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HOSTING CAPACITY: USING INCREASED TRANSPARENCY OF GRID CONSTRAINTS TO ACCELERATE INTERCONNECTION PROCESSES

The third in SEIA's *Improving Opportunities for Solar Through Grid Modernization* Whitepaper Series

AUTHORS:
Dave Gahl
Brandon Smithwood
Rick Umoff

SEIA Solar Energy Industries Association®

EXECUTIVE SUMMARY

Built during the last century, the United States electric grid was primarily designed to transport electricity from large central station power plants to end-use customers. But with rapid growth of distributed energy resources, such as solar, resulting from falling costs and technological advances, customers are increasingly taking charge of their own energy. These resources offer the promise of a more innovative, economic, and cleaner electric grid.

In recognition of the growing role, value, and opportunity of distributed energy resources, a number of states across the country are looking at how distribution system planning, operations, and investment must change. This paper series examines the potential changes being considered and the opportunities for solar and other distributed energy resources.

This paper is the third in SEIA's series on grid modernization and focuses on improving interconnection with hosting capacity analyses. As with the rest of the papers in this series, the experiences of two leading states, California and New York, are examined.

ABOUT THIS WHITEPAPER SERIES

This series of SEIA policy briefs takes an in-depth look at state-level efforts to modernize the electric utility grid. Built during the last century, the United States electric grid was primarily designed to transport electricity from central station power plants to end-use customers. But with rapid growth of distributed energy resources such as solar, customers are increasingly taking charge of their own energy. Today's electric grid must allow distributed energy technologies to flourish and provide reliable, low-cost power for consumers. Distributed energy resources, like solar, can also provide power where it is needed most and help avoid investments that a utility would otherwise need to make.

This series explores the elements of electric grid modernization, compares the ways in which two leading states are tackling these issues, and discusses how these efforts are creating new opportunities for solar power. Grid modernization efforts in states present significant risks and opportunities for solar. These efforts will determine how much new solar and other distributed energy resources can interconnect to the grid, identify areas where solar can provide grid services in lieu of utility investments, and in some states, will shape the future of net energy metering.

WHAT IS HOSTING CAPACITY?

One concept that has garnered considerable attention is the idea of developing better assessments of DER "hosting capacity" as part of the planning process. Hosting capacity is the amount of DERs that the electric distribution system can reliably accommodate without significant grid upgrades.[1] In conducting a thorough hosting capacity analysis, utilities consider voltage/power quality constraints, thermal constraints, protection limits, safety, and overall reliability to arrive at a capacity (kW, MW) of new generation or load which can be accommodated at a specific location on a distribution circuit.

Hosting capacity depends heavily on location. It is unique to specific feeders and is time varying. Given that customer needs are always changing, a hosting capacity analysis conducted today may yield different results than an analysis prepared five years from now. In general, carefully crafted hosting capacity analysis can give DER developers insight into where on the grid DERs can interconnect and potentially, on a forecast basis, where utility upgrades may be needed in anticipation of DER growth.

RULES OF THUMB NO LONGER WORK FOR INTERCONNECTION

Historically, general "rules of thumb" have been used to provide a preliminary estimation of available capacity for interconnecting new distributed generation. These conservative approximations often act as a significant and unnecessary barrier to many projects. These rules of thumb include generation as a percentage of peak load on a circuit or a percentage of minimum daily load. For example, since the late 1990s California's interconnection procedures for small generators (Rule 21) has established a threshold for supplemental interconnection review of 15% of peak demand. If the total installed distributed generation capacity on a line segment exceeds 15% of the line section peak annual load, further analysis must be undertaken before the project is approved. This standard has become common around the United States.

As an alternative rule of thumb, a percentage of minimum daytime load has often been used as a threshold, since the minimum load during the time when solar is producing is most relevant to whether the generation will cause challenges for the distribution system by producing energy flows back towards the substation.

Both installed capacity as a percentage of peak load or minimum daily load are inaccurate. Indeed, research from the Sandia National Labs have found no correlation between peak load and hosting capacity.[2] Instead, accurate hosting capacity analysis requires that the characteristics of an individual line segment in a distribution system are assessed to ensure that a potential solar generator or other distributed energy resources, such as combined heat and power generator or electric vehicle charging, do not result in violations of power quality/voltage, safety, protection, thermal or safety/reliability limits.

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[1] New York State Public Service Commission, "Order on Distributed System Implementation Plan Filings" at 10, March 9, 2017, available at: http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={F67F8860-0BD8-4D0F-80E7-A8F10563BBA2}

[2] Matthew Reno and Robert Broderick, "Statistical Analysis of Feeder and Locational PV Hosting Capacity for 216 Feeders", Sandia National Laboratories http://energy.sandia.gov/wp-content/uploads/dlm_uploads/2016/06/SAND2015-9712C_PES_GM-HostingCapacities.pdf

HOSTING CAPACITY ANALYSIS: REDUCING UNCERTAINTY AND INCREASING SPEED BY GETTING BEYOND RULES OF THUMB

The process of interconnecting a solar system requires assurances that the operation of the system will not impair the safe, reliable functioning of the distribution and transmission system. For larger DERs, this requires engineering studies which take significant time and can add substantial, and potentially unnecessary, expenses for project developers to upgrade the distribution system to accommodate the connecting DER.

Currently, when generators fail certain tests in the interconnection process they must undergo an interconnection study process. These tests often include the previously mentioned rule of thumb limits as an initial screen. In the subsequent interconnection study process, power flow modeling is performed by utility engineers to ensure that the generator will not violate any of the limits to power quality, safety, etc. In many cases the generator may fail the initial "rule of thumb" screens but ultimately learn that the distribution grid can easily accommodate their generator. However, even when this happens substantial costs are borne by the developer and customer in foregone bill savings and costs associated with project development delays. In some cases, large distribution grid upgrades can be identified which make the project uneconomical. News of these costs come after the solar company has invested substantial cost in acquiring the customer and designing the project.

A hosting capacity analysis uses the engineer's tools proactively to determine an amount of capacity that can be interconnected on any individual line segment. By using these power modeling tools to generate hosting capacity we can replace rules-of-thumb, like minimum daily load, and improve the interconnection process. Indeed, as we have shown, work is underway in several states to generate maps which have up-to-date amounts (in megawatts) of available integration hosting capacity.

Case Study: Rule-of-Thumb Hosting Limits Shut Down Hawaii

In 2013, Hawaii Electric Company (HECO) placed a moratorium on new solar interconnections on line segments where solar capacity exceeded 120% of minimum daily load. Following testing by the National Renewable Energy Laboratory, in collaboration with SolarCity and HECO, the limit was raised to 250% of minimum daily load with new systems required to install smart inverters. The market was able to reopen but only after a severe interruption based on an overly conservative rule-of-thumb interconnection test.

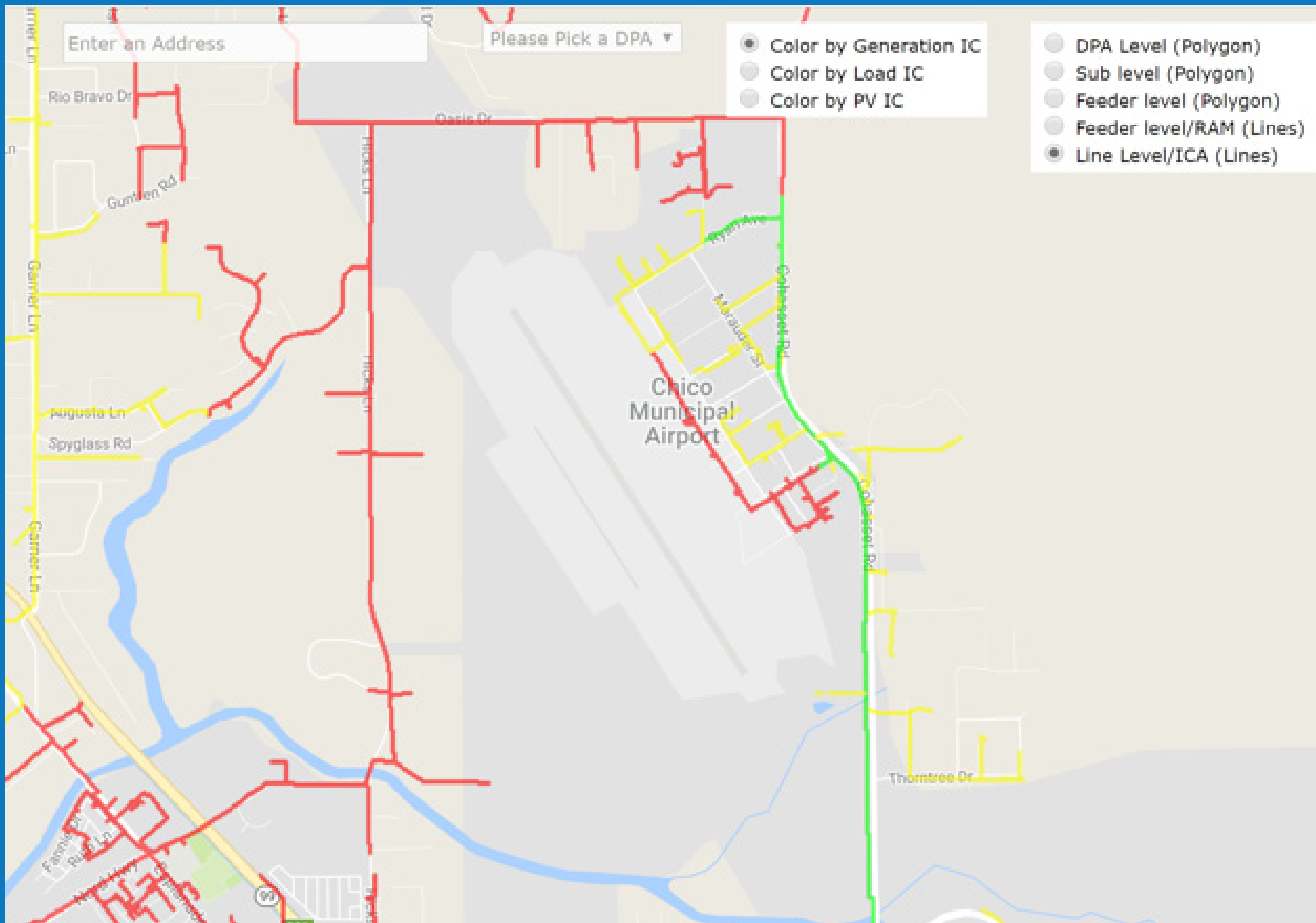

Figure 1: Snapshot of Pacific Gas & Electric Hosting Capacity Map[3]

NEW OPPORTUNITIES CREATED BY HOSTING CAPACITY

Hosting capacity analysis creates new opportunities for greater cost certainty and speed in interconnection. Hosting capacity analysis could also help developers plan their sales to avoid trying to interconnect in areas where hosting capacity is limited. However, hosting capacity also creates opportunities for identifying creative solutions for integrating a DER system that may not otherwise fit within available hosting capacity. Currently accommodating a distributed solar system while avoiding distribution system upgrades may be possible through a back-and-forth discussion between the developer and utility engineers modeling the distribution grid, but that is a drawn out process that leads to project delays. By providing a granular understanding of hosting capacity analysis - which hours are challenging and what conditions, such as voltage, are limitations - project developers can provide solutions to address that limitation without utility upgrades.

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[3] Pacific Gas & Electric hosting capacity map, available at https://www.pge.com/b2b/energysupply/wholesaleelectricsuppliersolicitation/PVRFO/DemoAMap/DemoA.html

A. Leveraging the Capabilities of Smart Inverters

Historically, inverters have had the humble role of converting direct current from solar systems into alternating current which could be distributed within a building or exported back to the distribution grid. However, the evolution of smart inverter technology and standards are increasing their capability. Starting in September 2017, all new solar systems applying for interconnection in California will need to have inverters enabled to provide some relatively basic grid support functions that inverters can do autonomously, including the ability to "ride-through" voltage and frequency disturbances rather than tripping off as current inverters do.[4] These rules will soon become standard features of interconnection in more states around the country as the IEEE 1547 interconnection standard is updated.

The updated IEEE standard is expected, by the end of the year, to require providing reactive power when voltage conditions go outside of an acceptable range. This new requirement in the standard should expand hosting capacity in all locations where inverter-based distributed energy resources are installed. Figure 2 below from the Electric Power Research Institute shows how Volt/VAR control can enhance hosting capacity.

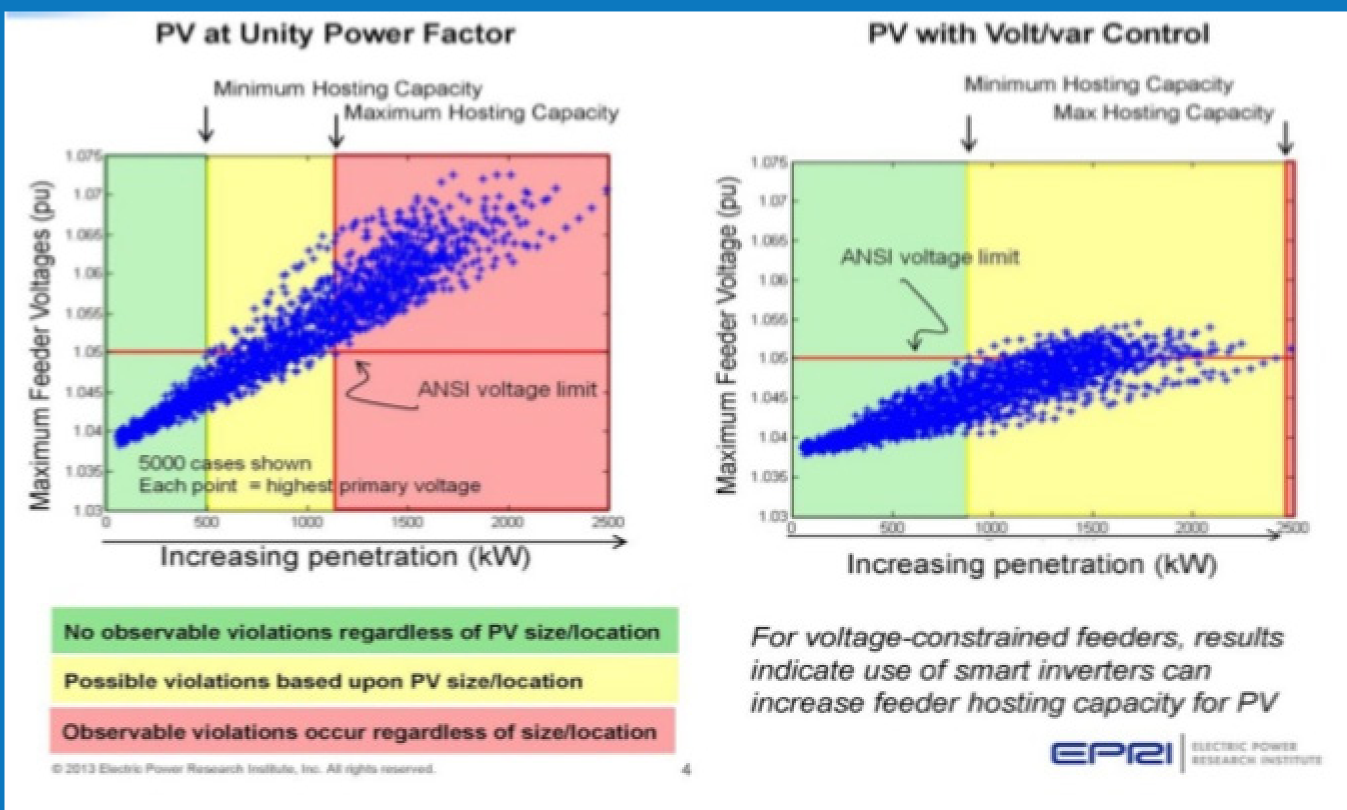

Figure 2: Improving Hosting Capacity Through Inverters (Volt/VAR control)[5]

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[4] Hawaii has adopted similar rules. Rule 14H

[5] Electric Power Research Institute as presented in May 6th, 2016 Presentation by Rachel Peterson, Advisor to California Public Utilities Commissioner Michael Florio, available at: https://www.slideshare.net/sandiaecis/wl-1cpuc-for-epri-sandia-modeling-workshop-6-may-2014

B. Enhancing Hosting Capacity Through Storage and System Configuration

In the past, interconnection studies would make limiting assumptions about system operations. For example, maximum potential solar production from a system might be compared to minimum daily load which occurs during spring or fall months when solar production is reduced. Knowing that minimum limitation, such as voltage on low-load days in shoulder months, could allow for a developer to modify their project to avoid distribution upgrades. For example, inverter settings could be set to limit real power output during these shoulder months or battery storage could be added to a solar system to avoid exports at these problematic hours. In California, the utilities have created "agnostic" hosting capacity curves which can allow for a myriad of project generation or load curves, better reflecting different DER configurations (e.g., solar plus storage) and providing for creative solutions to interconnecting projects where there are hosting capacity limitations.

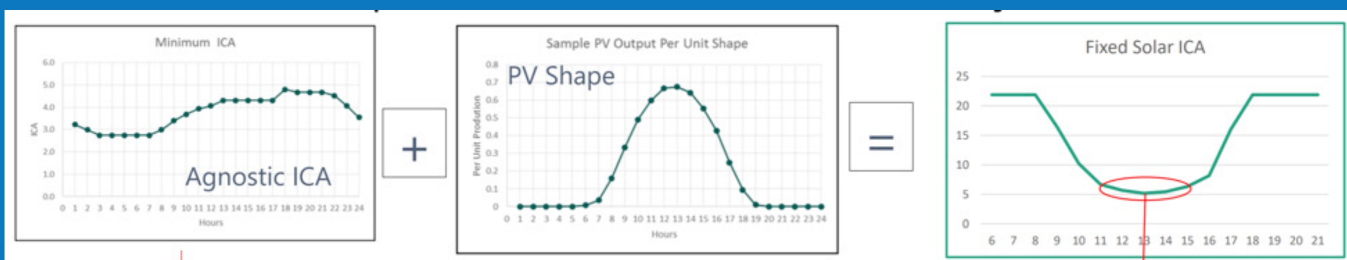

Figure 3: Identifying Hosting Capacity[6]

THE INTEGRATION CAPACITY ANALYSIS: HOSTING CAPACITY IN CALIFORNIA

California's IOUs are recognized for having some of the fastest interconnection processes in the country, largely as a result of automating interconnection application processes. However, larger projects can be delayed based on interconnection screens. California's interconnection process, Rule 21, includes rule-of-thumb limits in its Fastrak interconnection process. Often projects will fail these screens and have to undergo an interconnection study. In order to limit uncertainty for the developers, a 2016 Commission decision (D.16-06-052) created a requirement for upgrades which might be identified and bounded the costs which developers would ultimately need to pay if costs exceeded those limits.

Simultaneous to the Commission's efforts to bound the costs of unexpected results from interconnection studies, the Commission and utilities have been working on hosting capacity analyses (known as "Integration Capacity Analyses" or "ICA"). California's three largest utilities completed ICA pilots at the end of 2016 and are currently working with a working group to refine their methodology.

[6] Figure from Joint Utility presentation at Distribution Resources Planning Working Group meeting July 7, 2017, available at: http://drpwg.org/wp-content/uploads/2016/07/07.07.17-ICA-LNBA-WG-presentation-deck.pdf

The Commission is expected to adopt the ICA this year and has opened a proceeding to revise the interconnection process.[7] The ICA should allow for the replacement of several screens in the fast track interconnection process and hopefully allow for creative project design opportunities to avoid distribution upgrades where there may be a lack of hosting capacity.

NEW YORK: A FOUR STAGE PROCESS TO DEVELOP HOSTING CAPACITY MAPS

In New York, the Public Service Commission (PSC) approved a four-stage process for improving hosting capacity analysis. While there is still significant work to be done to implement this process, the four phases are as follows:

- Stage 1: Use of Red Zone maps to identify the layout of overhead circuits and indicated whether the interconnection of certain sized DG would have a higher or lower cost;
- Stage 2: Calculate hosting capacities using the Distribution Resource Integration and Value Estimation (DRIVE) tool developed by the Electric Power Research Institute (EPRI). This tool is based on circuit models and therefore requires circuit analyses.
- Stage 3: Development of "heat" maps that represent capacity ranges using color schemes consistent across utilities. The hosting capacity ranges will be based on the circuit characteristics and will provide information about currently interconnected DERs, as well as DERs in the interconnection queue. The data will be updated regularly by the utilities.
- Stage 4: Hosting capacity data to be further refined at more granular levels, such as incorporating host capacity data on the sub-feeder level and the locational value that interconnection of DERs would have on a particular feeder and/or substation.

Finally, the utilities have proposed ways in which hosting capacity can be increased by resolving voltage, thermal, and protection violations that limit additional DERs from interconnecting. Solutions include grid-side measures, operational measures, and customer-sided solutions. While questions remain about the New York utilities' ability to meet the timeframes required by the PSC for completing these analyses, the Commission's recognition that new processes must be put in place for determining an accurate hosting capacity is a small step in the right direction.

CONCLUSION

As distributed energy resources proliferate, ensuring that interconnection delays and costs do not stymie their deployment is critical. Improved utility distribution system planning tools and processes allow for an accurate assessment of how much new distributed energy resource capacity can be interconnected at any point in the distribution grid. As leading states are close to implementing hosting capacity analyses system wide we should begin to see the benefits in those states and have lessons for other states to follow.

[7] California Public Utilities Commission, Order Instituting Rulemaking to Consider Streamlining Interconnection of Distributed Energy Resources and Improvements to Rule 21, Rulemaking 17-07-007 https://apps.cpuc.ca.gov/apex/f?p=401:56:0::NO

Solar Energy Industries Association®
600 14th Street, NW | Suite 400
Washington, DC 20005
(202) 682-0556

WWW.SEIA.ORG

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