ENERGY MARKETS & POLICY

Integrated Distribution System Planning Data, Metrics, and Analyses

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Training for DOE Clean Energy Innovator Fellows

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Poll: Have you ever had more data than you knew what to do with?

☐ Yes

☐ No

Distribution system data, metrics, and analysis

Study Motivations

- Utilities perform extensive analysis to develop distribution system plans, but regulators and stakeholders often do not know:
  - What data are available
  - How the utility uses those data
  - What data they need to make informed decisions
- Distribution system data can inform:
  - Regulatory decisions
  - Stakeholder comments
    - e.g., state energy offices can help shape IDSP outcomes
  - Building and transportation electrification planning

Goals

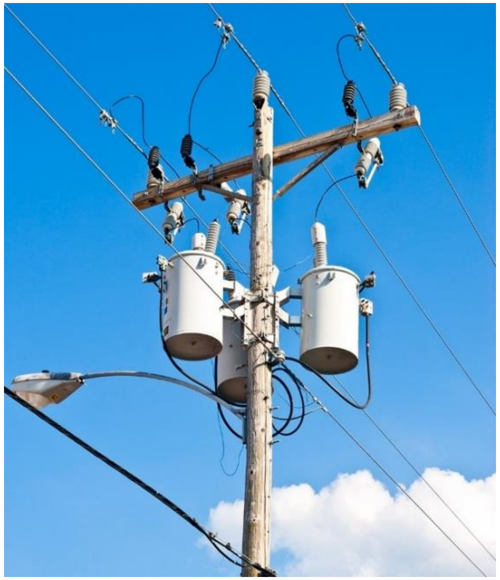
- Increased understanding of:
  - Types of data, metrics, and analyses that regulators and stakeholders can ask for in distribution planning proceedings
  - How data can improve regulatory decision-making

Source: EPRI

Asset management (1)

- Utilities establish an inventory of distribution system assets and analyze their condition and performance

- Key categories
  - Design standards
    - Provide transparency into engineering methods and design decisions
  - Programmatic investments
    - Support assessments of the reasonableness and cost-effectiveness of asset-related investments
  - Asset characteristics
    - Describe reliability performance and the configuration of equipment
  - Asset health and reliability investments
    - Explain how utilities use asset health information to identify and prioritize equipment replacements and upgrades alongside other drivers



Source: Westwood

Asset management (2)

- Data on design standards can include:
  - Construction standards (e.g., availability and readiness of devices such as voltage regulators)
  - Engineering standards (e.g., guidelines for undergrounding lines or cable replacement policy)
  - Assessments of the impacts of strategic initiatives, such as costs and reliability impacts of storm hardening

Source: EPRI

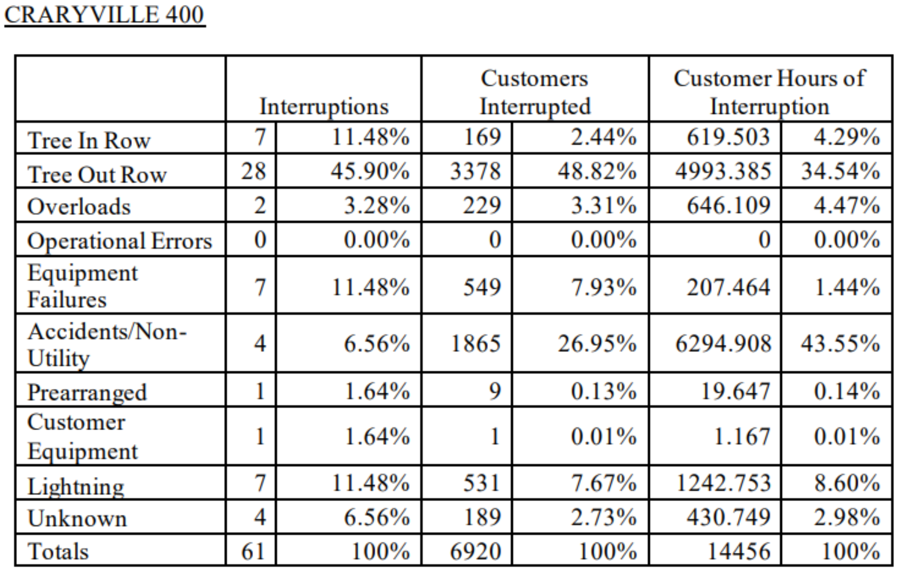
Worst-performing circuits (1)

- Utilities analyze the duration, frequency, and number of customer service interruptions to identify circuits (feeders) with the worst reliability
- Key categories
  - Metrics and criteria for identifying worst-performing circuits
    - Affect circuit performance, provide transparency into how utility ranks circuits
  - Characteristics of circuits
    - Provide context for potential remediation actions and the level of effort for remediation
  - Remediation plans for addressing poor reliability
    - Show how utility is responding to known reliability issues

Source: EPRI

Worst-performing circuits (2)

- Circuit characteristics in worst-performing circuit reports can include:
  - Technical details (e.g., voltage, line length, share overhead)
  - Customer counts (e.g., by class, medical rate status)
  - Reliability metrics (e.g., SAIFI, total number of interruptions)
  - Event history (e.g., date and cause of interruption)
  - Maintenance history (e.g., date of last tree trimming)



CRARYVILLE 400

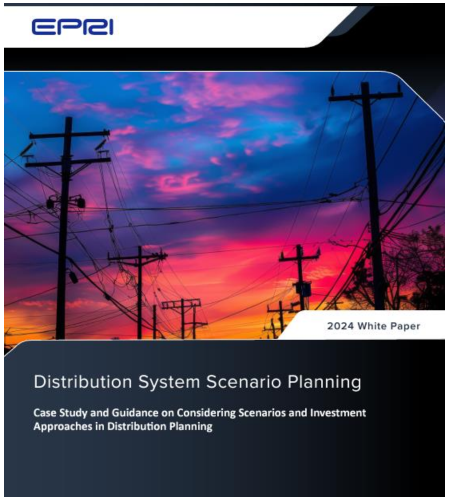
	Interruptions		Customers Interrupted		Customer Hours of Interruption	
Tree In Row	7	11.48%	169	2.44%	619.503	4.29%
Tree Out Row	28	45.90%	3378	48.82%	4993.385	34.54%
Overloads	2	3.28%	229	3.31%	646.109	4.47%
Operational Errors	0	0.00%	0	0.00%	0	0.00%
Equipment Failures	7	11.48%	549	7.93%	207.464	1.44%
Accidents/Non-Utility	4	6.56%	1865	26.95%	6294.908	43.55%
Prearranged	1	1.64%	9	0.13%	19.647	0.14%
Customer Equipment	1	1.64%	1	0.01%	1.167	0.01%
Lightning	7	11.48%	531	7.67%	1242.753	8.60%
Unknown	4	6.56%	189	2.73%	430.749	2.98%
Totals	61	100%	6920	100%	14456	100%

Source: [New York State Electric & Gas, 2022 Annual Reliability Report]()

Scenario analysis (1)

- Utilities consider the implications of future grid conditions on IDSP activities
  - Scenarios manage uncertainty by setting bounds on the range of conditions the distribution system may face
  - Scenarios are plausible futures but do not represent all possible conditions the distribution system may face

- Key categories
  - Scenario structure
    - Describes areas of uncertainty
    - Helps regulators and stakeholders interpret and compare scenarios
  - Assumptions
    - Enables regulators and stakeholders to assess whether scenarios align with policy, expected market and technology changes, and climate change
  - Implications of scenarios on planning activities
    - Increases awareness of risks to the distribution system and provides a starting point for discussions on mitigation and adaptation



EPRI

2024 White Paper

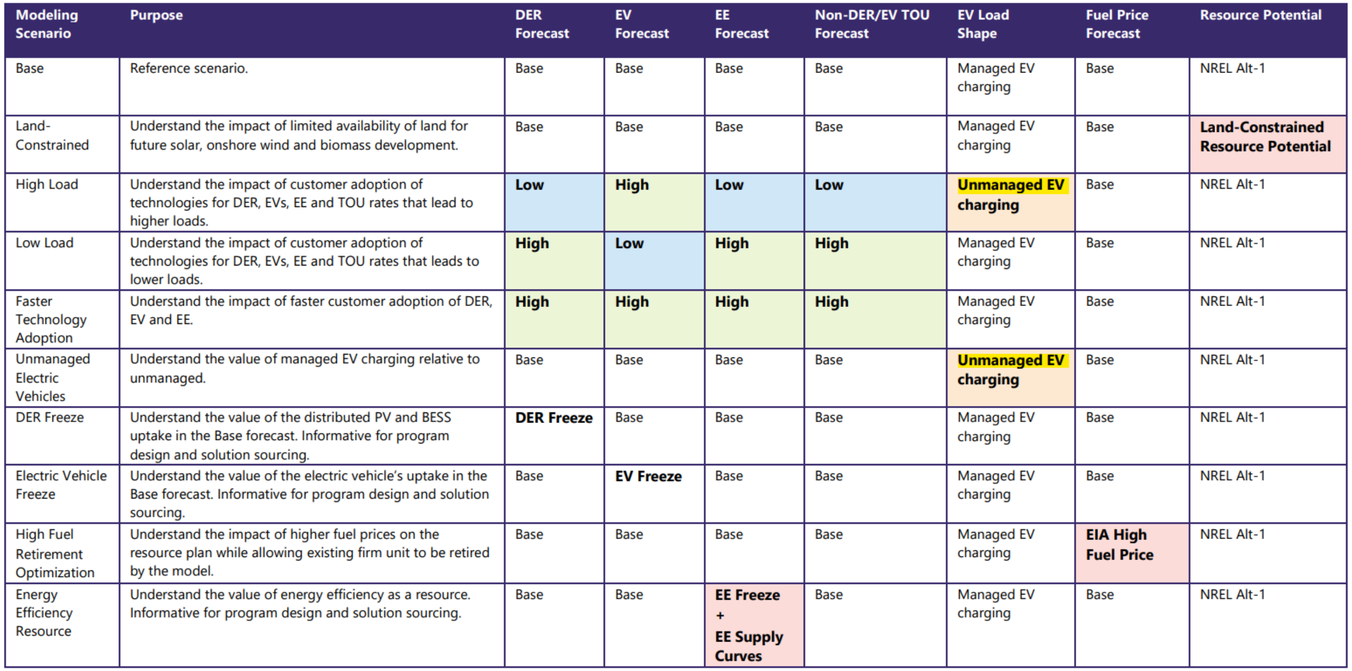
Distribution System Scenario Planning

Case Study and Guidance on Considering Scenarios and Investment Approaches in Distribution Planning

Source: EPRI

Scenario analysis (2)

- Scenario analysis assumptions can address uncertainty in technology
  - Adoption levels (e.g., low, medium, and high)
  - Efficiency (e.g., fuel efficiency for EVs)
  - Operations (e.g., managed vs. unmanaged charging)



Modeling Scenario	Purpose	DER Forecast	EV Forecast	EE Forecast	Non-DER/EV TOU Forecast	EV Load Shape	Fuel Price Forecast	Resource Potential
Base	Reference scenario.	Base	Base	Base	Base	Managed EV charging	Base	NREL Alt-1
Land-Constrained	Understand the impact of limited availability of land for future solar, onshore wind and biomass development.	Base	Base	Base	Base	Managed EV charging	Base	**Land-Constrained Resource Potential**
High Load	Understand the impact of customer adoption of technologies for DER, EVs, EE and TOU rates that lead to higher loads.	**Low**	**High**	**Low**	**Low**	**Unmanaged EV charging**	Base	NREL Alt-1
Low Load	Understand the impact of customer adoption of technologies for DER, EVs, EE and TOU rates that leads to lower loads.	**High**	**Low**	**High**	**High**	Managed EV charging	Base	NREL Alt-1
Faster Technology Adoption	Understand the impact of faster customer adoption of DER, EV and EE.	**High**	**High**	**High**	**High**	Managed EV charging	Base	NREL Alt-1
Unmanaged Electric Vehicles	Understand the value of managed EV charging relative to unmanaged.	Base	Base	Base	Base	**Unmanaged EV charging**	Base	NREL Alt-1
DER Freeze	Understand the value of the distributed PV and BESS uptake in the Base forecast. Informative for program design and solution sourcing.	**DER Freeze**	Base	Base	Base	Managed EV charging	Base	NREL Alt-1
Electric Vehicle Freeze	Understand the value of the electric vehicle's uptake in the Base forecast. Informative for program design and solution sourcing.	Base	**EV Freeze**	Base	Base	Managed EV charging	Base	NREL Alt-1
High Fuel Retirement Optimization	Understand the impact of higher fuel prices on the resource plan while allowing existing firm unit to be retired by the model.	Base	Base	Base	Base	Managed EV charging	**EIA High Fuel Price**	NREL Alt-1
Energy Efficiency Resource	Understand the value of energy efficiency as a resource. Informative for program design and solution sourcing.	Base	Base	**EE Freeze + EE Supply Curves**	Base	Managed EV charging	Base	NREL Alt-1

Hawaiian Electric, 2023 Integrated Grid Plan

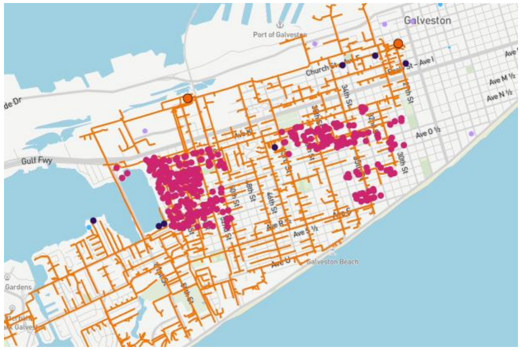
Load and DER forecasting (1)

- Utilities estimate peak demand at specific locations on the distribution system to inform timing, need, and type of distribution system investments

- Key categories
  - Input assumptions and modeling decisions
    - Enable regulators and stakeholders to validate assumptions and propose alternative approaches
  - Peak demand estimates
    - Characterize conditions that the grid will face in the future
    - Identify drivers of peak demand growth
    - Inform strategies to mitigate peak demand increases

Low Adoption

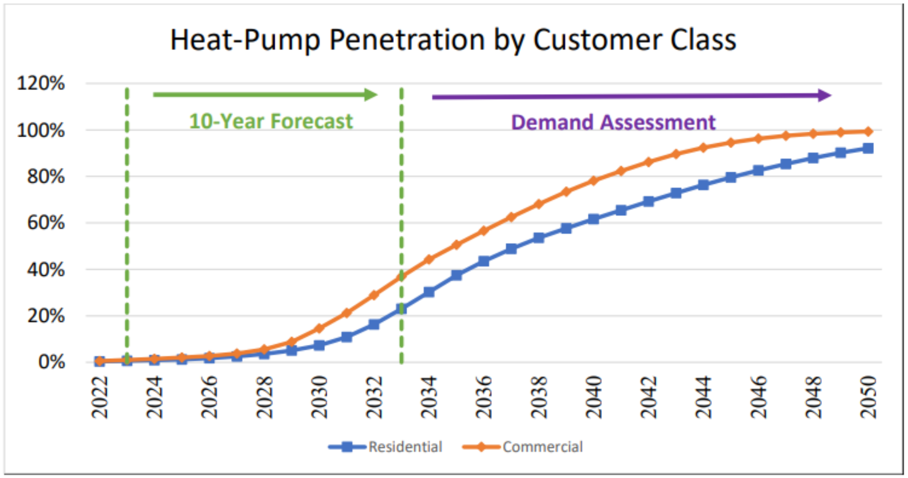
High Adoption



Source: Kevala

Load and DER forecasting (2)

- Input assumptions and modeling decisions can include:
  - Types of DER and electrification technologies accounted for in the forecast such as light and heavy duty electric vehicles (EVs)
  - Adoption rates at feeder-level or for whole jurisdiction
  - Technology efficiency (e.g., coefficient of performance for heat pumps or fuel efficiency for EVs)
  - Operating characteristics (e.g., managed vs. unmanaged EV charging, battery discharge profile)



Source: [National Grid New York, 2024 to 2033 Electric Peak (MW) Forecast and 2050 Load Assessment]()

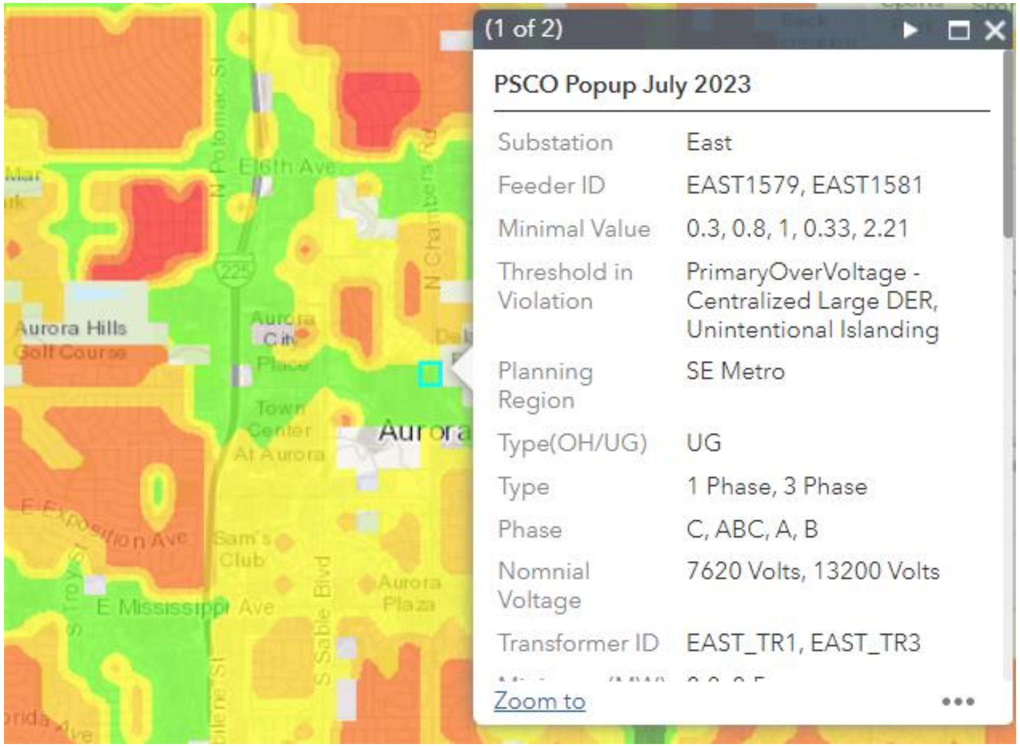
Hosting capacity analysis (1)

- Utilities determine the amount of DERs that they can interconnect without:
  - Adversely impacting power quality or reliability under existing control and protection systems
  - Infrastructure upgrades

- Key categories
  - Analytical methods
    - Affects hosting capacity estimates, use cases, and costs
  - Distribution infrastructure
    - Informs siting of DERs and provides inputs into HCA
  - Load and DERs
    - Informs siting of DERs and provides inputs into HCA
  - Hosting capacity outputs
    - Affects siting, sizing, and operation of DERs
  - Mitigation analysis
    - Increases hosting capacity by systematically assessing constraints and methods to resolve them

Hosting capacity analysis (2)

- Outputs can include:
  - Hosting capacity for:
    - Generation (e.g., rooftop PV)
    - Load (e.g., EVs, building electrification technologies)
    - Storage
  - Maps that show hosting capacity
    - In general areas (heat maps)
    - Within feeder footprint



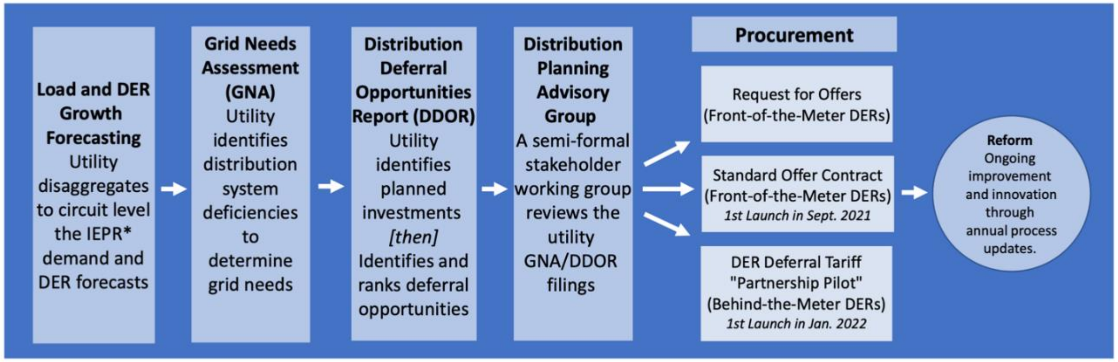
PSCO Popup July 2023

Substation	East
Feeder ID	EAST1579, EAST1581
Minimal Value	0.3, 0.8, 1, 0.33, 2.21
Threshold in Violation	PrimaryOverVoltage - Centralized Large DER, Unintentional Islanding
Planning Region	SE Metro
Type(OH/UG)	UG
Type	1 Phase, 3 Phase
Phase	C, ABC, A, B
Nomnial Voltage	7620 Volts, 13200 Volts
Transformer ID	EAST_TR1, EAST_TR3

Source: Xcel Colorado Hosting Capacity Map

Grid needs assessment (1)

- Utilities assess constraints for system assets under forecasted loads and DERs
- Key categories
  - Scope
    - Provides context for how an assessment fits into distribution planning strategy
  - Analytical approach
    - Provides transparency into utility's assumptions and tools
    - Enables regulators to propose alternative approaches and validate utility decisions
  - Grid needs characteristics
    - Describes type, timing, and scale of grid needs
  - Grid solutions selection
    - Prioritizes grid needs and identifies solutions to be acquired through other processes



Load and DER Growth Forecasting Utility disaggregates to circuit level the IEPR* demand and DER forecasts

Grid Needs Assessment (GNA) Utility identifies distribution system deficiencies to determine grid needs

Distribution Deferral Opportunities Report (DDOR) Utility identifies planned investments *[then]* Identifies and ranks deferral opportunities

Distribution Planning Advisory Group A semi-formal stakeholder working group reviews the utility GNA/DDOR filings

Procurement

Request for Offers (Front-of-the-Meter DERs)

Standard Offer Contract (Front-of-the-Meter DERs) *1st Launch in Sept. 2021*

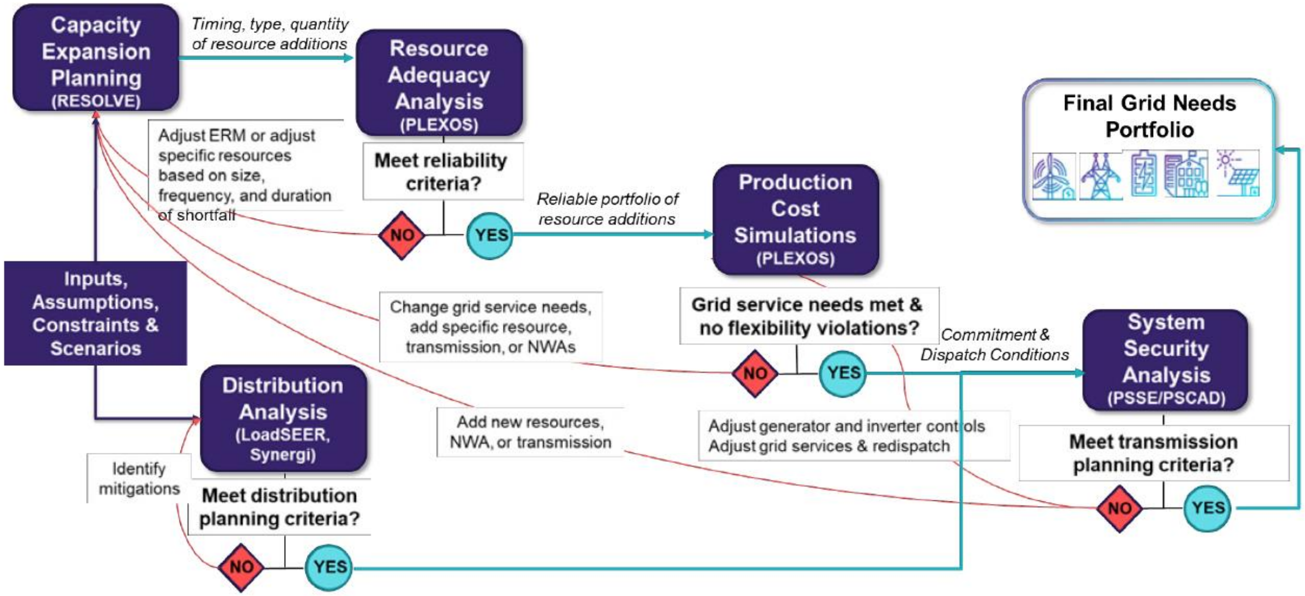
DER Deferral Tariff "Partnership Pilot" (Behind-the-Meter DERs) *1st Launch in Jan. 2022*

Reform Ongoing improvement and innovation through annual process updates.

Source: CPUC DIDF Overview

Grid needs assessment (2)

- Grid need characteristics can include data on:
  - Distribution system assets (e.g., ID numbers, locations)
  - Type of deficiency (e.g., capacity, reactive power, voltage)
  - Timing of deficiency (e.g., season, peak day hours)
  - Magnitude of deficiency (e.g., duration in hours, maximum)



Capacity Expansion Planning (RESOLVE)

Timing, type, quantity of resource additions

Resource Adequacy Analysis (PLEXOS)

Meet reliability criteria? NO / YES

Adjust ERM or adjust specific resources based on size, frequency, and duration of shortfall

Reliable portfolio of resource additions

Production Cost Simulations (PLEXOS)

Grid service needs met & no flexibility violations? NO / YES

Change grid service needs, add specific resource, transmission, or NWAs

Commitment & Dispatch Conditions

System Security Analysis (PSSE/PSCAD)

Meet transmission planning criteria? NO / YES

Adjust generator and inverter controls
Adjust grid services & redispatch

Add new resources, NWA, or transmission

Inputs, Assumptions, Constraints & Scenarios

Distribution Analysis (LoadSEER, Synergi)

Meet distribution planning criteria? NO / YES

Identify mitigations

Final Grid Needs Portfolio

Source: Hawaiian Electric Integrated Grid Plan 2023

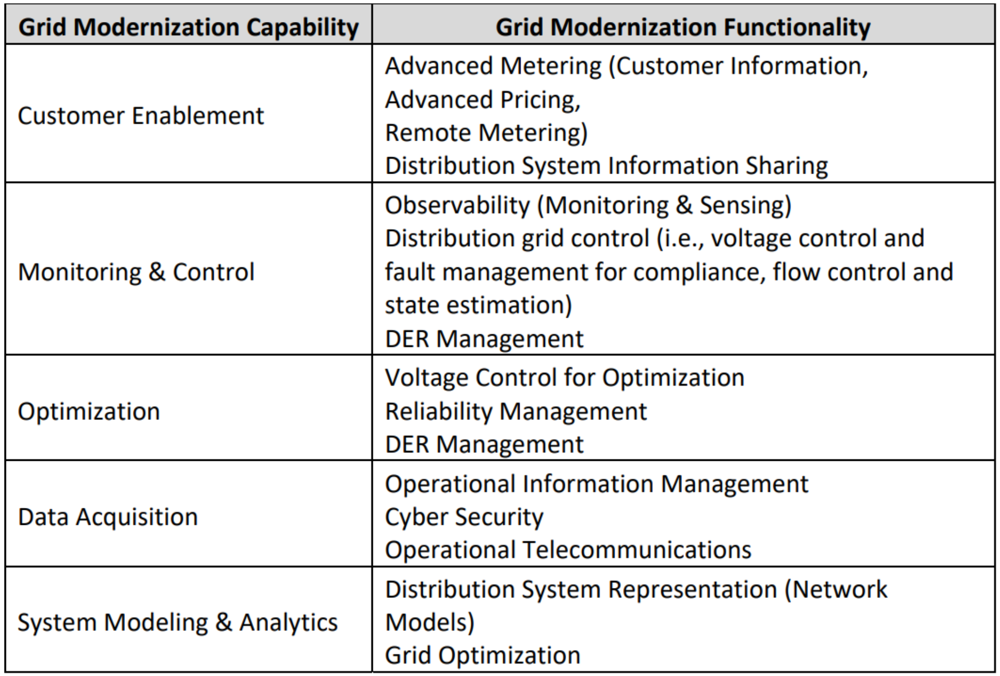
Investment strategy and implementation (1)

- Utilities establish long-term strategic plans to achieve distribution system objectives using insights from other distribution planning processes

- Key categories
  - Strategy development
    - Sets the vision for investments and provides context on market, policy, and technology factors that affect investments
  - Strategy implementation
    - Describes how the utility achieves stated vision and objectives

Investment strategy and implementation (2)

- Data on strategy implementation can include:
  - Description of progress-to-date (e.g., list of technologies upgraded)
  - Planned investments (e.g., list of technologies to be installed and their functionalities)
  - Costs and financing (e.g., spending required to achieve objectives)
  - Risk management (e.g., implementation risks and mitigation strategies identified)



Grid Modernization Capability	**Grid Modernization Functionality**
Customer Enablement	Advanced Metering (Customer Information, Advanced Pricing, Remote Metering) Distribution System Information Sharing
Monitoring & Control	Observability (Monitoring & Sensing) Distribution grid control (i.e., voltage control and fault management for compliance, flow control and state estimation) DER Management
Optimization	Voltage Control for Optimization Reliability Management DER Management
Data Acquisition	Operational Information Management Cyber Security Operational Telecommunications
System Modeling & Analytics	Distribution System Representation (Network Models) Grid Optimization

Source: Rhode Island 2022 Energy Grid Modernization Plan

Non-wires alternatives procurements (1)

- Utilities can use DERs to provide grid services at specific locations on the distribution system to reduce, defer, or avoid the need for upgrades to infrastructure such as feeders or substations.
  - NWAs can lower peak demand, address voltage issues, improve resilience, and reduce power interruptions

- Key categories
  - NWA screening
    - Indicates whether utility can consider an NWA given type of grid need, costs and timelines
  - Cost-effectiveness
    - Informs decisions to pursue NWAs by delineating benefits and costs
  - Procurement process
    - Establishes requirements for requests for proposals
  - Measuring performance
    - Provides framework for measuring impacts of NWA and summarizes those impacts

Non-wires alternatives procurements (2)

- NWA screening data can include:
  - Type of grid need (e.g., thermal loading, capacity)
  - Timing of grid need (e.g., years, months)
  - Cost of traditional investment
  - Technologies eligible for NWA (e.g., energy efficiency, demand response, storage)

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

Source: [Central Hudson NWA suitability criteria]

Additional content

Value of DER (1)

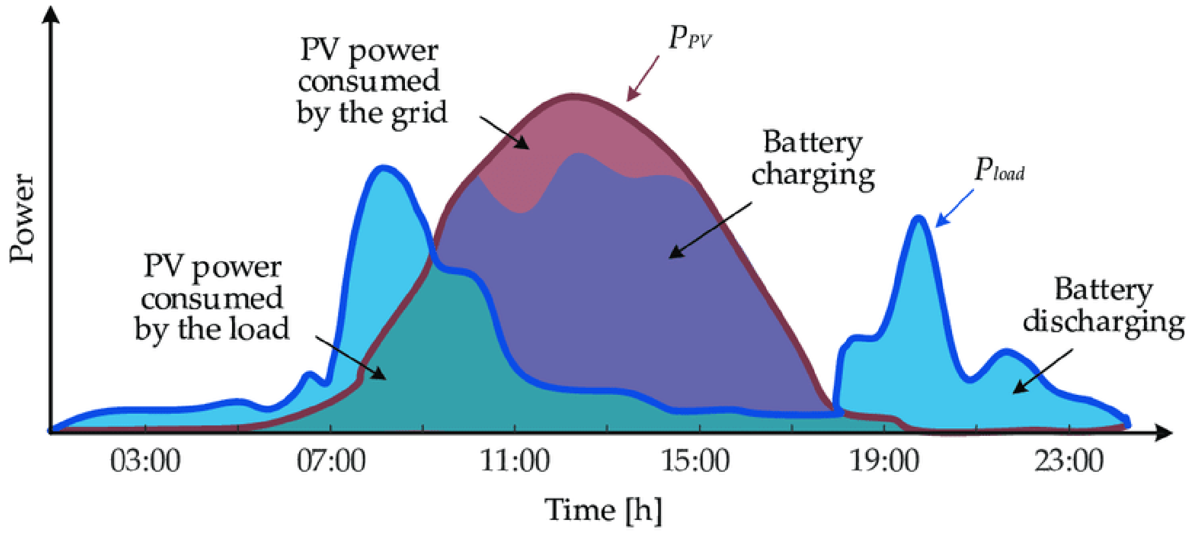
- Utilities quantify the benefits of DERs to the distribution system to inform DER compensation and guide DER deployment

- Key categories
  - Distribution system characteristics
    - Provide inputs for estimation of DER value
    - Include outputs of other distribution planning activities such as grid needs assessment, load forecasts, and asset management
  - DER characteristics
    - Inform the estimation of DER value by describing DER operations
  - Value drivers
    - Types of distribution system costs that DERs can avoid (e.g., distribution capacity)

Source: Con Edison

Value of DER (2)

- DER characteristics can include:
  - Types of DERs considered (e.g., rooftop PV)
  - Performance assumptions such as PV generation profile or smart inverter functionality
  - DER lifetimes, which determine the period over which DERs can provide value



Source: [Sandelic et al. 2019]()

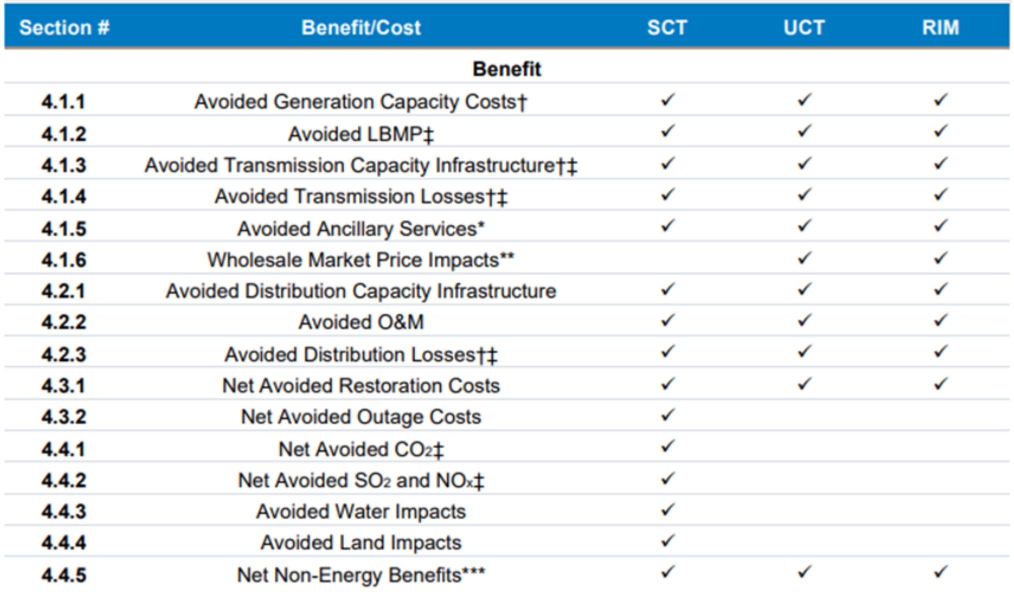
Cost-effectiveness framework for investments (1)

- Utilities assess the benefits and costs of distribution system investments and qualitative factors to determine the optimal approach to meet grid needs
  - Informs regulatory decisions on utility investment proposals

- Key categories
  - Investments considered
    - Identifies alternatives the utility considered
  - Benefit-cost analysis
    - A quantitatively focused method for monetizing benefits and costs of an investment over a defined time period
  - Least reasonable cost
    - Focused on the need for the investment as well as quantitative and qualitative assessment of benefits and costs

Cost-effectiveness framework for investments (2)

- Benefit-cost analysis data can include:
  - Methodological assumptions (e.g., discount rate)
  - Benefits (e.g., avoided operations and maintenance)
  - Costs (e.g., capital cost of transformers)
  - Sensitivity analysis (e.g., low, medium, and high discount rates)
  - Expected results (e.g., societal benefits expected prior to investment)
  - Realized results (e.g., societal benefits measures after an investment)



Section #	Benefit/Cost	SCT	UCT	RIM
	Benefit			
4.1.1	Avoided Generation Capacity Costs†	✓	✓	✓
4.1.2	Avoided LBMP‡	✓	✓	✓
4.1.3	Avoided Transmission Capacity Infrastructure†‡	✓	✓	✓
4.1.4	Avoided Transmission Losses†‡	✓	✓	✓
4.1.5	Avoided Ancillary Services*	✓	✓	✓
4.1.6	Wholesale Market Price Impacts**		✓	✓
4.2.1	Avoided Distribution Capacity Infrastructure	✓	✓	✓
4.2.2	Avoided O&M	✓	✓	✓
4.2.3	Avoided Distribution Losses†‡	✓	✓	✓
4.3.1	Net Avoided Restoration Costs	✓	✓	✓
4.3.2	Net Avoided Outage Costs	✓		
4.4.1	Net Avoided CO_2‡	✓		
4.4.2	Net Avoided SO_2 and NO_x‡	✓		
4.4.3	Avoided Water Impacts	✓		
4.4.4	Avoided Land Impacts	✓		
4.4.5	Net Non-Energy Benefits***	✓	✓	✓

Source: [National Grid – Version 4.0 Benefit-Cost Analysis ("BCA") Handbook, 2023]()

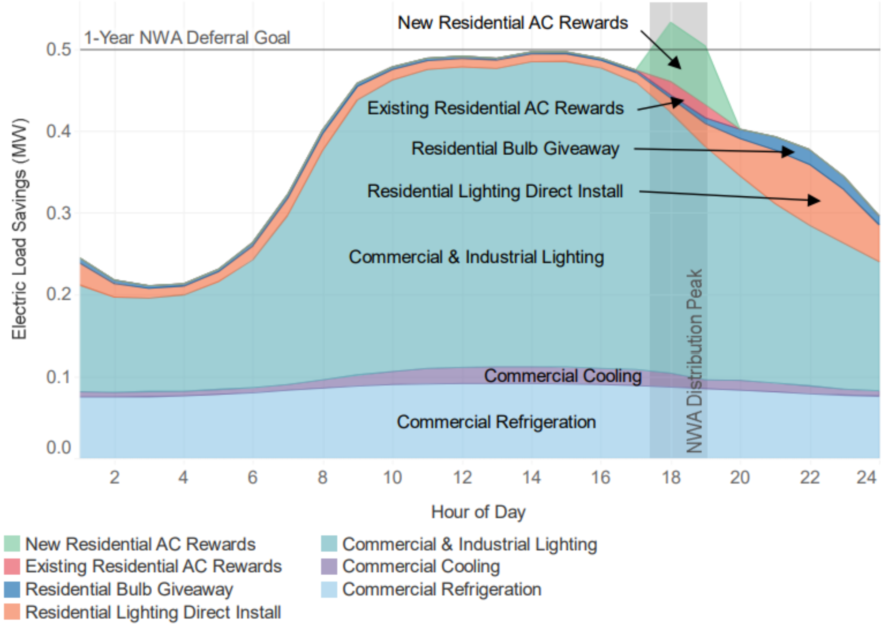
Geotargeted programs (1)

- Utilities use behind-the-meter DERs to provide grid services at specific locations on the distribution system to reduce, defer, or avoid the need for upgrades to infrastructure such as feeders and substations

- Key categories
  - Program needs
    - Describes the program’s goals and where and how it operates
  - Program design
    - Characterizes how the utility will structure the program to achieve the stated goals
  - Evaluating performance
    - Summarizes program outcomes and informs effectiveness of programs

Geotargeted programs (2)

- Program design characteristics can include:
  - Eligible measures (e.g., energy efficiency, managed EV charging)
  - Program duration (e.g., months)
  - Eligible customers (e.g., customer classes, locations)
  - Incentive types (e.g., technology rebates, performance incentives)
  - Marketing, education, and outreach (e.g., narrative on marketing initiatives)



Source: [CEE, 2021, Non-wires Alternatives as a Path to Local Clean Energy]

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