June 4, 2024

To: Michigan Public Service Commission (PSC) Staff
From: Cody Davis, Electric Power Engineers, for Lawrence Berkeley National Laboratory[1]
Re: Technical Review of Data Granularity and Attribute Types for Hosting Capacity Analysis Maps

On June 30, 2023, the Michigan PSC filed a Grid Integration Study Report in compliance with Senate Resolution 143, which encouraged the PSC to undertake a study on reliability, interconnection, and related grid integration issues for distributed energy resources (DERs). Several of the recommendations in the report address hosting capacity information, including the following (emphasis added):

- ***Revising Capacity Map Visualizations and Vocabulary*** *- It is necessary to revise the vocabulary and appearance of go/no-go decision pointers for publicly accessible hosting capacity maps to send proper signals to customers and developers. Providing additional hosting capacity information would lead to interconnection applications being less speculative. Areas with limited hosting capacity should be marked as "constrained" on circuit maps and different constraint levels should have clear identifiers such as gradient coloration of the maps should show the different constraint level (e.g., green, yellow, orange, and red for high, moderate, low, and no available hosting/load capacity, respectively). This would further enhance the visualization and utilization of the hosting capacity maps and provide necessary information to stakeholders while not stifling the further adoption and integration of DERs and EV infrastructure. From a planning perspective, this would also aid developers exploring investments in advanced control technologies such as managed charging or co-located solar PV and storage to make sure a new EVSE or PV installation operates within local grid constraints. Improving existing hosting capacity maps or publishing new ones should have a feedback process in place with stakeholder input to provide guidance on* ***appropriate levels of data granularity and attribute types shown on the hosting capacity maps****.*

PSC Staff requested Berkeley Lab to provide technical assistance on the appropriate levels of data granularity for publicly available hosting capacity maps for load and generation, including the impacts of varying levels of granularity and data availability on removing barriers to DER adoption.

Overview of Hosting Capacity Maps

A primary objective of publicly available hosting capacity maps is to enable utility customers and project developers to effectively site and size DERs (Table 1). Hosting capacity maps are most useful for large DER installations that are more likely to encounter utility system constraints and with greater ability to change interconnection location in response to system capacity constraints. Providing sufficient information to understand the viability of DER projects at a particular site on the distribution system helps to direct interconnection applications to better locations, minimizing interconnection cost and study time for applicants and streamlining queue management for utilities. Initially, utilities focused

[1] Contributions by Lisa Schwartz, Berkeley Lab

hosting capacity information on DERs with energy generation capabilities (e.g., solar PV). In recent years, utilities have applied the same concepts to loads to facilitate the interconnection of electric vehicle (EV) charging and energy storage, which can act both as generation and load.

Table 1. Hosting Capacity Use Cases[2]

	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

At a minimum, hosting capacity maps communicate the amount of DERs, in megawatts (MW), that can be added at a given location on the distribution system without adversely impacting power quality or reliability under existing control and protection systems and without infrastructure upgrades. Over time, utilities have provided additional information at higher levels of granularity. Project developers have become more sophisticated in using the detailed information provided.

Utilities may oppose some aspects of developing more detailed maps due to development or maintenance costs, information security, and other drivers. Utility regulators resolve such issues in regulatory proceedings, informed by state- and utility-specific goals, existing and planned capabilities, costs, and benefits.

Common Issues in Hosting Capacity Map Design

Following are typical issues addressed in utility regulatory proceedings related to hosting capacity maps: update frequency, geographic granularity, types and level of information provided, security concerns, cost, data validation, and data export. Each section includes a description and common utility and developer perspectives, summarized in Table 2. Importantly, other stakeholders may share either of these perspectives. Further, utility regulators must take into consideration state policy goals and directives — for example, with respect to reducing barriers to DER adoption. The National Association of Regulatory Utility Commissioners' *Grid Data Sharing Playbook*[3] provides a framework to effectively address questions related to grid data sharing in regulatory proceedings.

- Update Frequency
    - **Description:** The number of times per year that the hosting capacity map is updated with new information and calculations impacts its usefulness. Depending on the specific

[2] U.S. Department of Energy, 2018, *Utility Practices in Hosting Capacity Analysis and Locational Value Assessment*
[3] National Association of Regulatory Utility Commissioners, 2023, *Grid Data Sharing Playbook*

information provided, some elements may be updated more frequently than others. For example, peak and minimum load information may be updated annually based on measured values, while the amount of installed DERs on a feeder may be updated monthly or bi-weekly as applications are received or processed.
    - **Common Utility Perspective:** More frequent updates generally increase ongoing maintenance costs and require automation and data integration.
    - **Common Developer Perspective:** More frequent updates improve confidence in the data provided because it will be more accurate at the time it is used. Frequent updates to information such as installed and queued DERs are most likely to be impactful in application decision-making by developers.

- Geographic Granularity
    - **Description:** Geographic granularity refers to the size of the land area that is represented at a distinct point on the hosting capacity map. This may be referred to as the "block" size. Block size varies significantly, with some utilities providing detailed circuit maps while others show only aggregated results for larger geographic areas.
    - **Common Utility Perspective:** U.S. utilities have historically not provided circuit-level maps showing all distribution lines, generally driven by security concerns that detailed location information makes it easier for parties with malicious intent to target or otherwise damage utility equipment. Presenting results aggregated into blocks reduces these concerns and can lessen the number of calculations performed to generate the map.
    - **Common Developer Perspective:** Smaller block sizes, generally on the order of 500 feet by 500 feet, make the hosting capacity map much more useful for project evaluation. Detailed circuit maps are ideal for sophisticated developers because they allow for all relevant information to be assessed in detail.

- Types and Level of Information Provided
    - **Description:** In addition to the calculated hosting capacity, many hosting capacity maps provide other data that can be used by project developers to understand the likelihood that an application at a given site will be successful and cost-effective. Examples of additional useful information include nominal system voltage, peak and/or minimum load, large load or generation installations — both existing and queued, system protection information, and voltage regulator information.
    - **Common Utility Perspective:** Providing additional information can result in increased map development and maintenance costs, especially if the utility manually processes the information or additional software integration is required. More information also may increase utility security concerns, especially if data includes system peak load information.[4]
    - **Common Developer Perspective:** Additional information empowers project developers to understand the drivers of hosting capacity constraints at a given location, as well as the expected magnitude of costs for upgrades that would be needed to resolve those

[4] Utilities may be concerned that bad actors might target attacks at feeders with the greatest impact.

constraints as DER application size increases. Better information also helps inform expectations about study timelines, especially for locations where many projects are already in the interconnection study queue.

- Security Concerns
  - **Description:** Hosting capacity maps, by definition, provide information about the location and capabilities of physical distribution infrastructure. Security concerns generally refer to the ability of bad actors to use the information made available by hosting capacity maps to target, damage, or otherwise compromise infrastructure.[5]
  - **Common Utility Perspective:** Providing highly granular information about distribution infrastructure may increase capabilities of bad actors to target distribution equipment, including substations or areas supporting high amounts of load.
    - Some utilities have argued that some information requested for hosting capacity maps falls under FERC's designation for Critical Energy Infrastructure Information (CEII). CEII is defined as "a system or asset of the bulk power system…"[6] which is not broadly applicable to distribution infrastructure but may have applicability to specific assets, especially within large substations.
  - **Common Developer Perspective:** At least some information about the location and criticality of distribution facilities can be obtained from sources like Google Earth by motivated parties, including the ability to identify substation locations and assess their relative size and importance. Similar data of higher security facilities on the transmission system is already made public.[7]

- Cost
  - **Description:** Building, publishing, and updating the hosting capacity map involves engineering and IT processes with associated costs. Generally, these costs increase as the frequency of updates or volume of information increases. Both capital investment for map development and O&M expenses (e.g., for data cleaning) may be incurred, depending on the specific activities involved.
  - **Common Utility Perspective:** Costs related to hosting capacity maps are ultimately paid by customers and should be minimized where possible.[8]
  - **Common Developer Perspective:** Useful, publicly available information on hosting capacity helps meet state policy goals (e.g., achieving DER and clean energy resource targets). Improved information availability and update frequency help streamline the interconnection application processes and reduce study costs.

[5] See National Association of Regulatory Utility Commissioners, 2023, *Grid Data Sharing Playbook*
[6] https://www.ferc.gov/ceii
[7] Interstate Renewable Energy Council, 2021, *Key Decisions for Hosting Capacity Analyses*
[8] Some utilities recognize that providing hosting capacity maps can reduce the utility expenses associated with the review of interconnection applications. Maps can direct project developers to locations that are less constrained and, consequently, require less utility labor to complete interconnection studies. This is particularly relevant in jurisdictions where application costs are fixed and may not fully recover the cost to perform interconnection studies.

- Data Validation
  - **Description:** Data validation is the process of scrutinizing the results of hosting capacity analysis to ensure they are reasonable and accurately reflect system conditions and limitations. The National Renewable Energy Laboratory and the Interstate Renewable Energy Council developed detailed information on causes of errors and best practices for data validation.[9] Data validation should be captured as part of hosting capacity map development and regulatory reporting processes. It is not directly visible in the resulting public hosting capacity maps.
  - **Common Utility Perspective:** Data validation is an important step in the process, but results are fundamentally dependent on the quality of underlying data. Identifying and fixing data errors across the system can improve hosting capacity results, as well as distribution system planning and interconnection modeling processes. For utilities that have not maintained detailed and accurate field equipment records, field audits may be needed to improve model accuracy.[10]
  - **Common Developer Perspective:** Accuracy of hosting capacity calculations is critical to ensure that hosting capacity maps are useful for decision-making related to DER development. Because data and model quality improvements benefit other processes, including distribution system planning and interconnection, the cost of such improvements should not be solely reflected in cost-effectiveness evaluations for hosting capacity.
- Data Export
  - **Description:** Data export refers to the ability of third parties to access hosting capacity information outside of the web interface for the hosting capacity map. For example, hosting capacity results can be exported in table form. Information also may be downloaded through an application programming interface (API) using software or scripting tools.
  - **Common Utility Perspective:** Tabular or API access may require additional tools or capabilities, which may increase development and maintenance costs. In addition, providing such access may worsen security concerns if system data can be extracted or archived.
  - **Common Developer Perspective:** Map access is very useful for evaluating whether a specific site is a good candidate for a DER installation, but maps are difficult to use to identify high-potential sites across the utility system. Tabular data dramatically improves the ability to locate potentially successful DER development sites.

[9] National Renewable Energy Laboratory and Interstate Renewable Energy Council, 2022, *Data Validation for Hosting Capacity Analyses*

[10] See related discussion under "Cost Drivers for Hosting Capacity Maps and Associated Data" for potential costs.

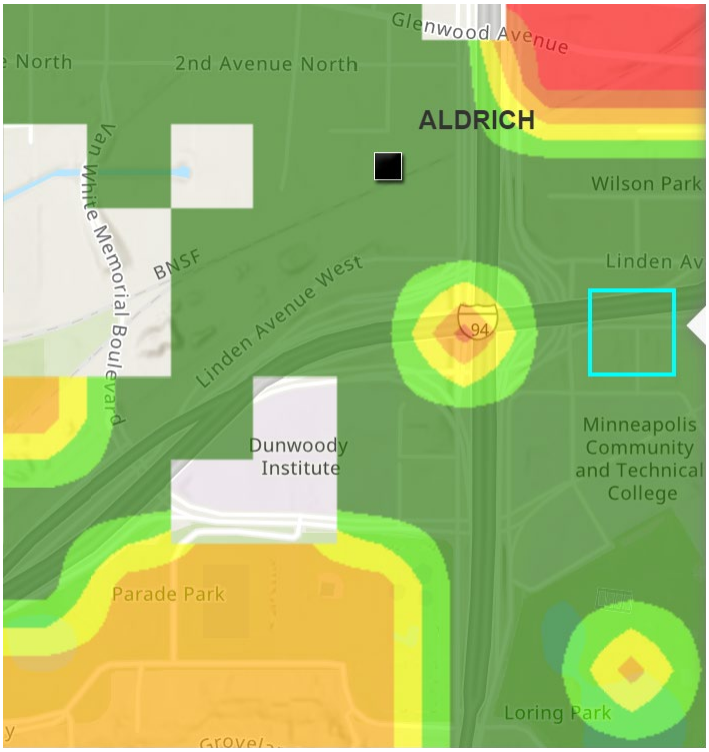
Table 2. Common Hosting Capacity Map Design Issues

Topic Area	Common Utility Perspective	Common Developer Perspective
Update Frequency (e.g., Annual, Monthly, Bi-monthly)	More frequent updates increase ongoing maintenance costs	More frequent updates improve usefulness due to increased accuracy
Geographic Granularity (Blocks vs. Circuit Maps)	Aggregated maps reduce risk to utility assets (security)	Detailed circuit maps improve developer capabilities for site selection
Amount of Information Provided (e.g., calculated hosting capacity, information on constraints, load profiles)	Providing additional information increases HC tool development and ongoing costs	Providing additional information increases project siting/sizing screening capability
Security Concerns	Highly detailed information may contain CEII or expose the distribution system to additional risk	HC maps are outside distribution substations and not part of the bulk power system, thus not CEII
Cost	Map development and maintenance costs impact utility customer bills and are not paid by developers	HC maps reduce utility study burden and aid in compliance with state goals and programs
Data Validation	Data validation is an important part of the process, but accuracy may be limited by data quality, which can be costly to improve in some cases	Data validation and confidence in hosting capacity results are critical to ensuring hosting capacity maps are useful for project siting. Improving data quality also benefits distribution planning and interconnection processes
Data Export	Allowing export in tabular format may increase system security risk	Tabular results are much easier to use for identifying good DER sites

Example: Highly Granular Hosting Capacity Map

Figure 1 and Table 2 illustrate publicly available hosting capacity maps and associated information provided by Xcel Energy in Colorado.[11] The utility provides a high volume of information at a relatively high level of granularity, pursuant to requirements by the Colorado Public Utilities Commission. This example illustrates additional information that could be provided by Michigan utilities and how customers and DER developers could use such information.

Figure 1. Xcel Energy Colorado Hosting Capacity Map



[11] https://xeago.maps.arcgis.com/apps/webappviewer/index.html?id=a04c42c922664381a2d35ba12305eb2e

Table 2. Xcel Energy Colorado Hosting Capacity Information

Feeder	ALD087, ALD086
Type	3 Phase Component, 3 Phase
Phase	ABC
OH/UG	UG
Voltage	13800 Volts
Primary Over-Voltage	10, 6.3, 8.3
Primary Voltage Deviator	10
Regulator Deviation	10
Thermal Discharging	4.8, 4.7
Additional Element Fault	0.65, 2.75
Breaker Reach	10
Unintentional Islanding	9.4, 3.05
VSR Equipped	No
Feeder Technical Planning Standard	Compliant
Hosting Capacity	0.65, 2.75
Constraining Metric	Unintentional Islanding
Substation	Aldrich
Transformer Name	ALD_TR03
Minimum Available Hosting Capacity (MW)	0.65, 0.6
Min Constraining Metric	Unintentional Islanding, Primary Over-Voltage
Maximum Available Hosting Capacity (MW)	0.65, 2.75
Max Constraining Metric	Unintentional Islanding
Substation Transformer Minimum Load (kVA)	15396
Transformer Absolute Min (kVA)	12671
Feeder Daytime Minimum Load (kVA)	800, 3590
Feeder Absolute Min (kVA)	800, 3590
Actual Daytime Minimum Load	Yes
LTC or Regulator	LTC
Network or Radial	Radial
Substation Transformer Installed DG (kW)	1350
Substation Transformer Queued DG (kW)	262
Feeder Installed DG (kW)	0, 35
Feeder Queued DG (kW)	0
Data Cutoff	10/30/2022
Latest Quarterly Update	1/31/2023
Notes	

The following is an assessment of Xcel Energy's hosting capacity map and associated publicly available data:

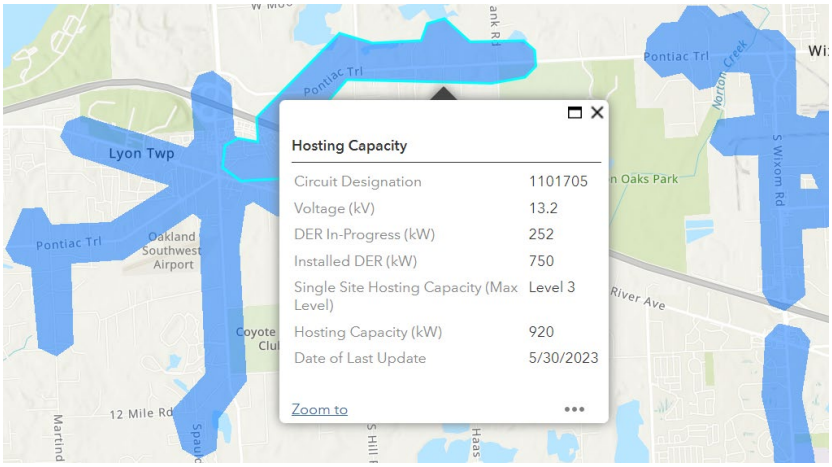
- **Overall:** The map provides highly localized results with a high volume of relevant and useful information for determining ideal DER project size and understanding the types and approximate costs for potential system upgrades.
- **DER Size Limitation:** The size limitation for hosting capacity calculations is set at 10 MW, which is a common practice to approximate the largest system that may be able to be accommodated by feeders in the 12 kilovolts (kV) to 15 kV voltage range.
- **Information Provided:** Xcel's map attributes provide a large quantity of information to help developers understand both the existing capacity at specific points on the distribution system and potential cost drivers to increase that capacity to accommodate additional DER development. The utility provided calculated hosting capacity results for each limiting criteria evaluated — overvoltage, voltage deviation, regulator deviation, thermal, fault current, protective reach, and unintentional islanding — including the minimum and maximum hosting capacity result for each geographic block. Relevant information about local facilities (overhead or underground, number of phases) and substation equipment and loading also aid in understanding likely interconnection costs. Information for each feeder in a block is provided separately, further improving the usefulness of the information.
- **Geographic Granularity:** The geographic area of each result block is small — on the order of a few hundred feet. That makes it easy to interpret localized results with high confidence.
- **Update Frequency:** Though the map update field is implied to be quarterly, the data was approximately a year old at the time of access for this memo (January 2024).
- **Data Accessibility:** Data is only accessible through the map interface. That limits the ability of DER developers to determine low-cost interconnection sites across the utility's service territory.

Current Michigan Utility Practices for Hosting Capacity

This section evaluates current hosting capacity map practices and information published by large investor-owned utilities in Michigan. The analysis focuses on the maps from a user perspective with the goal of identifying areas where modifications may improve usability and reduce barriers to DER adoption. Data validation efforts could not be evaluated from the published maps. They are a recommended follow-up area in future discussions about enhancement of hosting capacity data.

DTE

Figure 2. DTE Hosting Capacity Map[12]



- *Only interconnections less than 2 MW.*
- *Only overhead sections are displayed.*
- *Only certain sections are displayed which may be limited by protection devices, voltage support equipment and primary to primary voltage transformers, etc.*
- *Only 3-phase sections are displayed and connected in Delta or Wye grounded.*
- *Only distribution voltages are shown (4.8 kV Delta, 8.3 kV Wye ground & 13.2 kV Wye grounded).*

- **Overall**: DTE's hosting capacity map provides useful information about existing available hosting capacity. Improving geospatial resolution, available information, and update frequency would further enhance usability.
- **Size Limitation:** Hosting capacity maps generally are most useful for interconnection of large DERs, but the map is currently limited to a maximum size of 2 MW. Increasing the ceiling (e.g., to 10 MW) would improve information for larger systems and improve insight into the likelihood of distribution system upgrades needed even for systems 2 MW or less.
- **Information Provided:** Information provided in the existing map provides DER developers with a general understanding of the distance from 3-phase equipment, circuit voltage, current and expected DER penetration, and available hosting capacity. These are important components of evaluating the suitability of a location for DER development. However, no information is provided about which criteria are driving hosting capacity constraints or the specific parameters of the underlying distribution equipment and loading. Such information is important for

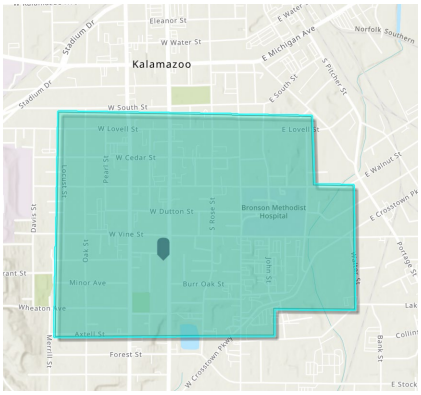
[12] https://dte.maps.arcgis.com/apps/webappviewer/index.html?id=64e9f4e0f82c42e7b7ed847273ec2764

estimating the magnitude of potential costs for distribution system upgrades that DER interconnection applicants may bear.

- **Geographic Granularity:** Overall, geographic granularity is relatively poor, with a single result generally covering large land areas. In some areas, a single result block may span distances up to 1.75 miles across. Smaller block sizes would improve usefulness by providing more accurate information about the location of distribution facilities and how hosting capacity changes across smaller distances.
- **Update Frequency:** At the time of access (January 2024), the date of the last update was May 30, 2023. At this update frequency, information for large sites is still potentially viable for project siting, but there is some risk that circuit conditions or the volume of DER applications or installations in that area have changed. Increasing frequency of updates would improve confidence in the information provided.
- **Excluded Facilities:** The decision to exclude distribution system sections with underground equipment could be a significant limiting factor in some cases, depending on prevalence of undergrounding and DER system configuration (e.g., a rooftop PV system of significant size).
- **Data Accessibility:** The existing map is useful for evaluating a specific site. The lack of tabular information makes it difficult to identify high-potential DER sites across the utility's service territory.

Consumers Energy

Figure 3. Consumers Energy Hosting Capacity Map[13]



- Generation resource is 2 MW or smaller.
- Connection will be 3-phase grounded wye.
- Point of interconnect will be within 0.25 miles of existing infrastructure.

Capacity Available	2 Megawatts
Phase Designation	3P
Primary Voltage	4.8/8.32 kV Wye Grounded
Analysis Date	12/9/2021

[13] https://cms.maps.arcgis.com/apps/instant/lookup/index.html?appid=b90ff63b338043b7bcae43dd685a419d

- **Overall:** It is difficult to use this map effectively to identify whether a specific site on the distribution system would likely be viable for DER interconnection and whether distribution facilities would need to be constructed or upgraded in order to accommodate a new DER project. The information provided is limited, aggregated across large land areas, and has not been updated regularly.
- **DER Size Limitation:** The map is limited to a maximum DER size of 2 MW. Increasing the ceiling (e.g., to 10 MW) would improve information for larger systems and improve insight into the likelihood of distribution system upgrades needed even for systems 2 MW or less.
- **Information Provided:** The information provided is minimal. It includes only circuit voltage, phase availability, and calculated capacity. No information is provided about existing and queued DERs, which criteria are driving hosting capacity constraints, or the specific parameters of the underlying distribution equipment and loading that impact the results.
- **Geographic Granularity:** Overall geographic granularity is poor, with results presented for large block areas. Both block width and height often are about 1 mile, making it difficult to determine the specific location of distribution facilities. Smaller block sizes would improve usefulness by providing more accurate information about the location of distribution facilities and how hosting capacity changes across smaller distances.
- **Update Frequency:** At the time of access (January 2024), the date of last update was over two years ago (12/9/2021). That leads to low confidence in the accuracy of the utility's hosting capacity calculations for distribution system conditions today.
- **Data Accessibility:** The lack of availability of tabular information makes it difficult to identify high-potential DER sites across the utility's service territory.

Indiana Michigan Power

Pilot hosting capacity results for Indiana Michigan Power are not currently publicly available. The pilot maps were stated to be developed using CYME and EPRI's DRIVE[14] tool, which are commonly used in the industry. Specific design decisions related to geographic resolution, update frequency, and information fields are not publicly available.

Cost Drivers for Hosting Capacity Maps and Associated Data

A primary factor to consider in hosting capacity map development is initial and ongoing costs. It is important to understand the key drivers of these costs and their relative magnitude.

- **DER Size Limitation:** The DER size limit serves as the upper bound for the hosting capacity calculations. The calculation process involves adding progressively more DER at a given location until either a constraint condition is violated or the maximum DER size limit is reached. Once either of these conditions occurs, the calculation process will move on to the next location. Consequently, increasing the threshold size increases the amount of computer processing time to calculate the results, but does not generally have a significant impact on the overall cost. For 12 kV to 15 kV distribution circuits, 10 MW is a common upper bound for hosting capacity

[14] https://www.epri.com/pages/sa/drive

analysis. For circuits using other voltage classes, 2-3 MW is common for 4 kV circuits and 30-50 MW is common for 25 kV to 34 kV circuits.

- **Information Provided:**
  - Providing data on **minimum or peak load** does not generally result in additional development or maintenance cost for hosting capacity analysis. Increasing the data granularity to monthly or seasonal load profiles will likely create some additional costs, as the data may not be readily available in a clean and presentable form.
  - Providing more data on hosting capacity results, including the **driver of the hosting capacity limitation and other potential limiting factors evaluated**, does not generally result in significant cost increases, as these values are calculated as part of the hosting capacity determination process.
  - Providing information on **queued and installed generation** may require integration of application management tools and calculated data, which can increase costs. This integration also can improve other modeling and planning processes, so the additional cost can be split with other programs that benefit. Decisions to pursue integration should be evaluated holistically.
  - Providing information about **local utility equipment parameters** (e.g., nominal voltage, number of phases present, overhead or underground construction) generally does not increase cost significantly, so long as distribution circuit model components have identifiers that correspond to specific locations within the utility's Geographic Information System (GIS). This information is readily available within the GIS system and can be easily cross-referenced. Depending on the hosting capacity map update frequency, this linkage may be performed manually or through integration within the hosting capacity publishing process.
- **Geographic Granularity:** Increasing geographic granularity does not typically result in higher development or maintenance costs if the utility is calculating hosting capacity using circuit models and analysis tools like CYME or EPRI's DRIVE tool, or both. Typically, results within these tools can be calculated at the individual line segment level and then aggregated to a specific geographic resolution. If results are being calculated at the substation or feeder level (e.g., one calculation result per substation or per feeder), transitioning to a more geographically granular analysis can significantly increase development and update costs because it will require cleaning and preparing circuit models.
- **Update Frequency:** Increasing the frequency of hosting capacity map updates can be a significant cost driver. Specific costs depend on the relative degree of automation and back-end system integration. Where information is compiled or integrated manually, moving from annual to monthly updates can result in significant increases in labor costs. Increasing system automation reduces labor for updates but requires upfront expenditures. Potential benefits to other utility business processes also should be considered. Decisions related to systems integration should be evaluated holistically based on expected costs and benefits across all impacted utility applications and business processes.
- **Data Validation:** Ensuring underlying data are reasonable and accurately reflect system conditions are critical steps for conducting hosting capacity analysis and publishing publicly available maps that are useful. Costs associated with data validation and subsequent data corrections can vary widely, depending on the degree of rigor and the cost to correct data or

modeling issues. Desktop methods of addressing common sources of error are generally highly cost-effective and can have crossover benefits for other utility business processes, including distribution planning studies, interconnection may instead make assumptions which tend to reduce the available hosting capacity in the calculation. Data validation processes and data quality limitations are important to studies, and outage recordkeeping and management. These methods are generally most effective when utility data quality for field equipment and connectivity is high. If the underlying data quality is low (e.g., if the utility cannot associate customers with the correct phase or service transformer), field audits are necessary to correct the data. These audits can be expensive. For example, Central Maine Power is currently undergoing a field audit of its entire 11,000 square mile service territory[15] at an expected cost of $12.58 million.[16] When data quality is relatively poor, planning models may instead make assumptions which tend to reduce the available hosting capacity in the calculation. Data validation processes and data quality limitations are important to consider holistically within the design process because of their cross-functional benefits.

- **Data Accessibility:** Costs associated with developing processes for delivery of tabular data vary depending on the publishing tool. Some GIS tools enable data viewing and exporting in tabular format within the map interface. In the absence of such tools, savvy DER developers may be able to extract information using data scraping techniques. In other cases, data extraction is actively blocked by utility design choices. Utilities can review existing capabilities to make hosting capacity data readily available to the public and consider the benefits of doing so when making decisions about the publishing process. Data access via API requires both initial development cost and ongoing maintenance and license costs, which may depend on the number of users and the volume of user requests fulfilled by the API.

Potential Areas of Focus for Improvements to Hosting Capacity Maps and Associated Data

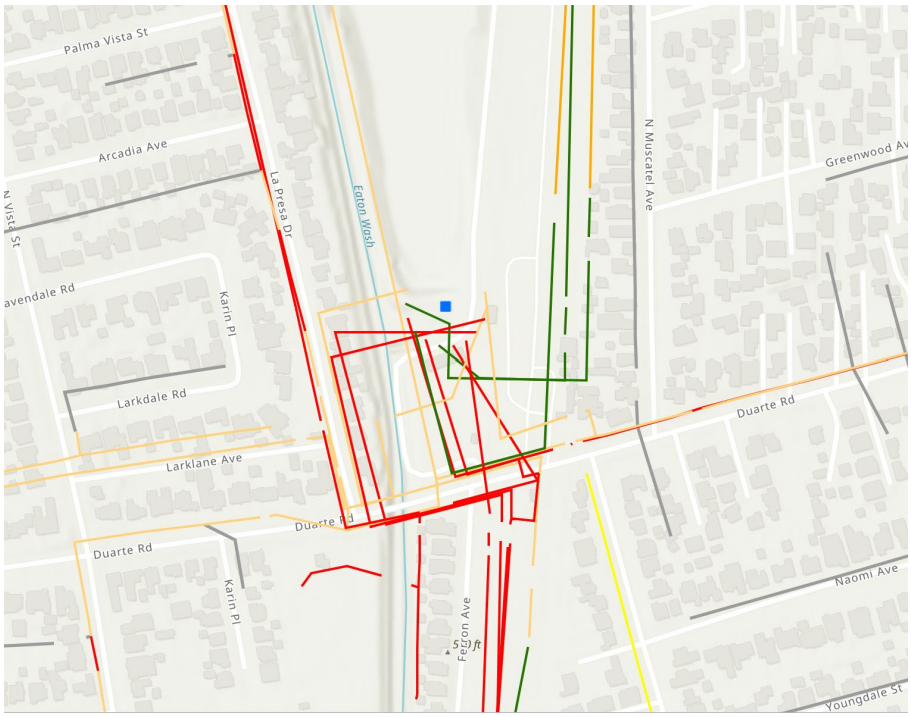
Geographic Granularity

Increasing geographic granularity of hosting capacity maps in Michigan would better enable utility customers (particularly large customers) and DER developers to more accurately understand the distance from a site to distribution infrastructure and reduce the uncertainty related to calculated results.

Maps that show individual line sections at their actual locations are ideal, as they provide the most specific information about the location of distribution facilities. Southern California Edison's Distribution Resource Plan External Portal[17] is an example of publicly available hosting capacity data using this approach (see Figure 4). If less granular results are deemed desirable due to potential utility security concerns, using smaller block sizes, like those illustrated in the Xcel Energy map from Colorado (see Figure 1), is strongly recommended.

[15] https://www.cmpco.com/ourcompany/whoweare/servicearea
[16] https://mpuc-cms.maine.gov/CQM.Public.WebUI/MatterManagement/MatterFilingItem.aspx?FilingSeq=116218&CaseNumber=2022-00152 Grid Modernization Testimony
[17] https://drpep.sce.com/drpep/

Figure 4. Illustrative Hosting Capacity Map for Southern California Edison



Calculations at the individual service transformer level are unlikely to yield significant benefits to the interconnection process and would incur additional costs. The primary beneficiaries of adding service transformer information to hosting capacity maps would be residential and small commercial customers and developers of small DER projects. Such granularity would enable them to understand whether they would require a service transformer upgrade to install a DER. This occurs as part of the interconnection application process, which does not require significant resource commitments from either the applicant or the utility. Service transformer results cannot be readily provided from hosting capacity calculations as currently performed. Generating these results would require integration with the utility GIS and potentially processing data from the utility's advanced metering infrastructure system.

Limiting Criteria Information

Hosting capacity calculations compare the distribution system impacts of adding DERs against a variety of distribution planning constraints intended to prevent power quality or reliability degradation. While many criteria are evaluated, hosting capacity at a particular location depends on which system criteria is violated at the lowest amount of DERs. Identifying the specific limiting criteria for each block of the hosting capacity map allows potential DER applicants to understand the expected interconnection cost that would result from adding a system larger than the existing hosting capacity. In addition, the amount of hosting capacity gained as a result of a system upgrade can be inferred from the next system constraint that would be violated, which can be useful for the distribution planning use case.

Communicating the limiting criteria for hosting capacity and results for other system criteria can significantly improve the ability of DER developers and utility customers to understand the expected cost to deploy DERs of varying sizes at specific locations. An important, but frequently overlooked, value of hosting capacity maps is to enable evaluation of the cost of distribution system upgrades prior to starting

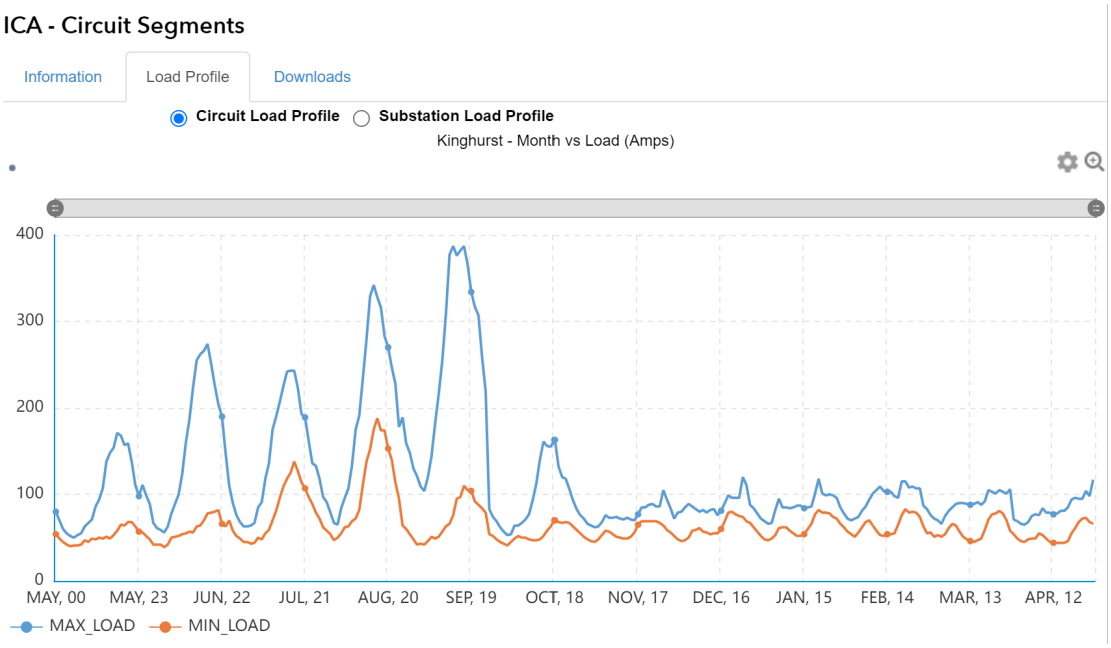
the interconnection process. Adding these fields to hosting capacity maps in Michigan would enable DER developers and utility customers to realize these benefits. Xcel Energy's hosting capacity map for Colorado (see Figure 1) provides a good example of how these results can be communicated.

Information on Circuit and Transformer Peak and Minimum Load

The addition of load information for circuits and substation transformers would be a significant improvement for hosting capacity maps in Michigan, especially when coupled with published information on utility interconnection screening and study criteria. Annual peak and minimum load information is the easiest to make publicly available, as it is used in model development for hosting capacity calculations. It also is generally the most useful load information for typical DER projects. Xcel Energy's hosting capacity map for Colorado (Figure 1) provides minimum load information at both the feeder and substation transformer. Peak load information also would be useful, especially when considering hosting capacity for EV charging loads and battery energy storage systems.

Providing full annual load profile or seasonal peak and minimum load data would enable DER developers and utility customers to understand how distribution system constraints may vary over time. This information is not generally useful for traditional DER interconnections but is important for Flexible Interconnection,[18] where system import or export limits are set dynamically based on present system conditions. Including such information in hosting capacity maps should be considered in parallel with the deployment of a utility DER Management System (DERMS) when utilities are pursuing Flexible Interconnection. Southern California Edison's portal[19] illustrates how peak and minimum load seasonal profiles can be communicated (Figure 5).

Figure 5. Example Load Profile Information Provided by Southern California Edison



[18] https://www.epri.com/research/products/000000003002014475
[19] https://drpep.sce.com/drpep/

Update Frequency

The frequency with which hosting capacity maps are updated plays a critical role in ensuring that the information provided is up-to-date and, subsequently, is trustworthy as a consideration in the decision-making process for siting and sizing DERs. Annual update cycles align with annual system peak and minimum load cycles. However, the amount of connected and queued DERs changes much more frequently, as new installations apply and move through the interconnection process. More frequent updates (e.g., quarterly or monthly) are strongly recommended, especially when application volumes are high, in order to provide accurate information. As an example, Dominion Energy in Virginia updates its hosting capacity maps quarterly.[20]

An alternative to periodic updates is a threshold-based approach. It relies on detecting changes in key interconnection or circuit parameters. Hosting capacity analysis is re-run for the specific feeder or substation any time a system change above a certain threshold occurs. For example, thresholds used by NV Energy in Nevada include changes in capacitor kVAR, voltage regulator quantity, feeder length, connected and queued DER, and forecast load growth.[21] This type of approach can improve update frequency without repeating analysis for all distribution feeders. The approach requires additional administrative work and recordkeeping to track feeder changes and trigger updates accordingly.

Data Accessibility

The ability to export hosting capacity results to a tabular format would significantly improve capabilities for identifying cost-effective sites for DER interconnection. Initially, underlying map data can be made available via Excel or a similarly accessible format. In Minnesota, Xcel Energy provides tabular results in a downloadable Excel format from the same webpage as its hosting capacity map.[22]

Utilities also can explore development of API-based delivery mechanisms to improve results processing and process automation for potential DER interconnection applicants. In New York, Central Hudson[23] provides a link to its API[24] (which uses the standardized REST API format), allowing users to extract data and export it into a machine-readable JSON file type.

Cost Considerations

Development and maintenance costs are an important consideration when evaluating any map design changes. Some enhancements could be made without significantly impacting costs, while others may require utilities to perform additional engineering work or procure or integrate new systems. When evaluating enhancements, consider the additional level of effort and cost, the degree to which the enhancement would improve DER sizing and siting capabilities of potential interconnection applicants, and current and forecasted application volume. Additional weight should be given to enhancements when application volumes are forecasted to be high, especially as a result of new programs or incentives.

[20] https://www.dominionenergy.com/projects-and-facilities/electric-projects/energy-grid-transformation/hosting-capacity-tool
[21] NV Energy 2021 Distribution Resource Plan, https://irecusa.org/wp-content/uploads/2021/10/IREC-Key-Decisions-for-HCA.pdf.
[22] https://mn.my.xcelenergy.com/s/renewable/developers/interconnection/hosting-capacity-map
[23] https://www.cenhud.com/en/my-energy/distributed-generation/solar-pv-hc-map/
[24] https://gis.cenhud.com/gisserver/rest/services/Public/HostingCapacity_Stage_3/MapServer

If DER penetration and application volume are relatively low today, there may be many cost-effective locations to interconnect new DER projects. However, when DER penetration hits a certain level, it can be very challenging to identify cost-effective sites, *even if the volume of new applications is low*. In such cases, hosting capacity enhancements are necessary to enable identification of cost-effective sites. Benefits and costs should be weighed holistically when considering map design enhancements.

Data Validation

In order to align with leading practices, the Michigan PSC may wish to improve understanding of the utilities' current data validation processes and the quality of underlying data the utilities use to develop hosting capacity maps. Unlike other facets of the map, data quality cannot be viewed or understood directly. Instead, data quality relies on quality assurance steps during the calculation process. Consequently, process oversight is the most effective way to ensure high quality results and address potential improvements.

Expansion of Hosting Capacity Use Cases

The Michigan PSC may wish to consider how enhanced hosting capacity maps and associated data can be used to improve utility distribution planning and publicly available information to support DER-related investments. In addition, hosting capacity maps and underlying data can be used during the interconnection screening process to improve efficiency of application processing. Hosting capacity data also can be used in distribution planning to identify potential distribution system constraints and opportunities for system upgrades to increase hosting capacity. The U.S. Department of Energy's Modern Distribution Grid Guidebook[25] provides additional information on these use cases and their applicability.

[25] U.S. Department of Energy, 2020, *Modern Distribution Grid*, Volume 4