QUANTA TECHNOLOGY

REPORT

# PG&E Integration Capacity Analysis Data Validation Plan Assessment

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# EXECUTIVE SUMMARY

## Purpose

This Integrated Capacity Analysis (ICA) Data Validation Plan Assessment is submitted as ordered by the California Public Utilities Commission in Rulemaking (R.) 14-08-013 on January 27, 2021. The ruling ordered the investor-owned utilities (IOUs) to retain an independent technical expert within 60 days of the ruling to review their ICA data validation plans and review the IOU's data validation efforts. Quanta Technology was selected as the independent technical expert.

Sixty days after Quanta Technology was selected, the IOUs submitted improved ICA data validation plans that document the results of the IOUs data validation efforts, deficiencies discovered, efficiencies realized in ICA implementation, and plans for ICA improvements.

Within 30 days after the IOUs submitted their data validation plans, Quanta Technology is scheduled to provide a report to the Energy Division's DRP Section at the conclusion of the IOUs ICA data validation plan assessment. The 30th day is scheduled as June 28, 2021.

A report is being submitted for each IOU that includes the following topics:

- Review of the resubmitted, improved data validation plans
- Recommendations on best practices for data validation
- Areas for improvement of the data validation plans
- Sufficiency of the data validation efforts
- Recommendations for additional data verification if required

This assessment is a review of the improved data validation plan submitted by Pacific Gas & Electric (PG&E) in Advice Letter 6212-E. While the assessment does not cover the actual model building, engineering analysis, and post-processing, it does cover the data validation for those processes.

## Methodology

To ensure that the assessments of each IOU's improved data validation plans were balanced and equitable, Quanta Technology developed a reference ICA data validation program structured to align with the ICA process. It also encompasses the program management activities required to sustain a sufficient data validation program along with example activities that should take place at each step of the ICA process. Figure E-1-1 shows the structure of the reference ICA data validation program.

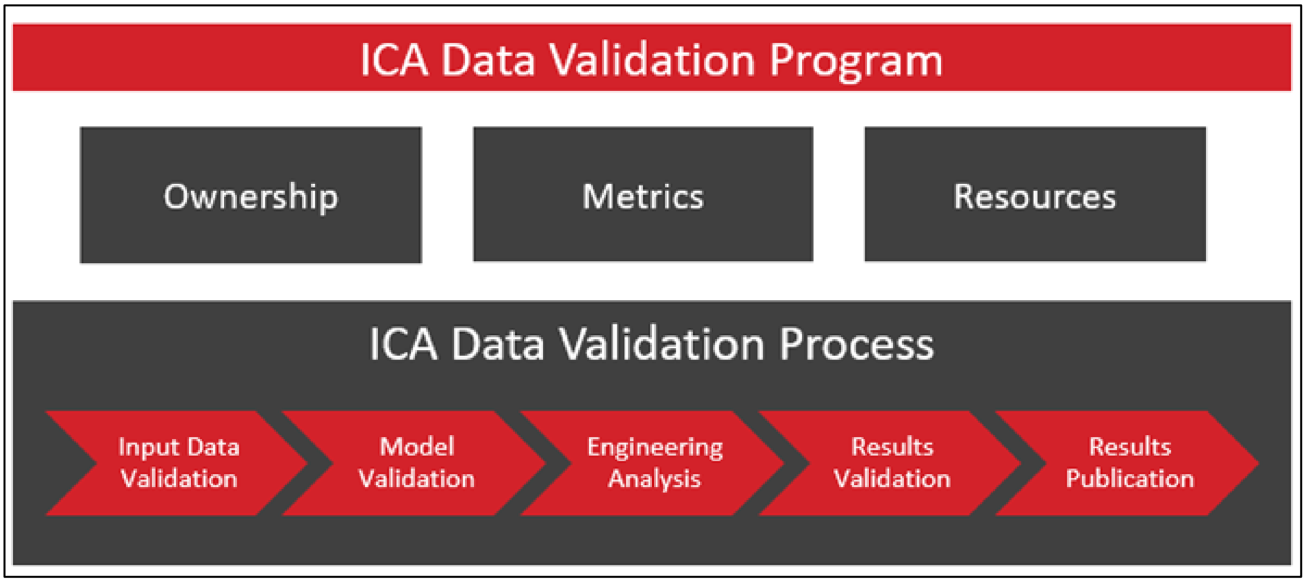


**Figure E-1-1. Reference ICA Data Validation Program Framework**

Quanta Technology assessed each IOU's improved data validation plan relative to the reference framework to identify areas for improvement and recommendations. The program management layer of the framework encompasses the need for an identified, recognized owner of the ICA results, metrics to monitor the process and ensure the quality of the output at each stage of the process, and the resources to support any manual intervention activities or investigations into potential issues.

The ICA data validation process spans the entire ICA process and has five stages:

- **Stage 1: Input Data Validation**—Ensure that input data is sensible and complete. The input data is used to build the CYME or Synergi models and includes GIS and tabular data. Datasets include circuit topology, conductor size, equipment settings, and existing or queued generation.
- **Stage 2: Model Validation**—Ensure that the CYME or Synergi models properly interpret the data, and the models reflect field conditions.
- **Stage 3: Engineering Analysis**—Ensure the process runs successfully using the streamlined ICA process and manual intervention. This effort can include using commercial software packages to run the analysis and help minimize human error.
- **Stage 4: Results Validation**—Ensure that ICA results are sensible before publication. Cases to evaluate include potential invalid zero capacity results.
- **Stage 5: Results Publication**—Verify that the published results reflect the results of the engineering analysis.

## Results

Overall, the plan describes the ICA process and data validation activities at various stages. The validation process is streamlined for the most part, driving efficiency of an overall process. The validation efforts have many challenges due to exposure of the ICA process to other processes, such as EDGIS and LoadSEER.

Any incorrect information from upstream processes may adversely affect the ICA process. PG&E has been successful in addressing these challenges, improving ICA results quality over the last 3 years.

[redacted]

While PG&E heavily automated ICA process to gain efficiency and ability to quickly refresh the ICA results, such automated process must be carefully managed to avoid results quality at the expense of speed & labor reduction. Ultimately, ICA results should not be far off from the results interconnection study engineers would obtain working with individual interconnection requests – require very similar, if not identical, CYME model (conditioning process). Therefore, PG&E is encouraged to continue to work with CYME developer to permanently resolve power flow model convergence issues within CYME – in addition to improving the EDGIS data that may be contributing to power flow convergence challenges – and over time reduce the temporary scripted recipes that help power flow convergence, securing consistency of models withing the ICA process and across the departmental activities.

Furthermore, we suggest that PG&E – and other IOUs that have significant number of temperature-controlled capacitors - work with the software developer to enable convenient use of temperature profiles as part of ICA rather than modeling temperature-controlled as voltage-controlled capacitors. Modeling of temperature-controlled capacitors as voltage-controlled will assure that distribution circuit models closely represent true behavior of the equipment in the field.

In terms of results validation, PG&E would benefit from supplemental results validation process using more advanced analytics and/or rule-based analytics to identify potential issues with ICA results. Also, PG&E may benefit from allowing hosting capacity map users to raise/report issues directly on the observed map (actionable by results publishing stakeholder) rather than to simply provide feedback.

General suggestion: Use of tables the report may help with the information flow. For example, a set of tables that list an issue, impact (both positive and negative) of that issue, and resolution steps (to be) set in place throughout data validation stages to address that issue.

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# 1 ICA DATA VALIDATION PROGRAM ASSESSMENT PROCESS

## 1.1 Overview

Quanta Technology began the integration capacity analysis (ICA) data validation program assessment process with two parallel tasks:

- Review existing investor-owned utility (IOU) ICA data validation efforts to develop a baseline understanding of each IOU's practices
- Develop a reference ICA data validation program framework to assess the ICA data validation plans and structure recommendations

Upon completing these tasks, Quanta Technology provided recommendations to each IOU for consideration in developing their improved data validation plans.

Lastly, Quanta Technology assessed the filed improved data validation plans using the reference ICA data validation program framework and provided the results in this report. The assessment was performed from the perspective of the generation ICA methodology and results. However, many of the findings and recommendations could apply to load ICA. This assessment was neither a validation of the ICA results nor a review of any engineering analysis, assumptions, or modeling efforts required to develop the ICA results and maps.

## 1.2 Review of Existing ICA Data Validation Efforts

Before the IOUs submitted their improved data validation plans, Quanta Technology met with each IOU and reviewed their current data validation efforts. This review covered all steps of the ICA process, including input data for the process and publishing results. After reviewing the IOUs' current practices, Quanta Technology provided recommendations for inclusion in the improved data validation plans.

## 1.3 Reference ICA Data Validation Program Framework

The reference ICA data validation program is structured to align with the ICA process. It encompasses the program management activities required to sustain a data validation program and some example activities that should take place at each step of the ICA process. Figure 1-1 shows the structure of the reference ICA data validation program.

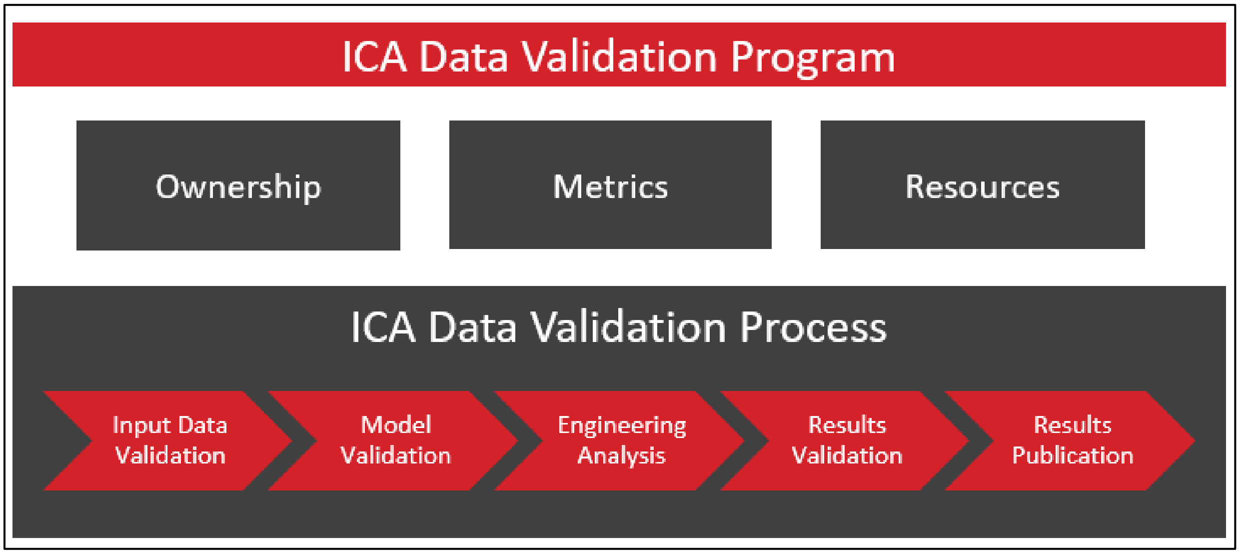



**Figure 1-1. Reference ICA Data Validation Program Structure**

The potential issues and metrics identified in this assessment are not an exhaustive set of issues that data validation could help address. Instead, the issues and metrics highlight the types of activities that the utilities should include in their data validation efforts. Given the complexity of the ICA process and the different system architectures that support the process at each IOU, identifying all potential issues and metrics was outside the scope of this assessment.

### 1.3.1 ICA Data Validation Program Management

The reference framework's program management layer includes the organizational ownership, objectives, and resources required to maintain a healthy data validation function. While some data validation activities can be and have been automated, there is still a need for an organization responsible for the quality of the ICA results.

#### *1.3.1.1 Ownership*

To ensure that there is long-term, ongoing improvement in the ICA results, each IOU should have an identified business owner solely responsible for those results. The business owner's responsibilities should include, but not be limited to, the following:

- Establishing performance targets and metrics for ICA results
- Establishing a long-term strategy to maintain ICA results quality
- Validating sample results regularly (spot-checking)
- Managing resources that support ICA validation
- Documenting the ICA process
- Tracking and implementing identified needs for improvement

The responsibilities listed above provide strategic direction, identify specific objectives, and provide structure for the data validation activities.

#### *1.3.1.2 Metrics*

The ICA business owner should establish metrics to ensure that the ICA process is functioning as designed and that the results are of sufficient quality. These metrics should be defined to assess the state of the data in each step of the process.

While individual values for the metrics are informative (e.g., there are currently 100 nodes with zero hosting capacity), trends in the metrics can help identify emerging issues in the input data or process (e.g., the count of nodes with zero hosting capacity is not changing over time) or show improvements in quality (e.g., the count of nodes with zero hosting capacity is decreasing on feeders that have recently had limiting factors mitigated). The metrics should also be tracked to support analysis at various levels of system granularity (e.g., system-level, feeder-level, node-level, etc.) and troubleshoot potential data issues.

Section 0, which covers the ICA process steps, includes example metrics that could support data validation at each step of the ICA process.

#### *1.3.1.3 Resources*

While portions of the ICA data validation program can be automated, there will be a need for resources that can correct models with convergence issues, perform spot-checks of results, and investigate any issues identified by the ICA metrics or the validation process.

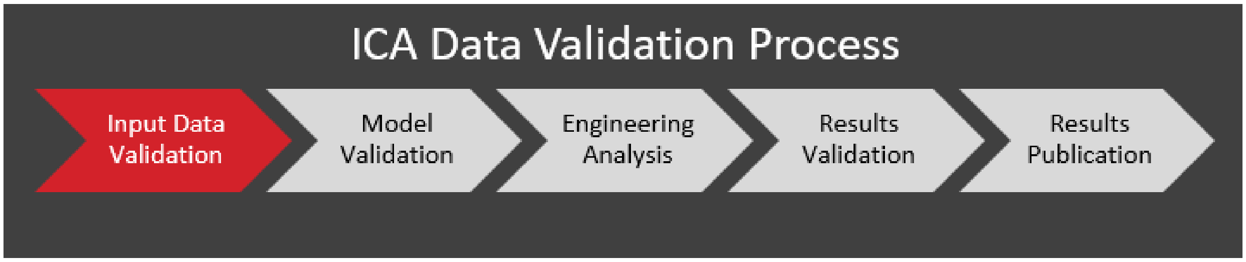
The resources should have experience with their utility's distribution engineering practices, circuit models, and design standards. They should also be familiar with the ICA methodology, their utility's implementation of the methodology, and the entire ICA process from the input data sources to the publication of the results.

### 1.3.2 ICA Data Validation Process

This section presents the focus of data validation efforts at each step of the ICA process with some potential issues that could be identified at each step. The ICA data validation process spans the entire ICA process from input data to results publication.

#### *1.3.2.1 Input Data Validation*

The initial stage of the data validation process is a critical gate to ensure that the data being used throughout the ICA process is of sufficient quality and will lead to valid results. This stage can be complex when considering the multiple sources and high volume of data required for ICA.




The objective is of this stage is to ensure that the data being used for the calculations is complete and sensible. Since the data has not been transformed into models at this stage, each dataset is checked for internal consistency. For the ICA process, the following datasets should be included in the input data validation program. Examples of potential issues are also provided:

- **Asset Data:** Incorrect data such as conductor size or equipment capacity could adversely impact hosting capacity results by imposing improper limits or excessive allowances.
- **Equipment Settings:** Incorrect equipment settings would improperly characterize system performance. For example, incorrect capacitor and voltage regulator model settings could lead to incorrect voltage analysis.
- **Distribution Circuit Topology:** Incorrect circuit topology could result in equipment, load, or generators being modeled at the wrong node or segment of a circuit.
- **Load Profiles:** If a circuit's load profile does not reflect its normal operating configuration, the ICA results could be artificially limited due to temporary operating conditions (e.g., temporary load transfers or outages).
- **Existing and Queued Generators:** Missing or incorrectly modeled generators could result in artificially high or low integration capacity.

If existing data validation programs are in place for any input datasets, the ICA data validation business owner should coordinate with the business owner(s) for those datasets. Awareness of input data issues could prevent the issue from propagating through the ICA process to publication. Likewise, the ICA business owner might identify a potential issue with the input dataset that should be communicated to that data's business owner.

Table 1-1 includes some of the potential issues, example metrics, and potential corrective actions that can be addressed during input data validation. These potential issues highlight the types that IOUs could consider at this stage in the process.

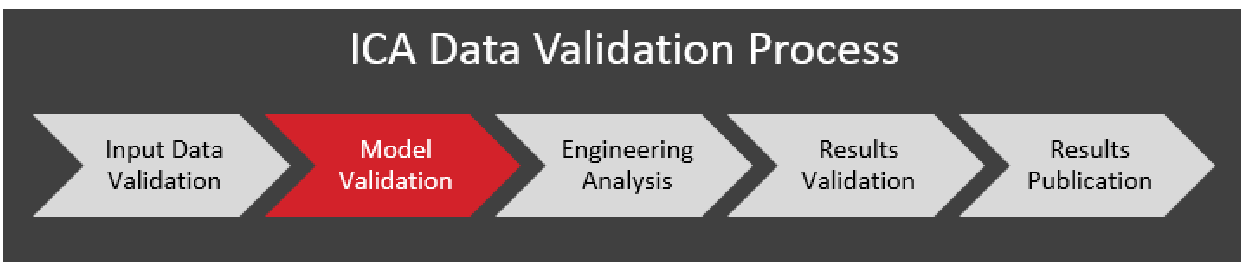
**Table 1-1. Potential Issues Identified during Input Data Validation**

| Potential Issue | Example Metrics | Potential Corrective Actions |
|---|---|---|
| Missing or incomplete asset data | • Types of infrastructure data discrepancies as a percentage leading to incorrect ICA results | • Monitor causes of inaccurate results and develop a sample field verification plan for high causes of incorrect results |

| Potential Issue | Example Metrics | Potential Corrective Actions |
|---|---|---|
| | | • Field verification can be done using SCADA data and/or limited field checks<br>• Review practice of updating GIS data |
| Missing or incomplete equipment settings | • Number of limitations due to improper voltage settings | • Confirm capacitor and regulator settings match field implemented settings |
| Inclusion of abnormal operating conditions | • Time and duration of abnormal events on distribution feeders | • Exclude data recorded during temporary abnormal operating conditions that would artificially skew ICA results (e.g., public safety power shutoff events or temporary load transfers) |

#### *1.3.2.2 Model Validation*

This second stage of the data validation process ensures that the models used to perform the calculations are complete and sensible. The conditioning process should be consistent across distribution planning activities, such as interconnection studies and ICA.




During this stage, the objective is to validate that equipment, asset, and generation data is correct in the context of the distribution circuit model. While datasets are checked for internal consistency in the previous stage, now that the datasets have been transformed into a model, it is possible to check if data that appears valid out of context is sensible (e.g., a span of #6 ACSR between spans of #336 ACSR or a *C* phase-to-ground tap being fed off an *AB* phase-to-phase line section). Some areas of focus during model validation include equipment settings, asset sizes and ratings, phase mapping, and existing and queued generation.

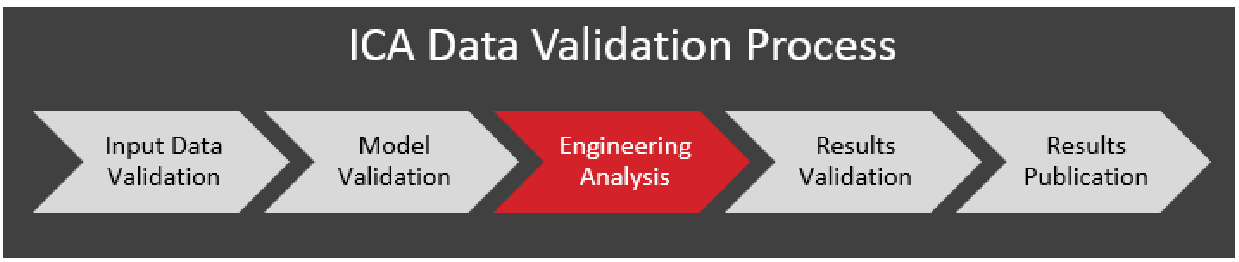
Table 1-2 includes some potential issues, example metrics, and potential corrective actions addressed during model validation. These potential issues highlight the types of issues that the IOUs could consider at this stage in the process.

**Table 1-2. Potential Issues Identified during Model Validation**

| Potential Issue | Example Metrics | Potential Corrective Actions |
| --- | --- | --- |
| Incorrect asset data | • Invalid or default material types | • Communicate incorrect data and propose a fix to input dataset owners |
| Pre-existing conditions in the model | • Presence of over-/under-voltage or thermal overloads | • Verify that the model reflects field conditions<br>• Modify the model to reflect field conditions |
| The model will not converge | Not applicable | • Correct asset data and equipment settings<br>• Temporarily modify load flow algorithm parameters and investigate the impact on ICA results<br>• Work with software developers to solve convergence issue |

### *1.3.2.3 Engineering Analysis*

This third stage of the data validation process includes the automated ICA process and the manual intervention required to ensure the process runs successfully.




Given the amount of computation required to implement the ICA methodology, using commercial software packages to run the analysis will help minimize human error. However, even with the use of commercial software, there are still situations that require manual intervention. For example, if the ICA process fails, a root cause analysis will need to be performed, and the model will need to be modified so that the ICA process can run successfully.

A best practice to reduce potential human errors when manual intervention is required is using a standardized approach to identify and resolve issues with the distribution circuit models and the ICA process.

### *1.3.2.4 Results Validation*

The objective of the results validation stage is to ensure that the engineering analysis results are sensible.

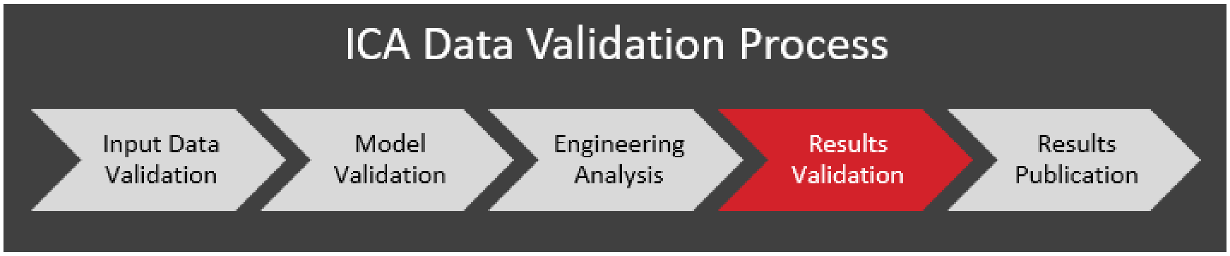



Table 1-3 includes some potential issues, example metrics, and potential corrective actions addressed during results validation. These potential issues highlight the types of issues that the IOUs could consider at this stage in the process.

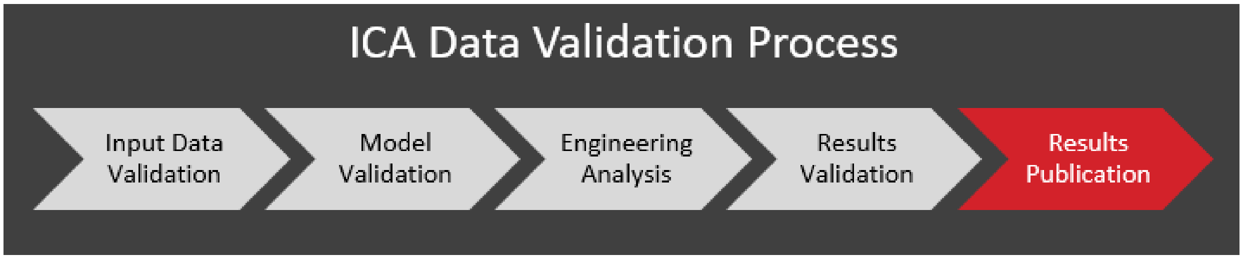
**Table 1-3. Potential Issues Identified during Results Validation**

| Potential Issue | Example Metrics | Potential Corrective Actions |
|---|---|---|
| Invalid zero capacity results | • Count of zero node-hour results<br>• Distribution of limit triggers, for example, dominant reverse flow for operational flexibility scenario | • Implement rule-based screening of zero hosting capacity sections to identify potential suspects (e.g., identifying zero reverse flow at upstream switching locations).<br>• Track trends in the count of zero node-hour results at each analysis refresh. Any significant changes (increase or decrease) could indicate an issue in the analysis.<br>• Develop criteria (e.g., > 10% results) to flag a need for manual validation. |
| Invalid results due to incomplete load profile data | • Count of node-hour results | • A count of node-hour results less than 576 could flag missing input data or failed engineering analysis. This metric could trigger manual validation unless input data is intentionally excluded (e.g., newly energized feeder). |
| Invalid results due to load profile processing | • Variation of nodal results over 576 h simulations | • Comparison of load profile variation with nodal results variation could signal an analysis error (e.g., if a load profile varies over time but the hosting capacity at a node does not). |

| Potential Issue | Example Metrics | Potential Corrective Actions |
|---|---|---|
| Invalid limiting factor | • Percentage breakdown of limiting factors<br>• Variation of limiting factors at a node | • Track trends in limiting factors. Any significant changes should be verified to see if they are a result of completed upgrade projects<br>• If a node has multiple limiting factors over the analysis period, it could be a sign to verify the results. |

#### *1.3.2.5 Results Publication*

Once the analysis results have been verified, the results are published to the IOUs' web-based mapping systems. The objective of the final stage of the data validation process is to ensure that the published data matches the validated results.




Map symbology, displayed data, and downloaded data are compared with the validated results during this stage. This stage can be facilitated with unit tests for the data extraction processes that support the publication of the ICA results. Sample verification, or spot-checking, can also be used to verify that the correct information has been published.

# 2 PG&E ICA DATA VALIDATION ENHANCEMENT ASSESSMENT

This report captures findings of PG&E's Improved ICA Data Validation Plan ("plan") as filed on May 28, 2021, in Advice letter 6212-E. The data validation framework and corresponding preliminary comments on the initial plan was provided to PG&E (and other California IOUs before plan filing. Accordingly, PG&E made enhancements to the plan before final plan submission. The assessment was based on the information provided in the filed plan and in accordance with the data validation framework described above - knowledge of PG&E's ICA process outside of the plan is not considered.

## 2.1 ICA Data Validation Program Management

### 2.1.1 Ownership

The plan provides an ownership structure for internal and external stakeholders, as illustrated in Figure 2-1. The ICA process has a business owner responsible for the results. PG&E presented a RACI matrix that captures internal—PG&E and vendor—roles and responsibilities. Furthermore, the plan confirms structured, frequent communication among the stakeholders, which is an important aspect of data validation efforts.

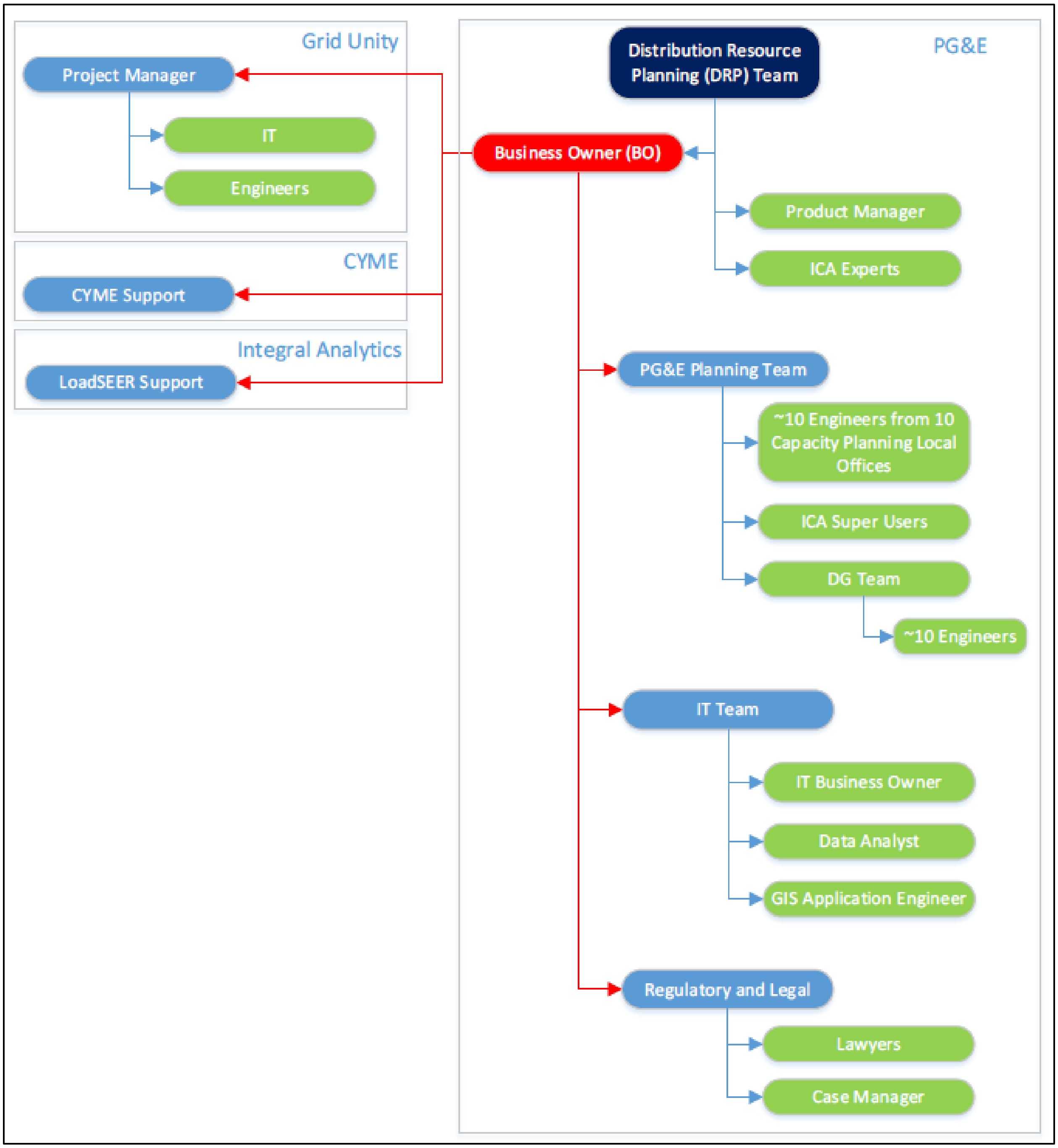



**Figure 2-1. ICA Organizational Structure (Chart Provided by PG&E)**

### 2.1.2 Metrics

Throughout the plan, PG&E points to various metrics as part of the ICA process. The presence of these metrics implies that PG&E's ICA data validation process has been evolving, ensuring that an overall ICA process is functioning properly and that the results are flagged for quality check. Figure 2-2, although related to load (not generation) hosting capacity, demonstrates PG&E's continuous improvement efforts.

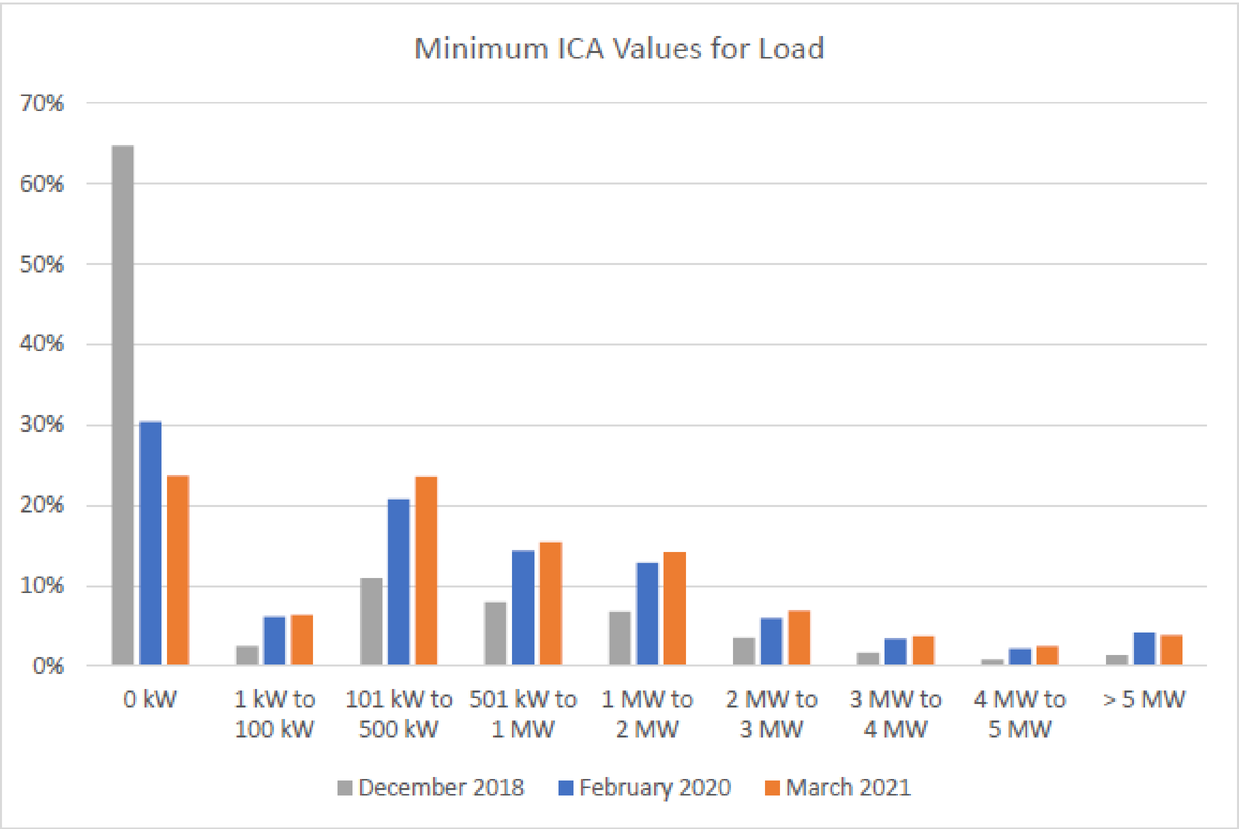



**Figure 2-2. Distribution of Uniform Load ICA Results (Chart Provided by PG&E)**

### 2.1.3 Resources

The plan's appendix illustrates resource allocation among internal and external ICA stakeholders. This resource allocation demonstrates stakeholder support, but it is unclear how many labor hours (full time equivalent staff) are required/committed.

### 2.1.4 Recommendations

Quanta Technology has no recommendations related to the ownership structure.

PG&E's plan designates metrics as part of model validation, and engineering analysis and results validation activities, but the plan would benefit from elaborating on metrics throughout process. Hence, PG&E should track trends of applied corrective activities within the ICA process and flag issues to upstream process business owners if metrics indicate recurrence. This would allow the flagging of recurring upstream issues (e.g., entry of incorrect conductor sizes), that may best be addressed upstream of the ICA process.

Resource allocation and process quality have a strong correlation. It is recommended to balance and/or strengthen resource allocation according to needs to meet expectations, given the complexity and exposure of the ICA process to other internal processes, such as LoadSEER and EDGIS.

## 2.2 ICA Data Validation Process

### 2.2.1 Input Data Validation

#### *2.2.1.1 Assessment*

Input data validation is the most difficult task because the ICA process consumes data from external processes. It is also the most sensitive task because it directly impacts ICA results. Therefore, constant oversight and improvement in the processes that ICA depends on are required to reduce the possibility for ICA to be adversely affected by incorrect input data. According to the plan, the EDGIS data is constantly updated as part of engineering intervention during the ICA process.

In addition to engineering intervention, PG&E has a broader initiative to improve EDGIS data. For example, the updated status of fixed voltage booster in EDGIS would eliminate the current practice to bypass fixed voltage boosters in the CYME models, improving the accuracy of ICA (not likely to impact generation ICA adversely). Also, elbows and regulator ratings, and some capacitor and voltage regulator settings are updated as part of the ICA process.

The plan states that PG&E takes action to clean load profile data associated with abnormal operating conditions, such as public safety power shutoff events, preventing adverse effects on the ICA results (and all other planning activities) of these abnormal conditions.

#### *2.2.1.2 Recommendations*

According to the plan, the input data validation process implies that it is executed as part of the ICA on individual circuits every time the ICA analysis is refreshed—monthly network model update from EDGIS, load information from LoadSEER, queued generation, and device settings. It is recommended to keep track/count of input data issues for each refresh. This tracking will help identify positive or negative trends related to input data quality and inform the root cause analysis. Input data issues could be one of the metrics associated with the ICA.

### 2.2.2 Model Validation

#### *2.2.2.1 Assessment*

PG&E has implemented a robust and efficient ICA process automating CYME distribution circuit model conditioning and validation, reducing manual engineering labor. The plan presents activities within the model intake, verification, and load allocation stages. Among many activities, PG&E checks for pre-existing overload conditions and validates the model's queued generation. The model conditioning activities are extensive and streamlined for efficiency purpose. Some are conservative in nature – such as bypassing of auto-booster – and may even overstate generation hosting capacity. Over time, PG&E model validation enhancements helped PG&E's ICA process generate less zero ICA results, as illustrated in Figure 7 of the PG&E Advice 6212-E document for load hosting capacity.

In addition to regular steps, such as updating equipment ratings and settings, PG&E's data validation process contains steps to addresses incorrect data. The process proposes to fix incorrect data upstream—at the source—to prevent the appearance of incorrect data points in the future. Furthermore, PG&E works with its vendor that develops the distribution modeling software CYME to augment software tools to better handle pre-existing loading conditions as part of the ICA.

#### *2.2.2.2 Recommendations*

PG&E is encouraged to continue working with the CYME developer to efficiently model temperature-controlled capacitors as part of the ICA analysis, especially if PG&E has a significant number of temperature-controlled capacitors in the field. Although modeling temperature-controlled capacitors as voltage-controlled is a practical solution, it does not necessarily capture the true state in the field. As noted in Table 1-2, the intent should be to have distribution circuit models representing true field conditions to the greatest extent possible. Otherwise, the results may overstate or understate (parts of) system hosting capacity.

Another important aspect is the adverse impact of automated model conditioning. It is important to understand the potential adverse effects on ICA results when modifying regulators and capacitor settings/operations when the power flow software does not initially converge. While the process gains efficiency, the accuracy of results should not suffer (to a certain degree). It would be beneficial if IOUs thoroughly study the adverse impact of such automated modifications and have a common approach in dealing with power flow convergence issues, preferably working with the power flow software vendor to address these convergence issues.

PG&E has already initiated software improvements activities with CYME vendor. As a result, CYME was improved to handle the pre-existing voltage and loading conditions better, identify ICA limiters, and enable power flow convergence that allows proper capture of the capacitor state. It is recommended for PG&E to continue to work with the CYME vendor to overcome challenges and eventually eliminate temporary custom scripting to enable CYME models specifically for ICA, as stated in the plan. Ultimately, CYME models used in the interconnection studies should be handled in the same way CYME models are handled for ICA. Otherwise, interconnection study and ICA outcomes may differ.

### 2.2.3 Engineering Analysis

#### *2.2.3.1 Assessment*

PG&E is using CYME, a commercial software package, to perform the ICA calculations. Other investments in its IT environment support more frequently refreshed ICA results to reflect more recent load profiles, DER projects, and circuit topology changes.

PG&E allocates engineering resources to support the ICA process where automated model conditioning fails validation or where ICA results require verification. The plan describes the process of engineering intervention to prepare the failed model for ICA analysis, including corrective actions to address identified issues in EDGIS. Also, the process allows PG&E engineer(s) to get insight into issues to be addressed as part of the engineering analysis stage.

Overall, the intervention process that PG&E set in place is typical in the industry and consists of the following:

- Identification of failure point/instance
- Acquisition of distribution models
- Manual alteration of the distribution circuit model, which often requires investigative work, such as finding appropriate data for the assets in question, usually from single-line diagrams or equipment nameplate records
- Re-initiation of analysis
- Initiation of corrective actions to prevent similar outcomes in the future

#### *2.2.3.2 Recommendations*

Quanta Technology has no recommendations for PG&E related to the engineering analysis part of the process.

### 2.2.4 Results Validation

#### *2.2.4.1 Assessment*

PG&E's improved plan describes a results validation process with automated checks and manual interventions by a dedicated team of engineers. For example, results are automatically checked for zero hosting capacity results—more than 50% of sections with zero hosting capacity results. Figure 2-3 illustrates the revision of the manual results as part of an overall process flow.

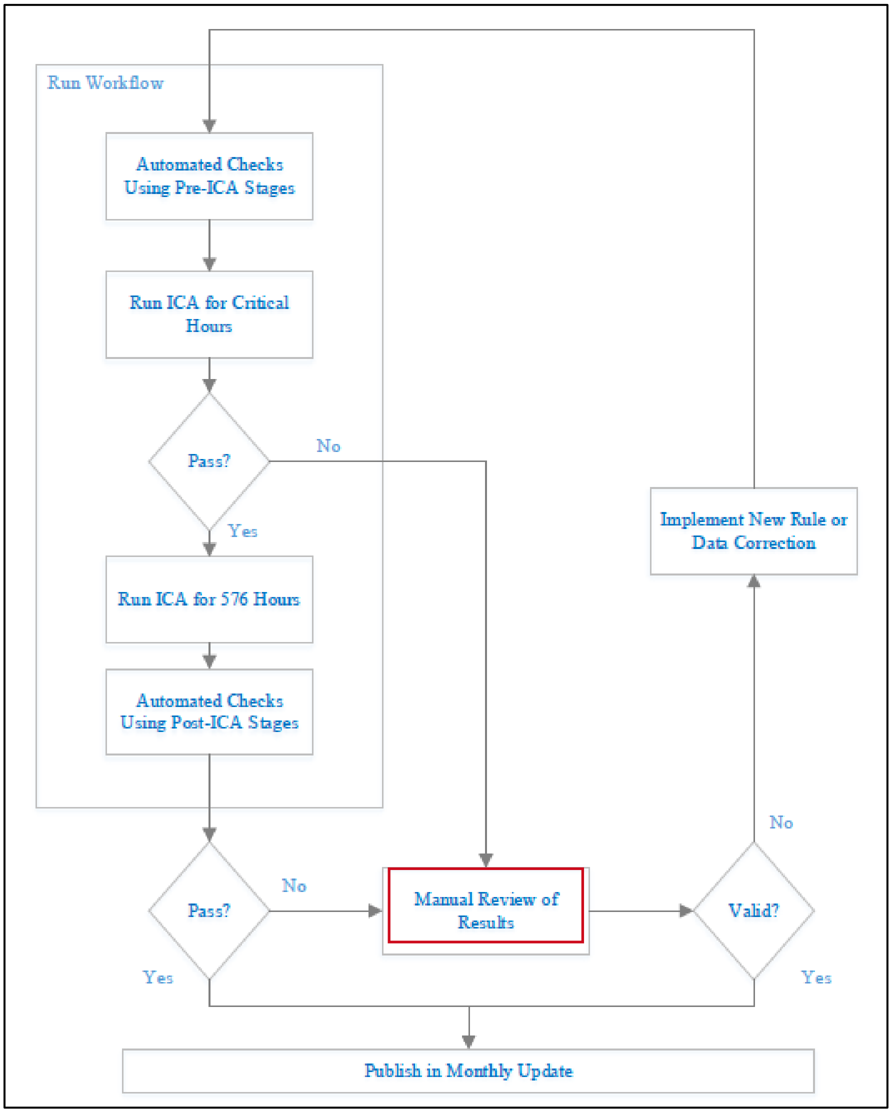



**Figure 2-3. ICA Process Flow—Results Revision**

#### *2.2.4.2 Recommendations*

Zero hosting capacity results are a good indicator that something may have adversely impacted the results. However, results validation should build confidence in overall results, beyond zero hosting capacity results. Therefore, Quanta Technology recommends that PG&E expand the automated checks in the ICA results validation process to account for potential upstream issues regardless of the hosting capacity value (zero or non-zero). PG&E's plans state an intent to perform system-wide statistical analysis on ICA to identify potential issues that may exist as part of the results validation process.

Further enhancements on the ICA results validation front may require additional investments and resources. Therefore, it is important to balance requirements and associated one time and recuring costs carefully.

### 2.2.5 Results Publication

#### *2.2.5.1 Assessment*

PG&E's plan thoroughly outlines steps from ICA results acquisition to display on the map, including validation of the data displayed on the developer and public map. According to the plan, the tracker would inform the product manager of missing results, reducing the risk that some results do not get published.

#### *2.2.5.2 Recommendations*

The plan does not indicate how to handle comments/feedback from hosting capacity map users. It is recommended to explain this feedback process in the context of the data validation process, including the roles and responsibilities of affected stakeholders. A potential enhancement in the results publication process is to use a commercial tool to validate the map's published data and functionality, minimize human error, and ensure that the map accurately displays the results.