



Integrated Distribution Planning

Utility Practices in Hosting Capacity Analysis and Locational Value Assessment

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COVER PHOTO CREDITS

Top: The Ántukš-Tiñqapapt or “sun trap” solar array recently installed by the Confederated Tribes of the Umatilla Indian Reservation in Oregon. Courtesy of the U.S. Department of Energy.

Middle: NREL-owned electric vehicles below solar canopy at the Vehicle Testing & Integration Facility. Courtesy of the U.S. Department of Energy.

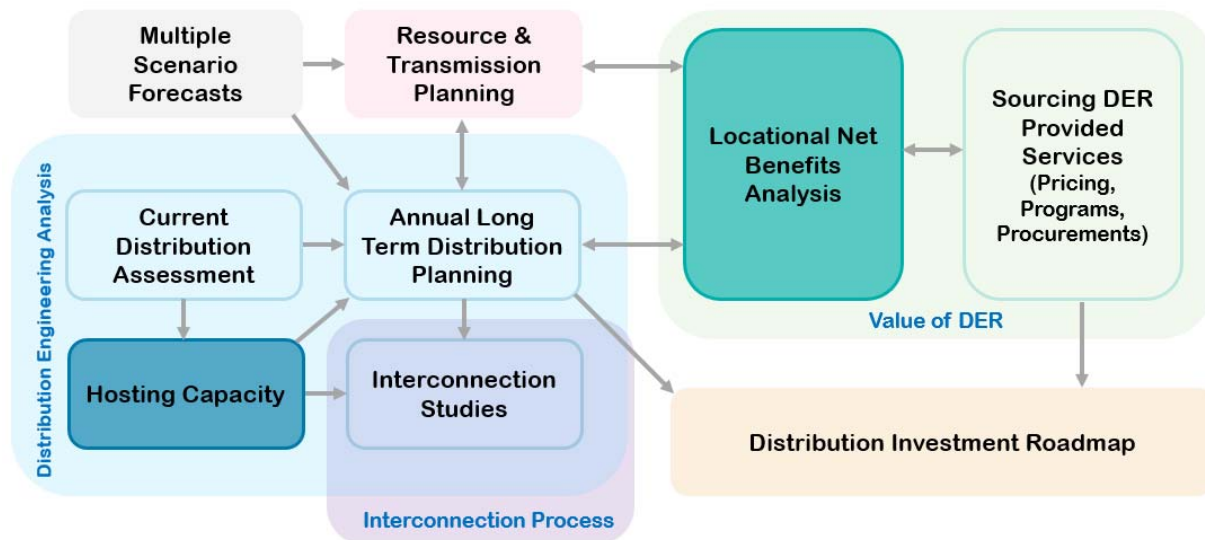
Bottom Left: Smart Meters in Washington, DC. Photo by Patricia D’Costa. Courtesy of ICF.

Bottom Right: Lotus Energy designed a solar plus storage system. Photo by Christine Bennett. Courtesy of the U.S. Department of Energy.

EXECUTIVE SUMMARY

Utility planning processes are quickly evolving to meet changing customer expectations,¹ guide distributed energy resources (DER) development, support prudent investments that serve customers and enable utilities to continue to ensure system reliability, resilience, safety and security as new resources connect to the system. Integrated Distribution Planning (IDP) refers to the collective set of capabilities that supports these objectives by enabling utilities to proactively plan the system, integrate new resources cost effectively, and better reflect the costs and benefits in planning (see Figure 1). The implementation of IDP is still nascent but many utilities have begun to develop these capabilities and the lessons learned from these early efforts are informing the development of emerging best practices. This report provides the summary of targeted interviews with 12 electric utility companies across the country as well as leading industry research organizations to provide input on current industry practices and evolving IDP use cases.²

Figure 1. Integrated Distribution Planning³



As DER penetrations rise, it is important to understand the amount of resources the system can host at a given location. Quantifying the hosting capacity for various DER types is an important

¹ As technology, such as solar energy systems and energy storage devices, becomes more available, customers of electric utilities are participating to a greater extent in the generation and management of electricity. Such technology adoption is growing rapidly among residential and commercial customers, especially where policies are favorable; industrial customers have traditionally been early adopters.

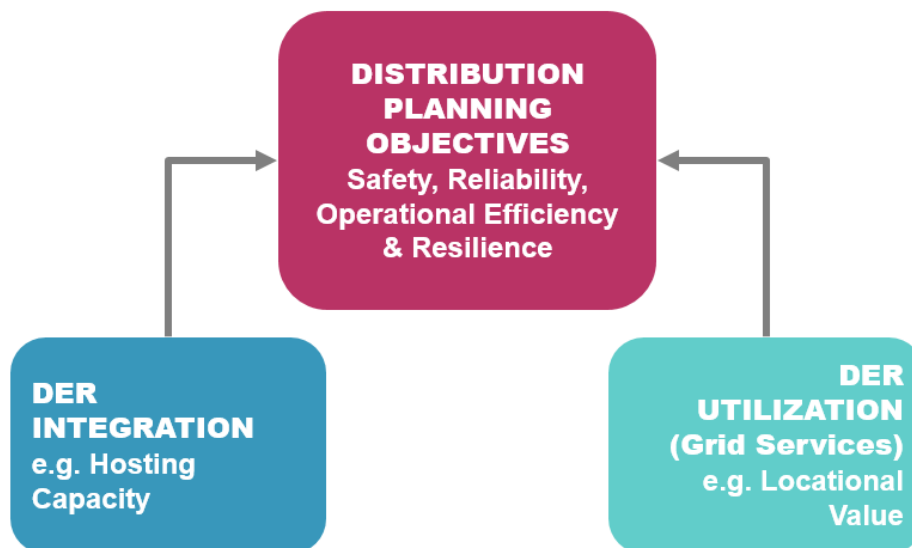
² The research conducted as part of this study included interviews with individuals representing the Association of Edison Illuminating Companies (AEIC) DER Subcommittee, Arizona Public Service, Consolidated Edison Company of New York (Con Edison), Electric Power Research Institute (EPRI), Hawaii Electric Company, National Grid, National Rural Electric Cooperative Association, Pacific Gas and Electric Company (PG&E), Pacific Northwest National Laboratory (PNNL), PPL Electric Utilities, Pepco, Oklahoma Gas & Electric, Southern California Edison, Southern Company, and Xcel Energy

³ ICF, Integrated Distribution Planning, August 2016.

IDP capability that can inform DER interconnection, and enable system planners to ensure that they can continue to provide reliable service with increasing quantities of distributed resources on the system.

Likewise, the reflection of DER costs and benefits at each location of the system is an essential prerequisite to integrating DER into planning and establishing efficient DER compensation based on their net value. In some cases, DER can help contribute to system attributes like distribution capacity, reliability, and resilience. Utilities can source DER and provide compensation for grid services through a variety of mechanisms. The locational value assessment of DER can be applied in the context of DER procurement for non-wires alternatives, in retail tariff design, and in targeted utility programs.

Figure 2. DER Supporting Distribution Planning Objectives



Use cases provide a lens through which to understand the value propositions that hosting capacity analysis and locational value assessment provide and to see how these capabilities can help meet utility and stakeholder objectives. Table 1 summarizes use cases that are representative of current utility activities.

One of the defining characteristics of this new planning paradigm is the extensive set of touchpoints and interdependencies between aspects of planning (e.g. between hosting capacity and load forecasting) and other utility functions (e.g. between planning and program design or between planning and operations). Thus, the current state of hosting capacity and locational value assessment efforts across the industry provides a window into how IDP is proceeding as a whole. Further, a close look at developments around these two aspects of IDP reveals how IDP is developing new touchpoints across the industry in order to meet key objectives. Effective DER integration and DER utilization enabled through integrated distribution planning can support system objectives (Figure 2). For example, DER could in some cases provide a faster, more cost effective reliability solution in a given geographic area, or enhance system resilience by

providing localized resources in the context of applications such as microgrids.^{4,5} This report explores some of the more common use cases for aspects of IDP to provide a snapshot of current utility practices, challenges, and considerations.

Table 1. Use Cases for Hosting Capacity and Locational Value Assessment At-a-Glance

	Use Case	Objective	Capability	Challenges
Hosting Capacity Analysis Use Cases	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
Locational Value Assessment Use Cases	Non-Wires Alternatives Procurement	Enable market-based provision of DER services	Procure non-wires alternatives to defer T&D investment	Quantification of costs and benefits; risk management
	Tariff Design	Provide price signals for DER locations	Link locational value analysis to tariff design	Efficient, transparent price mechanisms for benefits or costs
	Program Design	Enhance system value of programs	Targeted program customer acquisition and/or incentives	Customer acquisition; risk management; coordination

The ability of these capabilities to meet discrete needs define use cases that provide the value proposition for the implementation of IDP. Some deliver value to utility stakeholders while also providing value outside the utility. For example, hosting capacity maps can inform DER developers and support market-driven deployment by identifying areas of the system with potentially lower development costs. This use case accounts for the bulk of utility efforts to date related to hosting capacity, although additional use cases to support technical screens for distributed generation interconnection and to support proactive planning of system upgrades that address prospective DER integration constraints are garnering significant attention.

The application of locational value assessment has similarly focused on one primary use case: competitive solicitation of non-wires alternatives for deferral of traditional utility distribution system investments. Many efforts around the country are at an early stage, but they are providing lessons learned and contributing to the development of best practices for this

⁴ U.S. Department of Energy, Distributed Generation (DG) for Resilience Planning Guide, Critical Infrastructure (CI) 101, 2018

⁵ U.S. Department of Energy, Distributed Energy Resources Disaster Matrix, 2018

application of locational value and to make non-wires procurement a more routine aspect of system planning. Several utilities are building on these efforts to look at how to leverage these market-based sourcing mechanisms into planning and to implement approaches to non-wires alternatives that facilitate their evaluation alongside traditional solutions rather than strictly as a means to defer traditional investments.

The further application of locational value assessment for targeted program design and tariff design has begun to gain traction in select jurisdictions. In some cases, lessons learned from non-wires alternatives procurement can be instructive for how to best implement tariff design and program design use cases as well. However, each of these additional use cases also introduces unique advantages and challenges as described in Table 1.

The value proposition for developing new planning capabilities continues to evolve as new use cases emerge to meet customers' changing priorities and needs. Tools, methods, and approaches must evolve to meet these needs in order for utilities to continue to deliver value for their customers. Utilities will also have to manage an expanded set of interdependencies that emerge both internally and externally. Within IDP, there will be increasing interplay between forecasting, hosting capacity, locational value, interconnection and other facets within IDP. But there will also be growing interrelationships between IDP and other functions outside the utility distribution planning organization, including distribution operations, resource planning and transmission planning. Through effective management of these seams and connections, and continued evolution toward a more integrated planning approach, utilities can leverage IDP to deliver value for their customers.

Table of Contents

EXECUTIVE SUMMARY	2
1. INTRODUCTION	7
1.1. Background	7
1.2. Report Overview	9
1.3. Key Findings	9
2. HOSTING CAPACITY	11
2.1 Hosting Capacity as a Development Guide	12
Overview	12
Current State of the Industry	12
2.2 Hosting Capacity as an Interconnection Technical Screen	17
Overview	17
Current State of the Industry	19
Challenges and Considerations	20
2.3 Hosting Capacity to support Long-Term Planning	22
Overview	22
Current State of the Industry	22
3. LOCATIONAL VALUE ASSESSMENT	25
3.1 Locational Value Assessment for Non-Wires Alternatives Procurement	27
Overview	27
Current State of the Industry	28
Challenges and Considerations	29
3.2 Locational Value Assessment for Tariff Design	30
Overview	30
Current State of the Industry	31
Challenges and Considerations	32
3.3 Locational Value Assessment for Program Design	33
Overview	33
Current State of the Industry	33
Challenges and Considerations	34
4. EMERGING USE CASES	35
5. SUMMARY	36
REFERENCES	38

1. INTRODUCTION

1.1. Background

The role of distribution planning is extending beyond the traditional aims of designing and building safe, reliable, resilient, and efficient systems to meet challenges associated with new resources and changing customer expectations.⁶ Public policy goals and initiatives aimed at catalyzing the adoption of advanced distribution planning are also driving changes to the ways in which distribution planning is done.⁷ As the adoption of distributed energy resources (DER) continues to accelerate, utility planners can use existing and new capabilities to inform and facilitate resource integration and valuation. The term Integrated Distribution Planning (IDP) refers to the collective set of these capabilities. One of IDP's central functions is supporting utility planning to maintain safe, reliable and affordable service while accommodating the anticipated physical and operational changes to the electric grid. In this way, IDP enables utilities to maintain system resilience and security with growing penetrations of DER. Adoption of IDP capabilities can imply an evolution of the utility distribution planning function beyond the traditional planning aims of evaluating load growth and system reliability needs. IDP also enables planners to facilitate cost-effective DER integration and resource valuation in concert with traditional functions.

Enhanced planning capabilities can support multiple objectives related to grid operations, market services, and public policies. Therefore, IDP not only represents an expanded role for utility planning but also expanded impact of the planning function both within the utility and to external parties. Many utilities are pursuing elements of IDP to realize both internal and external values. This report explores the value proposition for IDP in the context of discrete use cases that provide insight into the ways in which IDP supports system and customer objectives. This report provides the summary of targeted interviews with 12 electric utility companies across the country as well as leading industry research organizations to provide a summary of current industry practices and emerging use cases related to IDP.⁸

⁶ As technology, such as solar energy systems and energy storage devices, becomes more available, customers of electric utilities are participating to a greater extent in the generation and management of electricity. Such technology adoption is growing rapidly among residential and commercial customers, especially where policies are favorable; industrial customers have traditionally been early adopters.

⁷ Cook, A., Homer, J. (PNNL), Schwartz, L., (LBNL). *Distribution System Planning – State Examples by Topic*. May 2018.

⁸ The research conducted as part of this study included interviews with individuals representing the Association of Edison Illuminating Companies (AEIC) DER Subcommittee, Arizona Public Service, Consolidated Edison Company of New York (Con Edison), Electric Power Research Institute (EPRI), Hawaii Electric Company, National Grid, National Rural Electric Cooperative Association, Pacific Gas and Electric Company (PG&E), Pacific Northwest National Laboratory (PNNL), PPL Electric Utilities, Pepco, Oklahoma Gas & Electric, Southern California Edison, Southern Company, and Xcel Energy

Hosting capacity analysis and locational value assessment have emerged as core elements of current utility activity in IDP; they are central to meeting the objectives of integrating DER and reflecting the value of DER in planning. The extent and pace of developing IDP capabilities depends on the values they offer. This value, in turn, depends on aspects such as regulatory environment, market factors, and system design and conditions.

The use cases described below illustrate the value propositions for hosting capacity analysis and locational value assessment, and provide a useful lens through which to view the current state of IDP more broadly. Utilities across the industry, despite their unique contexts, are pursuing common approaches for the use cases that frame the value propositions for hosting capacity analysis and locational value assessment.

Hosting capacity is the amount of DER that can be accommodated without adversely impacting critical factors such as voltage, power quality, and reliability under existing control and protection systems and without requiring infrastructure upgrades.⁹ A typical hosting capacity analysis utilizes data from distribution system models and can evaluate a wide range of criteria, including those related to local system voltage, thermal ratings, and protection considerations. The analysis may identify the hosting capacity of the total amount of DER that can be accommodated at a location, or the remaining hosting capacity net of existing assets on the system. The geospatial granularity of the results can be tailored to address considerations related to data security, data availability or the underlying uncertainties and the relative precision of the analysis. A large number of utilities have invested in developing hosting capacity analysis capabilities for a variety of reasons. This report will focus on three prominent use cases:

- (1) Accelerating DER deployment through the provision of hosting capacity information via external-facing tools and information
- (2) Enhancing the interconnection application process through improved technical screens
- (3) Improving proactive identification and mitigation of projected hosting capacity constraints

Locational value assessment is intended to quantify the benefits and costs of DER, which are often locational in nature. Locations may be associated with a distribution substation, an individual distribution feeder, a line section, or a combination of these components. Estimates of future grid infrastructure investment needs inform the value that DER can provide, such as load relief and reliability. Locational value assessment is emerging as a capability to support aspects such as non-wires alternatives procurement, retail price mechanisms, and utility programs like targeted demand response and energy efficiency measures. This report will focus on use cases for locational value assessment that enable utilities to:

- (1) Reflect DER's long-term impact on the system, either individually or in aggregate
- (2) Inform tariff designs to signal value
- (3) Improve the value and cost effectiveness of programs through improved localized and system-wide targeting

⁹ U.S. DOE, Office of Electricity Delivery & Energy Reliability, Modern Distribution Grid, Volume I: Customer and State Policy Driven Functionality, March 27, 2017.

1.2. Report Overview

This report provides a reference of emerging industry practices regarding hosting capacity analysis and locational value assessment. It is organized by use case and focuses on current practices, challenges, and intended outcomes, rather than specific tools and more specific methodological considerations.

A use case orientation places the emphasis on the value proposition for the analysis with the aim of informing how specific methodology, data, and tools can enable specific outcomes. Additionally, readers considering whether and how to invest in hosting capacity analysis or locational value assessment will benefit from examining the current state of the industry to identify suitable applications and important caveats.

For each application of the hosting capacity analysis and location value assessment capabilities, the report describes the use case, shares the current state of the industry, and discusses findings around important caveats and constraints.

1.3. Key Findings

In some areas of the country, forces like rapid customer adoption, technology cost declines, and policy objectives are causing the pace of DER deployment to accelerate rapidly. An increasing number of utilities are swiftly moving to extend their distribution planning processes to accommodate current or expected DER adoption levels. Understanding how utilities are leveraging hosting capacity analysis and locational value assessment within their IDP processes offers insights into the ways these capabilities can deliver value to customers. The research effort undertaken to produce this report included a review of relevant utility filings and regulatory dockets in AZ, CA, CO, CT, HI, MA, MD, MI, MN, NY, NV, OR, RI, and UT. This effort also included interviews with industry and research organizations including the Electric Power Research Institute, Pacific Northwest National Laboratory, and members of the Association of Edison Illuminating Companies DER Subcommittee as well as 12 electric utility companies across the United States including Arizona Public Service, the National Rural Electric Cooperative Association, PPL Electric Utilities, Oklahoma Gas & Electric, Southern Company, and Xcel Energy. This research provides several key insights about utility practices in IDP:

- In many of the hosting capacity and locational value assessment applications, utilities are pursuing a deliberately phased approach. Setting sights on the desired outcomes and placing interim goals enables utilities to deliver incrementally expanded capabilities as tools and data availability evolve. This also allows for logical adjustments along the way.
- There is widely recognized value in implementing hosting capacity analyses before DER penetration begins stressing any electric distribution or transmission systems. This enables utilities to start updating data and circuit models to support hosting capacity analysis and avoid unexpected issues as DER penetrations continue to increase.
- It is important to neither understate nor overstate the value of tools like hosting capacity analysis and locational value assessment. This requires a clear understanding of the assumptions, uncertainties, and approximations underlying each approach. Establishing a common understanding of the capabilities and limitations of existing methods can

foster productive dialog on the uses cases that deliver the most value to utilities and their customers.

- The ability to implement a specific use case for IDP and the value proposition for doing so might rely on factors that are external to utilities. For example, use cases like the development guide application for hosting capacity might be aimed at providing value to stakeholders rather than to the utility itself. Also, the use of hosting capacity analysis as a distribution planning tool could require cost recovery mechanisms as a prerequisite to more proactive integration of DER.
- Some IDP use cases have dependencies to the development of key enabling capabilities. For example, granular, bottom up forecasting of load and DER is an input that enables robust analysis of locational value as well as the use of hosting capacity analysis as a distribution system planning tool. Similarly, the use of hosting capacity as a technical interconnection screen should be done in coordination with efforts to improve the DER interconnection process as a whole.
- The lessons learned from IDP implementation can be leveraged across use cases. For example, the application of locational value in the context of non-wires alternatives faces many challenges including value quantification, addressing disparities between DER operational characteristics and utility planning criteria, utility-aggregator operational coordination, monitoring and control implications and technology performance risk. The application of locational value for the implementation of targeted utility programs face many of the same issues, and the solutions identified in each arena can inform one another by identifying commonalities and applicable solutions.
- The ways in which locational value is quantified continues to evolve. Many efforts to quantify the locational value of DER rely on the quantification of discrete value components. However, some integrated approaches seek to incorporate all resources, including market-based DER sourcing mechanisms, into the planning process. This enables approaches to non-wires alternatives that facilitate their evaluation alongside traditional solutions rather than strictly as a means to defer traditional investments.
- The use cases for IDP are continuing to evolve and the ways in which these capabilities can support utility and stakeholder objectives can extend beyond the context of distribution system planning. In particular, operational applications such as flexible interconnection and dynamic dispatch feasibility analysis demonstrate the increasing interplay between planning and operations and exemplify how the use cases for hosting capacity and locational value assessment continue to expand and evolve (see section 4 on “Emerging Use Cases” below).

2.HOSTING CAPACITY

Hosting capacity analysis can be applied across a wide range of use cases, but current utility activity is focused on three central applications. Hosting capacity analysis can help enable market-driven DER development by providing information to DER providers on locations where the cost to develop new projects may be lower. It can also advance the interconnection technical screening process by replacing existing rules of thumb with improved information that can provide a better basis for determining the need for more detailed analysis. Finally, working in concert with long-term planning tools, hosting capacity can offer visibility into how much DER the system can host in future years. Table 2 summarizes these use cases for hosting capacity analysis.

Table 2. Hosting Capacity Use Cases At-a-Glance

	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

The choices of methodology and modeling tools for hosting capacity analysis depend on the desired use case or combination of use cases. Important considerations include choosing appropriately robust analytical methods, identifying applicable boundary conditions, defining geographic scope, and determining a refresh frequency that facilitates reflection of circuit changes and incorporation of new analytical methods. It is worth noting that hosting capacity analysis methods and tools continue to evolve and expand to model more types of DER, reflect a wider range of system topologies, and analyze a greater set of criteria (e.g. related to system resilience or reliability) and conditions with greater degrees of accuracy. This further reinforces the benefit of viewing current utility practices in the context of use cases, which focus on the value proposition for building these capabilities, rather than on the quickly evolving landscape of industry methodologies and tools.

2.1 Hosting Capacity as a Development Guide

Overview

DER developers can face considerable uncertainty around the costs of interconnecting DER. System upgrades required to maintain the power quality and reliability of the distribution system can vary by location and result in significant costs for developers and have the potential to materially impact project economics. Further, in the absence of additional information on system constraints, developers sometimes submit multiple applications to find a suitable site location for larger projects; this could add to interconnection queue backlogs and make inefficient use of developer and utility resources.

The analysis of hosting capacity across the utility service territory can identify where violations due to thermal, voltage, protection, or operational limitations issues could arise as well as the increment of DER at each circuit node or line segment that may trigger a constraint. Utilities have used hosting capacity analysis to produce interactive geospatial mapping portals that display the hosting capacity across the system. Approaches for implementing hosting capacity maps range from static maps of constrained areas to highly dynamic, interactive mapping portals that provide additional system data at each location. These tools can help developers identify where system upgrades might be required to interconnect additional DER and where interconnection costs could be higher. Thus, developers can focus their activities on projects on the most promising sites and allocate marketing and development investments more efficiently.

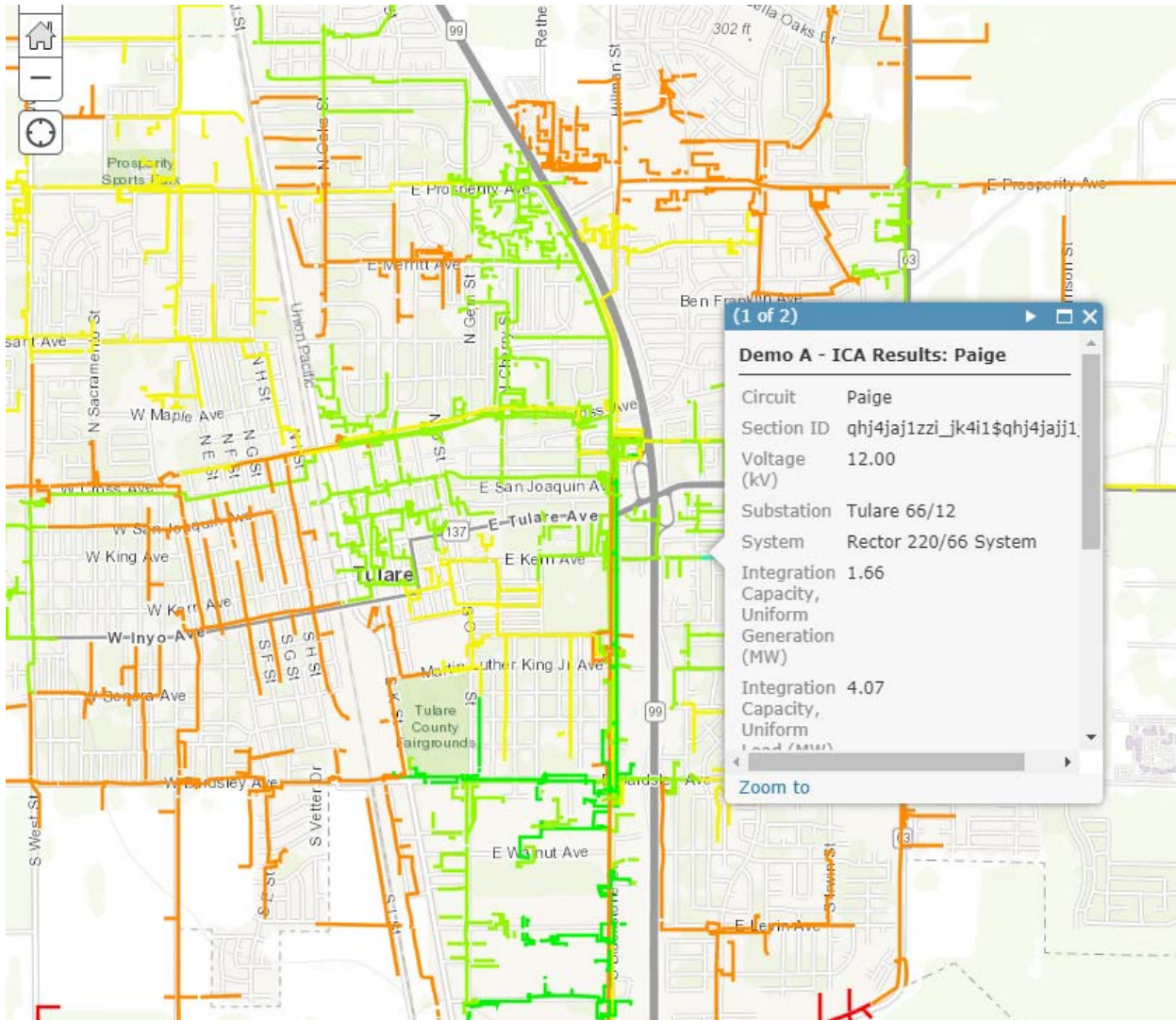
These mapping portals can provide information about where system upgrades might be needed when evaluating DER impacts under normal conditions. Hosting capacity in this context allows the utility to evaluate the entire service territory and to update the analysis regularly. This provides a snapshot of the full system rather than requiring developers to solicit information from the utility on an incremental, site-by-site basis. These hosting capacity maps are not meant to be predictive with respect to the outcome of a detailed interconnection study for a particular site, but rather to provide an early indicator to developers about the relative costs (in terms of time, dollars, special equipment, settings) of various sites across the utility service territory to inform the early stages of project development. These analyses typically rely on historical load data and reflect specific system conditions. This, along with other sources of uncertainty in the analysis, should be transparently conveyed to facilitate an accurate interpretation of the results by developers and other users.

Current State of the Industry

Some utilities are currently employing hosting capacity to support DER developers. The investor owned utilities (IOUs) in California published their first Integration Capacity Analysis (ICA) maps in 2015 to provide an indication of hosting capacity across their systems. Since then, California's DRP decision has issued a ruling that requires utilities to perform and publish ICA values for each circuit based on the iterative methodology by mid-2018. Additionally, several other utilities have published similar maps of their service territories. These maps indicate how much DER can be added at each location without significant upgrades. Figure 3 shows a snapshot of Southern California Edison's (SCE) ICA map, in which portions of the service territory are color coded according to the hosting capacity analysis value. It is also an example of the system data utilities might provide to supplement the hosting capacity analysis; this data

can be an additional input to developers deciding where to pursue new DER development projects.

Figure 3. SCE Integration Capacity Analysis Map, January 2018



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Many hosting capacity maps¹⁰ provide this kind of data, but the specific choice of data fields varies from map to map. As shown in Figure 3, the information provided in hosting capacity portals may include circuit identification, circuit voltage, and existing installed DER capacity (MW). The choice of values provided can reflect aspects such as distribution system design, data already made available through other venues, and developer use cases for system data. Future analysis may also include limitations that are driven by substation or transmission constraints, which may also influence available hosting capacity.

Some utilities' experiences have shown that development of hosting capacity portals can be stage-gated in a way to provide basic functionality quickly and then allow for continual development of the tool through subsequent updates and enhancements. This may be especially helpful if there is a short deadline to provide an initial version of the portal. In that case, an initial stage might provide indicators that contribute to hosting capacity based on available data but do not represent a complete hosting capacity evaluation. Another option is providing tabular results before a map is available.¹¹ It can also provide data extrapolated from an analysis of representative circuits¹² or it can provide hosting capacity for a subset of circuits (e.g. above a given voltage class).¹³

As hosting capacity portals develop, they can evolve to include interactive maps based on analyses of all relevant circuits on the system with further enhancements to increase the value these maps provide to developers. These improvements can include additional system data elements, higher geospatial granularity, expanded analysis reflecting a broader set of criteria, analysis of additional DER technologies and sizes, evaluation of additional constraints further upstream on the system, analysis of the impact of existing DER, or analysis of circuit reconfiguration. Specific developer use cases for these enhancements and the availability of data and tools to facilitate their implementation can help inform the prioritization of specific items in the development of a hosting capacity roadmap.

Joint Utilities of New York (JU) offer an example of this type of roadmap. Under the Reforming the Energy Vision Proceeding (REV), utilities outlined four stages in the development of a hosting capacity data portal, with each stage increasing in computational complexity, data requirements, and effectiveness. Initial indicator maps, developed before full hosting capacity analyses were available, inform developers of locations where DER interconnection costs are likely to be high and where DER are easily accommodated.¹⁴ Similarly, in California the IOUs

¹⁰ Additional examples of hosting capacity maps include Pepco:

<https://www.pepco.com/MyAccount/MyService/Pages/MD/HostingCapacityMap.aspx>, The Joint Utilities of New York (five utilities): <http://jointutilitiesofny.org/utility-specific-pages/hosting-capacity/>, and PG&E

https://www.pge.com/en_US/for-our-business-partners/energy-supply/solar-photovoltaic-and-renewable-auction-mechanism-program-map/solar-photovoltaic-and-renewable-auction-mechanism-program-map.page.

¹¹ Xcel Energy, Public Service Company of Colorado, Distribution System Study, Colorado PUC Docket No. E999/M-15-962, December 1, 2016.

¹² Southern California Edison, Distribution Resources Plan, Proceeding R1408013, July, 1 2015.

¹³ New York Department of Public Service Commission, Order on Distributed System Implementation Plans, CASE 14-M-0101, March 9, 2017.

¹⁴ Joint Utilities of New York, Supplemental Distributed System Implementation Plan, Nov. 1, 2016.

produced maps¹⁵ that were replaced by the hosting capacity analysis provided on the ICA maps as part of the July 2015 Distribution Resources Plan filings.

Subsequent phases of the New York hosting capacity roadmap articulated in the JU's Supplemental Distributed System Implementation Plan indicate a progression from the publication of indicator maps, to feeder-level solar photovoltaic (PV) hosting capacity analysis, to sub-feeder analysis of a broader set of DER technologies, and eventually to fully integrated value assessments. This type of a phased approach facilitates the release of the initial iteration of the tool while engaging stakeholders to provide input on later stages of development.¹⁶

Key considerations for utilities developing these analytic capabilities and contemplating the potential to publish these maps externally are the security implications of making certain system data, such as the location of sensitive loads and system assets, readily available to the public. For example, sufficiently detailed information on substation, feeder, and infrastructure data for airports, hospitals, and other critical infrastructure, if used improperly, could put those facilities at risk.

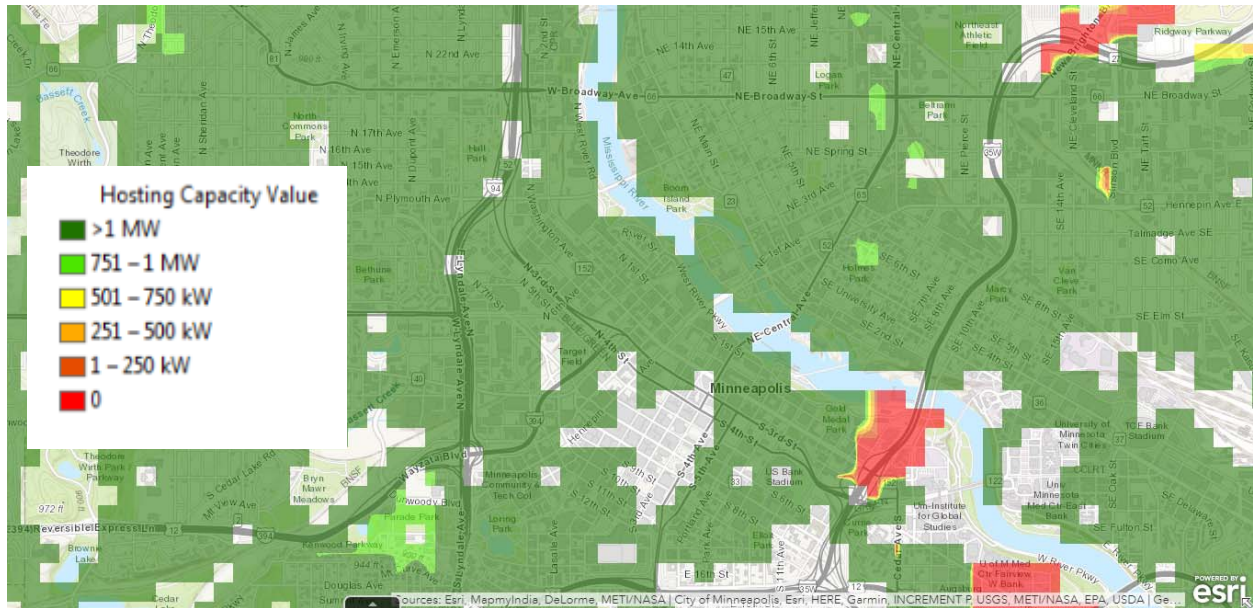
Utilities have begun to address these concerns in a few ways. Some share hosting capacity on request and at a specific location only, as opposed to providing maps containing information for the entire service territory. Some have determined that they can effectively communicate with developers about potential constraints by establishing mechanisms to quickly deliver data requests for a specific area relevant to a discrete application, rather than providing comprehensive data for their full territory. Other utilities, such as Xcel Energy, have made their hosting capacity analysis available via an online portal, but display the data in a way that does not reveal discrete circuits and provides less system information (see Figure 4). Hosting capacity analysis requirements in Minnesota continue to evolve as regulators pursue new distribution planning initiatives in the state.¹⁷

¹⁵ Pursuant to CPUC decision D.10-12-048, the CA IOUs produced maps to help DER developers identify interconnection sites. See: http://www.cpuc.ca.gov/Renewable_Auction_Mechanism/.

¹⁶ Joint Utilities of New York, Stakeholder Engagement Session: Hosting Capacity, November 2, 2017. Links to JU hosting capacity portals can be found at <http://jointutilitiesofny.org/utility-specific-pages/hosting-capacity/>.

¹⁷ Minnesota Public Utilities Commission, Correction to Attachment of June 8, 2018 Notice of Comment in E002/CI-18-251 Draft – Minnesota Integrated Distribution Planning Requirements for Xcel Energy, Minnesota PUC Docket No. E002/CI-18-251, June 8, 2018.

Figure 4. Xcel Energy Hosting Capacity Map, 2017



Each utility will determine the best approach for their system based on the value proposition of the relevant use case and the security risks associated with making various aspects of the system visible on public portals. This report provides a snapshot of some of the approaches currently implemented across the industry. As security concerns evolve and utility customer data portals mature, additional approaches to the presentation of system data will likely emerge.

Finally, while the up-front computational effort needed to build an initial model and map can be substantial, the effort required to maintain data and models on an on-going basis is a potentially even more important long-term consideration. The availability, accessibility, and accuracy of data as well as the ability to automate portions of the analysis and portal update will also impact the level of effort needed to maintain such a tool. While utilities may contract outside vendors for initial capability development or pilot analyses, those seeking to maintain a current hosting capacity analysis for their systems typically develop resources internally using commercially available modeling tools.

In order to adequately provide developers information relevant to their development efforts, the analysis should be updated regularly to reflect major changes to the system. Furthermore, system upgrades, interconnection of large DER, additions or departures of major loads, utility storm restoration efforts, and other changes could materially impact hosting capacity analysis results. The refresh rate will depend in part on the level of automation available to update input data and circuit models and on the resources available to support the ongoing maintenance of these portals.

For utilities interested in a pilot analysis of a portion of their system or a single snapshot that is not intended to be updated, this analysis can often be outsourced to an external vendor.

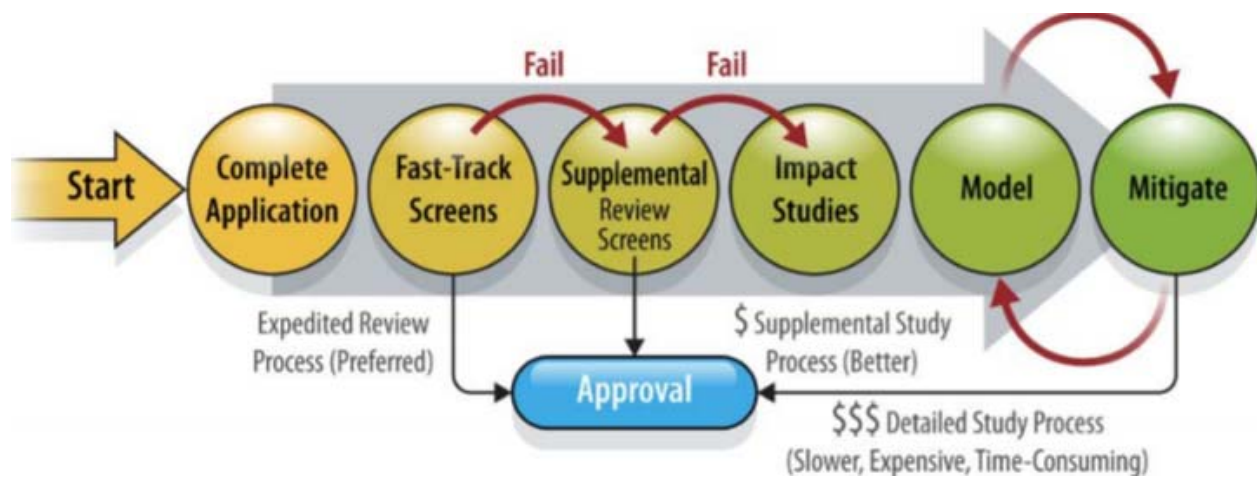
However, utilities seeking to carry out regular updates of their hosting capacity analysis often seek to build these capabilities internally as part of their planning and DER integration functions.

2.2 Hosting Capacity as an Interconnection Technical Screen

Overview

As the rate of DER deployment around the country rapidly grows, the expanding volume of interconnection applications makes it increasingly important for utilities to carry out interconnection processes efficiently and effectively. The utility interconnection process is intended to maintain grid safety and reliability and determines whether and how a DER can connect to the distribution system. As shown in Figure 5, an interconnection application passes through several stages of evaluation before receiving approval. For distributed generation and other DER, the process often includes a set of technical screens that evaluate whether the application can receive fast-track status. This enables an application to bypass some or all the additional supplementary technical screens or detailed study process.

Figure 5. Interconnection Screening Process¹⁸



Interconnection requests for some DER systems can be resolved quickly if they pass the relevant technical screens, whereas other interconnection applications, typically larger or more complex projects but also smaller projects on highly saturated feeders, require detailed system impact studies and may take days or weeks for approval. As DER growth increases, utilities need to juggle higher volumes of interconnection applications with complex analyses that ensure that reliability and safety of the grid is maintained.

¹⁸ National Renewable Energy Laboratory (NREL), Emerging Issues and Challenges in Integrating Solar with the Distribution System, NREL/TP-5D00-65331, SAND2016-2524 R, May 2016.

Interconnection technical screens can fall into several categories,¹⁹ and only a subset of these will be relevant for hosting capacity. Some reflect characteristics of the project, such as whether it makes use of certified equipment. Others reflect aspects of the system, such as whether the point of common coupling is on a networked secondary system.²⁰ Finally, some technical screens look at the presence of other DER on the relevant part of the system and their impact on the need for detailed study of the current application. Hosting capacity can reflect aspects of the system and can potentially reflect the impact of existing DER, but because the analysis is not repeated for each application, it may only include existing and known DER applications at a given time, or not include them at all. Thus, it will not reflect the characteristics of individual projects submitting interconnection requests.

In addition, while hosting capacity evaluates the amount of a specific type of DER that will, under specific conditions, trigger violations to criteria such as voltage, thermal, and protection, it does not address the full range of issues raised by a detailed interconnection study. For example, a hosting capacity analysis does not typically identify constraints based on multiple distribution-alternative configurations that can occur from field switching and load balancing. In some cases, the results can help identify when a more detailed protection study should be done, but it cannot provide the same level of information that a detailed protection study can provide.

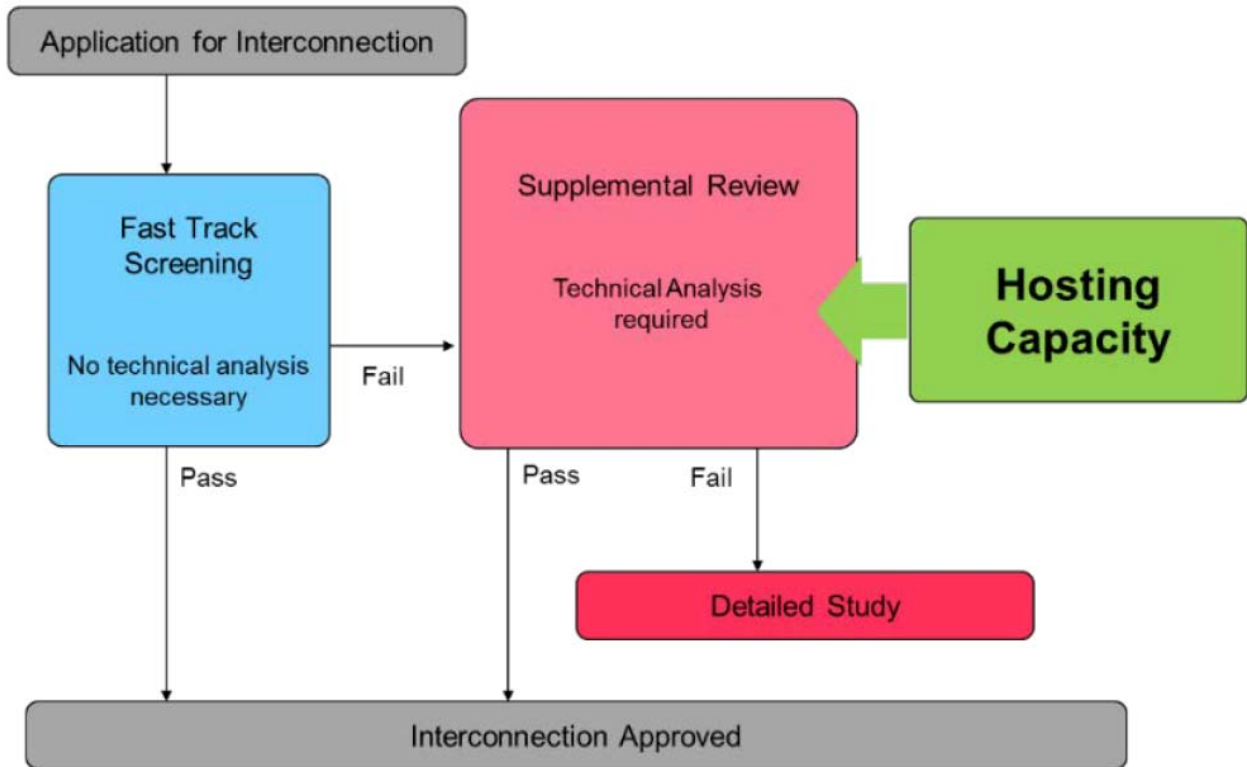
However, hosting capacity appears to be well positioned to inform specific technical screens and supplement the technical analysis of an interconnection application as shown in Figure 6. For example, one example of the technical screens described above evaluates the aggregate capacity of DER on the line section relative to the peak load or the minimum daytime load. These types of screens are designed to evaluate the risk of backfeed and unintentional islanding.²¹ These kinds of penetration tests typically rely on canonical rules of thumb based on industry standards and practices. For instance, a “15% penetration screen” is a test condition wherein aggregate generation shall not exceed 15% of a line section’s peak load. However, the hosting capacity analysis results can provide a more robust evaluation of the risk for reverse flow. Furthermore, if the analysis considers constraints upstream of the feeder to look at reverse flow at the substation, this could potentially better identify conditions that would merit a detailed interconnection study for a given application.

¹⁹ FERC, Small Generator Interconnection Agreements and Procedures, November 22, 2013.

²⁰ The secondary system is the low voltage (120/240 volts) portion of the distribution system that is closest to typical residential and commercial customers.

²¹ “Backfeed” refers to the electrical energy flowing in the reverse of the direction it is intended to flow. “Islanding” is a condition in which a distributed resource provides power to a circuit after it is disconnected from the electrical grid, such as in the event of a power outage.

Figure 6. Use of hosting capacity to inform interconnection technical screens²²



For many DER applications, the hosting capacity analysis and maps are a sufficient and efficient proxy for the technical screens employed by each individual utility.

Current State of the Industry

The use of hosting capacity analyses in the context of evaluating distributed generation interconnection applications is an active area of discussion, but implementation of these approaches is still limited. Currently, many utilities use a distributed generation interconnection process based in part on the Federal Energy Regulatory Commission Small Generator Interconnection Procedure screening process which relies on a 15% penetration screen as described above.²³ A variation of this approach used in the context of distributed solar PV interconnection application studies involves evaluating PV capacity as a fraction of minimum daytime load. This approach more directly addresses conditions that could result in the need for a detailed study to evaluate system upgrade needs. Also, some utilities have evaluated the

²² Electric Power Research Institute, Impact Factors, Methods, and Considerations for Calculating and Applying Hosting Capacity, 3002011009, Feb 2018.

²³ Federal Energy Regulatory Commission Order 2006, Section 2.2.1.2, Docket No. RM02-12-000, May 12, 2005.

possibility of increasing the percentage applied in the penetration test to 100% or more of the minimum daytime load.²⁴

Where DER penetration is high, such as in parts of California and Hawaii, the use of hosting capacity to inform DER interconnection technical screens has gained some traction. Hawaiian Electric Company has implemented this approach and reports that use of hosting capacity for interconnection screening has substantially increased the amount of rooftop systems that they could fast track relative to a screen of 250% of daily minimum load.²⁵ In California, the Public Utility Commission included interconnection and planning use cases for hosting capacity as part of efforts to streamline DER interconnection.²⁶

Other utilities have started to evaluate how hosting capacity analysis could improve interconnection technical screens. In some cases, this is being done in the context of broader efforts to improve the utility's internal methods for processing interconnection applications rather than as a change to the formal interconnection process itself. Using hosting capacity analysis in this way helps utilities manage large volumes of interconnection applications and allocate resources to evaluate those applications efficiently.

Challenges and Considerations

Evaluating options to incorporate hosting capacity into the interconnection process may benefit from careful consideration of both the value of the hosting capacity analysis results and the limitations of the analysis. Hosting capacity analysis can provide useful information and it can in some cases provide a better basis for determining the need for a detailed study than existing rules of thumb. However, each utility should focus its application to aspects of the process where it has the potential to provide value, given the utility's specific ways of planning and operating its system. For example, the types and sizes of transformers a utility has on its system can impact the design of the interconnection process and the ability to leverage hosting capacity to inform outcomes.²⁷ The application of hosting capacity in the interconnection context can be very case-dependent on these and other aspects of circuit configuration and system design. Therefore, the best application of hosting capacity in the interconnection context will similarly vary from system to system.

²⁴ As noted by a joint study conducted by the National Renewable Energy Laboratory, SolarCity (now Tesla), and the Hawaiian Electric Companies. Study results available at: <https://www.nrel.gov/esif/partnerships-solarcity-hawaiian-electric.html>. The study expresses the upper limit on solar power based on a transient overvoltage limit on a circuit to be equivalent to 250% of the circuit's minimum daytime load; 100% of a circuit's minimum daytime load has been commonly found to be equal to 15% of a circuit's peak load. For more information, see Rylander et al., *Alternatives to the 15% Rule*, 2015, 35, 40.

²⁵ Hosting capacity analysis increased rooftop solar headroom on Hawaiian Electric's system by 318 MW relative to their use of a 250% daily minimum daytime load screen. See: Marc Asano, *Integrated Grid Planning Symposium: Distribution Planning & Hosting Capacity*, Nov 15, 2017.

²⁶ The CPUC Order Instituting Rulemaking to Consider Streamlining Interconnection of Distributed Energy Resources and Improvements to Rule 21 (Rulemaking 17-07-007, July 2017) includes efforts to incorporate hosting capacity analysis into Rule 21.

²⁷ Under high DER penetration conditions, delta-wye transformers can become sources of fault current that can be difficult to detect and isolate. In these cases, additional protection studies could be required to safely interconnect new DER where these transformers are in place.

Validation of hosting capacity with actual grid data can help inform where the analysis can meaningfully improve the interconnection screening process. This can include an evaluation of various approaches and methodologies. There are three broad categories of methodologies for hosting capacity analysis: iterative, stochastic and streamlined. Within each category there is significant variation among methodologies, and all the approaches and methods are evolving quickly. In fact, some emerging hybrid approaches blend attributes of more than one category.²⁸ This complexity makes it difficult to design the use case of hosting capacity for an interconnection technical screen around a discrete methodology.

Rather than prescribing a specific method for hosting capacity analysis, some utilities have instead chosen to focus on use cases and outputs. Developing a performance-based approach that is not tied to a specific method, in concert with data from supervisory control and data acquisition (SCADA) and field sensors to calibrate models, will allow the use case to evolve as tools continue to evolve. A focus on the performance of the analysis and its validation against the results of a detailed study can inform ways in which hosting capacity analysis could improve aspects of the interconnection process and provides a context for the evaluation of new methodologies.

The value that hosting capacity analysis can provide to the interconnection process is also a function of the details of the circuit models themselves. The preparation of circuit models and data inputs to do hosting capacity analysis can require a substantial investment in utility resources. Not all utilities maintain models for all the circuits on their system; even those that do, either to do hosting capacity analysis or for other reasons, typically only explicitly model the higher voltage primary distribution system. Utilities often represent the lower voltage secondary system as equivalent loads because the data and resources needed to create and maintain an accurate detailed model of all the secondary circuits can be significant. Hawaiian Electric has found that representing DER on the secondary distribution system as an aggregated DER inverter-based resource is a suitable method of capturing the impact of all DER on the primary distribution circuit. These modeling considerations imply that issues on the secondary system stemming from high penetrations of small DER like rooftop solar PV are typically not reflected in a hosting capacity analysis unless DER on the secondary system is included in the hosting capacity modeling. Issues like secondary voltage rise can be significant for utilities seeing increasing penetration rates of smaller-scale DER. Some utilities are evaluating additional analyses of the system to capture these types of issues, which may help them better identify applications that can receive fast-track status. Small residential DER systems are typically not problematic for most utilities, but even moderately sized DER systems must be reviewed by utility engineers to insure the secondary wiring is not a limiting factor.

The electric utility industry is starting to look at how hosting capacity can inform the interconnection process. A few utilities have begun to implement these approaches and have reported positive results. However, identifying the appropriate application of hosting capacity analysis requires a consideration of specific characteristics of the system on which it is being

²⁸ A comparative analysis of hosting capacity methods by EPRI compares these approaches and the results obtained by each. This provides a helpful distinction between the iterative method that requires an analysis of DER Hosting Capacity at each location and DER deployment size versus hybrid and streamlined methods that offer reduced computational complexity. See: Electric Power Research Institute. "Impact Factors, Methods, and Considerations for Calculating and Applying Hosting Capacity" 3002011009, Feb 2018.

applied. Providing a means to validate the results from hosting capacity analysis can help inform its best applications in the interconnection context and allow those applications to evolve as tools and methods continue to develop. Nevertheless, it is important to understand the limitations of circuit models and hosting capacity's ability to capture all the relevant constraints on the system impacting DER interconnection, so that hosting capacity can be appropriately evaluated as one tool among many needed to safely and reliably integrate DER. In addition, as electric utilities develop and apply practices to enhance system resilience, they could potentially include new criteria to evaluate interconnection applications.²⁹

2.3 Hosting Capacity to support Long-Term Planning

Overview

In the two use cases described above, system hosting limits are evaluated in the context of current system conditions. However, by evaluating hosting capacity under projected loads, utilities can track how hosting capacity might vary over planning time horizons. Through the development of new planning tools, utilities can develop projections of how the consumption and production of distributed energy will evolve over time due to changes in load, policies, and DER adoption. This analysis produces projected circuit load curves that can inform how hosting capacity limits for either DER adoption or changing loads, such as electric vehicles (EV) or customer use of energy storage, could change under the current configuration of the system. The application of these methods to the analysis of hosting capacity for loads is especially important in light of the deployment of electric vehicles and battery storage that can materially impact the behavior of customer loads and their impact on system needs. For example, a particular substation that provides service to other critical infrastructure, might have a higher resilience level requirement than others, tailoring the evaluation criteria for hosting capacity by type of DER. This kind of forecasted hosting capacity could enable utilities to proactively assess the need for system upgrades to increase hosting capacity based on anticipated DER growth.

Some utilities with hosting capacity capabilities in place are looking at how to leverage those tools to understand how hosting capacity estimates evolve over time. Some utilities have started to evaluate the potential of planned projects on hosting capacity. To date, these efforts have focused on existing infrastructure projects that are intended primarily to serve other system needs. However, utilities could pursue projects designed to proactively increase hosting capacity if cost recovery mechanisms existed to enable such investments.

Current State of the Industry

The application of forecasted hosting capacity analysis as a key element in long-term distribution planning decisions is still relatively nascent. In areas that have been experiencing strong DER adoption, utilities recognize they must identify hosting capacity upgrades that are needed to enable customer DER adoption. This is an important consideration in states with high DER adoption and strong DER policy support.

²⁹ Sandia National Laboratories, Energy Infrastructure Resilience: Framework and Sector-Specific Metrics presentation, April 2014.

To-date, this type of hosting capacity analysis is often integrated with more traditional distribution planning analysis. Traditional distribution planning identifies system needs based on, for example, aging infrastructure and changing customer demand. However, understanding the current or expected hosting capacity constraints on each circuit can augment this assessment to determine priority order for upgrades. For instance, Southern California Edison cites hosting capacity as a factor that complemented the business case to upgrade 4 kV distribution lines to 15 kV class distribution.³⁰ In this way, the hosting capacity analysis can also enable optimized investments.

The planning use case is in the earliest stage of implementation of the three use cases presented here. These approaches are being pursued or contemplated primarily where DER adoption is relatively high and where system conditions make DER integration particularly challenging.

Leveraging hosting capacity analysis to advance distribution system planning analytics requires the development of detailed forecasts for how the net load of a circuit, load profiles, and location of DER will change over time. This in turn requires the development of a very granular view of how customer behavior, load growth, DER deployment, and DER export will evolve over time. These in turn depend on factors such as macroeconomic trends, the arrival or departure of individual loads, retail tariffs, policy changes, geographic diversity among variable DER, dispatch decisions related to controllable DER, and technology costs trends.

These detailed, granular forecasts require planners to use assumptions, some of which carry significant uncertainty. This suggests that reliance on a single, deterministic forecast in this context is insufficient to capture the bounds of possible outcomes. Furthermore, even if the future net load on the system were known with great certainty, the analysis does not typically reflect how distribution system conditions could change under reconfigured arrangements. In addition, these only reflect the challenges associated with analyzing forecasted hosting capacity as a function of changing loads. However, the distribution system itself is not static. Understanding how hosting capacity constraints evolve over time could also involve the incorporation of planned upgrades to the circuit models. The complexity of modeling projected topologies and the relative uncertainty of discrete projects makes these approaches challenging.

Finally, in addition to these technical considerations, there are also challenges associated with incorporating these approaches into distribution system planning. Traditionally, the objective of distribution system planning has been to design and build a distribution system that safely, reliably, and efficiently delivers electricity to customers. Part of the challenge of implementing integrated distribution planning is incorporating new objectives into the planning process. For utilities whose approach to integrated distribution planning includes identifying system upgrades to proactively facilitate DER integration, this requires changes to the planning paradigm and to cost recovery mechanisms in order to recognize hosting capacity as an element of the planning process.

³⁰ Southern California Edison. T&D- System Planning SCE-02. Available at: [http://www3.sce.com/sscc/law/dis/dbattach5e.nsf/0/64C26E22579296A68825802100663852/\\$FILE/SCE02V03.pdf](http://www3.sce.com/sscc/law/dis/dbattach5e.nsf/0/64C26E22579296A68825802100663852/$FILE/SCE02V03.pdf)

In summary, the challenge of implementing a planning use case for hosting capacity stems from the technical challenges of the analysis, the need to appropriately reflect the uncertainties in the outputs, the changes associated with identifying hosting capacity as either a primary or ancillary planning objective, and the attendant policy questions associated with that path.

3. LOCATIONAL VALUE ASSESSMENT

Locational value assessment capabilities provide a framework for the evaluation of grid resources with respect to temporal and geospatial variations. Since grid needs vary by location, time of day, and season, matching DER capabilities to grid needs requires detailed analysis of the performance of the relevant resources and the local system need as a function of time. For example, the ability to evaluate potential approaches for addressing system resilience³¹ requires decision processes that can address DER within the context of system resilience needs in a specific location and over the appropriate timescales of the need.³²

Locational value assessment informs each of the main methods of DER sourcing: procurement, pricing, and programs.³³ For utilities whose goal is to understand the impact of DER on short- and long-term system needs, locational value assessment can identify beneficial locations and offer an effective process to inform procurement of non-wires alternatives. In efforts to enable the provision of DER products and services via price signals, utilities are beginning to examine how to apply locational value in the context of retail rate design based on local distribution requirements. Finally, some utilities are using it to fine-tune programs to improve targeting and to enhance program cost-effectiveness. Table 3 summarizes these use cases, which are representative of current utility industry practices, but the application of locational value assessment approaches can extend to other areas as well.

Table 3. Locational Value Assessment Use Cases At-a-Glance

	Objective	Capability	Challenges
Non-Wires Alternatives Procurement	Enable market-based provision of DER services	Procure non-wires alternatives to defer T&D investment	Quantification of costs and benefits; risk management
Tariff Design	Provide price signals for DER locations	Link locational value analysis to tariff design	Efficient, transparent price mechanisms for benefits or costs
Program Design	Enhance system value of programs	Targeted program customer acquisition and/or incentives	Customer acquisition; risk management; coordination

Options for a more cost effective and robust way to meet system requirements forms the basis to value DER, based on distribution infrastructure upgrades required in a circuit or substation. This is the distribution locational value. California³⁴ and New York³⁵ utilities have developed total

³¹ U.S. Department of Energy, Distributed Generation (DG) for Resilience Planning Guide, Critical Infrastructure (CI) 101, 2018

³² U.S. Department of Energy, Distributed Energy Resources Disaster Matrix, 2018

³³ De Martini, Paul, et al., Missing Links in the Evolving Distribution Markets, December 2016.

³⁴ Pacific Gas and Electric Company, Demonstration Projects A and B Final Reports, December 27, 2016.

³⁵ Consolidated Edison, Distributed System Implementation Plan, June 30, 2016.

value stacks to assess the locational value of DER. These include the distribution locational value in addition to system-wide costs and specific transmission and distribution costs as well as environmental and customer benefits, as shown in Table 4. The inclusion and calculation of value components can vary across jurisdictions based on utility definitions, regulatory compliance mandates, and existing service markets.

Table 4. Locational Value Categories

Value Category	California ³⁶	New York ³⁷
Distribution	Avoided Feeder/Substation Costs	Avoided Distribution Capacity Infrastructure
	-	Avoided Distribution O&M
	Avoided Distribution Voltage/Power Quality Costs	-
	Avoided Reliability Costs	Net Avoided Outage Costs
	Avoided Resiliency Costs	Net Avoided Restoration Costs
	-	Avoided Distribution Losses
Transmission	Avoided Transmission Capital Expenditures	Avoided Transmission Capacity Infrastructure and O&M
	-	Avoided Transmission Losses
Generation	Avoided System Resource Adequacy (RA) and Local RA	Avoided Generation Capacity (ICAP), with Reserve Margin
	Avoided Flexible RA / Avoided Renewable Integration Costs	-
	Avoided Energy (via LMP)	Avoided Energy (LBMP)
	Avoided Ancillary Services	Avoided Ancillary Services
	RPS Costs	
Environmental / Society	Avoided GHG Costs (via LMP)	Net Avoided GHG (social cost of carbon)
		Net Avoided Criteria Air Pollutants
		Avoided Water Impacts / Avoided Land Impacts
	Avoided Societal Costs / Avoided Public Safety Costs	Non-Energy Benefits

DER benefits and costs can be reflected in various points within the planning process. The value components can each reflect separate analyses and the application of those results can vary across DER sourcing and procurement processes. In some cases, utilities are taking measures to look at all types of resources with an integrated approach that allows for endogenous modeling of traditional and non-traditional solutions in a self-consistent manner. For example, Hawaiian Electric’s Integrated Grid Planning & Solution Sourcing Process considers targeted DER programs, non-wires alternatives that are competitively sourced, grid modernization investment, and traditional grid solution estimates in a common framework that informs both short-term, 5-year planning and long-term planning efforts.³⁸ Rather than stacking values as in California’s Locational Net Benefits Analysis and New York’s Benefit Cost Analysis

³⁶ CPUC, Assigned Commissioner’s Ruling (1) Refining Integration Capacity and Locational Net Benefit Analysis Methodologies and Requirements; and (2) Authorizing Demonstration Projects A and B, May 2, 2016, p. 2.

³⁷ New York Public Service Commission, Order Establishing the Benefit Cost Analysis Framework, Appendix C, January 21, 2016,

³⁸ Hawaiian Electric Companies, Planning Hawai’i’s Grid for Future Generations: Integrated Grid Planning Report, March 1, 2018.

approaches, Hawaiian Electric’s process presents an integrated approach to planning that comprises resource planning, transmission planning, and distribution planning that includes both traditional infrastructure solutions as well as market-based sourcing solutions. The major components of the process are shown schematically in Figure 7.

Figure 7. Hawaiian Electric’s Integrated Grid Planning & Solution Sourcing Process³⁹



3.1 Locational Value Assessment for Non-Wires Alternatives Procurement

Overview

Within their typical planning processes, utilities first identify and define distribution system needs, then identify and assess possible solutions, and finally select a project or set of projects to meet those system needs. A utility long-term capital plan includes transmission and distribution solutions and cost estimates, typically over a 5- to 10-year period, and it is updated cyclically (often 1- to 3-year cycles). Non-wires alternatives are increasingly identified as options to transmission and distribution planners when considering solutions to meet system needs related to load growth, reliability, and resiliency.⁴⁰ These solutions typically consist of large DER or portfolios of resources that can meet the specified need.

The process of sourcing non-wires alternatives may include procurement through a competitive solicitation to assess market-based solutions. These are compared to traditional grid

³⁹ Hawaiian Electric Companies, Planning Hawai‘i’s Grid for Future Generations: Integrated Grid Planning Report, March 1, 2018.

⁴⁰ Grid Modernization Laboratory Consortium (GMLC), State Engagement in Electric Distribution Planning, December 2017: “Non-wires alternatives are non-traditional investments or market operations that may defer, mitigate, or eliminate the need for traditional transmission and distribution investments.”

investments to determine lowest reasonable cost (including relevant implementation and operational risk assessment).

Utilities can use procurement to evaluate and deploy resources that enable them to defer or possibly obviate the need for traditional investments. In several jurisdictions, this is being pursued as an element or extension of ongoing proceedings related to integrated distribution planning.⁴¹ As utilities continue to test and confirm DER operational capabilities, they will be able to more confidently rely on non-wires alternatives to achieve planning requirements.

Current State of the Industry

Across the country, efforts to facilitate procurement of non-wires alternatives are largely at the pilot stage, but examples abound. In mid-2016, the United States had 133 non-wires alternatives projects, totaling 1,960 megawatts (MW) of capacity, implemented or in the pipeline.⁴² Much of this activity focused on addressing bulk system infrastructure needs and transmission investment deferral. However, the development of non-wires alternatives on in the distribution context has expanded significantly.⁴³ Examples of planned and deployed non-wires alternatives projects for distribution system deferral include:

- **Chowchilla, El Nido Substation (Demo Project C) - PG&E:** This project seeks 4 MW of distribution baseload capacity by summer 2019 or 2020, and 1 MW of distribution peak capacity by April 2019 or 2020⁴⁴ to demonstrate DER locational benefits to provide distribution capacity services by mitigating overload.
- **Brooklyn Queens Demand Management project – Con Edison:** This project targets 52 MW of DER procurement to meet the area’s growing demand at a lower cost than traditional investments using an optimization portfolio approach to integrate DER into the planning and operation process.^{45,46}
- **Little Compton – National Grid (RI):** The project consists of a vendor-owned battery storage unit to provide up to four hours of 250 kW of peak load relief to defer a substation upgrade by four years⁴⁷.

⁴¹ Examples include: a. In California’s Integrated DER Proceeding (R. 14-10-003), the CPUC approved a pilot in December 2016 to test the competitive solicitation process and effect of utility DER sourcing as non-wires alternatives.

b. The Supplemental DSIP filed by the Joint Utilities of New York included a non-wires analysis suitability framework and implementation matrices. The JU filed a common NWA Suitability Criteria framework on May 8, 2017. In appendices to the filing, each individual utility also summarized its own planning process, capital work plan, and utility-specific NWA criteria.

c. Rhode Island’s electric and gas utilities submit System Reliability Procurement Reports annually pursuant to the state’s System Reliability and Least Cost Procurement statute (R.I. Gen. Laws § 39-1-27.7). These procurement reports set forth guidelines to incorporate non-wires alternatives in distribution system planning.

⁴² Jeff St. John, A Snapshot of the US Gigawatt-Scale Non-Wires Alternatives Market, August 22, 2017.

⁴³ Grid Modernization Laboratory Consortium (GMLC), State Engagement in Electric Distribution Planning, December 2017.

⁴⁴ PG&E, Distribution Resource Plan Request for Offers Demo C – El Nido Substation, August 14, 2017

⁴⁵ Michael Coddington, Damian Sciano, and Jason Fuller, “Change in Brooklyn and Queens,” March 1, 2017, 41.

⁴⁶ Consolidated Edison, Distributed System Implementation Plan, Appendix N, June 30, 2016.

⁴⁷ The Narragansett Electric Company, 2018 System Reliability Procurement Report, November 1, 2017.

- **Punkin Center – Arizona Public Service:** The project, launched in 2017, consists of a 2 MW, 8 MWh battery array that is deferring the need for 20 miles of transmission and distribution infrastructure⁴⁸.

The development of non-wires alternatives has taken hold across the country independent of DER growth. Regardless of the amount of DER currently being deployed, some utilities have pursued solicitations for non-wires alternatives in effort to better understand their value in place of traditional utility investments. These utilities see a proactive approach to non-wires alternatives as a way to deliver value to customers in the near term and to better understand the costs and benefits of DER if penetration rates increase in the future.

Some utilities are looking at market-based sourcing solutions as integral to the planning process. By embedding non-wires alternatives into the planning process, these procurement approaches have the potential to become additional elements in the planning toolbox rather than only means to defer traditional investments. As described above, Hawaiian Electric's Integrated Grid Planning & Solution Sourcing Process aims to do this by evaluating non-wires alternatives alongside traditional investments in the context of an integrated planning approach.⁴⁹ Meanwhile, California investor-owned utilities have incorporated in their planning process the Distribution Infrastructure Deferral Framework (DIDF). This initiative consists of the publication of annual Grid Need Assessment⁵⁰ (GNA) studies to later inform the Distribution Deferral Opportunity Reports⁵¹ (DDOR). These in turn identify preliminary non-wires solution opportunities that are evaluated in the context of a competitive solicitation process.

Other utilities are evaluating the impact of non-wires alternatives in a risk-based framework that supports a probabilistic analysis of DER value on the basis of outage risk and outage consequence, rather than on the basis of deferral of a discrete traditional utility solution. This approach will inform the potential additional resilience value that non-wires alternative projects may provide to the system.

Challenges and Considerations

Quantifying the value provided by non-wires alternatives can be a significant challenge, especially with regard to value streams, like resilience, that are not readily represented by a single metric or measure.

The ability to use certain value categories may be limited by data availability. In other cases, estimating the incremental value of a discrete resource might be challenging for measures that

⁴⁸ Arizona Public Service, APS brings battery storage to rural Arizona, APS Press Release, August 9, 2017.

⁴⁹ Hawaiian Electric Companies, Planning Hawai'i's Grid for Future Generations: Integrated Grid Planning Report, March 1, 2018.

⁵⁰ 2018 Grid Needs Assessment Report of Pacific Gas and Electric Company (U 39 E), Pursuant to Ordering Paragraphs 2.D and 2.E of D.18-02-004, June 1, 2018.

⁵¹ Pacific Gas and Electric Company's (U 39 E) Distribution Deferral Opportunity Report Pursuant to Ordering Paragraphs 2.D of D.18-02-004 Public Version, September 4, 2018.

are often quantified in terms of system-wide statistical metrics, like reliability.⁵² However, as early pilots are completed, they may yield data that could inform efforts to further refine these approaches and enable more accurate quantification of locational values to use in subsequent procurement evaluations.

In some cases, non-wires alternatives are not well situated to meet specific needs on the system. The procurement of non-wires services is in some ways an extension of the distribution system planning process, which is designed to address long-term system needs rather than dynamic services that operate over short characteristic timescales. Therefore, value categories such as distribution voltage support or power quality that require dynamic control are better addressed through an operations framework rather than a planning framework.

In addition to the challenges associated with quantifying the value of non-wires alternatives and evaluating competing solutions, numerous challenges are presented by other aspects of the process, from contracting to system integration and operation. These include the ability to attract sufficient interest in solicitations, the cost of non-wires alternatives relative to traditional solutions, the time needed to carry out a competitive solicitation and establishment of contractual requirements that govern performance obligations. Additional implementation challenges include reconciling disparities between DER operational characteristics and utility planning criteria, utility-aggregator operational coordination, and monitoring and control implications associated with the utilization of, and reliance on, DER. Local and municipal processes and stakeholder can present challenges as well. In addition, utilities must effectively manage risks associated with aspects such as technology performance, asset lifetime, and vendor execution.

3.2 Locational Value Assessment for Tariff Design

Overview

System-average benefit and cost values can inform retail rates designs applied to DER. Many of the approaches implemented thus far do not provide locational specificity for DER compensation. States are investigating how well net energy metering rates reflect the actual costs and benefits associated with distributed generation and exploring different tariff mechanisms to align compensation to locational value.

Some net energy metering successor tariff aim to provide a more equitable price for distributed generation by identifying the costs and benefits attributable to specific value components such as generation requirements, resource adequacy, transmission capacity and distribution capacity.⁵³ This approach may address cost subsidy issues, but does not typically provide a locational price to DER.

⁵² Grid Modernization Laboratory Consortium (GMLC), State Engagement in Electric Distribution Planning, December 2017.

⁵³ California Public Utility Commission, Decision Adopting Successor to Net Energy Metering Tariff, January 28, 2016.

Location-based pricing assigns a value to electricity by geographical areas. One approach being explored in New York is to base this price on the marginal cost of service (MCOS).⁵⁴ Locational value assessment can inform retail tariff design to more accurately reflect the locational and temporal costs and benefits that DER provide. This can facilitate retail pricing tariffs that monetize products and services on a locational basis and provide a more efficient signal for DER providers.

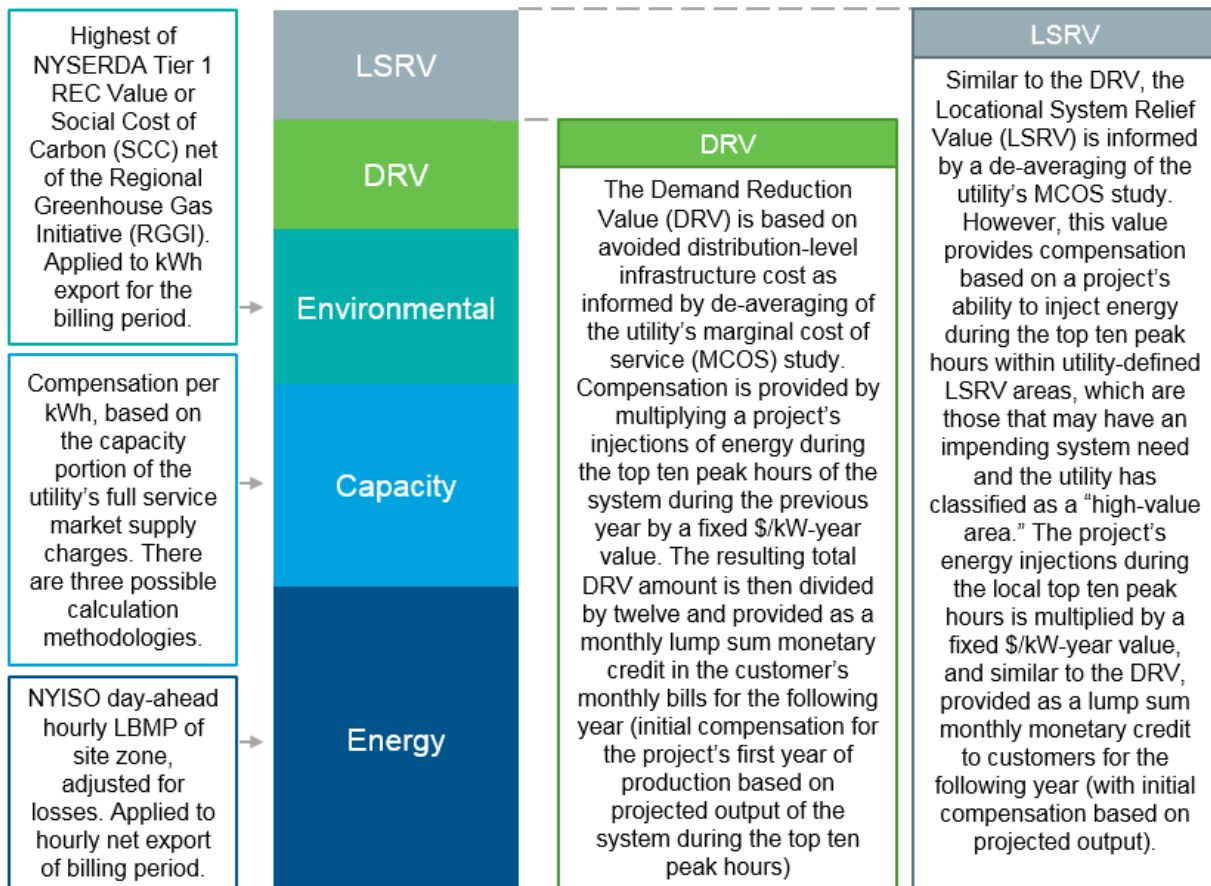
Current State of the Industry

This use case is in an early stage of development; while much work has been done to explore time-varying rate structures such as time of use rates, industry progress to implement geospatially varying rates has received comparatively less attention. For example the New York Value of DER (VDER) proceeding initially proposed to create location-specific value stack components that are calculated by disaggregating the MCOS across the system as a proxy for the load relief value of the resource at that location.⁵⁵ Such approaches could begin by using well-established metrics like MCOS and then evolve to rely on metrics more closely tied to DER value. The approach could be further applied by gradually expanding eligibility to broader classes of DER technology that can interconnect under the relevant tariff. The approach that New York Department of Public Service Staff proposed in 2016 for including a Locational System Relief Value (LSRV) in the VDER value stack is shown in Figure 7. This approach evolved from this initial proposal, but this prior draft reflects some of the locational components that industry has considered in this context.

⁵⁴ New York Public Service Commission, Order On Net Energy Metering Transition, Phase One Of Value Of Distributed Energy Resources, And Related Matters, Case 15-E-0751, March 9, 2017.

⁵⁵ New York Department of Public Service, Staff Report and Recommendations in the Value of Distributed Energy Resources Proceeding, Case 15-E-0751, October 27, 2016.

Figure 7. New York State Value of DER Tariff Phase One Value Stack Proposal (2017)



Challenges and Considerations

In contrast to non-wires alternatives, whereby DER operate subject to contractual performance obligations, retail tariff design does not offer the same level of certainty on the availability and operation of resources during critical times. This makes it challenging for utilities to include the impact of DER on circuit loading to meet distribution planning criteria. In some cases, utilities may choose to exclude the impact of DER with variable output when evaluating system load relief needs. Whereas the procurement of non-wires alternatives can provide contractual mechanisms to measure the ability of a resource portfolio to address system needs, retail tariff mechanisms do not typically provide that feedback loop that facilitates an evaluation of the impact of the resources on system needs. In addition, the marginal impact of DER at a location will change as a function of DER penetration, customer loads, and system changes. This creates a challenge for identifying the appropriate compensation value to provide resources interconnecting on these types of tariffs and to build in flexibility that allows compensation to adjust to reflect changes in factors related to system design, load distribution and resource mix.

3.3 Locational Value Assessment for Program Design

Overview

Locational value assessment can be leveraged in the context of program design as well. The methods described above can facilitate program targeting, enable programs to deliver greater system value and improve cost effectiveness. For example, some utilities are using locational net benefits to tailor programs as an evolution from system-wide avoided cost tests to more targeted measures. In other cases, utilities are leveraging demand-side management (DSM) programs as part of a non-wires alternative solution to provide load relief or other values.

Current State of the Industry

While there has been more activity implementing locational approaches for competitive procurement, there is growing interest in leveraging these tools in the context of utility program design. Although utility DSM programs have historically been evaluated on the basis of system-wide measures, there are initiatives today aimed at using locational methods to better capture the value programs provide in different areas of the distribution system.

The California IOUs have proposed extending the geographic granularity of avoided cost calculations to support design and evaluation of location-specific DER programs. For example, PG&E proposed increasing the geographic granularity of the distribution avoided cost from a climate zone level to a distribution planning area level.⁵⁶ PG&E and SCE further proposed “project-specific” methodologies to evaluate the ability to defer a traditional T&D project on the basis of factors such as location, timing, and availability.

These proposals build on each utility’s experience designing targeted program pilots. PG&E included a targeted demand side reduction solution as a one of its Electric Program Investment Charge (EPIC) programs in its 2015-2017 EPIC Triennial Investment Plan.⁵⁷ The program leverages high-resolution customer interval data and SCADA data to evaluate its ability to address forecasted capacity challenges at specific assets and over specified timeframes. In this case, the utility leveraged resources such as energy efficiency, demand response, distributed energy storage, and consumer-oriented energy tools to target demand reduction in local areas.

Similarly, National Grid’s distribution load relief program for the Village of Kenmore⁵⁸ leverages demand response resources to deliver a non-wires alternatives that will relieve an overloaded area.⁵⁹ The availability of demand response resources, such as air conditioning systems and

⁵⁶ Pacific Gas and Electric Company, Proposed Distribution Planning Area Avoided Cost Methodology Pursuant to Decision No. 17-09-026, Rulemaking 14-08-013, December 5, 2017.

⁵⁷ Pacific Gas and Electric Company, 2016 Annual Electric Program Investment Charge Report of Pacific Gas and Electric Company (U 39 E), February 28, 2017.

⁵⁸ National Grid, Petition by Niagara Mohawk Power Corporation d/b/a National Grid to Effectuate Dynamic Load Management Programs. June 30, 2015. https://www.nationalgridus.com/media/pdfs/bus-ways-to-save/dynamic_load_filing.pdf

⁵⁹ coolControl Map of Eligible Addresses. Available at: <https://www.coolcontrolprogram.com/eligibility/>

other controllable loads, enabled the use of a targeted program design to deliver the non-wires alternative solution.⁶⁰

Con Edison's Brooklyn Queens Demand Management project is a hybrid case. Although the utility is sourcing resources for the non-wires alternative solution through a competitive auction mechanism, Con Edison first used a targeted program approach to increase adoption of energy efficiency in the area. This allowed the utility to address system needs quickly using its existing demand-side management programs: by increasing marketing efforts and providing enhanced customer incentives, they can increase deployment of energy efficiency in the relevant load area.⁶¹

In Colorado, Xcel Energy proposed using DSM geo-targeting as a tool to strategically target DSM programs in areas that present system constraints, focusing on achieving energy savings where the marginal costs and emissions reductions are the greatest. The DSM geo-targeting approach would identify a specific set of customers, indicate if there is a specific rebate or benefit to program participant, and then tailor the outreach and message. The rebate or incentive might need to be enhanced for geo-targeted customers that may experience longer payback periods in order to induce participation and achieve system benefits.⁶²

Challenges and Considerations

Utilities applying locational value in the context of program implementation will need to address many of the same considerations relevant to procurement and implementation of non-wires alternatives. For example, if a targeted program approach is being used to defer the need for a traditional utility investment, the timeframe must be certain-enough to source sufficient resources far enough ahead of the system need date for the utility to ensure the solution can be implemented in time to meet the need.⁶³ Resource availability, resource duration and dispatch duration will be important considerations, just as they are in the context of non-wires alternatives. Program implementation considerations related to customer acquisition and participation could have significant reliability implications if targeted programs are being used as a means to address load relief or other system needs. In addition, coordinating programs with procurement and pricing could present an additional challenge for utilities to ensure resources are appropriately compensated for the system value they deliver or are available when needed.

⁶⁰ National Grid. Initial Distributed System Implementation Plan. June 30, 2016.

⁶¹ Consolidated Edison, Draft Energy Efficiency Transition Implementation Plan, June 1, 2017.

⁶² Xcel Energy, Verified Application of Public Service Company of Colorado for Approval of Strategic Issue Proposals Relating to its Next Electric and Gas Demand Side Management Plan, July 3, 2017.

⁶³ Grid Modernization Laboratory Consortium (GMLC), State Engagement in Electric Distribution Planning, December 2017.

4. EMERGING USE CASES

While the use cases explored above are representative of many utility efforts today, they do not capture all the possible use cases for hosting capacity analysis and locational value assessment in the context of an integrated distribution planning approach. Current efforts typically focus on applications with the greatest near-term benefits and those that are supported by existing tools and data. However, several use cases for hosting capacity analysis and locational value assessment are beginning to emerge for longer-term applications of these capabilities. The implementation of these use cases might be at the pilot stage or at the purely conceptual phase, but they capture some of the longer-term aspirations utilities see as the capabilities supporting these efforts continue to mature.

Applications for hosting capacity discussed thus far have focused on analyses of the system that inform DER development, interconnection screens, and distribution planning analytics. These typically rely on hosting capacity analysis that is updated at a frequency sufficient to reflect major changes to the system and the additions of large loads or DER. However, increased automation in hosting capacity analysis could enable more rapid updates that could lend themselves to applications to address operational issues rather than strictly planning-based applications. Ultimately, hosting capacity analysis may be updated immediately upon approving an interconnection application, thus reducing the chance of competing projects harming the state of a distribution circuit.

Applying hosting capacity and locational value in the context of distribution operations could include active network management approaches to manage DER output during times of system constraint and allow more DER to interconnect to a circuit than a static hosting capacity analysis would indicate.⁶⁴ These approaches require modern grid equipment to provide the visibility and flexibility needed to identify and manage constraints. Within the planning use case described above, system planners could assess the ability of system upgrades to increase hosting capacity as well as the ability of active network management to allow utilities to go beyond nominal hosting capacity limits.

The ability to analyze hosting capacity on operational timescales could also facilitate real-time dispatch of DER or DER aggregations in response to dynamic price signals. This use case would draw on both hosting capacity analysis and locational value assessment, whereby the former would help determine DER dispatch feasibility under the current system configuration and the latter would provide the price signal to facilitate efficient dispatch of DER across the system. This use case would require updated hosting capacity and locational value calculations that could track changes to system conditions on relevant timescales, as well as modern technologies in software and distribution equipment. Conceptual methodologies and pilot projects have been developed for this kind of dynamic price formation at the distribution level,

⁶⁴ NYSEG, NYSEG and RG&E Announce Technology Partnership to Lower Connection Costs for Renewable Generation, February 1, 2016.

and some early work has begun on applying hosting capacity methods in the operational context as well.⁶⁵

5. SUMMARY

This report provides the summary of targeted interviews with 12 electric utility companies across the country as well as leading industry research organizations to provide input on current industry practices and evolving IDP use cases. Utilities are making significant progress developing capabilities that support the IDP objectives of integrating DER and reflecting the locational value of distributed resources. The implementation of IDP is still nascent but many utilities have begun to develop these capabilities and the lessons learned from these early efforts are informing the development of emerging best practices in the industry.

The IDP use cases presented in this report reflect the input from utilities implementing these approaches on their systems. The application of hosting capacity analysis has focused largely on the external use case of providing heat maps to DER developers. The lessons learned from these early experiences will inform the relative value of hosting capacity analysis for informing development activities. The methods and approaches for developing hosting capacity portals is evolving quickly and the outcomes of these efforts across the country will unfold in the coming years. There are already numerous additional use cases in early stages of implementation or demonstration related to interconnection technical screens, distribution planning, and operations. Each use case will define a set of relevant input data needs, appropriate methods, and data visualization approaches tailored to delivering the functionality required.

There has been significant activity in utilities across the country related to the procurement of non-wires alternatives for deferral of traditional investments. This has spurred an interest in evaluation of non-wires alternatives as an integrated aspect of planning. These efforts are at an early stage and the industry is learning from experience gained with early projects how to address challenges associated with sourcing and implementation of non-wires alternatives. Lessons learned from these projects will help inform how they can be best leveraged in the context of distribution system planning. Work in Hawaii and elsewhere is beginning to examine the contribution of DERs across the integrated transmission-distribution system. It may be important to follow these efforts to determine effective approaches for integrating and valuing DERs.

Because these approaches face similar challenges associated with implementation timelines, technology risk, and alignment of DER performance characteristics with utility planning criteria, successfully addressing these in the context of non-wires alternatives will also advance aspects of targeted program implementation. The tariff design use case for locational value assessment is still nascent and faces the further challenge of identifying compensation levels that

⁶⁵ Tabors et. al., White Paper on Developing Competitive Electricity Markets and Pricing Structures, April 2016; Advanced Research Projects Agency - Energy - U.S. Department of Energy Network Optimized Distributed Energy Systems (NODES) Program, <https://arpa-e.energy.gov/?q=arpa-e-programs/nodes>; and National Grid, National Grid Proposed REV Demonstration Project Filing, July 1, 2016.

appropriately reflect DER costs and benefits to the system without the contractual mechanisms available in other use cases.

These use cases are representative of current hosting capacity analysis and locational value assessment efforts across the utility industry although they are by no means an exhaustive catalog of use cases and approaches. Just as the methods and tools continue to evolve so too will the use cases and applications of these capabilities.⁶⁶ We see a glimpse of this evolution in proposed operational use cases that leverage these capabilities to facilitate new distribution services. Touchpoints between planning and operations in these use cases, forecasting and hosting capacity in the planning use case, and DER interconnection and hosting capacity in the improved screens use case all embody the interdependencies that are foundational to Integrated Distribution Planning. It is through effective management of these seams and connections and through leveraging the lessons learned from experience with these capabilities that utilities can leverage IDP to deliver value for their customers.

⁶⁶ Grid Modernization Laboratory Consortium (GMLC), Electric Distribution System Planning with DERs - Tools and Methods. October 2018.

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