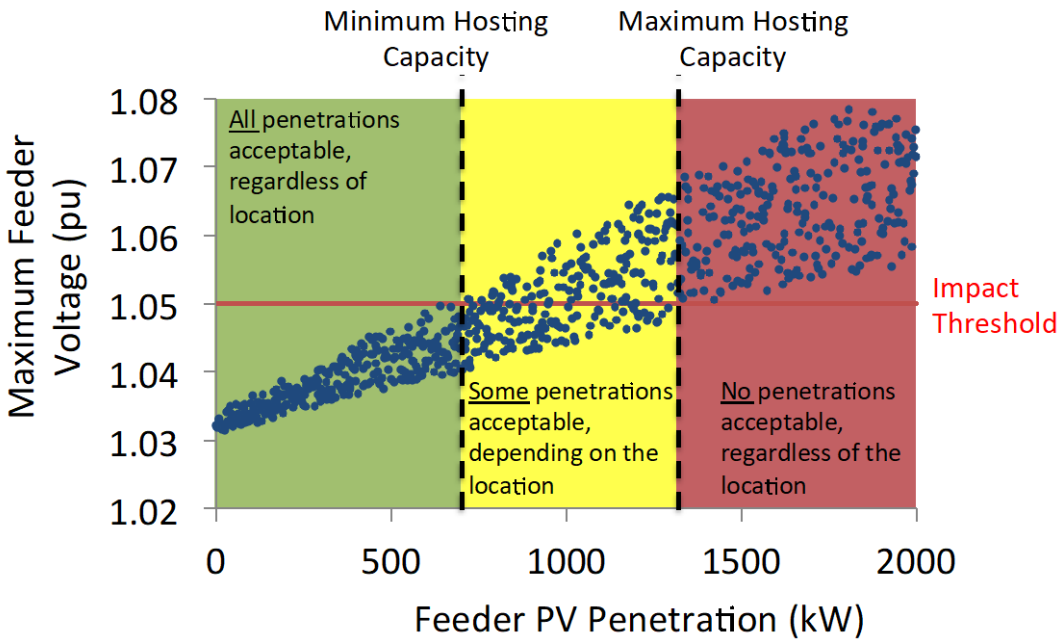


Figure adapted by Berkeley Lab from EPRI (2015), *Distribution Feeder Hosting Capacity: What Matters When Planning for DER?*

State drivers for hosting capacity analysis

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	Hosting Capacity
Hawaii *Key Driver: Legislative Mandates & regulatory requirements from Commission*	• Locational Value Maps available online • Integrated Interconnection Queue for all areas, including those currently exceeding hosting capacity • Customers can check the status of their interconnection application online
California *Key Driver: Distribution Resource Planning Proceedings*	• Goal is to streamline the interconnection review process. • Replaces interconnection screens in some instances • Interconnection Capacity Analysis (ICA) 2.0 maps expand analysis to include output values such as alternate circuit configurations and storage ICA with high accuracy and monthly updates
New York *Key Driver: Reforming the Energy Vision*	• Hosting Capacity maps are provided to guide solar PV developers to locations with lower expected interconnection costs • Goal is to eventually build to an integrated value assessment tool
Minnesota *Key Driver: Regulatory & legislative mandates for renewable generation, emission reduction and fossil fuel reduction*	• Focus on planning and incorporating lessons learned from other jurisdictions • Xcel published visual hosting capacity maps and allow for formal request for interconnection on-site and for pre-application data request

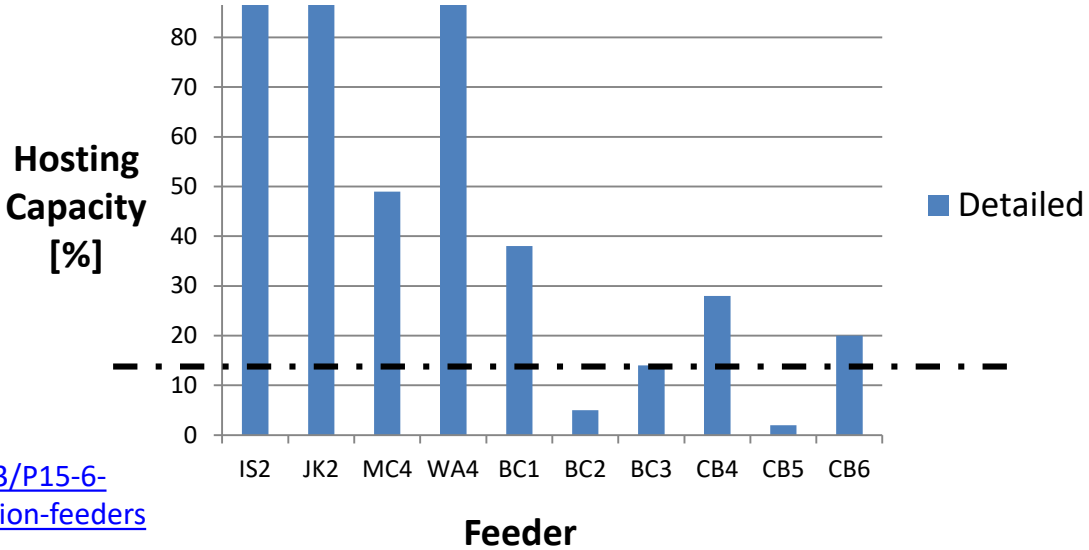
Source: ICF, for DOE

How and where is hosting capacity used (1)

Use Case	Objective	Method	Challenges
Development Guide	Accelerate DER deployment	Focus development capital in potentially lower cost areas	Regularly updated analysis of the full system and data visualization to facilitate external use
Technical Screen	Facilitate timely, more robust interconnection screening process	Hosting capacity replaces less accurate rules of thumb in the interconnection technical screens	High granularity required, model validation, benchmarking to detailed studies
Distribution Planning Tool	Reduce future barriers to DER integration	Proactive identification of system upgrades to increase hosting capacity	Higher input data requirements and granular load and DER forecasts
Dynamic Hosting Capacity	Real time dispatch feasibility analysis for DER services	Analysis of impacts of DER output on the as-switched system	Deployment of ADMS/DERMS to facilitate implementation

Source: ICF International for DOE

Example: Interconnection screening
15% rule of thumb allows aggregate DER penetration below 15% of feeder peak load — graph at right shows results of detailed hosting capacity analysis



Graph: DSTAR, http://www.dstar.org/research/project/103/P15-6-impact-and-practical-limits-of-pv-penetration-on-distribution-feeders

How and where is hosting capacity used (2)

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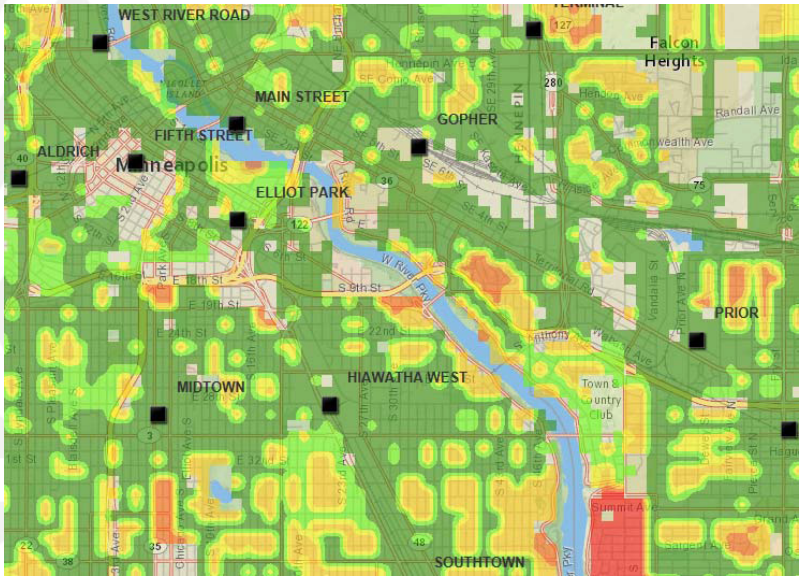
U.S. Department of Energy

Use Case	Description	CA IOUs	NY IOUs	HI	APS	Xcel	Pepco
Utility Interconnection Analysis	HCA as a utility tool for evaluating interconnection applications (SIS), (dependency: interconnection)				●		
Distribution Planning Tool	HCA as a tool to enable greater DER integration by identifying potential future constraints and proactive upgrades (dependency: locational value, forecasting)	●		●			
Interconnection Technical Screen	Use of HCA as a means to automate technical screens as part of the state interconnection process (dependency: interconnection)	●		●			●
Development Guide	HCA to identify areas with potentially lower interconnection costs	●	●	●		●	●
Dynamic Hosting Capacity	Identify impacts to the system from DER dispatch in real time based on the as-switched system (dependency: locational value)						

Source: ICF, for DOE

Example hosting capacity analysis requirements: Minnesota (1)

- State law (2015) requires Xcel Energy to conduct a distribution study to identify interconnection points for small-scale distributed generation (DG) and system upgrades to support its development
- PUC requires analysis of each feeder ≤1 MW and potential distribution upgrades necessary to support expected DG levels, based on utility's IRP filings and Community Solar Gardens program
- Xcel filed 1st hosting capacity analysis on 12/1/16 (Docket 15-962)
  - Commission decision requires hosting capacity analysis Nov. 1 each year and provided guidance for future analysis:
    - Reliable estimates and maps of available hosting capacity at feeder level
      - Details to inform distribution planning and upgrades for efficient DG integration
      - Detailed information on data, modeling assumptions and methodologies



Example heat map result – Source: Xcel Energy, 2019

Example hosting capacity analysis requirements: Minnesota (2)

- PUC's order on utility's 2018 hosting capacity filing (Docket 18-684) included required improvements for next filing
  - Work with stakeholders to improve value of analysis, with more detailed data in maps
  - Provide spreadsheet with hosting capacity data by substation and feeder, with peak load, daytime min. load, installed generation capacity, and queued generation capacity
  - For feeders with no hosting capacity, identify "The full range of mitigation options … including a range of potential costs … and financial benefits…."
  - In addition to continuing to provide an early indicator for ease of interconnection, identify with stakeholders cost and benefits of replacing or augmenting initial interconnection review screens and supplemental review and automating interconnection studies
- Xcel Energy's 2019 filing (Docket 19-685) used new EPRI mitigation assessment tool to determine most cost-effective mitigation for 77 feeders*
  - For peak and minimum load hours
  - Hosting capacity for 36 feeders increased by an average of 1.9 MW each with no-cost (vast majority) or low-cost solutions to over-voltage or thermal violations.

**See Minnesota in "Extra Slides" at the back of this deck.*

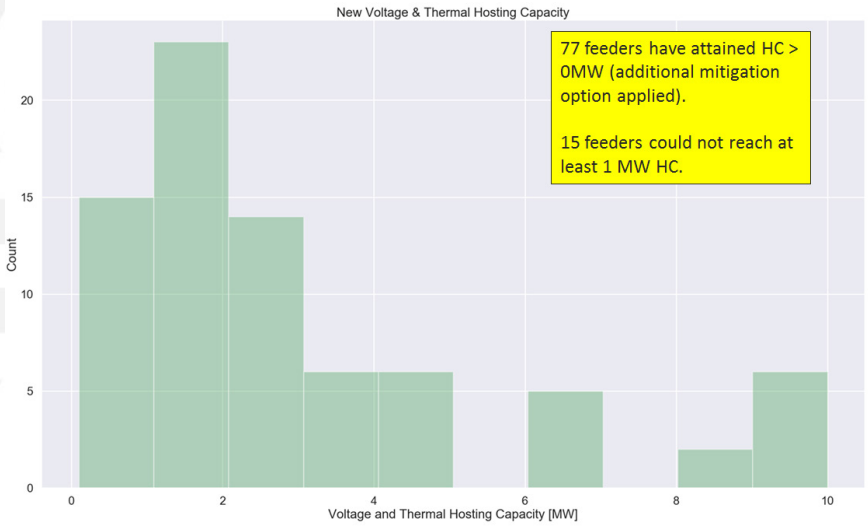


Figure: Xcel Energy, 2019 Hosting Capacity filing

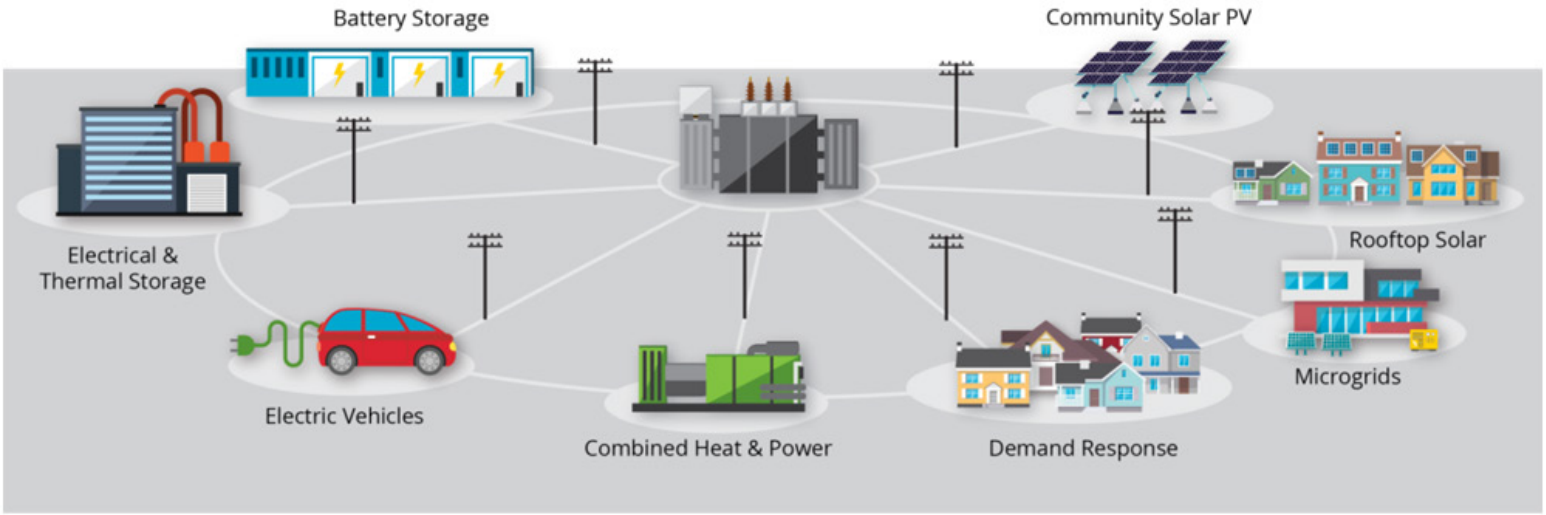
Possible places to start

Possible places to start

- *Take early integration steps* - Consistency in inputs (e.g., assumptions, forecasts) and scenarios — updated in time — across distribution planning, transmission planning and, in vertically integrated states, integrated resource planning
- *Account for all resources* – Consider energy efficiency, demand response (including direct load control, smart thermostats and time-varying pricing), distributed generation, and storage alongside traditional distribution solutions, where applicable
- *Specify DER attributes* – In order to meet identified distribution system needs
- *Test new sourcing and pricing methods* – e.g., competitive solicitations, tariffs, programs
- *Analyze multiple possible futures* – e.g., loads, DERs, markets

Possible places to start (2)

- *Phase in hosting capacity analysis* – Identify constrained areas on distribution system
- *Pilot non-wires alternative projects* – Evaluate where DERs might offer greatest benefits
- *Ask utilities to report planned large investments* over next 3 to 5 years – Specify how investments will be integrated with existing assets and systems, provide data for planning, and benefit consumers.
- *Education and training – You're doing that right now!*



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

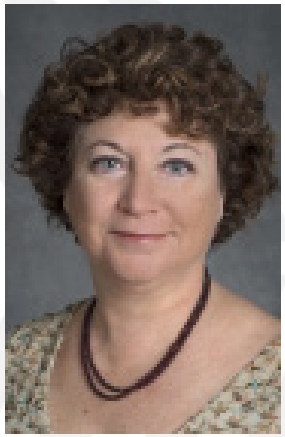
Berkeley Lab's Future Electric Utility Regulation reports

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

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

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* (forthcoming)

Contact



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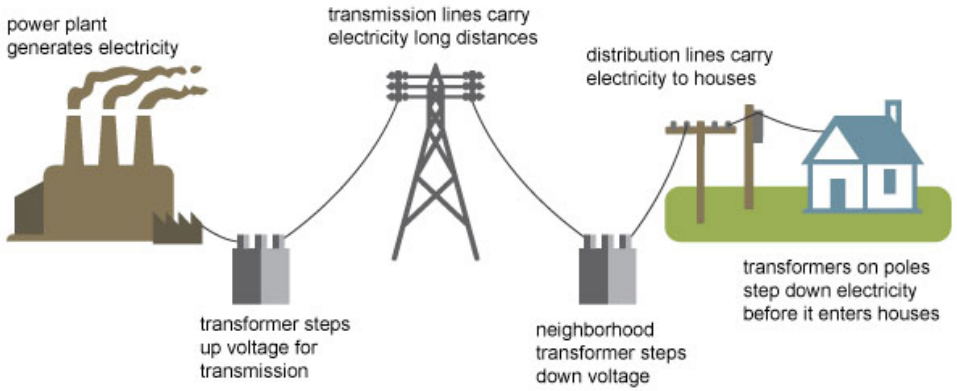
Extra Slides:
Variety of Other State Approaches

Example filing requirements*



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

- Distribution system plans
  - California, Indiana, Hawaii, Maine, Maryland, Michigan, Minnesota, Nevada, New York, Rhode Island
    - Description of planning process (e.g., questionnaire) — Ohio, Minnesota, Oregon
- Grid modernization plans
  - California, Hawaii, Oregon, Massachusetts, Minnesota, Ohio
- Benefit-cost handbook or guidance
  - Maryland, Nevada, New York, Rhode Island
- Hosting capacity analysis
  - California, Minnesota, Nevada, New York

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

State approaches – California (1)

- AB 327 (2013) requires utilities to prepare Distribution Resource Plans (DRPs) that identify optimal locations for the deployment of DERs.
- PUC proceeding on DRPs includes 3 tracks (order instituting rulemaking):
  - Track 1 – Hosting capacity and locational value methods and initial pilots
  - Track 2 – Additional demonstration pilots related to a) location benefits, b) distribution operations with DERs, and c) microgrids
  - Track 3 – Three policy issues
    - DER Adoption and Distribution Load Forecasting
    - Grid Modernization Investment Guidance
    - A Distribution Investment Deferral Process
- Series of Working Groups formed – all materials available online:
  - Locational Net Benefits Analysis (LNBA) Working Group
  - Integration Capacity Analysis (ICA) Working Group
  - DER Growth Scenarios and Distributed Load Forecasting Working Group
  - Integrated Distributed Energy Resources Competitive Solicitations Framework Working Group

State approaches – California (2)

- LNBA method consistent across IOUs, based on Avoided Cost Calculator enhanced to include location-specific values
  - Staff proposed major changes to DER Avoided Cost Calculator in Nov. 2019
  - CPUC proposes to adopt recommendations in *Staff Proposal on Avoided Cost and Locational Granularity of Transmission and Distribution Deferral Values*
    - Specified T&D values will be estimated through Distribution Investment Deferral Framework and CAISO planning processes
    - Unspecified distribution deferral value will be estimated through updates to the Avoided Cost Calculator considered in Integrated DER rulemaking (14-10-003)
- Integration Capacity Analysis
  - 9/9/19 workshop on long-term refinements, culmination of a request for comments on ICA data and online map functionality
  - Utilities request that interconnection use case be the top priority (relative to (policy and planning use cases) because CA Rule 21 is currently under revision. Utilities want ICA to be highly accurate for generation sources.

State approaches – California (3)

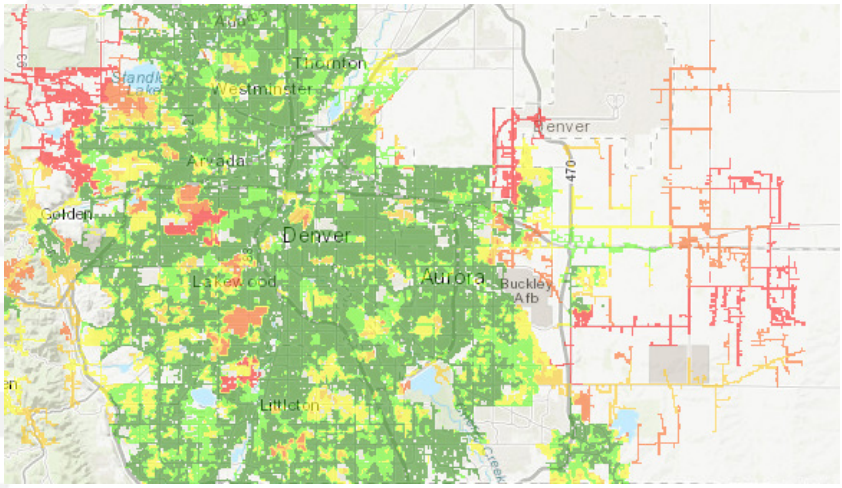
- Grid Modernization Investment Guidance - March 2018 decision
  - Defines grid modernization and establishes classification framework to serve as a common vocabulary (informed by DOE's DSPx work)
  - Requires Grid Modernization Plans to be submitted in general rate case
  - Provides guidance on how the CPUC will evaluate cost-effectiveness
  - *Cost-reasonableness* rather than *cost-effectiveness* is the basis for consideration, similar to other items in a general rate case (GRC):
    - "Benefits of grid modernization investments cannot be isolated from benefits provided by other grid investments or benefits of DERs enabled"
    - "IOUs shall propose the lowest cost approach to meeting grid needs"
    - "We find that current GRC approaches are effective and appropriate, and should continue to be used."
- In December 2018 an ALJ ruling rejected a request to require a non-disclosure agreement for accessing some distribution planning data.

State approaches – California (4)

- Energy storage mandate (AB 2514) – targets 1,350 MW by 2020
- SB 1339 (September 2018) requires CPUC and California Energy Commission actions to facilitate microgrids by December 2020:
  - Develop service standards to meet state and local permitting requirements,
  - Develop guidelines that determine what impact studies are required for microgrids to connect to the grid,
  - Develop separate rates and tariffs, as necessary, to support microgrids, while ensuring that system, public, and worker safety are given the highest priority,
  - Form a working group to codify standards and protocols to meet California utility and ISO microgrid requirements, and
  - Develop a standard for direct current metering in Electric Rule 21 to streamline the interconnection process and lower interconnection costs for direct current microgrid applications.
- CPUC approved $303M of Southern California Edison's proposed $2.1B in proposed grid modernization investments (A-16-09-001)
  - CPUC determined benefits of some investments (e.g., achieving full switching automation vs. targeted distribution automation) did not justify the costs.

State approaches - Colorado (1)

- SB 19-236 (2019) requires PUC to promulgate rules establishing filing of a distribution system plan (DSP), including:
  - Methodology for evaluating costs and net benefits of using DERs as NWAs
  - Threshold for size of new distribution projects
  - Requirements for DSP filings, including:
    - Consideration of NWAs for new developments (>10,000 residences)
    - Load forecasts from beneficial electrification programs
    - Forecast of DER growth
    - Planning process for cyber and physical security risks
    - Proposed cost recovery method
    - Anticipated new investments in distribution system expansion
    - Economic impacts of NWAs
    - Estimated year when peak demand growth merits analysis of new NWAs
  - Public interest in approval of NWAs
  - Ratepayer benefits from NWAs
  - Benchmarks or accountability mechanisms



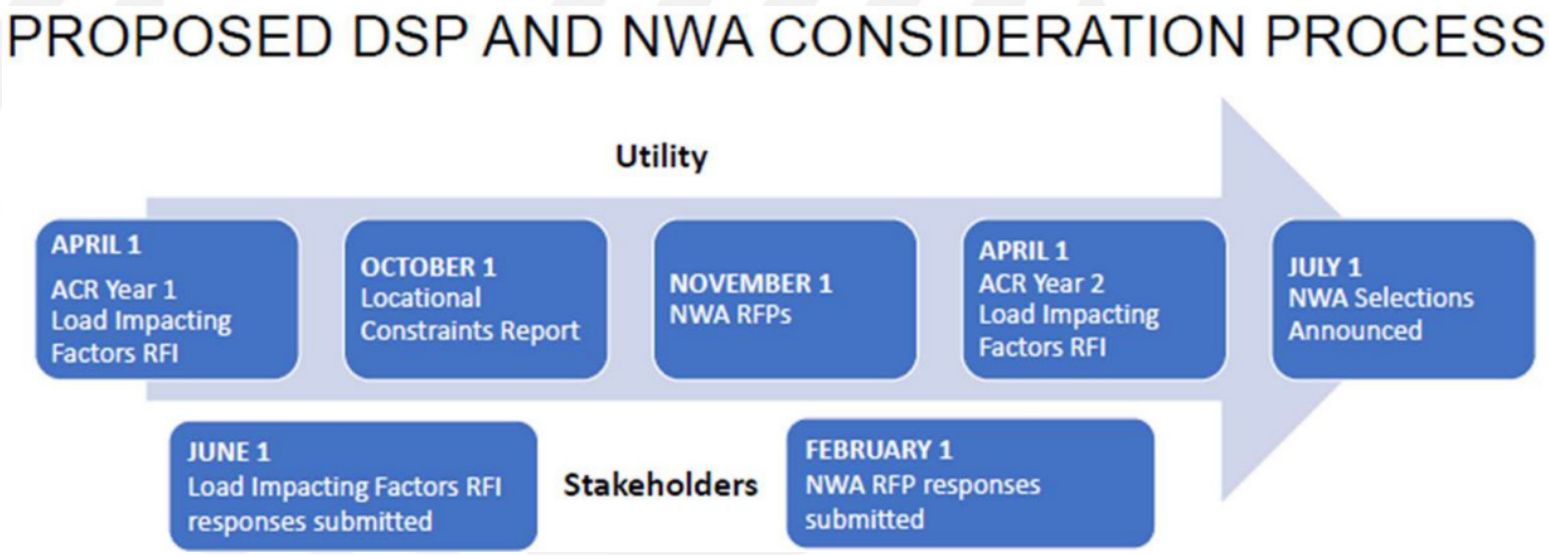
Xcel Energy hosting capacity map (Denver area)

State approaches - Colorado (2)

- Distribution planning has been raised in related proceedings:
  - Net metering; integration of new grid modernization systems such as Advanced Distribution Management Systems, Advanced Metering Infrastructure, and Volt/VAr Optimization
- In Proceeding No. 17M-0694E, initiated through Decision No. C17-0878, (Oct. 26, 2017), the Commission examined implementation of an Integrated Distribution System Planning process and invited comments on "initial regulatory steps that the Commission should take to ensure that investor-owned electric distribution systems have the capability to handle increased penetration of distributed generation, storage, and certain load building technologies such as electric vehicles."
  - Stakeholder engagement, development of Distribution System Planning work group
- Pre-rulemaking proceeding underway (No. 19M-0670E)
  - Decision No. C19-0957 seeks comments and information on initial regulatory steps to meet requirements of SB 19-236

State approaches - District of Columbia

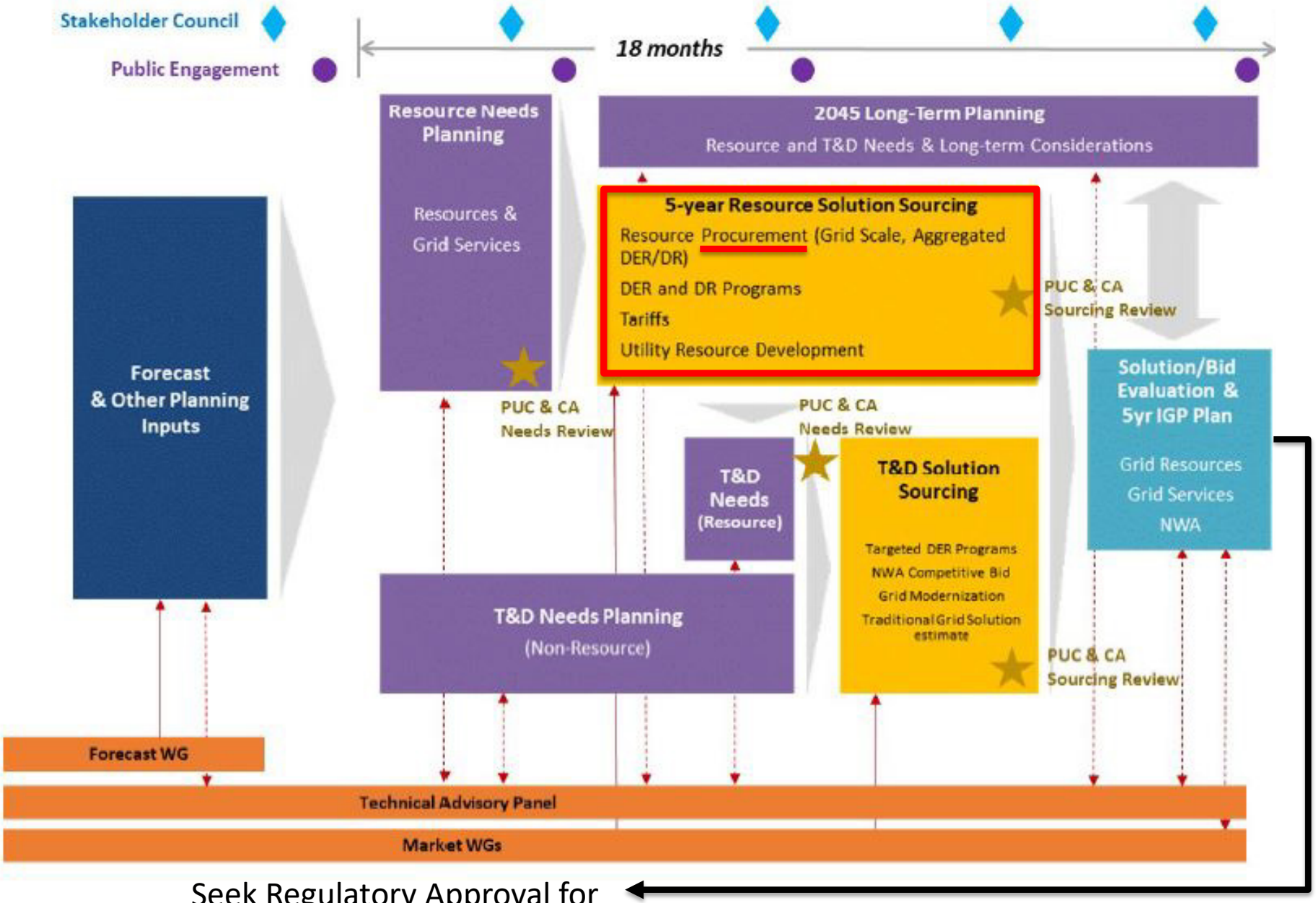
- Modernizing the Energy Delivery System for Increased Sustainability (MEDSIS) final working groups report, May 2019 – now "Power Path DC"
  - Implements an open and transparent distribution system planning process
    - Updates current Annual Consolidation Report (ACR) to include stakeholder working groups, Load Impacting Factors Request for Information (RFI), Locational Constraint Reports and NWA Request for Proposals (RFPs).
  - Establishes website for competitive supplier offers and energy education
  - Creates a secure utility web portal to enhance 3rd party data access



Source: Pepco, in final working group report

State approaches - Hawaii

- HPUC rejected piecemeal investment proposals and required Hawaiian Electric Companies (HECO) to file a comprehensive Grid Modernization Plan.
- Order No. 34281 provided guidance for a holistic, scenario-based grid modernization strategy to inform review of discrete projects submitted by utility
- HECO filed a new approach to power system planning, called Integrated Grid Planning, that merges planning processes for G, T & D
  - Integrates solution procurement
  - Identifies gross system needs, coordinates solutions, and develops an optimized, cost-effective portfolio of assets
  - Allows a variety of distributed and grid scale resources to provide power generation and ancillary services
  - Stakeholder council, technical advisory panel, ad-hoc working groups
- New DER proceeding opened in September 2019 to explore technical, economic, and policy issues associated with DERs, including:
  - What types of new DER programs should be examine and developed?
  - What advanced rate designs will be offered to customers?
  - What improvements can be made to the interconnection process?



Seek Regulatory Approval for
Integrated Grid Plan's 5-year plan & related applications

State approaches – Indiana (1)

- Commission required 3 IOUs to establish stakeholder collaboratives to develop performance metrics, incl. for distribution planning and operations
  - First raised in IURC Order in Cause 44602 for Indianapolis Power and Light (IPL) (3/16/16), then in an IURC order in Cause 44967 for Indiana Michigan Power Company and its compliance filing
  - Also see NIPSCO (Cause 44688) and I&M (Cause 44967)
- IRP rule requires utilities to consider effects of distributed generation on distribution system planning (and other types of planning)
- Transmission, Distribution, and Storage System Improvement Charge (2013 legislation) to encourage T&D investments for safety, reliability, modernization; amended in 2019 by HB 1470 in part to include advanced technology investments
  - 5-7 year plans for Indiana URC approval; detailed project descriptions all yrs
  - For capital projects only (e.g., *not* for vegetation management)
  - Charge limited to 80% of "approved capital expenditures and TDSIC costs"; remaining 20% addressed in general rate case

State approaches – Indiana (2)

- On July 24, 2019, IPL filed a new TDSIC plan (Cause 45264) including distribution automation ($109M) and advanced meter deployment ($55M)
  - "In some circumstances system import limits are improved. These changes also lead to reduced congestion, thereby lowering IPL's local zone locational marginal pricing (LMP) to which system participants are exposed."
  - The plan will add "new substation equipment to meet growth-driven capacity requirements," and "converting the 4 kV system to 13.2 kV operation will provide the needed capacity required for the neighborhood revitalization and contribute to local and regional economic development."
  - "IPL will reconfigure and/or add capacity at six existing substations and construct two new substations for additional distribution system capacity. These substation projects will improve load serving capability, operability, and reliability of the electric system."
- On Oct. 30, 2019, Duke filed an update to its TDSIC plan including proposed improvements to substations and circuits

State approaches – Indiana (3)

- On August 26, 2019, the 21st Century Energy Policy Development Task Force (a Legislative Interim Study Committee) met for the first time
  - The Task Force is required to develop recommendations on "How to maintain reliable, resilient, and affordable electric service for all electric utility consumers, while encouraging the adoption and deployment of advanced energy technologies."
  - The Task Force met 5 times during the interim session
  - "The Task Force adopted no findings or recommendations concerning any of the topics it considered during the 2019 interim."
  - For the 2020 Interim work program, members suggested:
    - Broadening the Task Force scope for energy policy
    - "Considering distributed generation and wireless solutions for meeting energy needs" and "Examining energy efficiency programs."
    - "Examining distribution infrastructure and distributed generation."

State approaches - Maryland

- Distribution planning is one of six topics* addressed in PC 44 - Transforming Maryland's Electric Grid proceeding.
  - PC-44 working group progress: proposing a statewide EV program, refining interconnection rules and processes, developing and proposing retail supplier regulations, and designing both time varying rates and storage ownership pilots
  - Benefits and Costs of Utility Scale and Behind the Meter Solar Resources in Maryland - Final report November 2018:
    - Presents benefits and costs as they accrue to (1) the bulk power system, (2) local power distribution systems, and (3) society and the economy
    - Original RFP for consultant to study benefits & costs of distributed solar in IOUs' service areas
- Orders in Case No. 9406 (BGE rate case) and Case No. 9418 (Pepco rate case) required a five-year distribution investment plan within 12 months
  - BGE distribution investment plan and Pepco plan filed
- Senate Bill 573 required an energy storage pilot program. PUC order August 2019 established energy storage pilot.
  - In December 2019, working group proposed metrics and value streams that energy storage applications should consider.

*Other topics: rate design, EVs, competitive markets/customer choice, interconnection process and energy storage

State approaches - Massachusetts

- Requirements for each electric distribution company to submit grid modernization plans every three years that include (next due July 2020):
  - A three-year short-term investment plan that the Department will review to determine which investments are eligible for preauthorization, and
  - A five-year strategic plan outlining how the company intends to meet the DPU's grid modernization objectives.
- DPU ruled on most recent Grid Modernization Plans in May 2018 Order
  - Denied AMI requests but approved reliability/resilience-related requests for ADMS, automation and Volt/var optimization – mentioned recent frequency of large storms
  - Required utilities to file performance metrics, a joint utilities proposed evaluation plan, a model Grid Modernization Factor tariff
    - In April 2019, joint utilities filed Grid Modernization Plan Performance Metrics, for each utility to use to measure progress towards grid modernization.
  - Required utilities to file Annual Grid Modernization Reports with updated projections, and metrics (feeder and substation, system level infrastructure, performance)
- House Bill 4857 (August 2018) – Established Clean Peak Standard and requirements for *Annual Resiliency Reports* for distribution systems with heat maps of congested/constrained areas

State approaches – Michigan (1)

- Michigan PSC webpage on distribution system planning
- PSC ordered utilities to file 5-yr distribution investment & maintenance plans "to increase visibility into the needs of maintaining the state's system and to obtain a more thorough understanding of anticipated needs, priorities, and spending."
  - Commission consolidated all 3 utility filings into Case No. U-20147 (April 2018)
- DTE Electric , Consumers Energy and Indiana Michigan Power Co. filed draft plans and parties commented
- DTE Electric final plan 1/31/18; Consumers Energy final plan 3/1/18
- PSC Staff Report - Distribution Planning Framework for an "open, transparent, and integrated electric distribution system planning process in Michigan" (September 2018).
  - PSC Order on staff recommendations: "*framework … is to be used as a guide for the next iterations of distribution plans…." "Unconventional solutions, including targeted EE, DR, energy storage, and/or customer-owned generation, that could displace or defer investments in a cost-effective, reliable, and timely manner should be considered and evaluated."*

State approaches – Michigan (2)

- Sept. 2019 order in docket U-20147:
  - Utilities must file their next distribution investment and maintenance plans by June 30, 2021
  - MPSC staff will examine the value of resilience (and its role in cost-benefit methodologies for rate cases and alignment of distribution plans with IRPs) for the next phase of distribution plans. Staff will file a summary of the stakeholder process—including discussions on the value of resilience—for input into distribution plans by April 1, 2020
  - MPSC directs utilities to "continue to develop detailed distribution plans over a five-year period, but also include in the plan their vision and high-level investment strategies 10 and 15 years out. This approach is consistent with the planning horizons used in IRPs."
- Draft MPSC staff report on stakeholder workshops

State approaches – Michigan (3)

- *Michigan Statewide Energy Assessment* by PSC staff (Sept. 11, 2019) recommends utilities:
  - *"better align electric distribution plans with integrated resource plans to develop a cohesive, holistic plan and optimize investments considering cost, reliability, resiliency, and risk. As part of this effort, Staff, utilities, and other stakeholders should identify refinements to IRP modeling parameters related to forecasts of distributed energy resources (e.g., electric vehicles, on-site solar) reliability needs with increased adoption of intermittent resources, and the value of fuel security and diversity of resources in IRPs. A framework should also be developed to evaluate non-wires alternatives such as targeted energy waste reduction and demand response in IRPs and distribution plans."*
  - *"work with Staff and stakeholders to propose a methodology to quantify the value of generation diversity in integrated resource plans."*
  - *"work with Staff and stakeholders to propose a methodology to quantify the value of resilience, particularly related to DERs. In addition, the value of resilience should be considered in future investment decisions related to energy infrastructure in future cases."*

State approaches – Michigan (4)

- Governor Whitmer established MI Power Grid initiative to maximize benefits of integrating new energy technologies and optimizing grid investments for reliable, affordable electricity service.
- MPSC issued Oct. 17, 2019, order launching the initiative:
  - *"No later than June 30, 2020, the Commission Staff shall file in this docket a status report on utility pilot projects, summarizing efforts to date, providing recommendations for objective criteria to apply when evaluating proposed utility pilot projects, and identifying potential areas for additional pilot proposals."*
  - Optimizing grid investments and performance will include quantifying *"the value of resilience, particularly as it relates to distributed energy resources"*
  - Among the MPSC's priority work areas for the MI Power Grid initiative over the next year is grid security and reliability metrics (Case Nos. U-20629 and U-20630)

State approaches - Minnesota

See information in main slide deck. Additional details on hosting capacity analysis below.

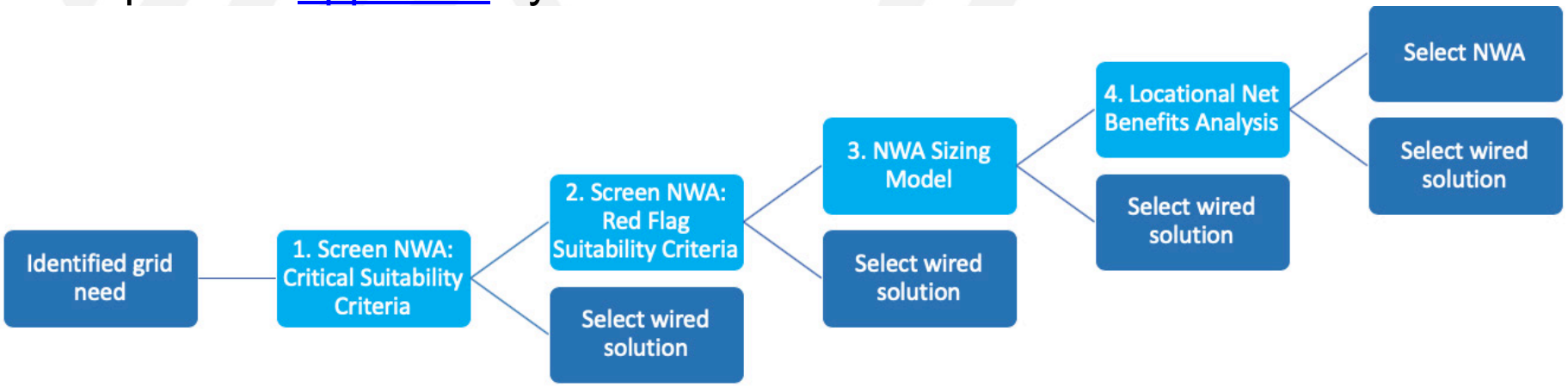
- Xcel Energy's Nov. 1, 2019, filing (Docket 19-685) used a new EPRI mitigation assessment tool that streamlines analysis to determine the most cost-effective mitigation for 77 feeders.
  - Over-voltage and thermal violations
    - *No-cost solutions* - 28 feeders gained at least 1 MW additional capacity with power factor adjustments to existing or new generators; 5 feeders reached 1 MW via volt-var advanced inverter function
    - *Low-cost solutions (under $5,000)* - 3 feeders reached 1 MW using volt-watt-inverter function
      - Hosting capacity for these 36 feeders increased by 1.9 MW each on average.
    - *Moderate-cost solutions ($75,000)* - 14 feeders achieved increased capacity (2 MW on average) with a new regulator.
    - *High-cost solutions ($500k to >$3M)* – Remaining feeders required extensive reconductoring
  - Reverse power flow and unintentional islanding
    - The majority of feeders (53 out of 77) could be mitigated at a total cost <$300k, including solving over-voltage and thermal violations.

State approaches - Nevada (1)

- SB 146 (2017) requires utilities to file distributed resource plans (DRPs) to evaluate locational benefits and costs of distributed generation, energy efficiency, storage, electric vehicles and demand response technologies
  - *"…based on 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."*
  - DRP identifies standard tariffs, contracts or other mechanisms for deploying cost-effective distributed resources that satisfy distribution planning objectives
  - DRP filed with integrated resource plan every three years and covers utility's three-year IRP action plan
- PUC adopted temporary planning regulations in 2018 and permanent regulations in 2019 (D-17-08022)
  - 6-year forecast of net distribution system load (down to feeder level) and distributed resources
  - Hosting capacity analysis and public access to utility's online distribution maps/data
  - Grid Needs Assessment compares traditional and DER solutions for forecasted T&D system constraints
- *"A utility may recover all costs it prudently and reasonably incurs in carrying out an approved DRP, in the appropriate separate rate proceeding."*

State approaches - Nevada (2)

- NV Energy filed its 1st DRP in April 2019 (Docket D-19-04003)
  - Distribution system and distributed resource load forecast
  - Hosting capacity analysis
  - Grid Needs Assessment that identified distribution system constraints
  - NWA analysis
    - Utility's suitability/screening tool identified 10 distribution system projects and 107 transmission projects for NWA analysis
  - Locational net benefit analysis considered 8 costs and benefits; identified 3 projects with similar estimated costs for traditional solutions and NWA
- Stipulation approved by PUC



State approaches - Nevada (3)

- Nevada Power's Clean Energy Programs Annual Plans, filed February 2020, include incentives for energy storage with solar energy systems (Docket 20-01040)
  - Residential - Utilities request storage incentives between $0.08 and $0.22/watt-hour based on participation in a time of use rate or demand response program
  - Non-residential
    - Small Energy Storage Program - Utilities request incentives between $0.35 and $0.55/Wh based on Investment Tax Credit (ITC) eligibility, whether the system is standalone, and whether the participant is a for-profit or non-profit organization
    - Large Energy Storage Program - Utilities request incentives between $0.40 and $0.60/Wh based on ITC eligibility and whether the facility is critical infrastructure
  - Under SB 145 (2017), eligible storage systems must:
    - Reduce peak demand for electricity,
    - Avoid or defer investment by the utility in generation or T&D assets, or
    - Improve reliability of T&D operation

State approaches – New York (1)

- Reforming the Energy Vision – Utilities file Distributed System Implementation Plans (DSIP) every two years
- Hosting capacity maps required for all circuits ≥12 kV
- Value Stack tariff
  - Location-specific relief zones
  - Payments to DER (including storage) projects based on energy, capacity, environmental, demand reduction and locational system relief value
    - NY DPS released an updated Value Stack Order in April 2019.
      - Demand reduction value is now based on a fixed window of peak hours
      - Locational system relief value now uses a call system where eligible projects may receive compensation for responding during utility call windows. Calls made 21 hours in advance. At least ten calls windows a year guaranteed for each LRSV zone.
      - Expansion of Phase One NEM eligibility for certain additional projects under 750 kW
      - Establishment of the Community Credit and related incentives for certain community projects in some utility territories (to replace the Market Transition Credit)
      - Capacity Value calculations modified to reflect actual peak hours and NYISO prices
    - Solar Value Stack Calculator estimates revenue under value tariff

State approaches – New York (2)

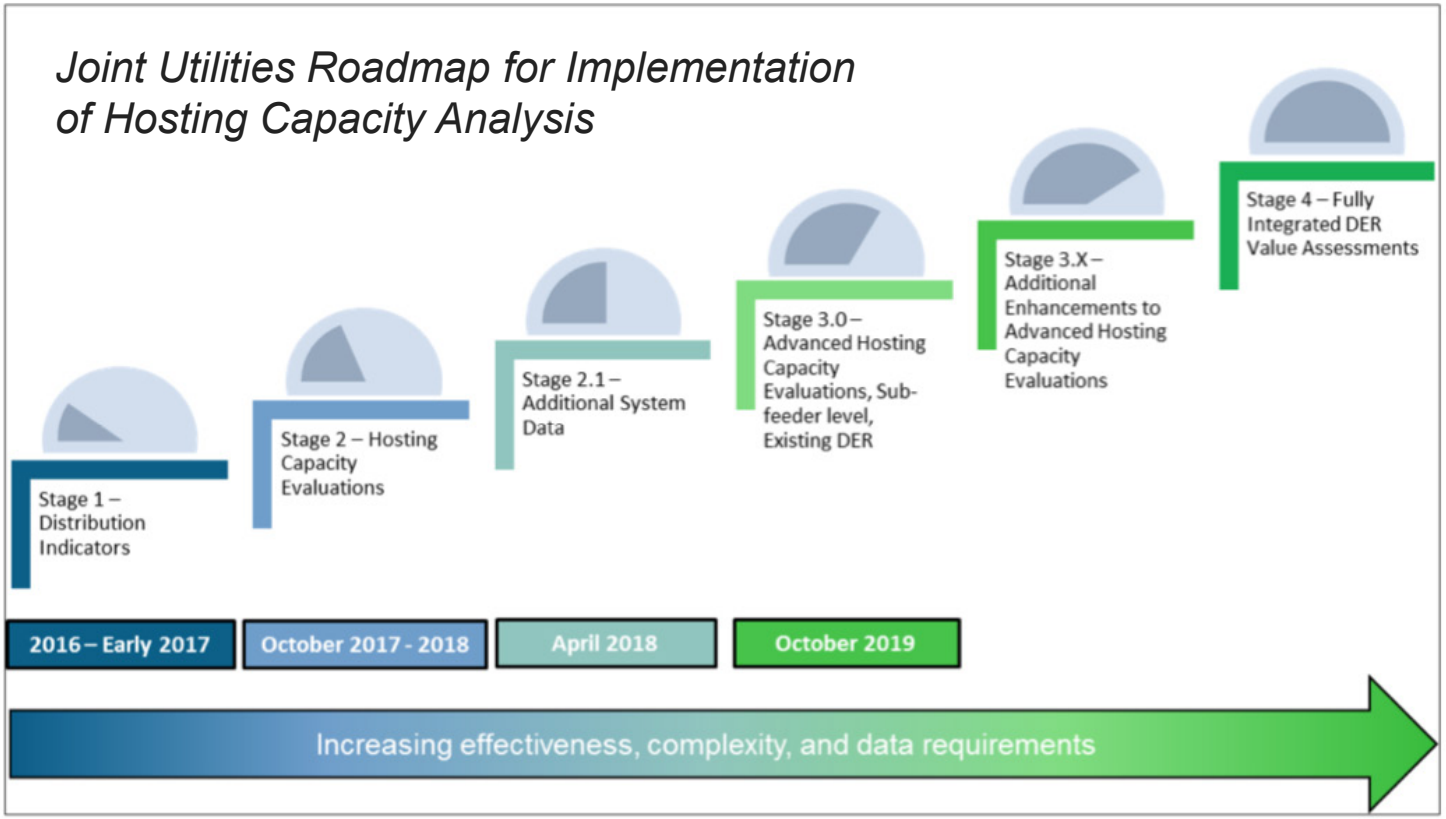
- Updated NY PSC DSIP Guidance (April 2018) – Must include sections on:
  - Integrated planning, advanced forecasting, grid operations, energy storage integration, electric vehicle integration, energy efficiency integration and innovation, distribution system data, customer data, cyber-security, DER interconnections, advanced metering infrastructure, hosting capacity, beneficial locations for DERs and NWAs, and procuring NWAs
- DSIP also must address governance, marginal cost of service studies, and utility's most recent Benefit-Cost Analysis Handbook
- Each utility must maintain a Benefit-Cost Analysis Handbook (BCA order)
  - Common handbook template provides a consistent and transparent methodology and presents general BCA considerations and notable issues on data collection required
  - Definitions and equations for each benefit and cost are provided along with key parameters and sources. Where applicable, utilities customize the handbook to account for utility-specific assumptions and information.
  - The NYDPS regularly updates a capacity spreadsheet for calculating avoided costs for Installed Capacity auctions.
  - Recent comments from the Utility Intervention Unit on DSIP: BCA should use dynamic analysis, not fixed values.

State approaches – New York (3)

- Energy Storage Roadmap – 1,500 MW by 2025 and 3,000 MW by 2030, established 12/18
  - NYPSC directs the utilities to compile an inventory of unused, suitable land for non-wires alternatives, as well as interconnection upgrade costs for non-wires alternatives that can be included in RFPs.
  - NYPSC directs the utilities to work with NYSERDA to develop a pilot DER data platform including anonymized customer and system data for DER developers. In January 2020, the Pilot Integrated Energy Data Resource was completed and announced.
  - NYPSC directs the utilities to file in their next general rate case an Earning Adjustment Mechanism metric for system efficiency. This is to incentivize utilities to consider resources like energy storage to reduce ratepayer costs.

State approaches – New York (4)

- Distribution System Implementation Plans - Docket 16-M-0411
  - Pilot Integrated Energy Data Resource launched 1/1/20 - Database and web analytics platform to help DER developers identify, evaluate and initiate DER development
- Hosting capacity maps — e.g., National Grid maps PV >300kW at sub-feeder level



State approaches – Ohio

- PUCO's PowerForward initiative - reviewing technological and regulatory innovation that could enhance the consumer electricity experience.
  - Workshops with industry experts "to chart a path forward for future grid modernization projects, innovative regulations and forward-thinking policies"
- PowerForward Roadmap released August 2018 - vision for the modernization of Ohio's grid with a series of recommended next steps
  - Distribution utilities to file grid architecture status reports & current state planning assessments in April 2019, followed by applications for grid arch investments
  - Utilities filed respective grid architecture status reports on April 1, 2019.
  - October 2018 - two separate working groups/dockets: Distribution System Planning and Data and the Modern Grid
- Distribution System Planning Workgroup (EnerNex) final report and Data and Modern Grid Workgroup final report issued Jan 2020
- OH Commission approves Duke PowerForward rider in Dec 2018 to recover capital and O&M costs for new PowerForward related initiatives
- Distribution system reliability code, distribution circuit performance codes and annual reliability compliance filings

State approaches - Pennsylvania

- Distribution System Improvement Charge can be used to recover reasonable and prudent costs to repair, improve or replace eligible distribution property
  - Long Term Infrastructure Improvement Plans (LTIIPs) must be filed
  - In January 2020, regulators approved grid modernization investments for four FirstEnergy utilities based on LTIIPs (Metropolitan Edison, Penelec, PennPower, WestPenn Power)
  - Investments approved included: ADMS, DMS, Distribution Automation, SCADA
- Distribution reliability code directs PSC to regulate distribution inspection & maintenance plans, requires utilities to report quarterly on worst-performing circuits and make annual compliance filings (2016 PA reliability report)
- May 2018 - Commission issued Proposed Policy Statement Order with factors it will use to determine just and reasonable rates and to invite utilities to propose rate designs that achieve multiple objectives in their rate case filings
- In November 2018 a statewide partnership led by Department of Environmental Protection issued Pennsylvania's Solar Future report with 15 strategies to reach 11 GW of solar by 2030

State approaches - Vermont

- Annual solicitations for distributed renewable projects with standard-offer contracts to "plants that have sufficient benefit to the…electric grid"
  - Screening Framework identifies areas where distributed generation may provide benefits or reduce grid constraints, implemented by a stakeholder group — Vermont System Planning Committee
- PUC can approve alternative regulation plan if it will "offer incentives for innovations and improved performance that advance State energy policy" (30 V.S.A. § 218d).
  - July 2018 order on principles and considerations for plans
- Green Mountain Energy proposed a pay-for-performance energy storage innovation pilot in August 2019
  - Payments provided to aggregators based on actual capacity performance of the aggregate load each month and value of services provided that year
  - Aggregator would receive 70% of value of demand reduction, and Green Mountain Power would retain 30% of the value

State approaches – Washington (1)

- HB 1126 Distributed Energy Planning Act establishes objectives for DER planning, including:
  - Identifying data gaps impeding a robust planning process
  - Identifying upgrades (AMI, monitoring equipment, and simulation tools) that would allow utilities to quantify locational and temporal value of DERs
  - Proposing monitoring, control, and metering upgrades supported by a business case
  - Identifying potential programs that are cost-effective and tariffs to fairly compensate customers for the monetizable value of DERs
  - Forecasting growth of DERs on the system
  - Provide a 10-year plan for distribution system investments and an analysis of NWAs
  - Including DERs in the Integrated Resource Planning process
  - Including high level discussion of cybersecurity and data privacy practices
  - Discussing lessons learned in the planning cycle
- Docket UE-190698, opened August 2019, to align IRP rules with HB 1126
  - Commission filed draft rules Nov. 2019, opened comment period

State approaches – Washington (2)

- Washington's overarching principles for DER planning for distribution systems
  - **Transparency**: DER planning should *fairly consider both wire-based and non-wires resource alternatives* for meeting distribution system needs. Planning should *optimize the investment decisions of customers and third parties by identifying points on the grid where distributed resources have greatest value*.
  - **Coordination**: Distribution plans should *inform and interact with other utility planning processes*, including integrated resource plans & capital budget plans.
  - **Flexibility**: The planning *process needs to improve over time and adapt* to changing grid conditions, new technologies, and improved modeling capabilities.
  - **Reliability and Security**: DER planning should *ensure that reliability, physical security, and cybersecurity are maintained* as the distribution grid changes.
  - **Inclusion**: *All customers should have opportunities to participate in grid modernization* through tariffs and programs that compensate customers for the value of their distributed resources, with particular consideration given to low-income customers.

From Washington Utilities and Transportation Commission, *Report on Current Practices in Distributed Energy Resource Planning*, report to Washington Legislature, Dec. 31, 2017 [emphasis added].