Distributed Energy Resources Planning

DOE Clean Energy Innovator Fellows Training

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Prepared for Berkeley Lab

November 14, 2024

Agenda

- Introduction
- Hosting Capacity Analysis
- Non-Wires Alternatives
- Questions

INTRODUCTION

Types of DERs

Solar Photovoltaic Systems

Wind Turbines

Energy Storage Systems

Combined Heat and Power

Electrical Vehicles
Managed or Price-Based Charging

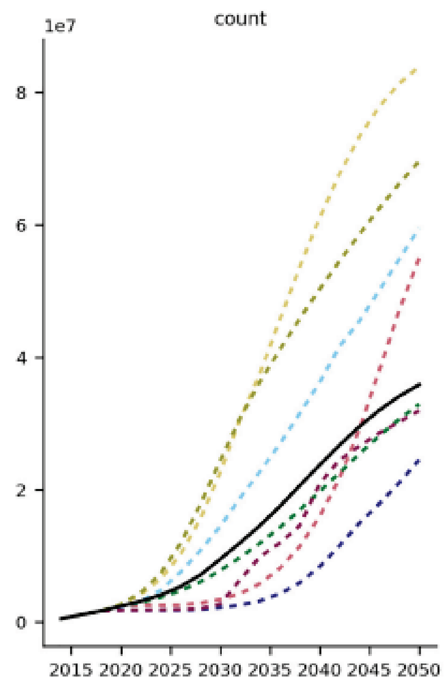
Grid Interactive Buildings
Building equipped with smart appliances and energy management systems to contribute in EE and DR programs

Energy Efficiency

Microturbines
Localized generation using natural gas

Planning for DER Growth – Predict, Identify, Resolve

DER Forecasting	Hosting Capacity Analysis	Non-Wires Alternatives



- Estimate Future Adoption
- Understand System Impacts

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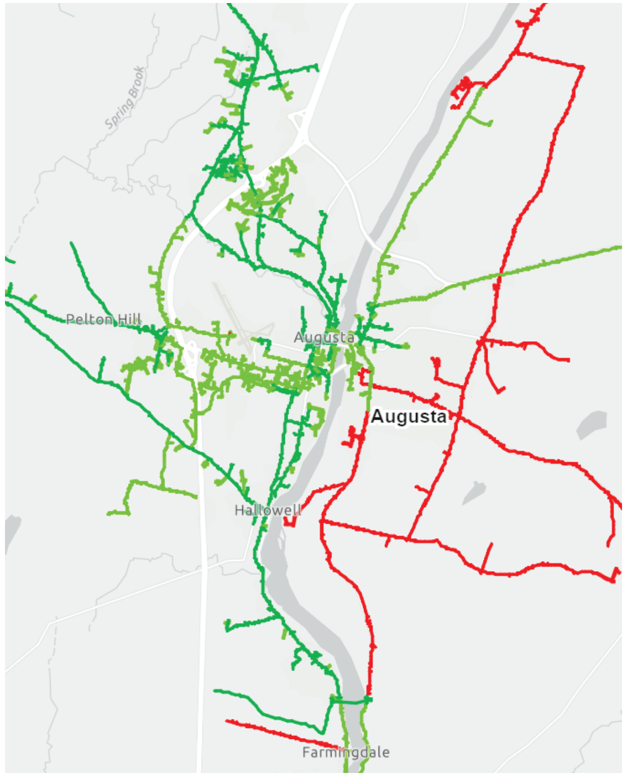

- Identify System Constraints
- Inform Applicant Siting/Sizing

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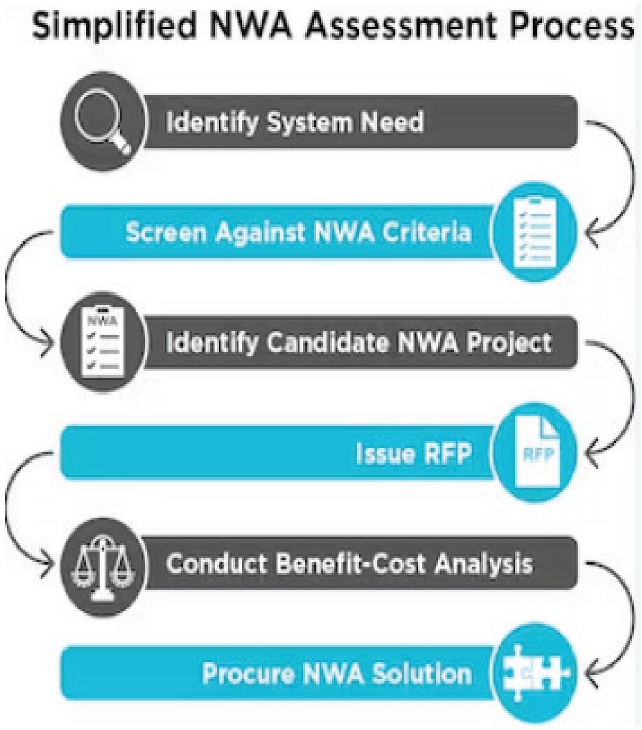


- Leverage DER As a Resource
- Mitigate System Needs Efficiently

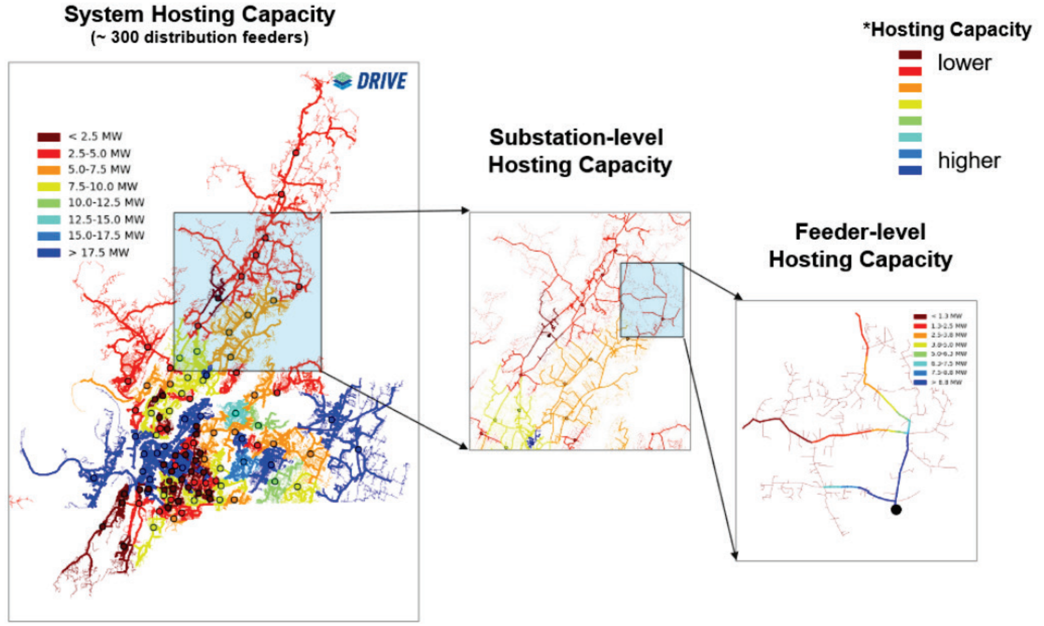
[Source]

Hosting Capacity Analysis

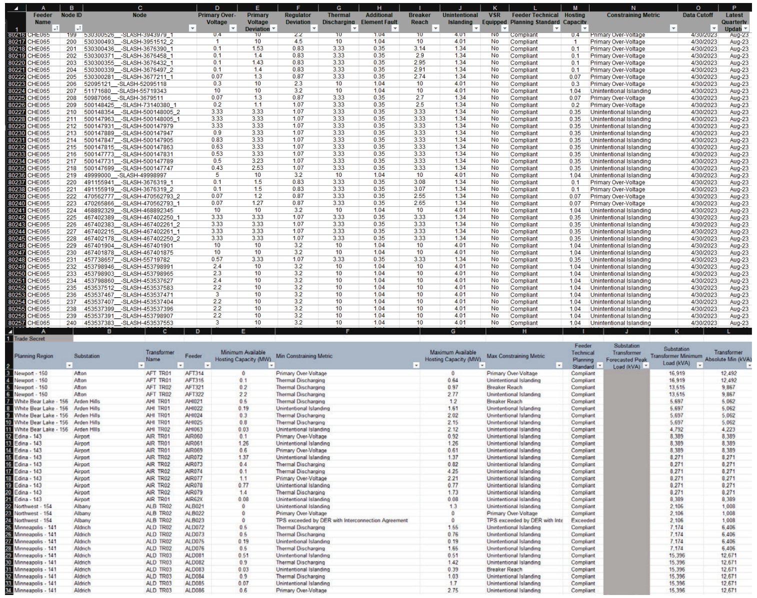
Hosting Capacity - Overview

Hosting capacity is the amount of DERs that can be **interconnected** to the distribution grid without compromising power quality or reliability, and **without necessitating upgrades** to the current control, protection systems, or infrastructure.

- Hosting capacity analysis evaluates a subset of interconnection criteria at various system locations, commonly including:
  - Thermal Limits
  - Overvoltage
  - Reverse flow limitations
  - Protection Considerations
- It is usually represented as a map, with varying level of information.
  - In some cases, utilities provide tabular information about constraints (e.g., minimum daytime load) in conjunction with maps.
- Due to scale, analysis results may not be as accurate as detailed interconnection studies, creating potential discrepancies.



Source: Jeff Smith, Methods, Applications, Opportunities and Challenges, EPRI. MPSC Distribution Planning Stakeholder Meeting, June 27, 2019, p.4.



Xcel Energy Minnesota Hosting capacity study and sub feeder spreadsheets

Hosting Capacity Use Cases

	Objective	Capability	Challenges
Development Guide	Support market-driven DER deployment	Identify areas with potentially lower interconnection costs	Security concerns; analysis/model refresh; data accuracy and availability
Technical Screens	Improve the interconnection screening process	Augment or replace rules of thumb; determine need for detailed study	Data granularity; benchmarking and validation to detailed studies
Distribution Planning Tool	Enable greater DER integration	Identify potential future constraints and proactive upgrades	Higher input data requirements; granular load and DER forecasts

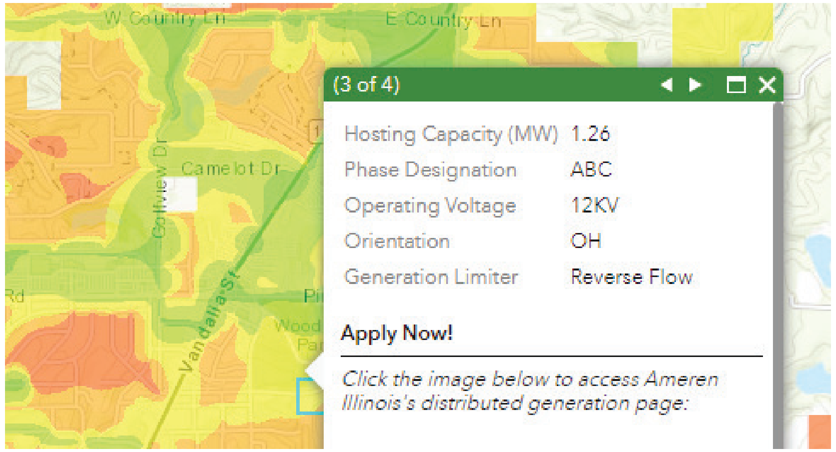
Source: U.S. DOE, Office of Electricity, Integrated Distribution Planning - Utility Practices in Hosting Capacity Analysis and Locational Value Assessment, 2018, p.3.

Use Case #1 - Facilitating Efficient Project Siting

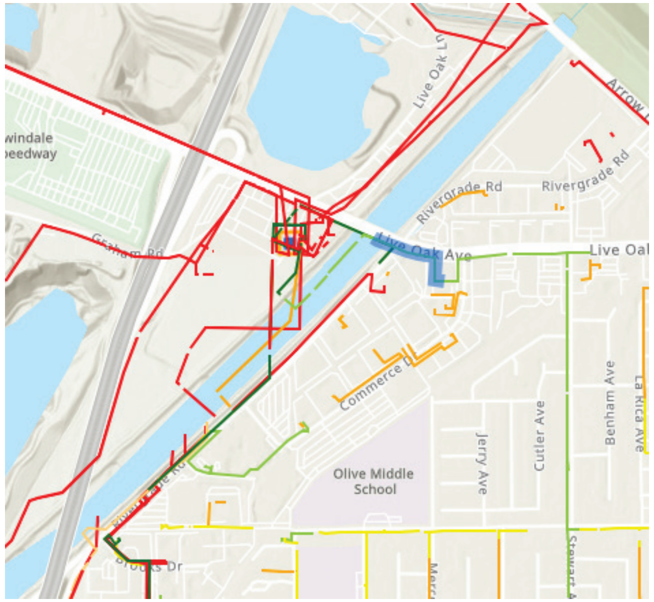
Goal: Direct project developers to sites with available capacity to **reduce the submission of non-viable applications**.

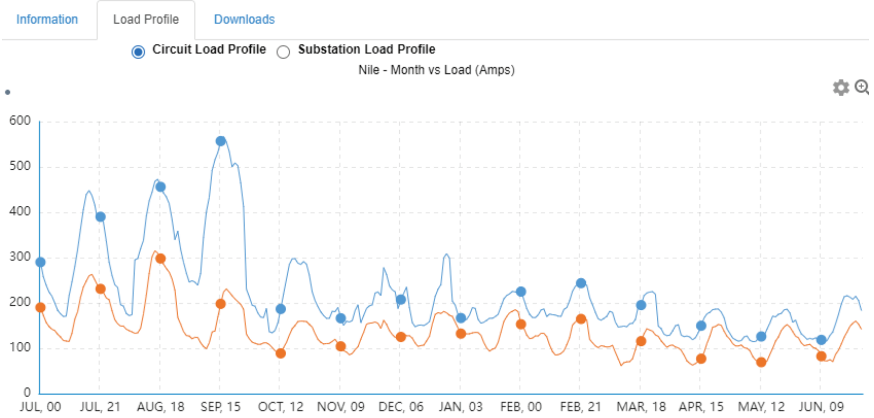
- **Basic Information:** Utilities may offer calculated DER megawatt (MW) capacity values across geographic blocks, typically visualized through a **"heat map"** indicating areas with good versus limited hosting capacity.

- **Most Effective Information**: **All data** necessary to **effectively site and size projects**, for example, calculated hosting capacity values, information on existing and queued DER projects, load profiles, grid constraints and more



Basic Hosting Capacity Map Example [Link]





Segment Level

Segment ID	236667746
Node ID	236667932
Rule 21 Screen L	Likely to Pass

	Integration Capacity (MW)	
	Static Grid	Operational Flexibility
Uniform generation	13.15	0.66
Photovoltaic	14	0.72

Circuit Level

Circuit Name	Nile
Circuit Voltage (KV)	12
Substation Name	Rio Hondo
System Name	Rio Hondo 220/66 System
Existing Generation (MW)	1.89
Queued Generation (MW)	0.26
Total Generation (MW)	2.14

Hosting Capacity Advanced Information Example

Hosting Capacity Map Information Breakdown

Hosting Capacity (HCA) Map Elements	Benefits to DER Developer
Substation location and HCA data	• Determine substation level constraints (e.g., size and voltage of transformer) • Identify equipment that may impact hosting capacity (e.g., load tap changer or regulator) • Determine approximate distance from circuit to substation
Feeder location and HCA data	• Determine feeder HCA constraints for DER load and generation • Assess if costly system upgrades are likely at a location given constraints • Identify equipment that may impact HCA (e.g., voltage supervisory reclosing)
HCA criteria violations	• Determine which violation criteria (e.g., thermal, voltage) is causing the limit, identify appropriate technical solutions to overcome constraint(s), and estimate associated costs (e.g., for system upgrade)
Substation/feeder load profiles	• Screening tool for locating DER load interconnections (e.g., storage, EV chargers) • Assess if costly system upgrades are likely at a location given constraints
DER connected and in queue	• Determine if hosting capacity is likely available to new projects

Benefits of Hosting Capacity Information to Developers – Source: Synapse Report

Use Case #2 - DER Interconnection Screening

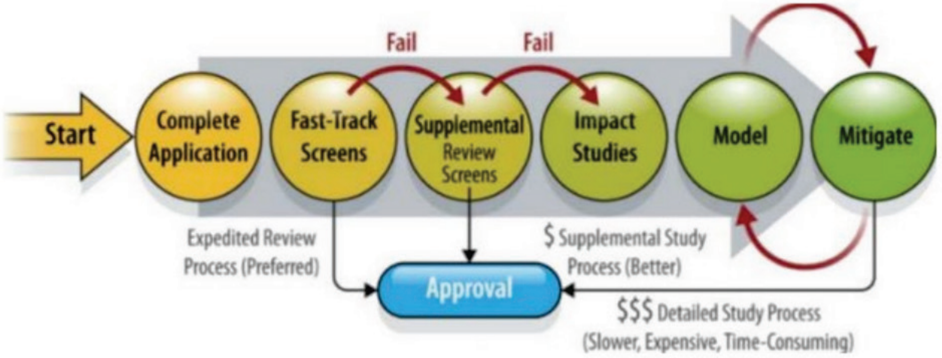
Goal: Integrate hosting capacity into the DER interconnection screening process to **<u>improve efficiency, reduce conservative assumptions, and improve screening process timelines</u>**.

Current Role in Interconnection Screenings:

- Not commonly used directly as part of interconnection screening criteria
    - Screens usually set by state codes or in utility tariffs
    - May be used to identify "restricted" or "closed" feeders
- Significant synergy between data collected for hosting capacity and data-driven screening methods
    - Use actual minimum daytime load instead of rule of thumb based on 15% of peak capacity of the feeder
    - Substation protection / reverse flow limits
    - System-wide distribution model clean-up

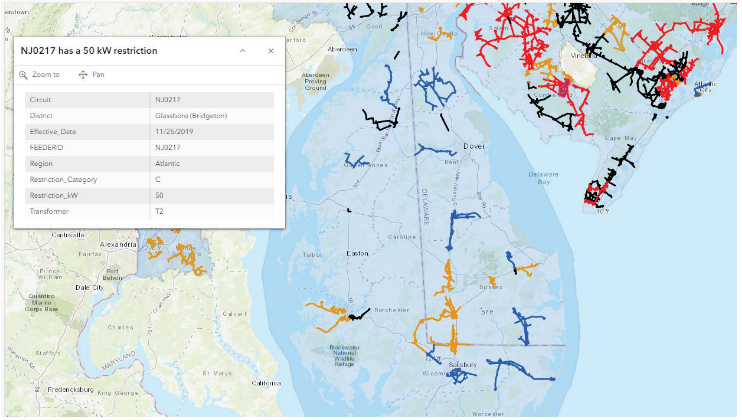
Implementation Challenges:

- Requires application/model management for queued generation and resulting system upgrades
- Models used for system-wide analysis not as trustworthy as application-specific studies (scale trade-offs)
- Difficult to account for site-specific factors (e.g., volt/var curve, co-located storage)
- Modifying screening criteria may require state-level modifications

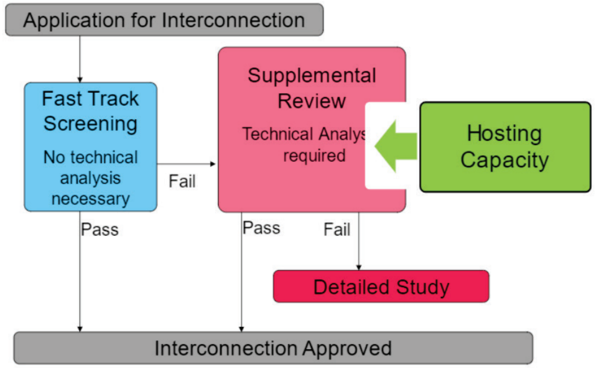


Source: NREL, Emerging Issues and Challenges in Integrating Solar with the Distribution System, May 2016.

Interconnection Screening Process



Restricted application Example

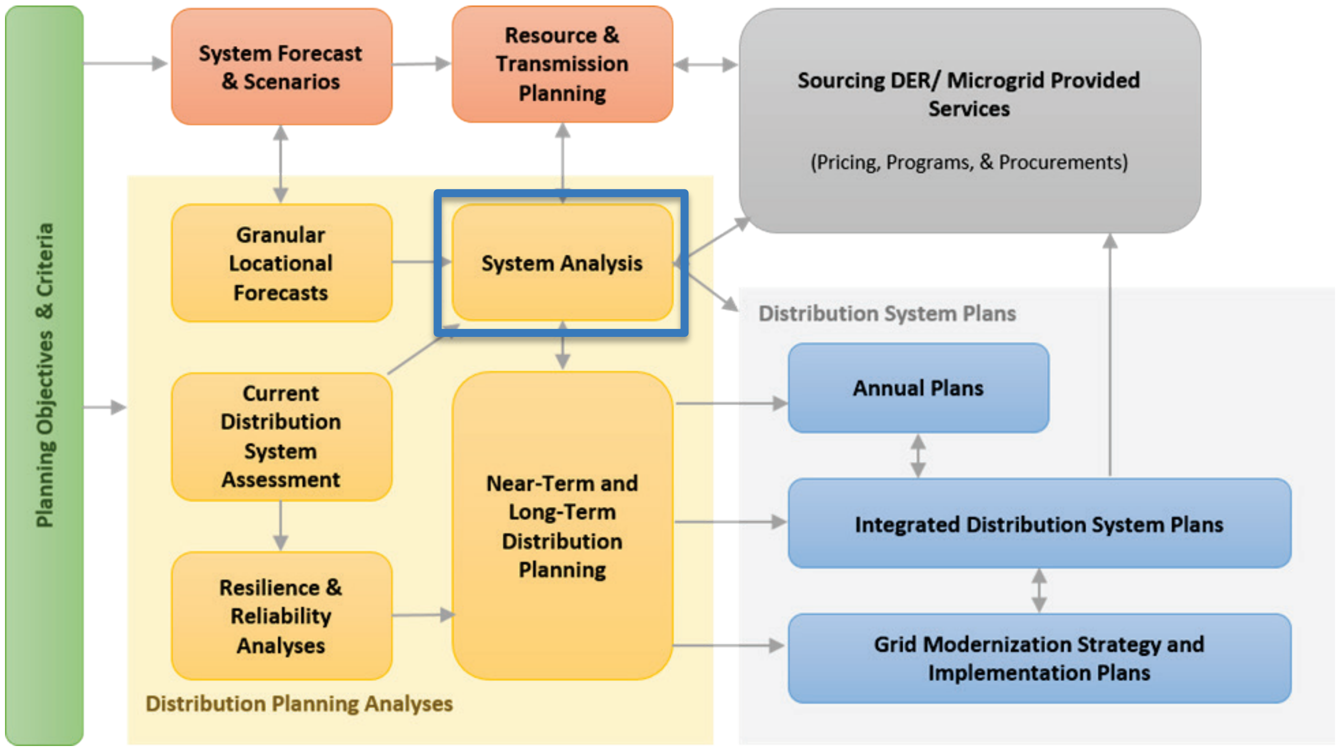


Source: Jeff Smith, Methods, Applications, Opportunities and Challenges, EPRI. MPSC Distribution Planning Stakeholder Meeting, June 27, 2019, p. 24.

Hosting Capacity Analysis Can Assist in Interconnection Screening

Use Case #3 - Distribution Planning Tool

- Hosting capacity plays a crucial role in scenario analysis, allowing for the assessment of various 'what-if' situations concerning DER integration.
- When combined with projections of load and DER expansion, the analysis facilitates detailed evaluations of future effects on a per-feeder basis.
- Utilities can use these scenarios to consider mitigation strategies and necessary infrastructure enhancements and to conduct cost-effectiveness analyses.
- Advanced analytical capabilities will equip utilities to gauge the distribution system's readiness to leverage DER services, including non-wires alternatives, and to understand how DERs affect grid restructuring, operational tactics, and the adoption of advanced inverter technologies.



Source: Modern Distribution Grid Guidebook, DSPx Volume 4, June 2020, PNNL: Grid Architecture - Modern Distribution Grid Project

Common Hosting Capacity Map Design: Tensions and Trade-Offs

Topic Area	Common Utility Perspective	Common Developer Perspective
Update Frequency: (e.g., Annual, Monthly, Bi-monthly)	More frequent updates increases ongoing maintenance costs	More frequent updates improve usefulness due to increased accuracy
Level of Geographic Granularity (Blocks vs. Circuit Maps)	Aggregated maps reduce risk to utility assets (security)	Detailed circuit maps improve developer site selection capabilities
Amount of Information Provided (e.g., calculated HC, information on constraints, load profiles)	Providing additional information increases HC tool development and ongoing costs	Providing additional information increases project siting/sizing screening capability
Security Concerns (Critical Energy Infrastructure Information – CEII)	Highly detailed information may contain CEII or expose the distribution system to additional risk	HC maps are outside distribution substations and not part of the bulk power system, thus not CEII
Cost Burden	Map development and maintenance costs impact utility customer bills and are not paid by developers	HC maps reduce utility study burden and aid in compliance with state goals and programs
Data Export and Tabular Format Availability	Allowing export in tabular format may increase system security risk	Tabular results are much easier to use for prospecting good sites

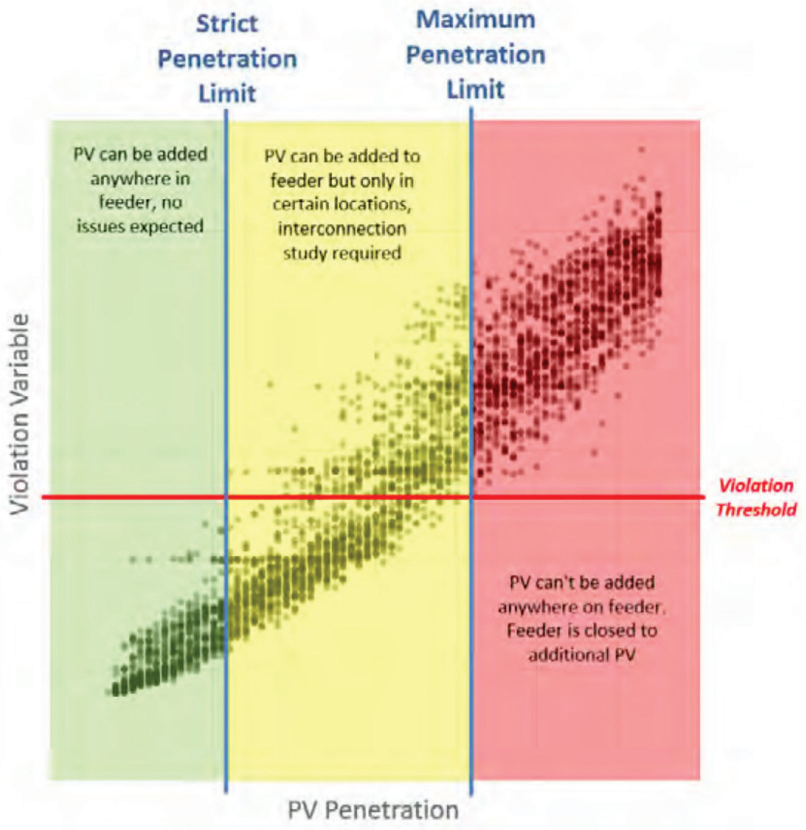
Use Case - Examples

California IOUs

- Integrate hosting capacity information to refine the Rule 21 interconnection process
- In 2020, mandated by the CPUC to use Integration Capacity Analysis (hosting capacity) results in the interconnection process to:
    - *Determine where and when existing circuits can accommodate additional DERs without needing upgrades*
    - *Allow interconnection resources to export up to those limits [Source CPUC]*

Pepco (Washington, DC)

- Uses hosting capacity results along with a Heat Map to indicate existing and pending installations on feeders
- Pepco's Hosting Capacity Analysis provides customers with the ability to assess the interconnection point to estimate the available capacity on a feeder, in relation to the current and anticipated solar photovoltaic (PV) projects awaiting connection



Pepco's Definition of Strict and Maximum PV Penetration Limits – Source DE-EE0006328

Use Case - Example

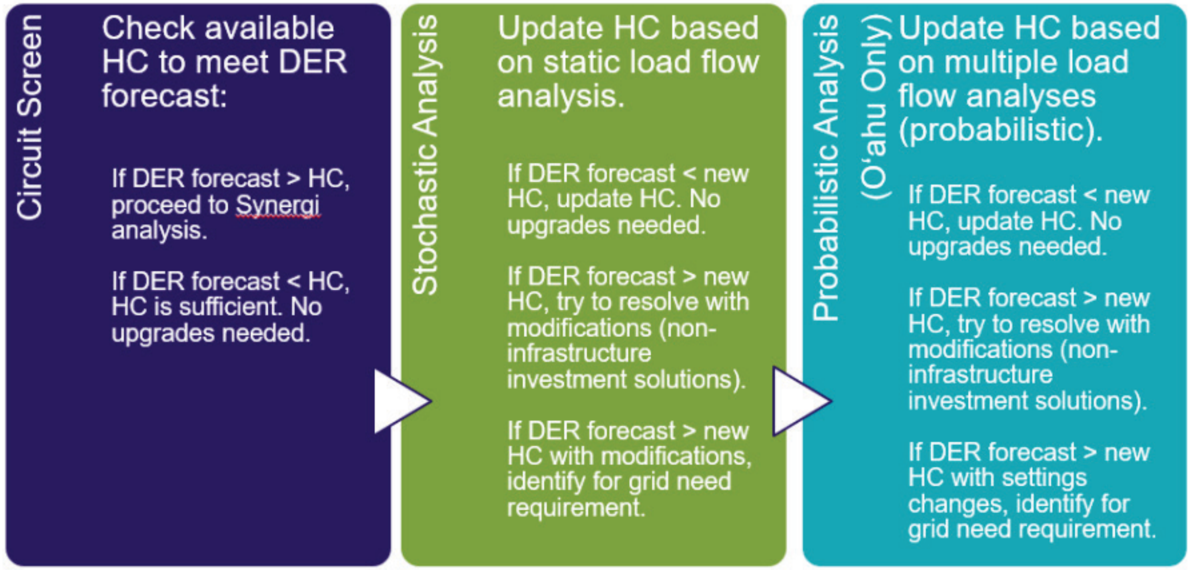
Hawaiian Electric Company

HECO employs a multi-step, increasing complexity screening process to assess a circuit's capacity to host forecasted DERs through 2025.

Based on the multistep process, Hosting Capacity is categorized in the following groups by circuit.

- **Existing Hosting Capacity Satisfies Need**: Existing hosting capacity can accommodate the total anticipated DER in year 2025. No grid needs are required.
- **Updated Hosting Capacity (Without Modifications) Satisfies Need:** Updated hosting capacity can accommodate the total anticipated DER in year 2025. No grid needs are required.
- **Updated Hosting Capacity (With Modifications) Satisfies Need:** Updated hosting capacity along with modifications that do not require infrastructure investments can accommodate the total anticipated DER in year 2025.
- **Solution Option Required:** Updated hosting capacity is unable to accommodate the total anticipated DER in year 2025. Grid need identified.

Source: HECO



Summary of Hosting Capacity Analysis – Source: HECO

Island	Total Circuits	Existing Hosting Capacity Satisfies Need (Analysis Not Required)			Total Anticipated DER in 2025 > Hosting Capacity (Analysis Required)		
		Low	Base	High	Low	Base	High
O‘ahu	384			303			81
Hawai‘i Island	137			76			61
Maui Island	88			52			36
Lana‘i	3			1			2
Moloka‘i	8			3			5
Total (All Islands)	620			435			185

Summary of Circuit Selection Screening – Source: HECO

Non-Wires Alternatives

Poll Question

Which of these best describes your initial gut reaction to the phase “Non-Wires Alternatives”?

- What does that mean?
- Opportunity / Optimism
- Complicated
- Frustrating

Non-Wires Alternatives

“Non-wires alternative (NWA)” is any action or strategy that uses **non-traditional** transmission and/or distribution solutions – such as distributed generation, energy storage, energy efficiency, demand response, and grid software and controls – with the intent to **defer or replace** the need for specific **energy delivery system equipment investments**. An NWA must meet energy delivery system needs and be more **cost effective** consistent with the guiding principles of sustainable, well-planned, secure, affordable, and non-discriminatory.”*

NWA Benefit Category	Traditional Solutions	NWA Solution	DER Types Considered
Capacity – Reduce thermal loading on utility equipment during peak load hours to defer upgrades	Upgrade overloaded equipment, construct new circuit or substation for segmentation	Inject power locally to reduce thermal load on equipment	Grid-following DER — e.g., PV, battery energy storage system (BESS), combined heat and power
Reliability – Provide an alternate source during loss of utility supply	Build circuit ties, construct redundant substation or circuit	Intentional island to restore service to unfaulted area	Grid-forming DER (grid-forming inverter or synchronous generator)
Voltage Support – Mitigate voltage violations	Install capacitor bank or voltage regulator, reconductor	Real and reactive power injection and absorption	Inverters with Volt/Var curves, BESS, etc.

*SEPA Non-Wires Alternatives (NWA) – Incorporating NWAs into Your Grid Modernization Program

Identifying NWA Opportunities – Levels of Targeting

System-Level Initiatives

- No specific locational drivers; impact to specific grid needs is coincidental
- Examples: Lighting LED Conversions, Net Metering

Geotargeted Programs

- Tailor programs and incentives to target areas of expected future distribution needs
- Ex: Value of DER Tariffs

Specific Grid Needs

- Dedicated procurement of specific size/type of resource to meet known constraint
- Ex: Microgrid for reliability

NWA Evaluation Framework – Cost-Benefit Evaluation

Cost-benefit analysis for NWAs scrutinizes a variety of factors to ascertain NWA economic viability compared to traditional grid upgrades, such as:

- Initial capital expenditure
- Operational expenditures
- Economic lifespan and depreciation
- Benefits and savings
- Scalability costs
- Avoided energy benefits
- Avoided capacity benefits
- Avoided non-energy benefits
- Benefit to cost ratio

Individual Cost and Benefit Calculations for an Example Project, Used to Calculate the Net Impact

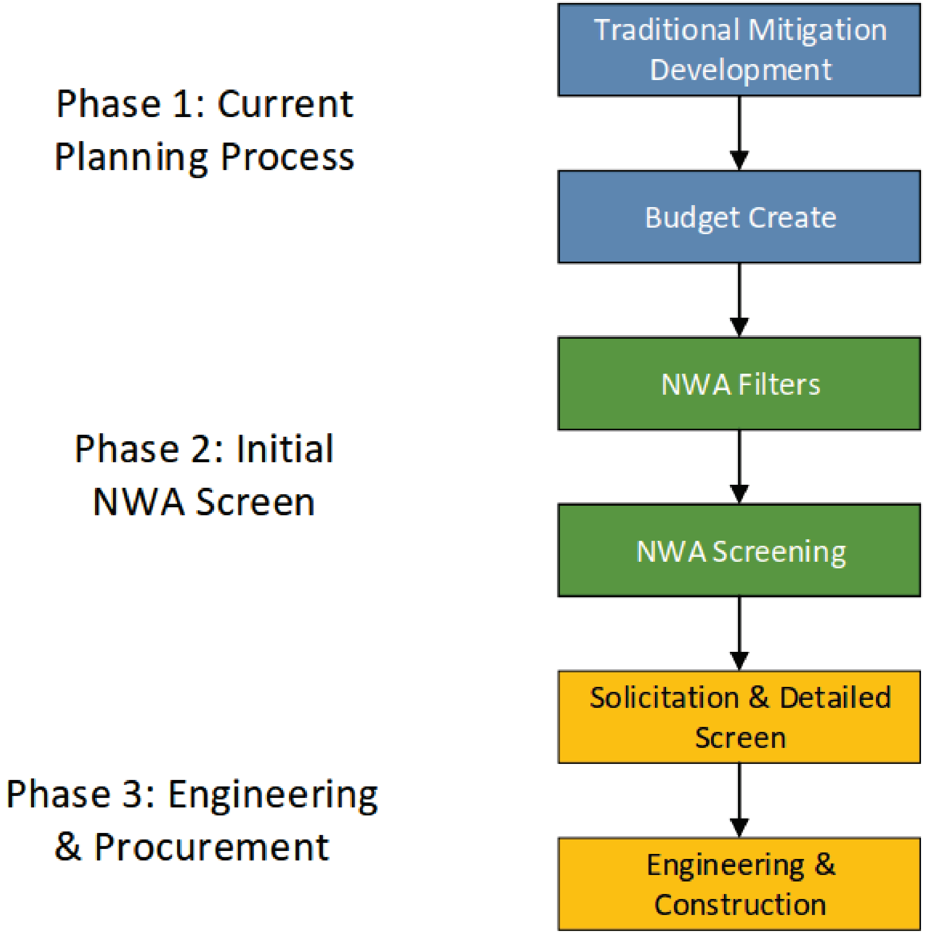
Cost and Benefits Summary	
Energy Generation	$1,544,526
Generation Capacity + MISO Reserves	$473,600
Transmission Capacity	$20,332
Deferral Benefit	$800,717
GHG Emissions + Other Environmental	$2,112,750
Solar Cost	$(2,177,637)
Battery Cost	$(438,363)
Interconnection Fees	$(204,000)
Total Benefit	**$4,951,924**
Total Cost	**$(2,819,999)**
Net Impact	**$2,131,925**

Source: Xcel Minnesota 2023 Integrated Distribution Plan – NWA Appendix F, Pg 24

NWA Evaluation Framework – Comparison with Alternatives

Evaluating Non-Wires Alternatives requires comparing them to traditional infrastructure solutions to understand benefits and limitations of NWAs in addressing specific grid needs. This comparison is a multi-faceted comparison including, but limited to, the following factors :

- Capital and operational costs
- Time to implement
- Scalability and flexibility
- Environmental impacts
- Reliability and resiliency measures
- Regulatory and policy compliance
- Public/community impact
- Maintenance and long-term use
- Finance and business models
- Risks



Source: Xcel Minnesota 2023 Integrated Distribution Plan

NWA Procurement Mechanisms

Specific Grid Need
Direct Procurement

- Utility-initiated acquisition of resources to meet identified grid needs.
- Utility-owned/leased and directly controlled, offering a streamlined approach.
- The approach simplifies access to the value stack, mitigating contractual or control complexities associated with third-party operations.
- Suitable for vertically integrated utilities. More challenging for deregulated distribution utilities (ownership, market revenue, and dispatch coordination challenges).

Specific Grid Need
Distribution Services Approach

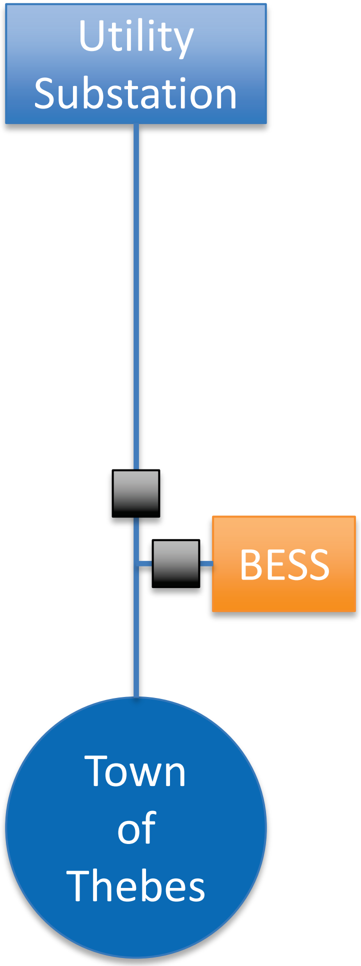
- Utility issues a call for proposals from third parties or customers for NWAs to address specific grid needs.
- Such solicitations enable the integration of customer or third-party-owned resources, which are then compensated for their services to the grid.
- These resources can be directed by the utility for distribution system needs as necessary, while otherwise participating freely in other market opportunities.

Geotargeting or System Level
Programmatic Approach

- Employ systematic studies to discern the locational value of DERs, aiming to direct them to where they're most beneficial on the grid.
- Adjust incentive levels to promote DERs in locations which can offer the greatest value/relief to the system.
- The goal is to prevent as many specific grid needs as possible by managing load growth in targeted areas, thereby reducing reliance on traditional infrastructure upgrades.

Specific Grid Needs Example – Ameren Illinois Thebes BESS

- Ameren Illinois installed a battery energy storage system to provide backup power for the town of Thebes.
    - Approximately 300 residents
    - Historically worst performing circuit for reliability
    - Served via radial supply through dense Mark Twain National Forest
    - Traditional alternate source construction not viable due to distance and trees
- **1 MW battery** installed and used as an automatic transfer voltage source for the community during an outage situation
- Estimated Cost: **$1.4M**
- This project resulted in **fewer and shorter outages with positive community feedback**.



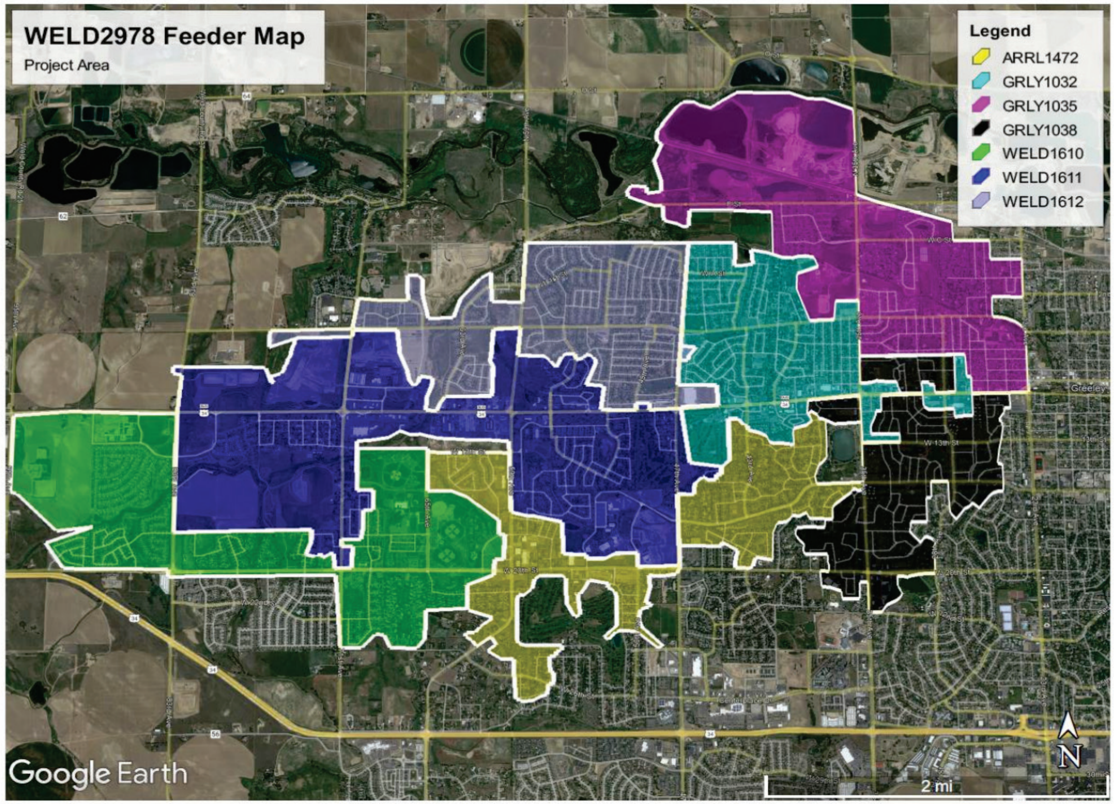
Ameren Illinois Thebes Battery [Link]

Specific Grid Needs - Distribution Services Approach - Colorado

In May of 2023, Xcel Energy (PSCo) issued an RFP to solicit NWA solutions for two capacity-driven projects to defer system upgrades

- Goal: Defer $4.1M for new feeder from 2025 to 2031 for each project location
- Expected to utilize demand response, energy efficiency, energy storage, and/or distributed generation

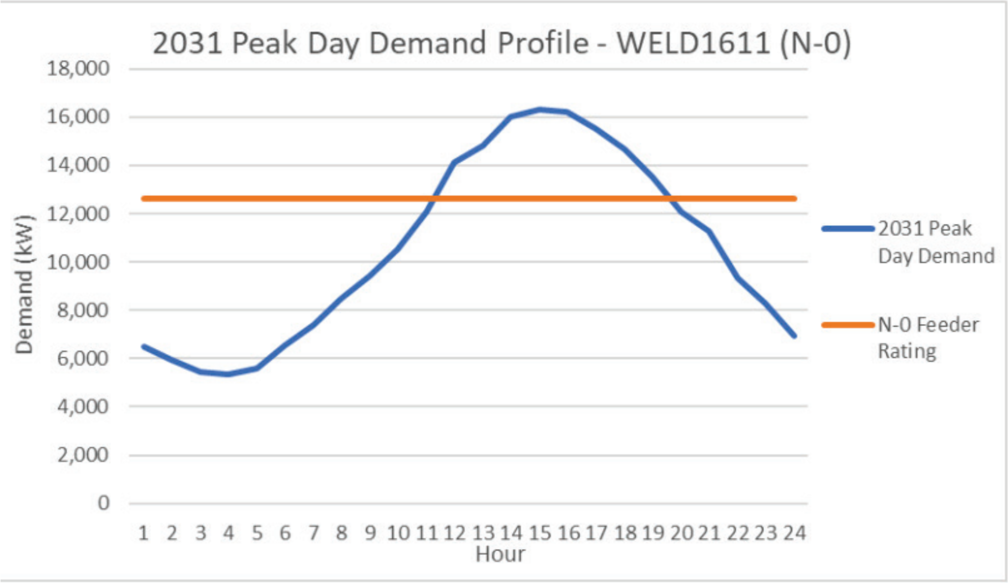
Area of Need



Timing of the Need

Asset	Capacity Need (MW)	Need Period (Hours)	Peak Hours	Deferral Period (Years)	120-Day Load Relief Period
WELD1611 (N-0)	4.6	10 hours	11:00 – 20:00	2025 - 2031	June 1st – September 28th
WELD1611 (N-1)	11.5	20 hours	4:00 – 23:00	2025 - 2031	
GRLY1032 (N-1)	7.0	21 hours	3:00 – 23:00	2025 - 2031	

Table 7: Timing for System Risk Relief Requirements



[Source]

Geotargeting DER Programs

- **Customer-centric approach** where customers choose the size, location, and type of DER installations, such as solar panels or energy storage systems, and are **compensated based on the locational value their DERs** provide to the grid, **encouraging deployment in areas where can provide maximum benefits**.

Example: NY VDER
New York's Value of Distributed Energy Resources (VDER) program, which includes the **Locational System Relief Value**, **compensates** DER providers based on the **location-specific value** they bring. VDER also employs studies on the marginal cost of service to determine a general "**Demand Reduction Value**" applicable across **all locations**.

Ongoing Proceeding – Illinois Value of DER
Illinois is engaged in an ongoing proceeding to determine "base value" and "additive services" value of DER as a replacement for the distribution component of net metering compensation

- Driven by state legislation
- Framework to be proposed in 2024
- Workshop Materials: [Link]

Value Name	Description	Eligible DERs
Energy Value (LBMP)	LBMP is the day-ahead wholesale energy price as determined by NYISO. It changes hourly and is different according to geographic zone.	All technologies: PV, storage, CHP, digesters, wind, hydro, and fuel cells.
Capacity Value (ICAP)	ICAP is the value of how well a project reduces New York State's energy usage during the most energy-intensive days of the year. Developers can choose from three payout alternatives and most ICAP rates change monthly.*	All technologies receive ICAP. Dispatchable technologies (stand-alone storage, CHP, digesters, and fuel cells) will receive Alternative 3.
Environmental Value (E)	E is the value of how much environmental benefit a clean kilowatt-hour brings to the grid and society. The E value is locked in for 25 years.**	PV, wind, hydro, and storage charged exclusively from PV or wind energy. Stand-alone storage is not eligible at this time.
Demand Reduction Value (DRV)	DRV is determined by how much a project reduces the utility's future needs to make grid upgrades. DRV is locked in for 10 years.**	All technologies.
Locational System Relief Value (LSRV)	LSRV is available in utility-designated locations where DERs can provide additional benefits to the grid. Each location has a limited number of MW of LSRV capacity available. The LSRV is locked in for 10 years.**	All technologies. Project must be on a utility-specified substation.
Community Credit (CC)	CC is available on a limited basis to encourage the development of Community Distributed Generation (CDG) projects. CC is the successor to the Market Transition Credit (MTC) and is similar in structure. The CC is locked in for 25 years.** PV projects in utility territories that have fully expended their CC may be eligible for the Community Adder – an upfront incentive administered by NY-Sun.	Available for CDG projects including PV and digesters. Wind, hydro, and fuel cells receive CC at a derated value. Not available for stand-alone storage or CHP.

NY Value Stack Elements [Link]

Example – Central Hudson Peak Perks Program

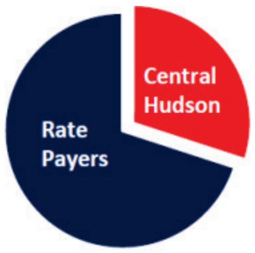
- Central Hudson in New York faced challenges with peak load management, especially during the summer months when energy usage spikes.
- The utility was looking for a way to manage these peaks more effectively without resorting to costly infrastructure upgrades in three targeted zones for 5 to 10 years.
- Peak Perks is a voluntary program that incentivizes residential and commercial customers to allow the utility to install devices that can remotely cycle off air conditioning systems or adjust thermostat setpoints for brief periods during peak demand times.
- Participants receive an initial enrollment bonus and annual participation incentives.

Estimated Cost of Traditional T&D Solutions

– Actual Cost of DR Solution

+ Actual Capacity Savings

= Program Financial Benefits



70% of benefits go to rate payers by reducing future bill pressure

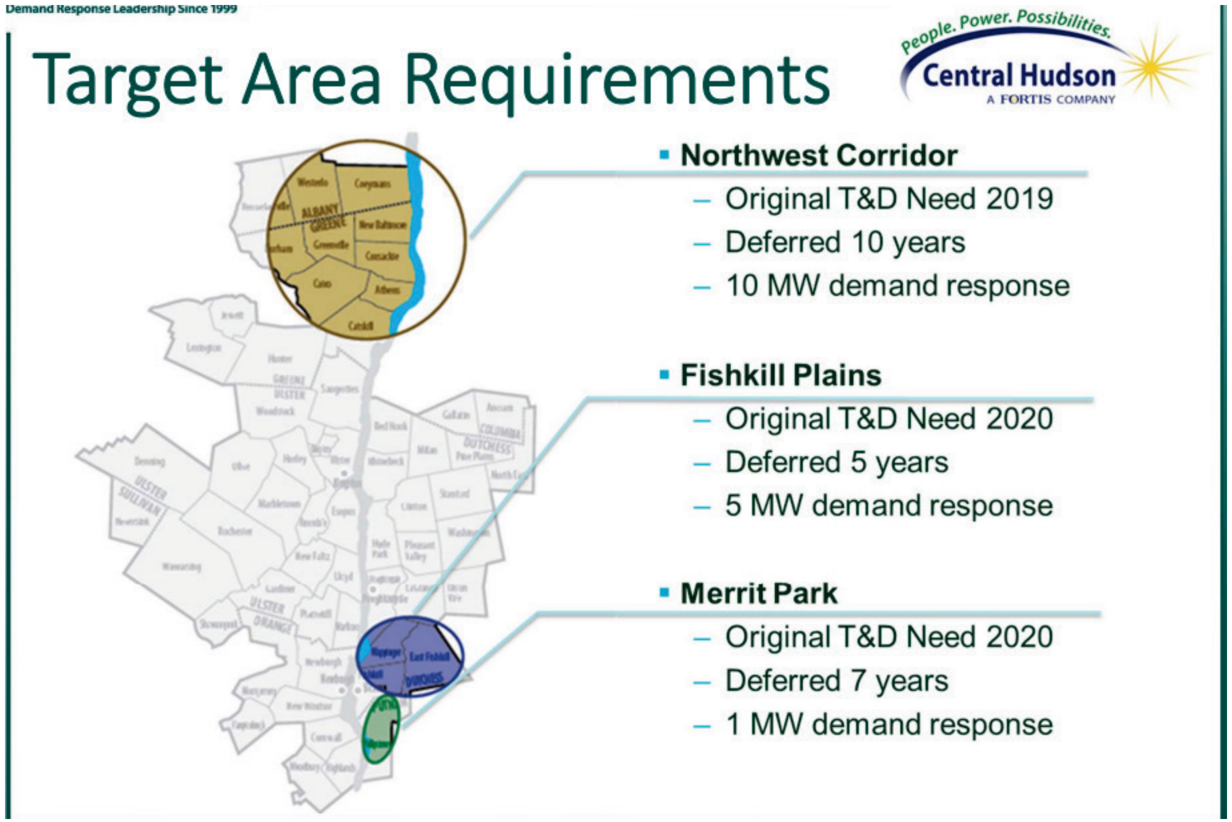
30% of benefits are provided to utility as incentive to achieve the program targets

Source: PLMA Award Wining DR Initiatives

Example – Central Hudson Peak Perks Program

Outcomes

- By targeting specific areas with the highest demand or where the system was most constrained, Central Hudson optimized its demand-side management efforts.
- The program exceeded the total first year MW target of all three locations, achieving **<u>5.9 MW</u>** of load reduction compared to 5.3 MW target.
- Overall, Central Hudson's Peak Perks program successfully curbed peak energy demand, contributing to more stable and efficient grid operation.
- Program participants contributed to a collective effort that helps to maintain reliable service and keep energy costs down for all customers.



Q&A

Questions?

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