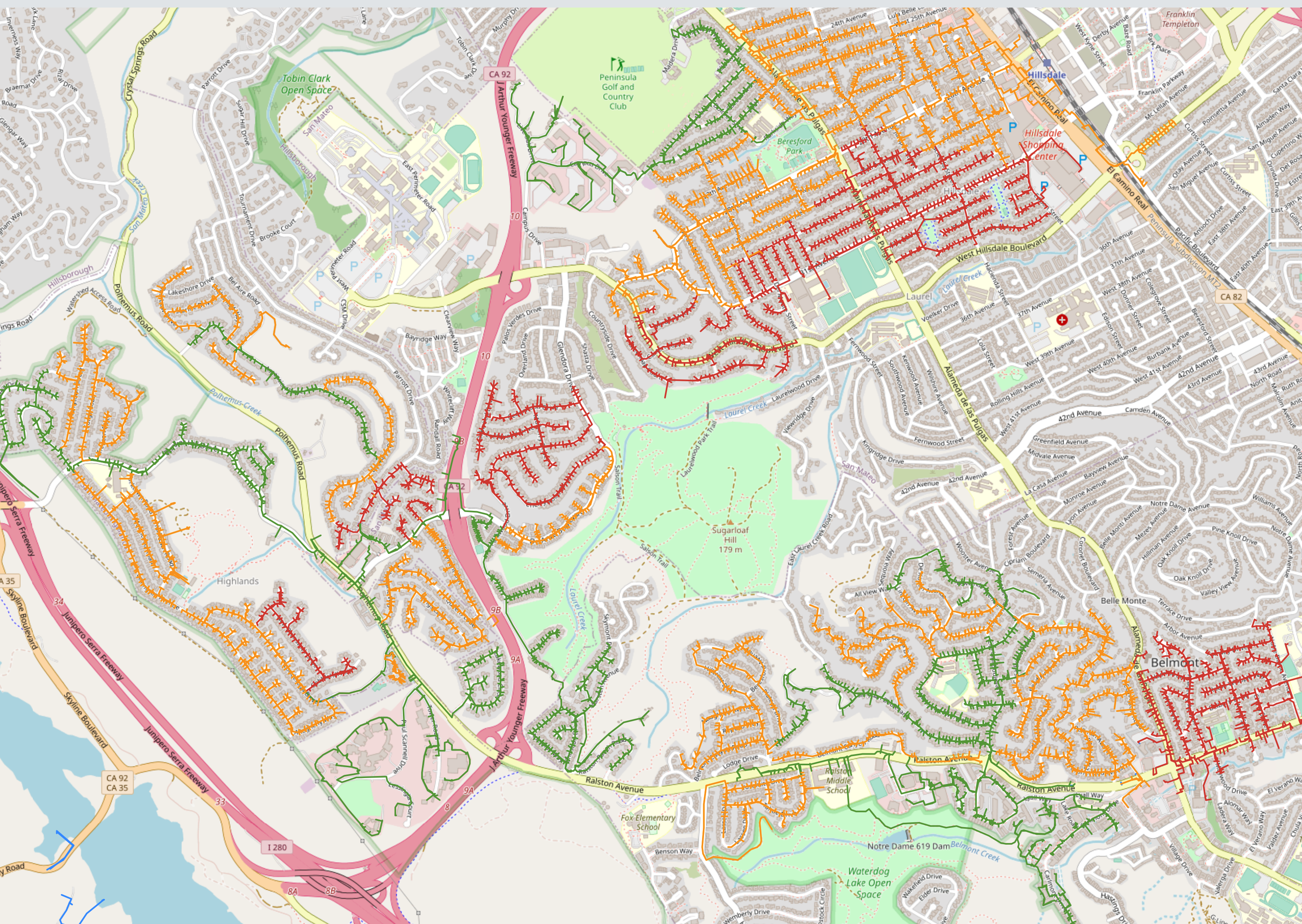
Data Validation for Hosting Capacity Analyses

EXECUTIVE SUMMARY



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Preface

This report was authored by the National Renewable Energy Laboratory (NREL) and the Interstate Renewable Energy Council, Inc. (IREC).

NREL is a national laboratory of the U.S. Department of Energy (DOE) that specializes in the research and development of renewable energy sources, such as solar, wind, water, and geothermal. NREL is a lead in developing the future of sustainable and integrated energy systems with researchers who harness the power of data and high-performance computing, integrated testing and who focus on integrated solutions, delivering grid modernization and security. NREL has decades of experience providing leadership and novel research in distribution system analyses and planning. The research team that supported this project consisted of subject matter experts on the topic of hosting capacity analysis and has experience exceeding a decade. NREL regularly performs power flow analyses for various purposes, including analyses to further its research on advanced hosting capacity analyses and as a service to distribution utilities.[1]

IREC builds the foundation for rapid adoption of clean energy and energy efficiency to benefit people, the economy, and our planet. Its vision is a 100% clean energy future that is reliable, resilient, and equitable. IREC develops and advances the regulatory reforms, technical standards, and workforce solutions needed to enable the streamlined integration of clean, distributed energy resources. IREC has been trusted for its independent clean energy expertise for nearly 40 years, since its founding in 1982. IREC's Regulatory Team has been involved in numerous regulatory dockets and research projects associated with the development of distribution system plans and Hosting Capacity Analyses (HCAs).[2] IREC has published two papers and multiple in-depth blog posts about HCA design, which are available at: https://irecusa.org/our-work/hosting-capacity-analysis/.

[1] For more information, see "Advanced Hosting Capacity Analysis," NREL, https://www.nrel.gov/solar/market-research-analysis/advanced-hosting-capacity-analysis.html.

[2] CA Pub. Util. Comm., Dkt. R.14-08-013, Distribution Resources Plans; CA Pub. Util. Comm., Dkt. R.21-06-017, Rulemaking to Modernize the Electric Grid for a High Distributed Energy Resources Future; NV Pub. Util. Comm., Dkt. 17-08022, Rulemaking to Implement Senate Bill 146 (2017); NY Pub. Service Comm., Dkt. 14-M-0101, Reforming the Energy Vision; NY Pub. Service Comm., Dkt. 16-M-0411, Distributed System Implementation Plans; MN Pub. Util. Comm., Dkt. E999/CI-15- 556, Investigation into Grid Modernization; MN Pub. Util. Comm., Dkt. E002/M-15-962, Xcel Energy Biennial Report on Distribution Grid Modernization; MN Pub. Util. Comm., Dkt. E002/M-17-777, Xcel Energy 2017 Hosting Capacity Study; MN Pub. Util. Comm., Dkt. E002/CI-18-251, Xcel Energy Distribution System Planning; MN Pub. Util. Comm., Dkt. E002/M-18-684, Xcel Energy 2018 Hosting Capacity Study; MN Pub. Util. Comm., Dkt. E002/M-19-685, Xcel Energy 2019 Hosting Capacity Study; MN Pub. Util. Comm., Dkt. E999/CI-20-800, Grid And Customer Security Issues Related to Public Display or Access to Electric Distribution Grid Data; MN Pub. Util. Comm., Dkt. E002/M-20-812, Xcel Energy 2020 Hosting Capacity Analysis.

Executive Summary

Solar generation, energy storage, electric vehicles, and other distributed energy resources (DERs) are arriving on the electric distribution grid in fast-growing numbers, but it is not always clear how much incremental DER capacity the distribution system can accommodate. Clarity about grid capacity is of special importance to utilities, developers, and regulators, as well as customers, who are adding more DERs and require accurate, accessible, and trustworthy information.

Such information can be gathered in a hosting capacity analysis (HCA)—a process used by utilities and regulators in multiple states to determine the available capacity for new DERs without requiring expensive and time-consuming studies or grid upgrades. If performed properly, an HCA can streamline and add transparency to DER planning and interconnection processes.

However, some of the first-published HCAs included inaccurate data. For example, a published HCA result showed a feeder with zero capacity, but after an interconnection application was processed, it turned out the feeder actually could accommodate multiple megawatts. This undermined users' confidence in the HCA and raised doubts that the analysis accurately reflected real-world grid conditions. Without confidence in the HCA, users are unlikely to rely on the data and the HCA cannot fulfill its intended purpose. To improve the quality, accuracy, and trust in HCA data and to avoid the challenges found in early rollouts, the National Renewable Energy Laboratory (NREL) and the Interstate Renewable Energy Council (IREC) provide in this report a suite of best practices for HCA data validation.

Implementing this report's HCA data validation practices can increase trust in the HCA, making the results more useful for DER planning and interconnection processes. **The best practices recommended here could be useful for:**

- **Utilities**, to develop or refine their HCA data validation procedures
- **Regulators**, to inform their oversight of utilities' HCA data validation practices
- **Other stakeholders**, to evaluate the effectiveness of utility efforts.

For this work, NREL and IREC interviewed utilities, software vendors, U.S. Department of Energy national laboratories, regulatory commissions, and solar developers to identify common issues in HCA, and reviewed examples of HCA from utilities around the United States to understand current practices. From these findings, this report identifies both procedural and technical best practices for HCA data validation. Our goal is to reduce barriers and provide utilities, regulators, and all stakeholders with a replicable roadmap to help HCA deployments provide accurate, trustworthy, and reliable results from the day they are published.

At a high level, HCA best practices include:

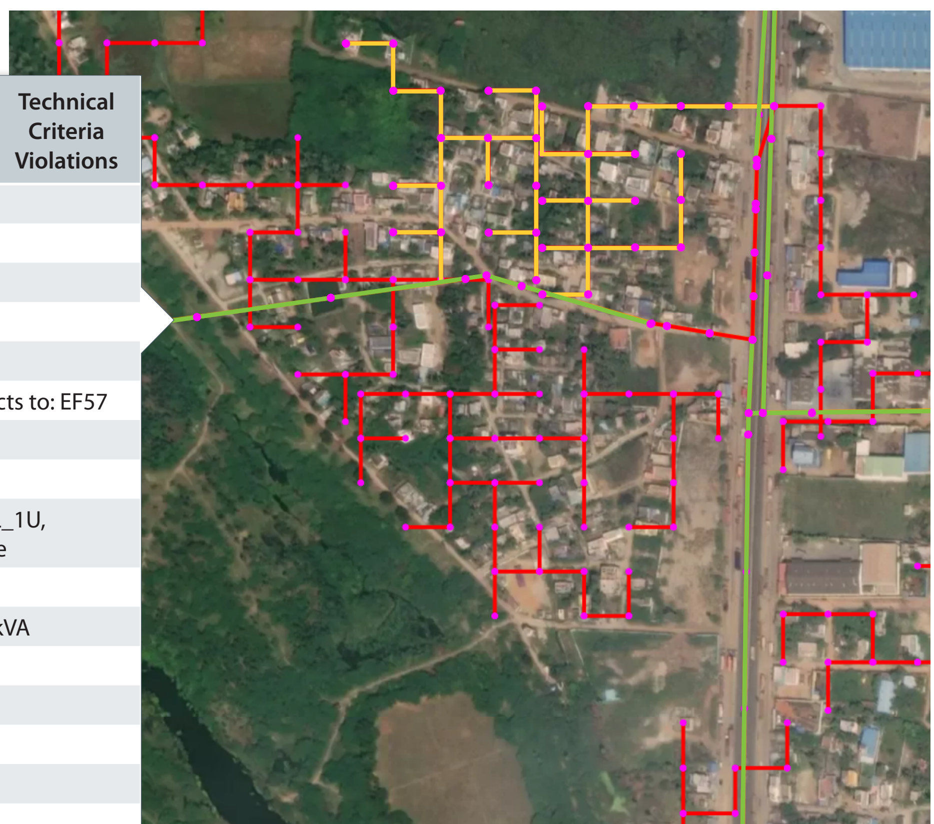
- **An appropriately resourced HCA team** that tracks metrics at each step of the process
- A **well-documented, repeatable process** for data validation, using suitable software to ensure digital feeder models reflect real-world grid conditions
- **Transparent and collaborative information sharing** for feedback and identification of errors.

To start, an HCA requires dedicated attention. Successful HCAs are managed by a specific HCA manager to oversee data validation and ensure their HCA team is well resourced. The role of the manager includes establishing and tracking metrics to assess the quality of HCA data in each step, as well as the quality of final results. The manager also works to ensure that each step of the HCA process functions efficiently altogether.

Effective data validation practices include developing, documenting, and following a standardized approach, so that the HCA team can efficiently identify errors and correct the failures in the thousands of nodes that comprise a typical service area. HCA data can have diverse origins involving different utility departments. HCA processes run most efficiently when errors identified by the HCA team are corrected in the source database, even when a different department is responsible for that database.

An HCA also involves building models of distribution feeders to simulate power flow, which is the most common root cause of errors. This report includes tables with examples of validation procedures for each step in the feeder model building process. It is a best practice

Line Section	Substation	Load Profile	Technical Criteria Violations
Section ID: 148104500			
Hosting Capacity: 5,000 kW			
Feeder ID: 23			
Feeder voltage: 12.47			
Number of phases: 3			
Which substation transformer the feeder connects to: EF57			
Feeder type: radial			
Feeder length: 6.213 miles			
Feeder conductor size and impedance: 1000_AL_1U, R1=0.517416 ohm/mile, X1= 0.267376 ohm/mile			
Service transformer rating: 100kVA			
Service transformer daytime minimum load: 35kVA			
Existing generation (weekly refresh rate): 50 kW			
Queued generation (weekly refresh rate): 20 kW			
Total generation (weekly refresh rate): 70 kW			
Currently scheduled upgrades: No			
Federal or state jurisdiction: State			



HCA map example by NREL

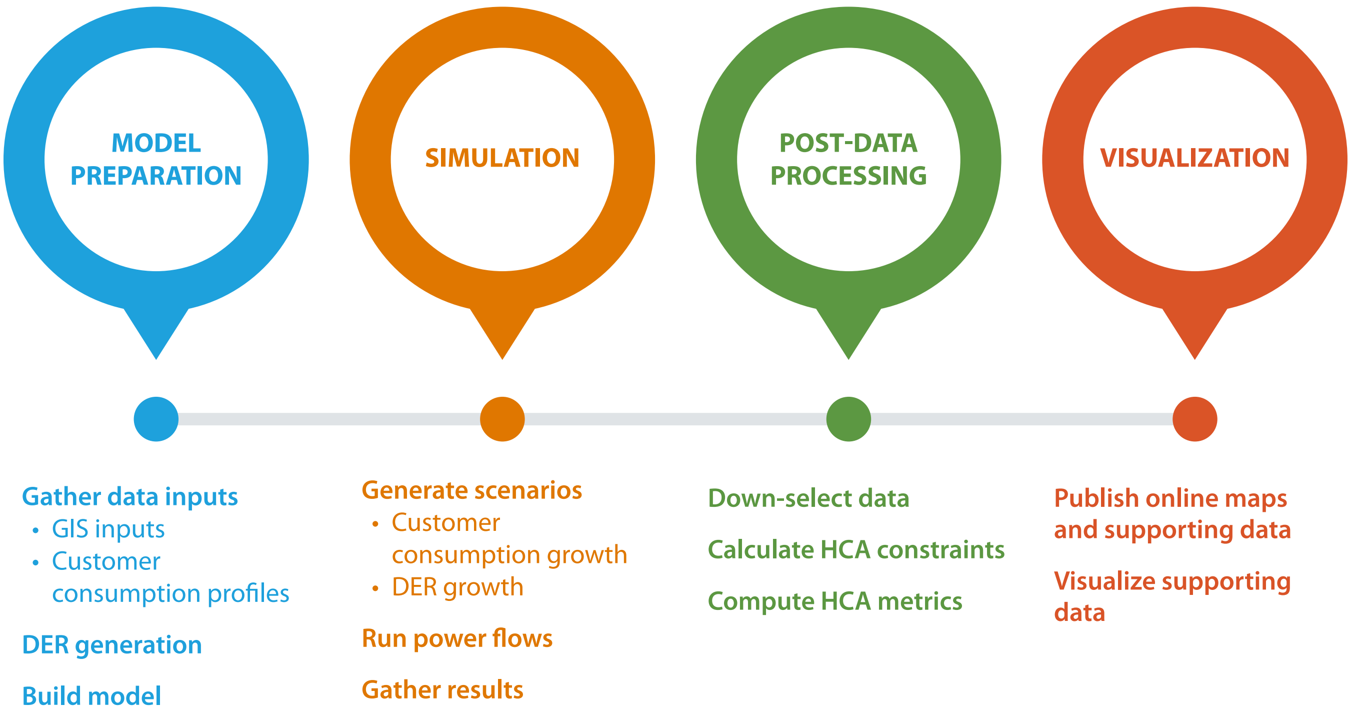


Figure 1. Steps in an HCA. *Illustration by Nicole Leon, NREL*

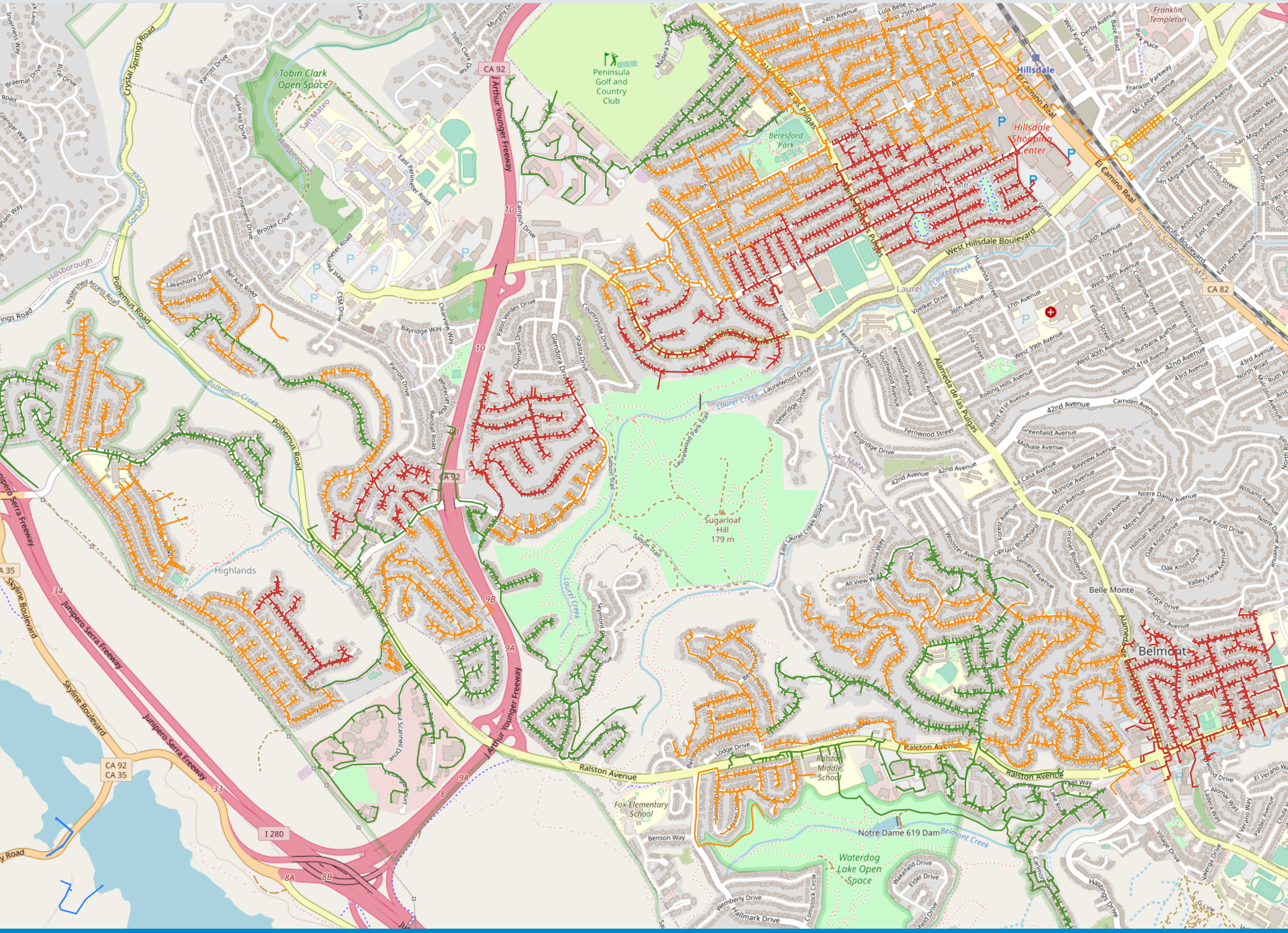
for utilities to standardize and document the steps in the feeder model building and validation process:

- Feeders that experience similar challenges would benefit from **being batched** so that engineers can easily develop solutions to common problems.
- **Scripting** can be used to automate error correction when building feeder models and to significantly accelerate decision making. Code base management tools are effective in preventing and resolving errors because they allow utilities to track the evolution of code and quickly revert to previous versions if needed.
- Using **actual—not estimated—customer consumption data** improves data accuracy. Existing commercial software, versus tools developed in-house, also provides an advantage in managing consumption profiles since they typically include helpful data validation features.
- Instead of attempting to perform the power flow simulations for an entire year and an entire service area at once, we propose examining a **prioritized set of load hours and a representative sample of feeders** first.

To maximize efficiency and effective public oversight, the HCA process can include measures that prioritize transparency and feedback to help catch errors and elevate confidence in HCA results. Suggested measures include a review process to flag irregularities before publication, as well as a mechanism to allow customers and HCA data users to offer feedback about user experience, identified errors, and usefulness of the HCA data.

Likewise, it is a best practice for regulators to provide transparency into the data validation process. This could be done by reviewing and requiring improvements to data validation plans, tracking the quality of HCA results over time with metrics that describe data quality, and requiring a root cause analysis for recurring problems in the HCA process.

The full report is available for download at https://www.nrel.gov/grid/hosting-capacity-analysis-data-validation.html. The report identifies best practices for validation procedures, specific rules for identifying data errors, and suggestions for regulatory oversight. Using these processes, utilities and regulators can provide confidence that HCA results accurately reflect grid conditions. With that confidence, trusted HCA data can be used in modernized DER planning and interconnection processes.



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