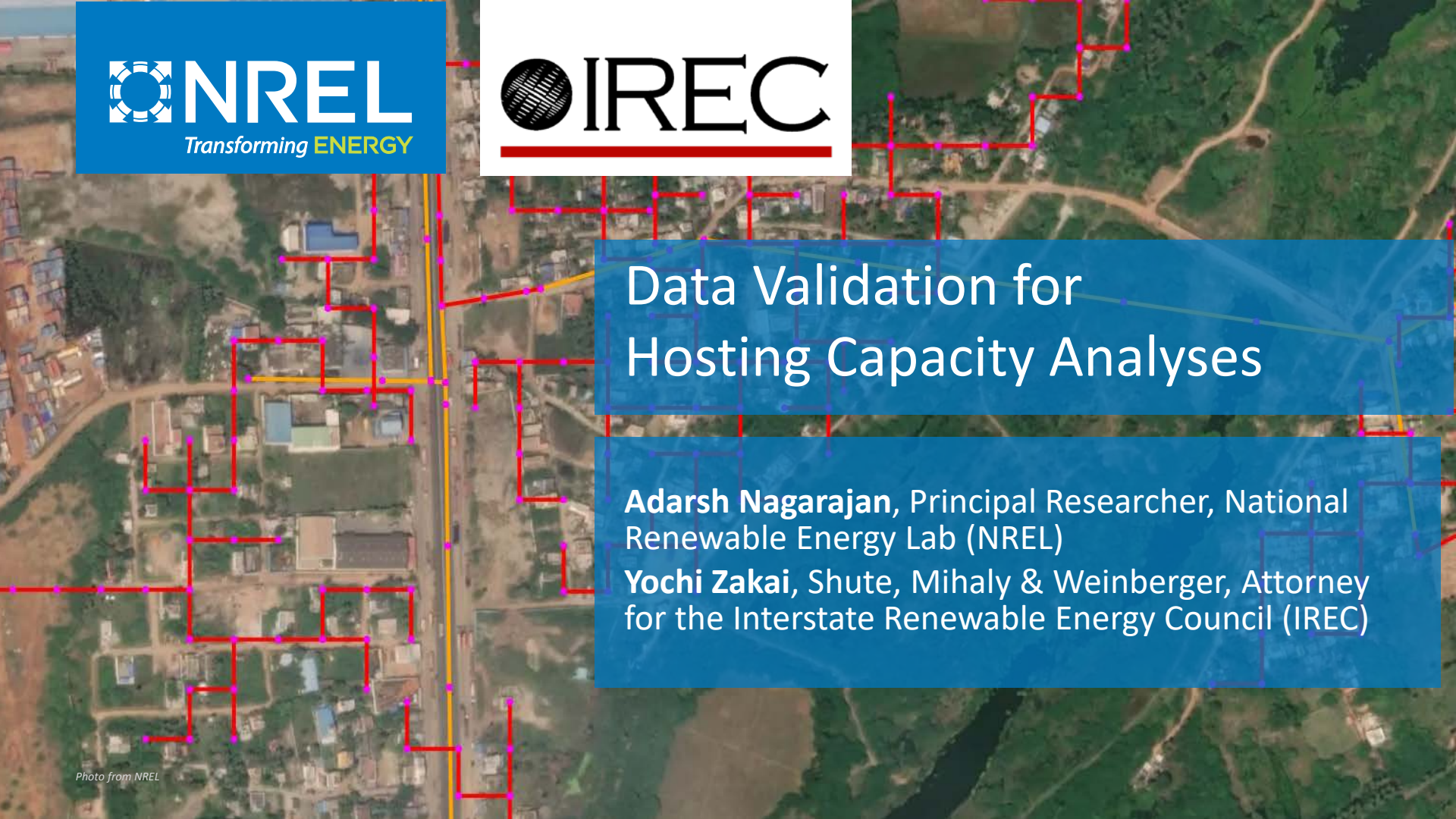

Data Validation for Hosting Capacity Analyses

Adarsh Nagarajan, Principal Researcher, National Renewable Energy Lab (NREL)

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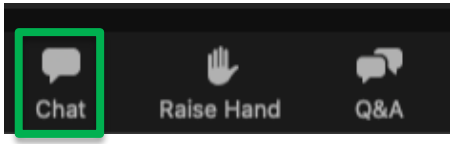
Photo from NREL

Welcome!

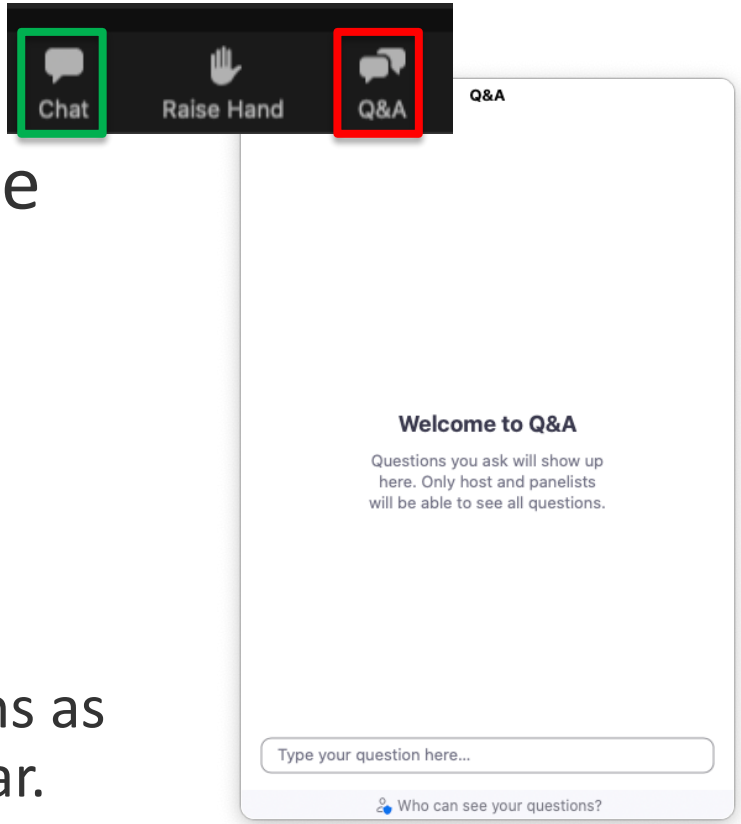
- We invite you to type into the Chat panel your:
  - **Name**
  - **Organization**
  - **Interaction with hosting capacity analyses**



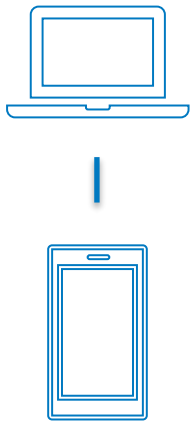
Housekeeping – Q&A

- Technical issues? Message the "Host" using the Chat panel.

- Have a question?
  - Please submit it using the "Q&A" panel.
  - We will answer as many questions as possible at the end of the webinar.



Setup Real-Time Poll via Poll Everywhere



- Go to **pollev.com/nrelwebinars303** in your browser:
  - Link is in the chat!
  - Or text **nrelwebinars303** to **22333**.
- Enter your first and last name.
- Respond to each poll as they appear on your screen.

Agenda

1. Introductions
2. Background and Methodology
3. Business Processes
4. Quality Control During the Feeder Model Development Process
5. Validation of Results Before Publication
6. Customer Feedback and Regulatory Oversight
7. Q&A

Follow-up questionnaire for additional thoughts and feedback

Introductions

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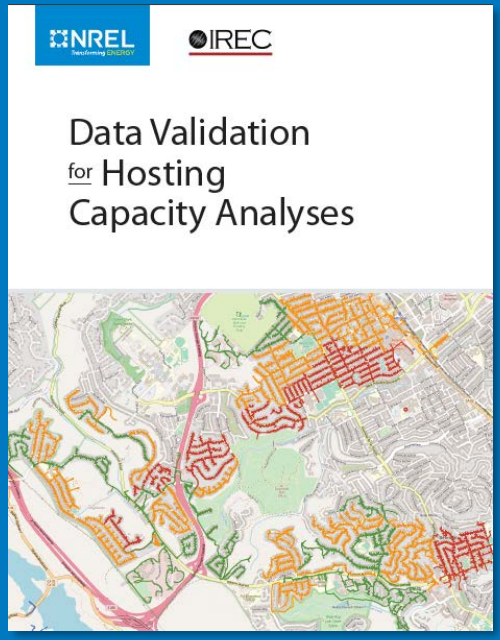
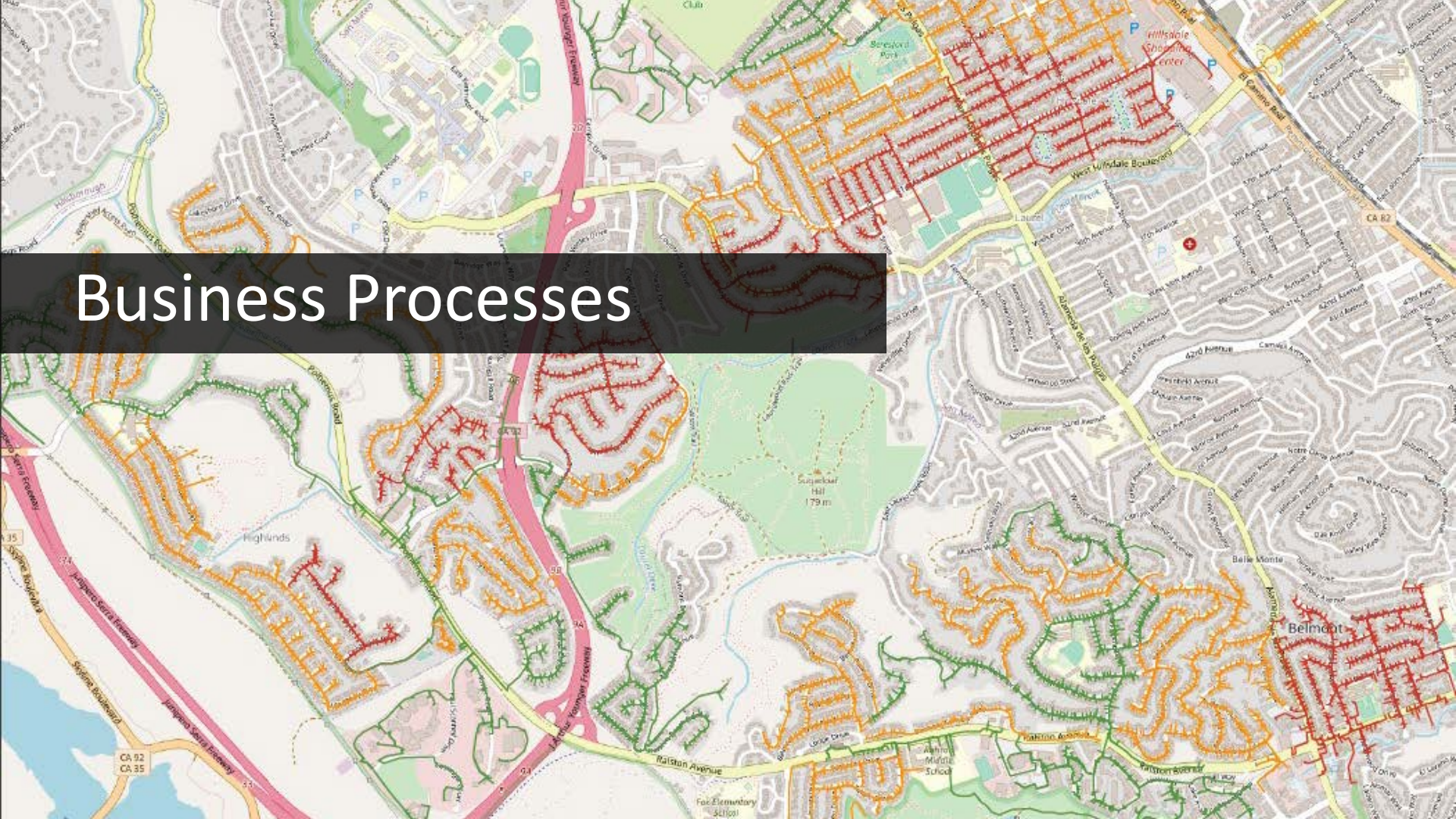
Background and Methodology



Read the full report at
https://bit.ly/HCAValidation

- Our goal is to provide utilities, regulators, and all stakeholders with a **replicable roadmap** to help hosting capacity analysis (HCA) deployments provide **accurate, trustworthy, and reliable results** from the **first day** they are published.
- To understand current practices, NREL and IREC interviewed experts and reviewed available literature.
- Based on this research, the report identifies practices for HCA data validation in five areas:
  - Business processes
  - Quality control during the feeder model development process
  - Validating results before publication
  - Feedback from customers and users
  - Regulatory oversight


Business Processes

Business Processes

Identify an HCA Manager for overseeing and improving the HCA and verification processes.

HCA manager responsibilities would include:

- Standardizing and documenting the HCA process
- Validating results
- Tracking problems and needs for improvement
- Establishing a long-term strategy to improve HCA efficiency and maintain the quality of results

Business Processes

Establish metrics to track the quality of input data and HCA results over time.

- The frequency of errors and issues for each HCA update
- The frequency of each type of failed flag or check for each HCA update
- Whether the team completed its processes in the desired time frame and the HCA update was published on time
- The number of recurring problems in the model building process, and with which source database the problem is associated, if any

POLL

Do you have any additional HCA metrics to add to this list?

When poll is active, respond at **pollev.com/nrelwebinars303**

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Do you have any additional HCA metrics to add to this list?

“ Potential impact on system protection ”

“ Spatiotemporal voltages ”

“ Time to complete each HC ”

“ rate of change of DER deployment ”

Total Results: 5

Business Processes

Fix identified problems in the source database.

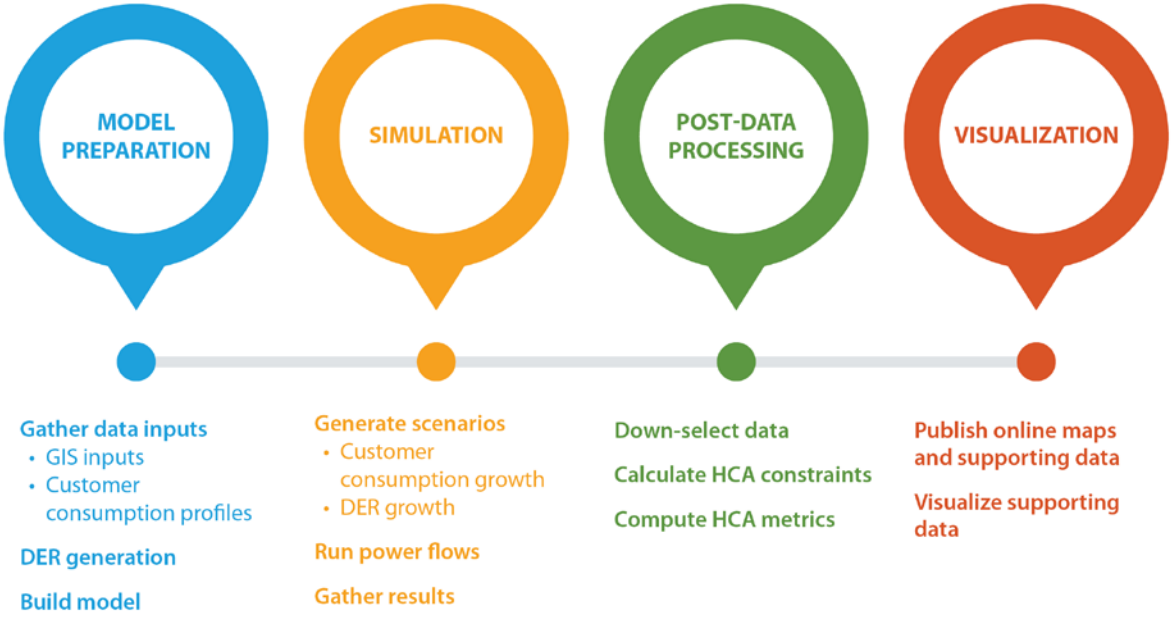
- An error in a source database must be addressed by the HCA team each time they update a feeder model via:
  - manual fixes
  - a script or another automated solution
- HCA managers should follow up with the source database owner to avoid the need to spend resources continually fixing the same problem.

Business Processes

Use appropriate employee and computational resources.

- Skilled and experienced engineers with knowledge of the entire HCA process
- Appropriate computational technologies, such as cloud computing
- At what point does increased automation provide diminishing efficiency returns?

Stages in a Hosting Capacity Analysis



POLL

Which stage of an HCA is the most error-prone?

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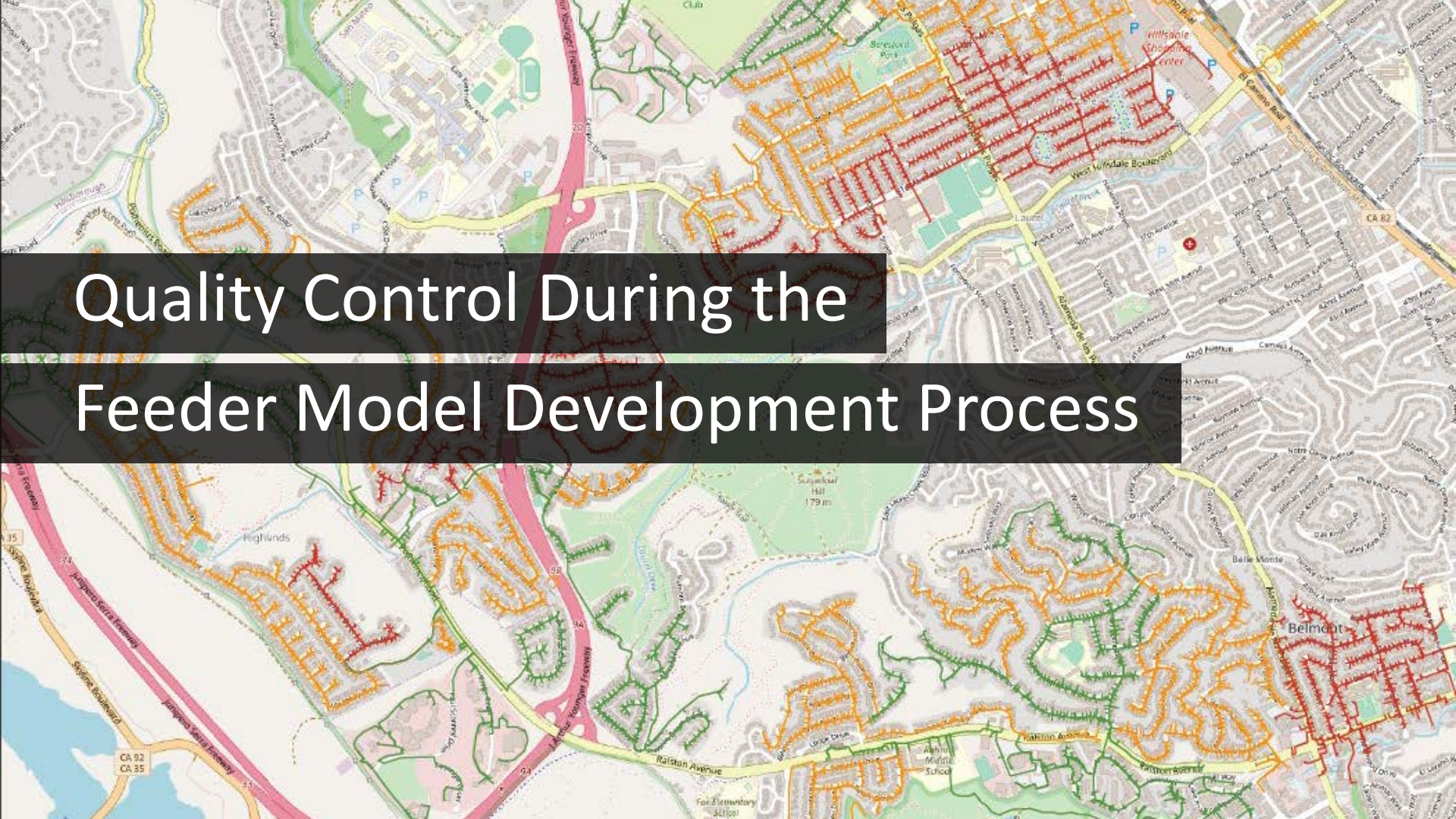
Which stage of an HCA is the most error-prone?



Quality Control During the Feeder Model Development Process

Feeder Model Development

Use of scripts and code base management tools.

- A large portion of generating HCA maps involve software programming.
- **Code base management tools** ensure the HCA team knows who changed the code most recently, can track the evolution of code, and can revert to previous versions if needed.
- Using **central code bases** facilitates better script versioning and reduces misalignment in post-processing.
- Train engineers with needed software development practices.

Feeder Model Development

Create a baseline model and validate its accuracy.

- **Primary purpose**: The baseline feeder model should accurately reflect the physical feeder.
- **Value**: Confirming the accuracy avoids unnecessary work for the HCA team later in the process.

Feeder Model Development

Prioritize the screening process.

- An HCA is an iterative process; expect the first set of power flow simulation scenarios to produce numerous errors.
- **Examine a prioritized set of load hours and representative sample feeders to begin:**
  - critical load hours:
    - summer peak and summer minimum
    - winter peak and winter minimum
    - summer daytime peak and summer daytime minimum
    - winter daytime peak and winter daytime minimum
- Identified errors can then be fixed throughout the system to minimize manual intervention.

Recommended Attributes to Look for

Baseline model validation checks

Validation Checks	Validation Procedure
Voltage base	Check whether the feeder head voltage matches the real-world value.
Voltage at nodes	Check for nodal voltage violations at peak load allocation and minimum load allocation.
Loading check	Check for device overloads including transformers and conductor thermal ratings.
Equipment default settings	Check the settings of transformers, capacitors, and regulators in the model to ensure they match the settings of this equipment in the field. If the utility changes settings seasonally, check the model to reflect this seasonal change.
Short circuits	Check value of fault duty (i.e., the maximum current) on each node.
Circuit reactive power	Check the power factor at the feeder head at peak and minimum load.
Circuit losses	Check aggregate active power losses and check power losses as a percentage of load served at the feeder head.
Aggregate active power	Check whether the aggregate active power consumption at the feeder head matches the allocated peak load.

Feeder Model Development

Develop, document, and follow a standardized approach to resolving errors.

- **An organized approach** to identifying and resolving problems with feeder models will *speed up the HCA process* and *avoid human errors*.
- **Develop a tracking tool** to monitor which and how many circuits have passed, produced warnings, or failed each milestone in the HCA process.
- After identifying feeders with errors, **batch feeders with similar challenges** to allow engineers to develop efficient, systematic, and repeatable solutions to common problems.

Example Tracking Tool

The data produced by this tracking tool can be used to create metrics that allow the HCA manager to monitor the team's progress.

Statuses distribution engineers can use to batch distribution circuits for batch processing:

Status	Description
Completed	The circuit has successfully passed the stage.
Failed	A problem occurred that was serious enough to stop the workflow.
Completed with errors	Indicates an engineer should review the circuit results because the software raised a warning flag.
Stopped	A user chooses to stop a circuit.
In progress	Analysis is actively running.

Feeder Model Development

Develop, document, and follow a standardized approach to resolving errors.

- To streamline the root cause analysis of failures, it is important to document the procedures used to verify four categories of data:
  1. Topology
  2. Equipment
  3. Conductor
  4. Customer consumption and generation

Topology Verification

Errors stemming from incorrect geographical information should be corrected in both the feeder model and the source GIS database.

Topology validation procedures:

Validation Check	Validation Procedure
Unintentional islands	Check for the presence of a cluster of nodes with voltages close to zero. This occurrence may indicate the presence of an unintentional island.
Unintentional meshes	Check for meshes in the feeder. Some radial feeders may erroneously mesh due to incorrect switching states. Erroneous meshes will produce incorrect hosting capacity limits.
Incorrect phase loadings	Checking for incorrect phase loadings is not always straightforward. One possible way is to check voltages at nodes during peak load. Incorrect phase loadings are often caused by errors in GIS data, phasing information, or loads.
Incorrect feeder switching states	Check if switch states match field data. If a switch is modeled in the incorrect position, the topology of the feeder model is also likely incorrect.
Incorrect phases for voltage correction equipment	Check the phasing of this equipment matches its placement in the real world. Voltage correction equipment such as regulators or capacitors can be single-phase equipment.
Location of existing DERs	Check whether the model places existing DERs on the correct feeder and in the correct phase.

Equipment Verification

For an HCA, regulating devices—including transformers, capacitors, and regulators—should be considered at their full operation range.

Equipment validation procedures:

Equipment to Check	Typical Issues Associated with Equipment
Substation data for default settings	Substation equipment with default setting (e.g., switches, regulators, reactors, and load tap changing transformers) need to be verified.
Substation regulator or load tap changer	This device sets the voltage of the feeder head and changes the voltage depending on time and the load it is serving. Incorrect voltage step band, time delays, and ratings need to be checked.
Line regulators	Line regulators should be checked for voltage band, time delays, phase, and control modes. With reverse power flows, control modes available in physical device may not have a match in the software.
Capacitors	Capacitors should be checked for kVAr ratings, voltage triggers, time delays, phase, control modes, and seasonal variations.

Conductor Verification

A trained distribution engineer is helpful to take on the challenge of automating the verification of conductor types to produce a correct reactive power mix, correct losses and correct voltage profiles.

Conductor validation procedures:

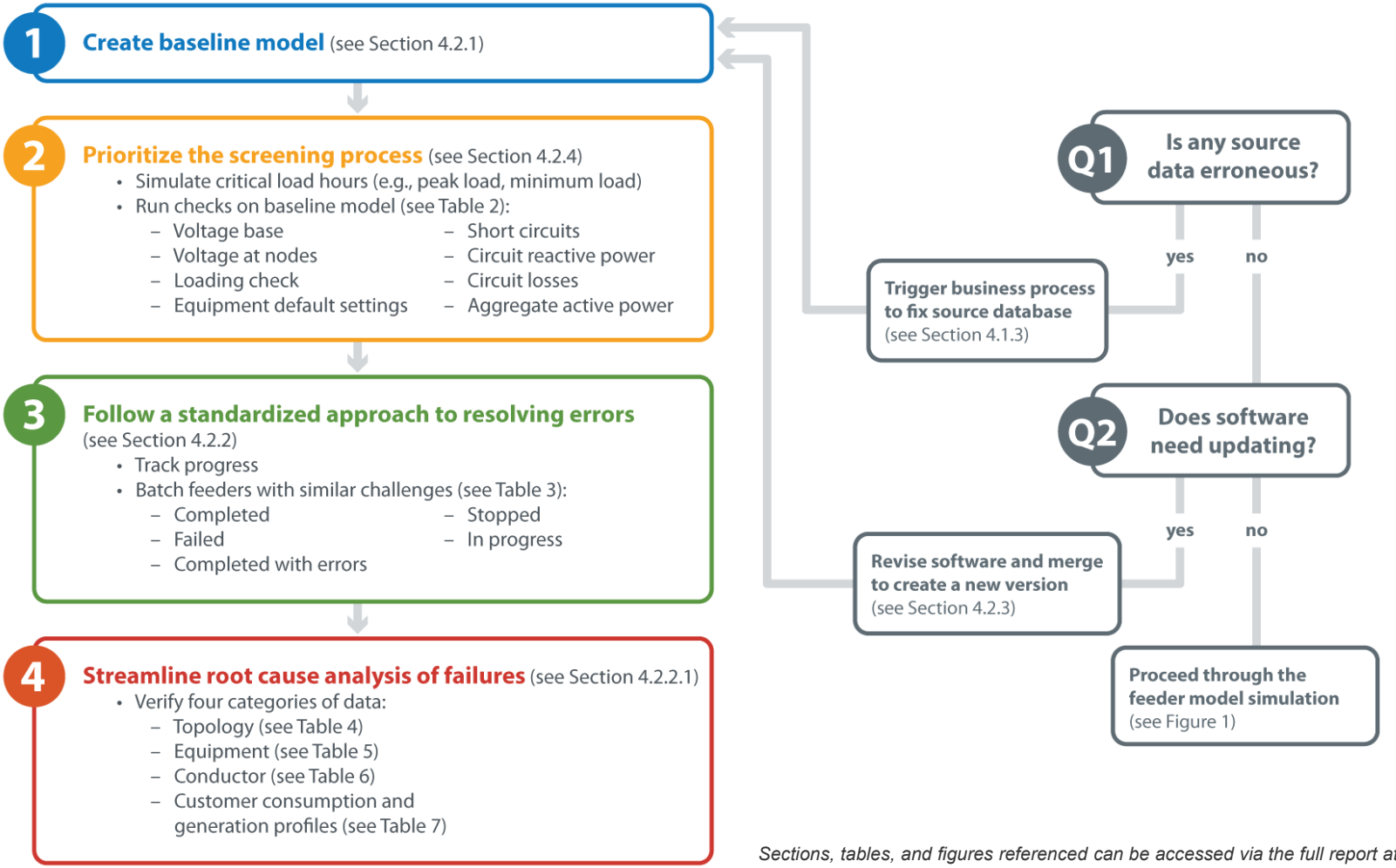
Validation Check	Validation Procedure
Reactive power	Check for the power factor at the feeder head. If a model shows higher or lower VAr or power factor at the feeder head, conductor inductance or capacitance may need validation. This may also mean incorrect power factor allocate for each load as well.
Circuit losses	Check for aggregate power losses of the feeder. Suppose these values are higher or lower than expected and validate line resistances.
Voltage drops at peak load	Check for voltage drop per mile for peak load allocation; higher or lower voltage drops for peak load allocation should indicate higher or lower circuit losses.
Short circuit currents	Check for short circuit currents; higher or lower short circuit currents at nodes may mean incorrect conductor impedances.

Customer Consumption (Load) and Generation Profile Verification

- 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.

Customer consumption and generation profile validation procedures:

Validation Check	Validation Procedure
Reactive power allocation	Check whether the load power factor matches the customer class. Each customer class (residential, commercial, and industrial) consumes a different amount of reactive power. Utilities may match reactive power consumption to individual customers or typical power factors for each class. Other times utilities allocate a certain power factor to all loads on a feeder irrespective of customer class. Different assumptions can lead to different errors.
Load allocation	Check for accuracy of active power values (kilowatts or megawatts) either as a proportion of aggregate feeder consumption or as individual values. Raw AMI or SCADA load data must be validated and corrected before used in an HCA. For example, load data from abnormal events (e.g., public safety power shutoffs) should be excluded. Typical checks in customer consumption data include, but are not limited to, nonnumerical results, zeros, and blanks.



Sections, tables, and figures referenced can be accessed via the full report at ***https://bit.ly/HCAValidation***


Validation of Results
Before Publication

Pre-Publication Validation

- Establish a process to flag irregularities that will trigger a review before publication.
- Feeder model building process is most commonly the root cause of errors.

Sample list of triggers to validate HCA results before publication:

Validation Check	Validation Procedure
No (null) or invalid results	Check for null or invalid results. Implement rule-based screening for null or invalid results, for example: • Are results present for all hours? • Are more than 20 node-hour results blank (null)? • Does the number of null results increase by more than 5% in the current HCA cycle compared to the previous HCA cycle? • Are results numeric? • Are there any null nodes in the final output map?
Zero hosting capacity available	Check for zero hosting capacity values. Implement rule-based screening of zero hosting capacity sections to identify potentially erroneous results. Trigger based on count of feeders or nodes: Most utilities check all HCA results for false negatives, manually reviewing a feeder model if the results show no hosting capacity remains on the entire feeder or when results for 10% or more nodes equal zero for each study criterion.
Duplicate entries	Check for repeating or duplicate entries. Implement rule-based screening for duplicate entries, for example: • Check for duplicate records in final output map. • Check for duplicate records in network section table. • Check whether the node has the same or repeating result in more than two hours.

Customer Feedback and Regulatory Oversight

Customer Feedback

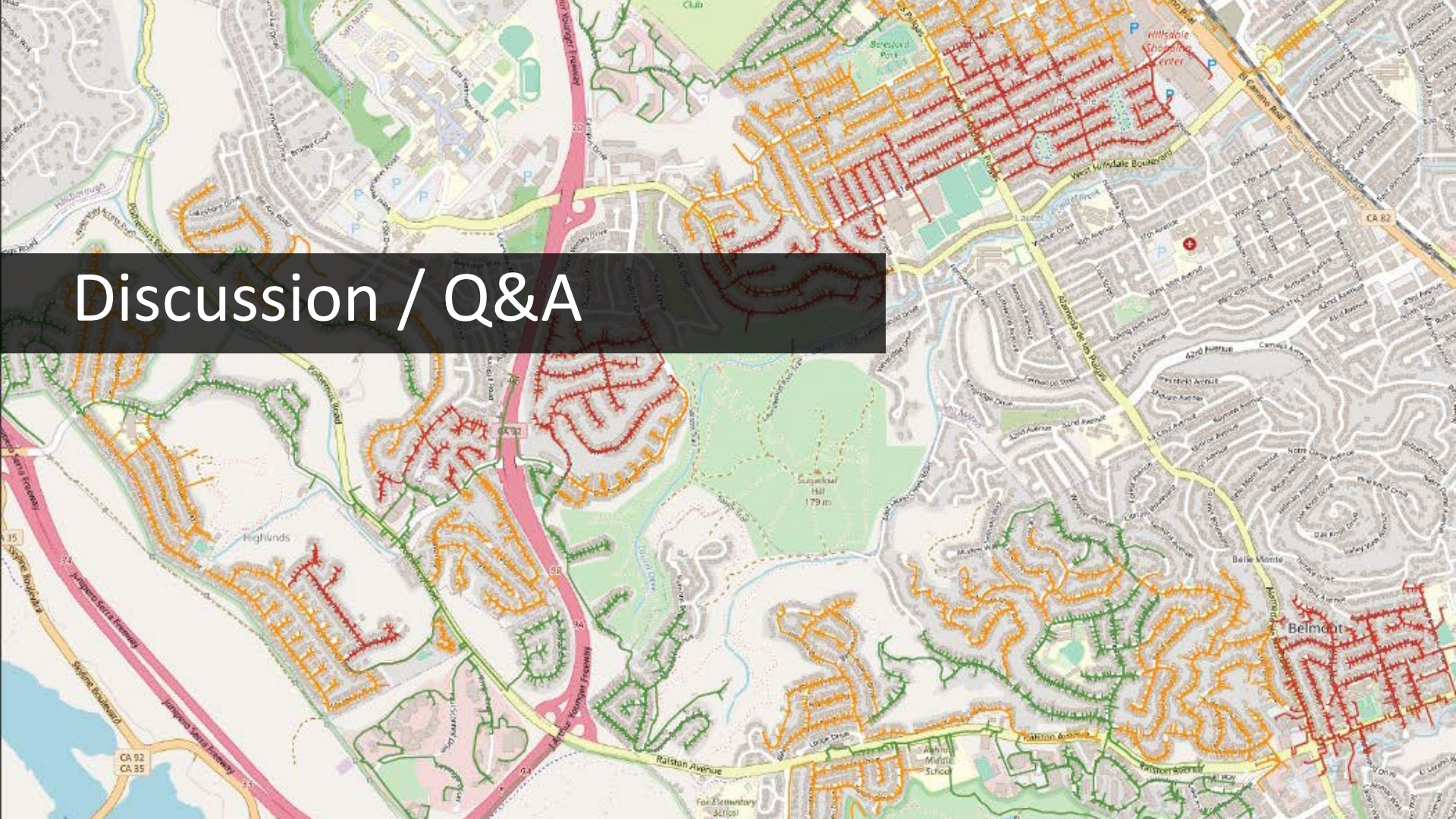
Provide a mechanism to allow customers and HCA data users to provider feedback:

- User experience
- Errors
- Usefulness of the HCA data

Regulatory Oversight

Regulators provide transparency into the data validation process by reviewing and requiring improvements to HCA data validation plans:

- Require written data validation plans
- Require reporting of metrics used to track the quality of HCA results over time


Discussion / Q&A
Highlands
Belle Monte
Belmont
Ralston Avenue
Hillsdale Shopping Center
West Hillsdale Boulevard
El Camino Real
Alameda de las Pulgas
Skyline Boulevard
Junipero Serra Freeway
CA 92
CA 35

Thank you!

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yzakai@smwlaw.com

https://www.nrel.gov/grid/hosting-capacity-analysis-data-validation.html

https://irecusa.org/our-work/hosting-capacity-analysis/

Look out for a follow-up questionnaire from the NREL and IREC teams in the chat!

IREC

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