PACIFIC GAS AND ELECTRIC COMPANY

APPENDIX

TO

INTEGRATION CAPACITY ANALYSIS

WORKING GROUP FINAL REPORT

California Distribution Resources Plan (R.14-08-013)
Integration Capacity Analysis Working Group
Final ICA WG Report

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1 Executive Summary

Assembly Bill 327 (Perea 2013) established Section 769 of the California Public Utilities Code, which requires the Investor Owned Utilities (IOUs) to prepare Distribution Resource Plans (DRPs) that identify optimal locations for the deployment of distributed energy resources. In August 2014, the Commission began implementation of this requirement through Rulemaking (R.) 14-08-013, the DRP proceeding. A Ruling from the Assigned Commissioner in November 2014 introduced the Integration Capacity Analysis (ICA) as a tool to specify how much capacity for integrating circuits on the distribution system may have available to host Distributed Energy Resources (DERs).

This document serves as the Final ICA WG Report of the Integration Capacity Analysis (ICA) Working Group (WG) to the California Public Utilities Commission (CPUC). The Working Group is comprised of the California IOUs and interested stakeholders. A complete list of participating Parties may be found in the Appendix. This report summarizes the development of the ICA to date, the recommended ICA methodology for the Investor Owned Utilities (IOUs) to implement across their service territories on the first system wide roll out, an implementation timeline, and recommendations on how to improve the methodology through the long-term enhancements via the ICA WG. This report also provides recommendations on how the ICA results may be used to inform decision-making on the part of the Commission, utilities, providers of distributed energy resources, and customers.

At a high level, these include recommendations in the following categories:

1. **Uses of ICA:** The WG identifies two primary use cases for the ICA. The first and most developed use case for the ICA is to improve interconnection, which includes a more automated and transparent interconnection process and the publication of data that helps customers design systems that do not exceed grid limitations. The second, and currently less developed use case for the ICA, is to utilize ICA to inform distribution planning processes to help identify how to better integrate DERs onto the system. The Final ICA WG Report outlines near and long term methodological refinements to enable the use of ICA within the interconnection process, and lays out considerations for the planning use case, with a goal of developing methodology recommendations for use within the planning context in the near-term (and in coordination with ongoing planning proceedings at the CPUC).

2. **Development of Common IOU methodology**: The ACR stated that the CPUC envisioned approving a final ICA methodology common across all utilities through an early 2017 Decision. The IOUs conducted the ICA using two separate methodologies in Demo A, known as “iterative” and “streamlined”. A majority of WG members, including SCE and SDG&E, recommend that the IOUs use the iterative methodology for interconnection purposes, assuming added refinements detailed further in this report can be achieved at a reasonable cost. PG&E recommends a “blended” approach using both methods for interconnection[1]. The WG believes the streamlined methodology may provide value in the planning process, and will continue to consider it while defining the uses of the ICA in system planning. The two methodologies each may be more

[1] See PG&E’s final Demo A report: http://drpwg.org/wp-content/uploads/2016/07/R1408013-PGE-Demo-Projects-A-B-Final-Reports.pdf

suited to specific circuits, situations, and tool capabilities and that blended use of both methods may be considered for future use.

3. **Refinements to ICA methodology**: The WG made recommendations on how the ICA methodology may be refined. These include both recommendations directly responding to the discrete activities identified by the ACR (*see Section 10*), as well as recommendations made after reviewing IOUs' final Demo A reports. Some of these latter recommendations fall under the ACR-defined WG purpose of "continuing to improve and refine the ICA methodology." Some of these recommendations endeavored to weigh utilities' cost estimates within the context of necessary granularity to meet the identified use case, but efforts to do so are limited by the available estimates for review and limited discussion to-date. Several of these recommendations are not consensus items. Those applicable to the first system-wide rollout of ICA for the interconnection use case are identified in Section 13, Table 1.

4. **Timeline:** As outlined in Section 3.3, the IOUs recommend that the first rollout of ICA methodology across their entire distribution service territories begin 12 months after a CPUC Final Decision on a common Commission-approved methodology, due to the number of processes required before ICA is ready for full implementation. At least one stakeholder offers a second opinion and recommends that IOUs begin the implementation process within 12 months of the Final Demo A WG Report filing.

5. **Modifications to ICA methodology and schedule:** WG recommends that the Commission establish two processes to incorporate modifications to the ICA which are made during the long-term refinement phase of the ICA WG:
    1. The CPUC should adopt a process whereby IOUs consult with the WG, followed by a Tier 1 advice letter, to approve ICA methodology changes as IOUs continue to enhance and incorporate refinements.
    2. The CPUC should adopt a process whereby requests for modification of scope and schedule due to unforeseen circumstances during system-wide implementation be sought through Tier 1 advice letter.

2 Introduction and Background

Overview

Assembly Bill 327 (Perea, 2013) established Section 769 of the California Public Utilities Code, which requires the California Investor Owned Utilities (IOUs) to prepare Distribution Resource Plans (DRPs) that identify optimal locations for the deployment of distributed energy resources (DERs). In August 2014, the California Public Utilities Commission (CPUC, or Commission) began implementation of this requirement through Rulemaking (R.) 14-08-013, the Distribution Resources Plan (DRP) proceeding. A Ruling from the Assigned Commissioner in November 2014 introduced the Integration Capacity Analysis

(ICA) as a tool that would support the determination of optimal locations by specifying how much capacity for integrating circuits on the distribution system may have available to host DERs.[2]

Pursuant to Commission direction, the IOUs filed their DRPs as Applications[3] , including a proposal to complete a Demonstration of their ICA methodology ("Demo A"). Stakeholders provided input on the IOU proposals, leading to an Assigned Commissioner's Ruling (ACR) issued in May 2016. That guidance authorized a demonstration project of the ICA, requiring the IOUs to meet the following nine functional requirements:

> *1. Quantify the Capability of the Distribution System to Host DER*
> *2. Common Methodology Across All IOUs*
> *3. Analyze Different Types of DERs*
> *4. Line Section or Nodal Level on the Primary Distribution System*
> *5. Thermal Ratings, Protection Limits, Power Quality (including Voltage), and Safety Standards*
> *6. Publish the Results via Online Maps*
> *7. Use Time Series Models*
> *8. Avoid Heuristic approaches, where possible*
> *9. Perform the complete ICA analysis for all feeders down to the line section or node on two Distribution Planning Areas (DPA).*[4]

The ACR also established the ICA Working Group (WG) to monitor and provide consultation to the IOUs on the execution of Demonstration Project A and further refinements to the ICA methodology. CPUC Energy Division staff has oversight responsibility of the WG, but it is currently managed by the utilities and interested stakeholders on an interim basis. The utilities jointly engaged More Than Smart (MTS), a 501(c)3 non-profit organization, to facilitate the WG. The Energy Division may at its discretion assume direct management of the working group or appoint a WG manager.

Between May 2016 and March 2017, the WG met 18 times. The WG has benefitted from contributions by a large range of stakeholders who are listed in the Appendix. The WG expects to continue its efforts through the next six months as it begins to address long-term ICA refinement.

In December 2016, Pacific Gas & Electric (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E) submitted their final Demo A reports, representing a substantial milestone for the demonstration projects.[5] These reports summarize Demo results, lessons learned, and the IOUs' recommendations on the methodology selection and feasibility of implementation of the ICA across the entire distribution system.

The WG collectively discussed the IOU final Demo A reports in January, February, and March. Many of those discussions informed the recommendations found in this report.

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[2] Assigned Commissioners Ruling, November 2014.
(http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M141/K905/141905168.PDF)
[3] http://www.cpuc.ca.gov/General.aspx?id=5071
[4] Assigned Commissioner's Ruling, May 2016.
(http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M161/K474/161474143.PDF)
[5] IOU Final Demo A Reports can be found at: http://drpwg.org/sample-page/drp/

Scope and Process

The "Working Group" references all active parties participating in ICA WG meetings, which include the IOUs, government representatives, DER developers, nonprofits, and independent advocates and consultants. All meeting dates and topics covered, as well as all stakeholder groups attending at least one meeting or webinar of the ICA WG, are described in Appendix A. This report is the product of significant written edits and contributions from the following organizations:

- CPUC Energy Division (ED)
- Office of Ratepayer Advocates (ORA)
- California Solar Energy Industries Association (CALSEIA)
- Clean Coalition
- Community Environmental Council
- Independent Advocates
- Interstate Renewable Energy Council (IREC)
- Pacific Gas & Electric (PG&E)
- San Diego Gas and Electric (SDG&E)
- SolarCity
- Solar Energy Industries Association (SEIA)
- Southern California Edison (SCE)
- The Utility Reform Network (TURN)
- Vote Solar

The ICA WG met regularly to discuss the proposed methodology for Demonstration A and to review the final Demo A reports. A full summary of WG documents including meeting agendas, presentation slides, and participant list is included in the Appendix.

All three IOUs submitted their Final Demo A Reports at the end of December 2016 in compliance with the ACR. The ACR additionally specified that maps and downloadable data should be made available for stakeholder review[6]. These reports lay out in detail the assumptions and calculations used within the ICA methodology. Additional information about the methodology was shared during the subsequent WG meetings which dived into the details on numerous aspects of the process that had not been fully detailed in the reports. Additionally, the IOUs each separately made recommendations on which methodology (*i.e.,* using a streamlined, iterative, or blended approach) to use going forward in a system-wide rollout of ICA. WG stakeholder review and further discussion of these recommendations led to different conclusions in some areas.

The ACR additionally specifies multiple items the WG should focus on to continue refining the ICA methodology. The WG filed an interim long-term refinement report in December 2016 detailing work to-date on those items, and sorting topics into a tiered system to develop a rough schedule for WG work in 2017. After reviewing the IOUs' final Demo A reports, the WG identified additional items to refine the ICA in support of the first system-wide rollout (*see Section 14: Next Steps*). The WG will prioritize the

[6] At the time of the filing of this report, stakeholders have reviewed SCE's maps and downloadable data, and some parts of PG&E's (required information was provided for substation, customer breakdown percentage, existing generation, queued generation, and total generation). SDG&E's maps and downloadable data were made available on March 10. SDG&E realizes this does not provide sufficient time for stakeholders to review results prior to submission of the Final ICA WG Report.

development of this list as an action item during the beginning of its long-term refinement work. For the WG, "long-term refinement" means WG activity 6 months after the filing of the Final ICA WG Report, beginning March 15, 2017.

To this end, the WG agrees to identify items where parties have built consensus, and to identify where there is non-consensus by particular parties and alternative proposals have been made.

3 Recommendation Categories

The report details the WG's recommendations for selection of the ICA methodology and further refinements. Where possible, recommendations are mapped to the specific section in the ACR.

The WG recommendations are in these categories:

1. Use cases of ICA
2. Development of common IOU methodology
3. Schedule and timelines
4. Review of cost estimates
5. Frequency of updates
6. Presentation of values
7. Standardization of methodology
8. ACR requirements
9. Short-term activities
10. Long-term refinement activities
11. Modifications to scope and schedule
12. Additional cost recovery
13. Recommendation summary table

These recommendations are based on WG discussion of IOU Demo A Reports from May 2016 to March 2017, and focus only on additional areas of refinement discussed through WG meetings rather than providing a full summary of Demo A projects. Areas where this report does not comment on methodology outlined in IOUs' Final Demo A Reports are considered as support for, or non-opposition to, methodological choices made for Demo A. Readers of this report should refer to the IOU Final Demo A Reports for additional detail on how ICA methodology was tested under ACR requirements.

4 Use Cases of ICA

The WG agreed to identify the specific uses of ICA and make recommendations on ICA based on concrete use cases, to the full extent possible. The WG expects that methodological considerations regarding frequency of updates, hourly load profiles, the basic methodology (streamlined vs. iterative), and other modeling options, may change based on the intended use of ICA.

At a high level, the WG has so far identified two uses of ICA:

1. **Inform and improve the Rule 21 interconnection process.** In the interconnection use case, ICA information may be used to update Rule 21 interconnection procedures and improve the interconnection processes. The results can also be used to better inform proper siting of

projects prior to entering the interconnection process. The WG recognizes that the interconnection process changes must be made via an appropriate Rule 21 proceeding.

2. **Inform and identify DER growth constraints in the planning process.** In the planning use case, the ICA information may be used as an input into system planning processes to identify when and where capacity upgrades are needed on the distribution system as a result of various DER growth scenarios.

The WG report outlines methodological refinements to enable the use of ICA within the interconnection process as determined by a future Rule 21 proceeding, and lays out considerations for the planning use case with a goal of developing methodology recommendations for use within the planning context.

These two use cases of ICA are described in further detail below:

1. **Informing interconnection siting decisions and facilitating an eventual automated and transparent interconnection process**

   The CPUC's Final Guidance on DRPs document calls for the "dramatic" streamlining of interconnection as one of the key purposes of the DRP.[7] ICA results can also help customers and third parties design DER systems that do not exceed hosting capacity by providing accurate information about the amount of DER capacity that can be interconnected at a specific location without significant distribution system upgrades. The WG expects that future Rule 21 proceedings will closely coordinate with the development of ICA to implement the recommendation in this report. Thus, the WG proposes that the Commission adopt an interconnection use case and that it include the following considerations, pending discussion under a still-to-be opened Rule 21 proceeding or equivalent. Utilities also specifically point out a need to coordinate the application of ICA with the need to install the required interconnection facilities. The WG identifies the following features as the core components of the interconnection use case:

   1. Developers should be able to submit a Rule 21 Fast Track application for DER interconnection up to the identified ICA value at the proposed point of interconnection, based on ICA figures shown on the map, changes in queued DER since the last map update and in the underlying data, and be able to pass those screens representing criteria the ICA has evaluated. The Rule 21 proceeding should identify processes and procedures which are required to support safety and reliability, while maximizing the ICA values to improve the interconnection process including, but not limited to, procedures associated with the evaluation procedures to account for frequency of updates, queued generation, ICA value at the time of interconnection, and resolution of screens not addressed by current ICA methodology.
   2. The ICA values identified at a point of interconnection are expected to replace and/or supplement the size limitations in the Fast Track eligibility criteria and will be able to address and/or improve the technical screens in the Rule 21 Fast Track process which are part of the ICA methodology. These include: screens F (Short

[7] "Final Guidance Assigned Commissioner Ruling on Distribution Resource Plans. http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5108

circuit current contribution); M (aggregate generation less or equal to 15% of the line section peak load); G (short circuit interrupting capability); O (power quality and voltage fluctuation); and N (penetration test). With few exceptions, interconnection customers should be able to use the ICA value at their point of interconnection to know whether a proposed project will pass these screens in the Fast Track process. In the near-term, there will be additional screens that still need to be evaluated due to data not currently analyzed in the ICA.

3. The Rule 21 proceeding should develop a process to incorporate future enhancements to ICA which are developed in the DRP proceeding. These future enhancements would potentially address other screens such as screen L (transmission dependency/stability test), screen P (safety and reliability) and evaluation of single-phase lines and other advanced functions, which are pending additional information, modeling, and study through ICA long-term refinements.
4. The published ICA value used for the interconnection review should be the same ICA value shown on the online maps and in the underlying data, accounting for discrepancies which may occur due to queue changes and frequency of map updates.
5. The ICA shall be updated frequently enough to allow for an eventual automated and transparent interconnection process for projects that are a proposed size below the ICA value at their point of interconnection, taking into account changes in the project queue. There are multiple opinions on frequency of updates (*see Section 8: Frequency of Updates*).
6. The ICA should provide hourly data about hosting capacity limitations that enables a developer to design a system that takes full advantage of the available hosting capacity at their proposed point of interconnection. The use of this information in the interconnection process will require verification that the proposed operational profile meet the ICA hourly limitations. It may also require some additional communication and operational visibility provided to the utility. As Rule 21 refinements are made, and greater resolution is provided on the cost of a more data intensive ICA (i.e., more hours analyzed), a more granular hourly profile may be needed and justified.

2. Informing the Distribution Planning Process and Decision Making

The WG determined that there is a role for a planning use case for the ICA, as it may be possible that the ICA can help determine and guide where and when future integration capacity is a limitation, among other possible planning uses. The ICA results may also guide sourcing and procurement of DER solutions with additional locational granularity in the future. The three IOUs all propose to use the streamlined methodology in the planning context, as the iterative methodology creates a large amount of data, and requires considerable resources to conduct multiple scenario analyses. However, many components of this use case remain undefined, due to multiple ongoing efforts in other CPUC proceedings that will inform how ICA will be used in system planning, as well as the need for further clarity into the utility annual planning process itself. Further, the multiple ways ICA may be incorporated into planning (from guiding grid modernization investments, to how DERs may be evaluated as solutions in the Integrated Resource Planning process (IRP)) are quite variable in the level of detail (e.g., granular hourly profiles, frequency of updates, etc.) they require from the ICA methodology. Because many open questions remain about the precise definition of the planning use case, the WG was not able to make specific recommendations regarding the appropriate methodology (or the details of that methodology) that would ultimately serve this use case best. Finally, the WG determined that the need to incorporate ICA in planning, while highly important, is less immediate when compared to the use of ICA in expediting the interconnection of DERs through Rule 21 modifications.

Thus, the WG proposes to further define the planning use case as a key high-priority long-term refinement issue beginning March 15, and outlines several considerations for the planning use case going forward:

1. Further refinement of the planning use case will allow the WG to form a specific list of uses of ICA in planning, evaluate the methodological needs for each use case, and determine whether the iterative or streamlined method may better serve that use case, and define what, if any, changes to these methodologies may be necessary to best serve the use case.
2. Some of the steps the IOUs will take to implement the first system-wide rollout of ICA for the interconnection use case will also eventually benefit the deployment of ICA for the planning use case.
3. Achieving the ICA values for these identified uses may require a blended approach (using aspects of both iterative and streamlined methodology) based on future discussion on planning use cases. The WG appreciates and understands the benefits that employing a streamlined method offers regarding computational resources, and looks forward to better evaluating its application to the planning use case in further WG meetings.

The WG requests further guidance from the CPUC on uses of ICA within the planning context, and the role the WG is expected to play in developing uses that may be included in other proceedings or DRP tracks. These concepts may need to be discussed and refined in Track 3 of the DRP proceeding. To date, some members of the WG have suggested the following discussion items as a starting point, though these are not met with consensus by the full WG:

- The scale, pace and prioritization of ratepayer funded grid modernization investments may be guided by projected ICA values. ICA may be one tool to guide and prioritize ratepayer-funded investments for grid modernization as determined by other proceedings.
- IOUs may use the ICA to evaluate DER as potential solutions to address needs identified in the IRP process.
- The current system capacity revealed through the ICA may be combined with location-specific projections of DER growth (i.e., DER growth scenarios) to project hosting capacity needs.
- IOUs and stakeholders may consider the ICA and LNBA may in tandem to identify opportunities where additions to hosting capacity can enable DER growth and avoid more costly distribution system upgrades.

5 Development of Common IOU Methodology

5.1 Overview

Within Demo A, the IOUs tested the ICA under two separate methodologies, referred to as the "iterative" and the "streamlined" methodologies. The iterative ICA method is based on iterations of successive power flow simulations at each node on the distribution system, whereas the streamlined method uses a set of equations and algorithms to evaluate power system criteria at each node on the distribution system. The iterative method parallels detailed study procedures used within the interconnection process relying on direct simulation of resources. During implementation of Demo A projects, the IOUs tested the variance between the iterative and streamlined analyses, as well as among the three IOUs, using a reference circuit.

The IOUs presented a comparison summary of Demo A results using both methodologies, and outlined recommendations within their Final Demo A Reports on which methodology, or portions of methodology, they believe should be employed in a full system-wide rollout. The rationale behind these recommendations is based on lessons learned from the Demo projects and full system-wide implementation considerations, computational efficiency, capability of CYME/Synergi software, and costs. [8]

5.2 Streamlined method

The streamlined method uses an abstraction approach, applying a set of equations and algorithms to evaluate power system criteria at each node on the distribution system. The streamlined method first performs a baseline power flow and a short-circuit simulation to acquire the initial conditions of the circuit that will be used in the streamlined calculations. These conditions can be, but are not limited to, electrical characteristics such as thermal ratings, resistance, voltages, current, fault duties, etc. The streamlined method then evaluates the full set of criteria, including thermal, voltage, protection, and safety limits independently to determine the maximum hosting capacity at a given node or component of the system. Simpler methods utilized in the streamlined methodology may not capture some of the more dynamic effects on the more complex circuits. However, the ability to utilize simpler equations and algorithms can enable faster computations on more scenarios and hours.

5.3 Iterative method

The iterative method performs iterative power flow simulations while varying the DER level at each node on the distribution system to determine the maximum amount of DER that can be installed without triggering thermal or voltage criteria violations. Fault current simulations are used for protection criteria not dependent on power flows. Due to the large number of iterations required, iterative analysis can result in longer processing times, especially when expanded to large numbers of distribution circuits. However, the use of an iterative simulation parallels what IOUs would perform as part of a detailed interconnection study, and therefore produces more accurate results. This technique

[8] Please refer to final Demo A reports.

is also expected to provide more confidence in representation of integration capacity in more complex circuit conditions.

The iterative method adds a fixed incremental level of DER in each grid location until an ICA violation is triggered. In Demo A, this incremental level was up to 500kW. A smaller increment could add value to the ICA, but would increase processing time. The incremental DER value may be an additional methodological detail to be considered in future iterations of ICA.

5.4 Recommendations

The WG recommends a consistent approach be used across all three IOUs to facilitate future advancements and maintain consistency across the state, and in accordance with the Commission guidance ruling.

After multiple meetings, the WG developed two different recommendations:

1. A majority of the WG (SCE, SDG&E, and all WG stakeholders involved in the active development of this report) recommended that the iterative methodology be used for the interconnection use case (with the following refinements detailed in this report) to update the interconnection maps, improve the interconnection process and be deployed in the first system wide deployment of ICA. Within their Demo A reports, SCE and SDG&E supported the use of iterative method as appropriate means of supporting the interconnection processes, as the iterative method parallels the study procedures followed in the Rule 21 process, and considered that future changes to Rule 21 may be potentially be significantly simplified with the use of the iterative method.

2. PG&E instead recommends the use of a "blended" approach, using both the iterative and streamlined methods within the interconnection use case. The streamlined method would be applied to an overall analysis for the whole system (and be the results shown on the map and in the underlying data), and iterative would be utilized to analyze specific conditions within the interconnection process. This approach could result in a more cost-effective implementation given that the iterative method requires additional IT and engineering resources to complete. The blended approach is fully detailed in PG&E's Final Demo A Report.[9]

PG&E's Argument Supporting the Blended Approach:

PG&E's Demo A report explained that adopting the application-based iterative and system-wide streamlined recommendation would allow PG&E to more efficiently use existing resources and tool capabilities. Additionally, PG&E states that the blended approach better parallels an efficient tiered Rule 21 process that has proven to be a major success in California and promotes an efficient and accurate interconnection process. PG&E notes that there are application-specific components within interconnection that can't be considered proactively and thus can only be automated within the interconnection process, not through ICA. PG&E notes that if full automation is desired, then focus

[9] http://drpwg.org/wp-content/uploads/2016/07/R1408013-PGE-Demo-Projects-A-B-Final-Reports.pdf

must shift to automating more of the interconnection process versus the proactive ICA, which can only improve portions of the interconnection review.

PG&E notes that adoption of this blended approach would require fewer engineering resources for PG&E. PG&E projects that if iterative, along with recommendations regarding planned projects and pre-existing conditions, is required for use in the maps and in the interconnection review, then it would need a new team to manage the ICA process, SCE and SDG&E do not share this opinion. PG&E projects if streamlined is adopted for system-wide updates and the iterative approach is adopted more efficiently on an application basis, then it is projected that the new work load can be more efficiently managed with current engineering resources.

PG&E is also undergoing existing planned work on modifications to its gateway to (1) utilize the new GIS system implemented in 2016, (2) expand the gateway to include substation models, and (3) expand its ability to include service transformers in the models. If recommendations require the incorporation of planned modifications and automated iterative across the whole system, then significant additional work would be required on the gateway and could postpone work to include substation and service transformers. Also, if PG&E's recommendation of application only based used of iterative is not adopted, then more engineering resources would have to be hired and trained in order to perform the regular iterative ICA analysis. Adopting the application-based iterative and system wide streamlined recommendation would allow PG&E to more efficiently use existing resources and tool capabilities (*for further explanation, see PG&E's final Demo A report*).

The Argument Supporting the Use of the Iterative Approach for Mapping and Interconnection Processing:

Other members of the WG discussed application of the "blended" approach as suggested by PG&E and concluded that the approach was unsatisfactory in meeting the goal of the interconnection use case, which seeks to move towards an automated process that requires less manual review by engineers and would enable the ICA information displayed on the map to be the same as what is applied in the interconnection process. If the maps and data are derived from the streamlined method, which Demo A demonstrated is inaccurate in too many cases, then interconnection applicants would not be able to rely on this information and would be left in their current business-as-usual situation, where obtaining accurate interconnection information requires a manual review by the utility. These other members of the WG consider this to be insufficient progress.

The other members of the WG appreciates that PG&E is in a different position from the other utilities with respect to the rollout of its models and software, and shares PG&E's concern about how it will implement the iterative process on its system in light of the work planned on its gateway and other concerns. However, the WG believes that a consistent methodology is a fundamentally important principle, one required by the Commission in its Guidance, and is necessary to avoid a slippery slope of further diversion once rolled into the Rule 21 process. Additionally, the WG discussed that there may be reasonable ways to reduce the data intensity while utilizing more efficient computing resources to address concerns regarding computational intensity of the iterative method. For example, IOUs could look for additional solutions in their efforts to reconcile their data using the iterative approach. In the long run, it seemed likely to the majority of the WG that the costs of the computing issues could be reasonably managed as technology and understanding of the ICA methodology advance.

The WG also recommends that the ICA WG continue to evaluate the streamlined method for potential use in the planning use case. Given that uses of ICA within planning are still being evaluated, the WG recommends that further discussion is needed to determine the appropriate ICA methodology for the planning use case, and that continued discussion of the use of the streamlined method to support the planning use case be part of long-term refinements to ICA.

6 Schedule and Timelines

6.1 Timeline for implementation

Following the completion of Demo A, the IOUs plan to perform final system-wide implementation of ICA. The WG engaged in multiple discussions surrounding expediency around this implementation, given the size and complexity of this project.

Stakeholders and the IOUs have separate recommendations regarding when the IOUs should implement the ICA across their service territory. Multiple stakeholders involved in the drafting of this report, including IREC, SEIA, and Vote Solar have expressed no preference in recommendations regarding implementation timeline. In both recommendations, the ICA methodology should include the identified short-term recommendations from the final report.

Proposal 1: Implementation within 12 months of a PUC Final Decision on final ICA methodology.

The IOUs understand the urgency of implementing an approved ICA methodology system wide and are committed to implement the ICA Methodology in an expeditious manner, given the need to implement a very large and complex project which has not been attempted by any utility. For reference, in Demo A, SCE performed the ICA on 82 distribution feeders in 4 months. In the system wide implementation, SCE will need to implement ICA on more than 4,500 distribution feeders, an amount which is exponentially higher in magnitude with a significant reduction in time compared to what was done in Demo A (Demo A: 21 circuits/month, System implementation: 375 circuits/month).

While a Final Decision is pending, the IOUs will continue to work on preparation activities, including preparation of network models, data sources, work force plans and implementation procedures. Once the CPUC issues a Final Decision, IOUs anticipate 12 months will be necessary for implementation.

Additional details on which IOUs work activities will begin prior to and after the Final Decision are outlined below, as prepared by SCE and applicable to all three IOUs:

Work to commence while a Final Decision is pending:

- **Model creation and validation:** SCE engineers to create distribution system models. Activity can start prior to a CPUC Final Decision, but it is estimated to last 10 months.
- **Preparation of data sources:** Preparation of data sources such as, SCADA Historian, GIS, and Distribution Management System is required.

Work to commence after decision (12 months):

- **Implement ICA methodology:** SCE estimates 4 months of development once final ICA Methodology is established. Work cannot start prior to CPUC Final Decision, as development requires all assumptions and functionality be outlined prior to start of solution design. In addition, based on Demo A work, various iterations of testing are required to stabilize code (e.g., troubleshoot bugs) to render solution production ready. Code will not be stabilized until after various distribution circuit models have been analyzed. Vendor engagement is required.
- **Run ICA**: Perform the ICA on the distribution system models. Based on the ICA Methodology requirements (e.g., number of hours, frequency of updates) computing resources need to be configured and computing resource management systems may need to be developed. Work with vendor community is required.
- **Quality assurance and control:** Quality control and quality assurance systems and processes need to be designed, developed, and implemented to support ICA methodology implementation activities, and to support SCE in the publication of most accurate results.
- **Publication of results**: Develop interfaces between ICA results databases, mapping databases, and other data sources required by a CPUC Final Decision. Edit map symbology to meet ICA requirements.

Separately, PG&E recommends that the ICA be implemented by June 2018, to coordinate with PG&E's planning process (currently distribution planning analysis and engineering review occur in the January to May timeframe). PG&E notes that if the CPUC adopts PG&E's recommendation to use the blended approach ("streamlined" method for system wide analysis and the "iterative" method on an as-requested or pre-application basis), then it is expected that fewer engineering resources are needed to implement this efficient approach.

IOUs strongly recommend that the appropriate time to complete full system wide implementation of ICA be 12 months following a CPUC Final Decision. This will ensure that IOUs can implement the appropriate methodology without the risk of losing valuable engineering work if the Proposed Decision is different than anticipated. Additionally, IOUs will continue to prepare those elements, such as preparing network models, data sources, work force plans and implementation procedures, that are needed for full implementation before a Final Decision is provided.

Proposal 2: Implementation within 12 months of ICA WG Final report. CALSEIA recommends that the IOUs begin the implementation process following the publishing of the ICA Final WG report, and finish implementation within 12 months of final report submission.

6.2 Recommended regulatory process

The WG recommends that the Commission establish two processes to incorporate modifications to the ICA both as part of the implementation of ICA system wide on its first rollout and as future enhancements are added to the methodology. These processes should balance the need for flexibility in implementation and in following appropriate CPUC practices:

1. **The CPUC should adopt a process whereby IOUs consult with the ICA WG, followed by a Tier 1 advice letter, to approve ICA methodology refinements:** As the utilities continue to refine and enhance the ICA methodology through long term enhancements

to ICA and consideration of future refinement studies, such as inclusion of smart inverters, single phase line sections and transmission impacts, it is requested that the Commission establish a process to allow the ICA WG to collaborate and determine how enhancements to the methodology are to be deployed system wide. The WG views the ICA methodology as one which will continue to evolve in an expedited and effective manner. This process should provide flexibility to phase in refinements within boundaries established by the CPUC.

2. **The CPUC should adopt a process whereby requests for modification of scope and schedule, due to unforeseen circumstances during full system rollout, be sought through a Tier 1 advice letter:** The methodology and refinements recommended in this report are based on the best available knowledge of software and tool capabilities, costs of implementation, and complexity of the project through review of Demo A Final Reports and subsequent WG discussions. Further, there are several meaningful recommendations made in this report that were not required to be tested as a part of Demo A, but were discussed among the WG as part of its direction from the ACR to "improve and refine the ICA methodology." For these recommendations, the WG engaged in discussion regarding the need for changes, and the practical feasibility of incorporation within either the initial system-wide rollout, versus establishing as longer-term goals. Given the scope and complexities of system wide implementation of ICA, the WG acknowledges that new challenges and limitations may surface that are not possible to predict at this time, but may arise during full system rollout be sought through a Tier 1 Advice Letter.

7 Review of Cost Estimates

After reviewing the results of the Demo A, the WG determined it would be additionally necessary to access how to best deploy ICA methodology with sufficient granularity to meet the use case, while acknowledging considerations regarding computing time and costs. The WG had identified inaccuracies in the streamlined method results during its review of Demo A. Understanding that the majority of the WG supported the use of the iterative method for the interconnection use case (*see Section 4: Use Cases*), the WG began discussions to determine how to best deploy the iterative approach in a manner that would achieve sufficient granularity in the calculated ICA, while also balancing the computing time and costs.

There are at least three different elements to consider when evaluating how to reduce the computational burden of the iterative method: (1) the methodology itself, (2) the software/hardware it is run on, and (3) the staff time associated with running the model and any manual efforts required to maintain it. As indicated in the Demo A Final Reports, each utility reported significantly different processing times for the iterative method (the WG notes that that this was not an apples-to-apples comparison as the utilities used different hardware, software, and computational efficiency measures in their Demo A results). In slides prepared for the WG meeting on January 6th[10], the utilities reported the following times on average per feeder: PG&E - 23 minutes, SCE - 83 minutes, and SDG&E - 1,620 minutes.

[10] http://drpwg.org/wp-content/uploads/2016/07/ICA-WG-Jan-6-slide-deck.pptx

- **Methodology:** The IOUs identified a number of factors that could be modified within the iterative methodology in order to reduce the computational burden. These included: reducing the number of nodes; reducing the number of hours in the load profile; reduction of the limitation categories evaluated on strong feeders; the frequency that the analysis was run; and whether it was run system-wide or on a more “as needed” or “case-by-case” basis. Note the utilities did not all deploy each of these computational reduction strategies due to time and other factors in Demo A, which may be one factor in the difference in computational time seen in the results. The WG also identified a need to understand the computational effect of allowing voltage regulating devices to “float” instead of remaining “fixed” or “locked” in the model. Other than the reduction in nodes and limitation on categories (which the WG concluded were logical computational savings that should be implemented since they did not have a significant impact on the results), each of the other factors could affect the ultimate usability of the ICA to achieve the interconnection use case goals and the accuracy of the ICA that is ultimately calculated. WG discussions on these methodological choices are detailed further in this report.

- **Hardware/Software**: Each IOU used a different combination of software and hardware to run the Demo A results. For example, SDG&E indicated that the “streamlined simulation was performed on a server based computer, while the iterative was performed on office laptop computers.[11]” PG&E “used a combination of local machines and servers which relied on many parallel computing streams for the analysis.[12]” SCE’s report did not specify the hardware used to run the models in their Final Report, but they explained to the WG that SCE utilized local servers to run the results. In addition to the differences in hardware, the use of CYME or Synergi and other related software also impacted the computational burden of Demo A.

- **Staff Time:** An additional factor that did not get covered in as much detail in the Demo A Final Reports or WG discussion was amount of staff time required to run and maintain the models depending upon the methodology selected. PG&E in particular indicated that running the iterative method for the interconnection use case on their system could require significant increases in engineering staff support, as they are not currently able to maintain their models in an automated fashion.

Recognizing that the ultimate formula of these different factors selected for the final ICA methodology could have a potentially significant impact on the costs associated with deploying the ICA, the WG sought cost estimates that would help illuminate which factors have the greatest effect on costs, and assist both the WG and the Commission in making an informed recommendation for how to deploy the ICA for the interconnection use case. Stakeholders of the ICA WG requested[13] that the IOUs provide a base case estimate of the costs to run a plausible scenario for each of the two methodologies and then identify the cost factors associated with a set of defined sensitivities. For the iterative method, the WG asked for information on the following sensitivities: (i) Frequency of running the model; (ii) Hours (i.e. 96, 576, 8760); (iii) Movement of voltage regulating devices; (iv) Method of updating a system-wide ICA (i.e. a “case-by-case” basis or on an “on-demand” basis). The WG also asked the utilities to identify (i)

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[11] SDG&E Demo A Final Report, pp. 43
[12] PG&E Demo A Final Report, pp. 143.
[13] See stakeholder recommendations submitted on 1/30. http://drpwg.org/wp-content/uploads/2016/07/WG-Recs-and-Questions-1.30-002.docx

what costs are one-time costs, (ii), which costs are variable but will decline over time, and (iii) which costs are variable, increasing with increased levels of computational intensity.

On February 27th, the IOUs provided the following table that summarized their cost estimation efforts, and subsequently provided a list of factors that went into those cost estimates.

Table 1: Cost Estimates Comparison of Multiple ICA Implementation Scenarios

Iterative	Cost ($000) (Year 1)		Cost ($000) (Beyond Year 1)	
Scenario 1: 96 loading conditions, monthly updates ICA WG Iterative Methodology base case	**PG&E**	$2,040-$3,800	**PG&E**	$1,740-$3,050
	SCE	$3,300-$6,300	**SCE**	$1,400-$2,600
	SDG&E	$2,200-$3,300	**SDG&E**	$1,100-$1,700
Scenario 2: 576 loading conditions, monthly updates	**PG&E**	$2,990 - $5,300	**PG&E**	$2,690 - $4,550
	SCE	$3,800-$7,000	**SCE**	$2,200-$3,900
	SDG&E	$2,400-$3,500	**SDG&E**	$1,500-$2,200
Scenario 3: 96 loading conditions, weekly updates	**PG&E**	$4,130-$7,100	**PG&E**	$3,830-$6,350
	SCE	$4,300-$8,100	**SCE**	$2,900-$5,200
	SDG&E	$3,100-$4,700	**SDG&E**	$2,200-$3,300
Streamlined	**Cost ($000) (Year 1)**		**Cost ($000) (Beyond Year 1)**	
Scenario 1: 8760 loading conditions, annual updates ICA WG Streamlined Methodology base case	**PG&E**	$1,480-$3,060	**PG&E**	$680-$1,560
	SCE	$2,000-$3,600	**SCE**	$600-$1,400
	SDG&E	$1,700-$2,500	**SDG&E**	$600-$900
Scenario 2: 8760 loading conditions, monthly updates	**PG&E**	$1,630-$3,360	**PG&E**	$830-$1,860
	SCE	$2,000-$3,600	**SCE**	$1,100-$2,100
	SDG&E	$1,700-$2,500	**SDG&E**	$900-$1,400
Scenario 3: 8760 loading conditions, weekly updates	**PG&E**	$1,810-$3,720	**PG&E**	$1,160-$2,470
	SCE	$3,300-$5,900	**SCE**	$1,700-$3,200
	SDG&E	$2,300-$3,500	**SDG&E**	$1,500-$2,200

These cost estimates consider resources to complete tasks required for system wide rollout implementation and for continue on-going support and maintenance. The typical tasks are outline as follows:

- **Model creation and validation**: typically includes 1) the creation of distribution system models by integrating data from multiple sources, including SCADA Historian, GIS, and Distribution Management System data; and 2) the validation of the distribution circuit models ensuring accurate modeling of the distribution system (i.e., validate that models reflect actual planned conditions).
- **Implement ICA methodology:** typically includes 1) implementation of final ICA methodology on an enterprise-friendly system capable of handling large datasets; 2) development of databases, data structures, and processes; 3) implementation of algorithms and assumptions (e.g., pre-existing conditions); and 4) additional work with vendor community.
- **Run ICA:** typically includes 1) performing ICA on distribution system models and 2) working with vendor community and software licensing. Based on methodology requirements (e.g., number of hours, frequency of updates), computing resources need to be procured and configured. In addition, based on volume of data, computing resource management systems may need to be developed. "Stop and run" of ICA to troubleshoot problems is expected, proportional to the number of scenarios/loading conditions analyzed.
- **Quality assurance and control**: once ICA is complete, the results need to be evaluated for abnormal data due to divergence or modeling issues. These data can include ICA results that fail to converge, which will require manual troubleshooting by engineers.
- **Publication of results:** based on the final data attributes, volume of data, and frequency of updates, development work is required to update the mapping systems and integrate these to ICA results databases.
- **Periodic updates**: software development to support Tasks 1-5 to meet periodic update requirements as mandated by final ICA methodology, including automatic identification circuitry changes requiring ICA update, and end-to-end integration of processes and data.

WG discussions surrounding these cost estimates have led to separate recommendations regarding two methodological refinements in particular: 1) hourly load profile, and 2) frequency of updates. The IOUs discuss in their Final Demo A Reports whether utilization of load profile reduction methods can significantly improve ICA runtime performance, while still providing the required level of accuracy *(see Section 11.3: Computational Efficiency)*. IOUs additionally recommend that ICA is updated no more than on a monthly basis, and set a longer-term goal for more frequent updates as necessary to meet the uses of interconnection *(see Section 8: Frequency of Updates)*. Many stakeholders recommend maintaining a 576 hour load profile (as tested in Demo A) and that ICA results are updated on a weekly basis.

Further detail regarding the recommendation of a subset of WG stakeholders is detailed below. The IOUs recommend review of their Demo A Final Reports for full discussion and detail of their recommendation on hourly load profile, and how often ICA should be updated.

Stakeholder subgroup recommendation:
Written by Interstate Renewable Energy Council (IREC), on behalf of a stakeholder subgroup including CALSEIA, Clean Coalition, SEIA, SolarCity, Vote Solar

The WG appreciates that the utilities had limited time to prepare the cost estimates, and that some of the cost elements are hard for them to precisely predict, as they may be dependent on software vendors and other unknown factors associated with conducting a system-wide ICA for the first time. However, the stakeholders of the WG found the cost estimates to be lacking in sufficient detail to adequately guide the decision-making process. The estimates look at a limited number of scenarios without identifying the specific sensitivities associated with each factor (and only two conditions varied: the hours and frequency of updates). The estimates also provide very high ranges; in many cases, the top end of the provided range is nearly double that of the low end of the range. The estimates do not identify what costs may overlap or be duplicative with services or costs that have already been identified in other forums (i.e., in distribution system planning or DER integration cost estimates in the utilities' respective general rate cases). The costs are not broken out by category so that stakeholders of the WG could understand what portion of the costs are associated with corresponding variables (e.g., staff time vs. server costs, etc.) Finally, it is also very important to recognize that these cost estimates have not taken into account any potential cost savings associated with using the ICA to create a more efficient, and less manual, interconnection process. It is expected that over time, the utility engineering and administrative time associated with the interconnection process could be reduced through the use of the ICA and those savings should be considered in assessing the costs of ICA rollout.

With these limitations in mind, these WG stakeholders have the following comments about how these estimates have influenced this set of recommendations. First, this subset of WG stakeholders recognize that the costs of running the iterative method are higher than those of the streamlined method, but concludes that those costs are warranted in order to extract actual benefit from the ICA in the interconnection use case. For DER customers to be able to reduce the costs of project development, it is important to have transparent ICA results that will correspond to actual interconnection decisions. Correspondingly, utility costs associated with processing interconnection results will not be meaningfully reduced if the ICA results cannot be relied upon in interconnection decision-making. It will take time to fully implement and realize the cost savings associated with integrating the ICA into the interconnection process, but starting with the right foundation is important to achieving that long-term goal.

Second, while it does appear that costs associated with updating the ICA weekly are notably higher, the increased frequency is important to ultimately enabling a process whereby interconnection applicants can utilize the ICA information displayed in the maps and underlying data to accurately predict their ability to achieve an automated or semi-automated interconnection decision. The WG believes that monthly should be the very minimum frequency with which the ICA should be updated, but it is inclined to recommend that weekly updates be required from the outset. While the cost information is quite speculative at this point, the WG would like to see if the utilities could identify more efficient ways of updating the ICA on a weekly basis if truly tasked with that requirement.

Third, similar reasoning applies to the number of hours evaluated in the load profiles. One of the core improvements of ICA is moving from a process that only includes annual maximum or minimum values to a process that considers seasonal maximums and minimums. Since 96-hour data includes only two representative days per year, this is not a strong enough step toward improved granularity. The WG therefore recommends 576-hour data.

Thus, this subset of WG stakeholders recommend that the utilities be required to do an initial rollout of the ICA that aims to update any changed circuits on a weekly basis and that applies a 576 hour load profile. If the cost estimates provided by the utilities are accurate, the costs associated with initial rollout will be higher under this scenario compared to other options, but the marginal increase may be estimated at $1-4 million dollars per utility which, in the big picture, is a quite modest cost (i.e. a one-time cost of a few cents per electric customer). It is the yearly maintenance costs that are of greater concern, but it seems likely to these WG members that these costs are more speculative at this point and could fall over time as technology improves and internal efficiencies are identified - though the WG acknowledges this point is currently just speculation.

Thus, this subset of WG stakeholders recommend that the Commission require the utilities to document their processes and the costs associated with them in a granular manner for three years. Subsequently, the Commission should utilize that information to evaluate what the yearly maintenance costs are, and are likely to be going forward. At that point, the Commission can reevaluate whether the actual costs are justified based upon the applied experience and, if not justified, the frequency of the updates or the hourly profile (or other factors) could be adjusted accordingly. The Commission may also want to consider applying an overall not-to-exceed cost cap should the estimates turn out to be overly conservative.

8 Frequency of Updates

The WG recommends that ICA be updated frequently enough to allow for a meaningful impact to interconnection process for projects that are proposed below the ICA value at their point of interconnection. To meet this goal, members of the WG have different opinions on how often ICA should be updated.

The IOUs support system-wide monthly updates for the initial rollout with consideration of additional functionality and higher levels of frequency of updates in subsequent iterations, such as case-by-case updates, weekly or on demand updates contingent upon cost, funding and system capabilities. The additional envisioned condition-based updates requested by some WG stakeholders will require significant front-end coding and development to implement properly, and may create additional costs and/or delay the first system-wide implementation.

Other WG stakeholders believe that, at a minimum, system-wide ICA values should be updated annually and that specific ICA values be at minimum updated weekly to reflect new queued projects or other system changes above a defined threshold. Since the GIS databases of the utilities are updated weekly, this recommendation corresponds with those parallel updates. This would allow the ICA figure shown on the maps to provide the most accurate ICA to be used for interconnection requests. The ICA should be run system-wide as needed to reconcile local changes.

As a long-term vision, and not part of the ACR's long-term refinement scope, some members of the WG envision that the ICA should be updated on a real-time or daily basis to the extent possible to allow the reflecting values to be used in an automated interconnection process. Future enhancement should work towards this goal, while considering issues such as the following in coordination with the Rule 21 proceeding:

- Development of automated interconnection studies which considers specific application information that cannot be known ahead of time to be reflected in ICA. Generation queuing, commercial operation dates, and planned work/transfers can all have a unique impact on certain locations in the system and currently must be considered application-by-application with manual engineering review.
- Stricter enforcement of applicant timelines and milestone provisions to prevent the risk of individuals claiming queue positions via speculative process.
- Costs associated with the work needed to develop necessary tools and procedures.

9 Presentation of ICA values

The WG recommends that the ICA information be presented in both online maps and downloadable data formats. The ICA information to be used in the maps and to be downloadable includes three ICA values with two separate applications of operational flexibility limitations. The three ICA values to be published are: (1) the uniform operation ICA value for generation (technology-agnostic ICA value), (2) the uniform operation ICA value for load (technology-agnostic ICA value), and (3) ICA value using a typical fixed PV production shape. The two applications of operational flexibility are described in further detail in *Section 10.4: Safety and Reliability*.

In total, six ICA values should be published:

Table 2: Published ICA Values in Maps

Uniform load ICA value, operational flexibility limit	Uniform load value, reverse power flow up to the substation low-side busbar
Uniform generation ICA value, operational flexibility limit	Uniform generation ICA value, reverse power flow up to the substation low-side busbar
ICA value using typical PV profile, operational flexibility limit	ICA value using typical PV profile, reverse power flow up to the substation low-side busbar

The WG will develop a standard PV generation profile to be used within the online map in time to be used in the first system-wide rollout of ICA. The profile will be sufficiently conservative to be relied upon for interconnection approval, and will include monthly variation in solar production. In addition, the IOUs developed an offline ICA Calculator that can be used to help determine ICA values at specific locations for user-defined DER profiles.

The ICA value used for the interconnection review should be the same ICA value shown on the online maps –thus, the ICA maps and underlying data should be updated with the same frequency as the ICA itself. Further modifications and procedures in future modifications in the Rule 21 process should take this into account.

10 ACR Requirements

10.1 Modeling and extracting power system data

The IOUs used either LoadSEER or an equivalent load forecasting analysis tool to develop load profiles at the feeder, substation, and system levels. In Demo A, IOUs aligned load allocation methodology with current interconnection practices, and further detailed how weather assumptions were incorporated through separate written responses[14].

Stakeholders of the WG posed questions on assumptions used in load forecasting, including questions on inclusion of weather conditions (e.g., temperature, irradiance, wind speed, concurrent with each hour of the load forecast). Because load forecasts are significant factors in forecasting grid conditions and which can influence ICA values, the WG recommends that the findings and recommendations from the CPUC workshop from Track 3, sub-track 1 on Load and DER forecasting, as well as all findings from this DRP sub-track, be incorporated as appropriate into the ICA methodology.

The WG additionally provides the following considerations, to help inform the Track 3 process:

- Stakeholders of the WG request additional transparency regarding underlying weather assumptions from which IOU high and low load hours are derived. Understanding the conditions underlying load forecasts is important if developers are meant to model DER performance to ensure hosting capacity limits are not violated.
- Currently, there are differences among the methodology employed by the three IOUs. Stakeholders of the WG would like to further understand reasons for methodological divergence.
- Within PG&E and SDG&E's methodology, some stakeholders would like to further understand whether the synthetic days created are sufficiently reflective of real conditions that would be experienced on the distribution system.

10.2 Power system criteria methodology

ICA results are dependent on the most limiting power system criteria. The four criteria used for Demo A are:

1. **Thermal criteria:** amount of additional load or generation that can be placed on the distribution feeder without exceeding equipment thermal ratings
2. **Power quality/voltage criteria:** steady state voltage violations and voltage fluctuation calculated based on system voltage, impedances and DER power factor. Violations outside of Electric Rule 2 and voltage fluctuation of up to 3% is part of system design criteria for all three utilities.
3. **Protection criteria:** amount of fault current at various protective devices factoring in contributions from DER.
4. **Safety/reliability criteria:** operational flexibility that accounts for reverse power flow issues when DER/DG is generating into abnormal circuit operating scenarios. Other limitations supporting the safe and reliable operation of the distribution system apply, including thermal overloads due to new configuration, and high or low voltage issues due to new configuration.

[14] http://drpwg.org/wp-content/uploads/2016/07/WG-Recs-and-Questions-SCE-PGE-SDGE.docx

The WG developed recommendations regarding the input assumptions for the power quality/voltage and the safety/reliability criterion, and anticipates the ICA methodology may change depending on its specific use case.

10.2.1 Power quality/voltage criteria:

The IOUs take various approaches to how they treat voltage regulating devices within the iterative methodology. Devices may be "locked", meaning that these voltage regulating devices do not adjust from one simulation to the next simulation in the ICA, or the devices can be "unlocked", meaning that these voltage devices adjust to maximize voltage profile from one simulation to the next. In the field, the voltage regulating devices are not locked, thus, by locking them in the model the calculated ICA will not accurately reflect field conditions. Currently, CYME software (used by PG&E and SCE) does not have the capability for "unlocked" operations allowing voltage control devices to adjust during ICA iterations (referred to as "float"), while Synergi (used by SDG&E) does have that capability. Through WG meetings, the IOUs explained that the CYME module used for Demo A locked voltage devices to better allow for modeling convergence. Although allowing devices to float more closely models real-world conditions, it adds to model complexity which increases divergence and runtime.

The WG is in consensus recommendation that voltage regulating devices should be "unlocked" within the iterative methodology, but are not in consensus with regards to process and timing of implementation which would allow the IOUs to enable this feature.

PG&E, SCE, and SDG&E recommend that for the first system-wide rollout, voltage regulating devices may be operated as applied in Demo A for each IOU (i.e. locked for SCE and PG&E, but allowed to float for SDG&E); The IOUs will work with software vendors to encourage the inclusion of an optional function to "unlock" the voltage regulating devices into the ICA modules, using a set of operational assumptions to be developed by the WG. As this requires action and commitment from vendors, assessment of impacts on runtime and analysis of ICA convergence (i.e., successful completion), this function should not be required for the first system-wide rollout but rather on subsequent rollouts when the function has been added to the power flow tools. The WG should continue to evaluate the value of not locking down the voltage regulator.

Other WG stakeholders recommend that IOUs work with software vendors to encourage its inclusion into the first system-wide rollout, given that Synergi has already shown the capability to do so, although CYME currently does not include this functionality. Stakeholders would like to first see whether this can be achieved before deferring to subsequent rollouts, though understand the need for delay if software vendors are unable to achieve this functionality in time.

The WG is open to continued discussion on the number of iterations of adjustment that are appropriate to determine the most accurate ICA value in an efficient manner. The effect of unlocking the voltage regulating devices was not included in the cost estimates provided by the utilities, though it is believed that SDG&E's estimates included that capability.

10.2.2 Safety and reliability, or "operational flexibility"

Demo A required two power flow scenarios for compliance with the ACR ruling which states that:

The demonstration is to employ two different methodologies of calculating the ICA values using:

a) *A scenario which limits power flow analysis to ensure power does not flow towards the transmission system beyond the distribution substation bus;*

b) *A scenario which determines the technical maximum amount of interconnected DERs that the system is capable of accommodating irrespective of power flow direction;*

To comply with the requirements of (a), the IOUs employed a method which prevented reverse flow of power across any SCADA-operated device on the distribution feeders. This method ensured that no power would be sent toward the transmission system as required by (a).

To comply with (b), the IOUs removed the limitation at the SCADA devices. This method provided an ICA value irrespective of power flow direction as required by (b).

Feeders contain open ties to other feeders in a distribution planning area that allow utilities to reconfigure circuits in response to loading condition, faults, or during system maintenance. Utilities maintain adequate “operational flexibility” to restore service to as many customers as possible and as quickly as possible during those events. This creates a challenge for evaluating hosting capacity because the reach of a DER system’s impact is not only along the circuit to which it is normally connected but also to all other circuits to which is could potentially be actively connected. For example, a DER system that could impact the power quality or thermal capabilities of an adjacent feeder should be considered even if the two items are not electrically connected during normal operating conditions.

The method of calculating the requirements for (a), where the utilities applied a “no reverse power flow across SCADA devices”, also served as limitation to provide an “operational flexibility limit” as required to maintain safety and reliability. This operational limit is used to maintain the operation of the distribution system without affecting distribution system reliability. That is, this methodology is designed to allow the highest levels of DER to be connected to the distribution feeder, without a reduction on operation of the distribution system. While the WG members agree with this general principle, some WG members also note that it has not been shown that retaining 100% operational flexibility in all cases is actually necessary to avoid safety and reliability concerns.

The intent of the safety/reliability constraint is to ensure that all operational flexibility is preserved when DERs are added to the grid. The SCADA-operated devices represent points at which the grid can be reconfigured, either permanently or temporarily. Because the ability of the grid to tolerate reverse flow depends on the configuration, by prohibiting reverse flow at these points, the ICA determines the DER adoption that produces no reverse flow in any configuration.

The WG recognizes that the operational flexibility criterion as implemented and described above is based on engineering practices that allow for calculation of the operational flexibility criteria across all circuits. However, the results of Demonstration A show that operational flexibility, as currently modeled by the IOUs, is a limit to ICA that produces results which ensure power quality to all customers and DER but may be overly conservative as a result. The WG recognizes that the method used to determine operational flexibility is heuristic in nature and encourages further discussion to determine non-heuristic methods to analyze operational flexibility.

The operational flexibility criterion based on no reverse power flow across SCADA-operated devices was implemented in Demo A because no other options for ensuring operational flexibility were identified and determined to be feasible given the current understanding of the capabilities of either the iterative or streamlined methods. The WG agrees that this was a reasonable short-term path, but believes that developing an improved approach to evaluating DER adoption limits related to operational flexibility should be an ICA development priority.

Additionally, the IOUs included in their Demo A projects a no-reverse-flow limit across voltage regulators, in some cases, in order to prevent power quality and voltage limits violations. This is because some voltage regulators currently on the system (both field and substation) may not be designed to allow for backflow, and existing control settings may not be adequate to properly manage increased levels of DER (some controls are programed to existing system conditions). Some voltage regulators and load tap changer (LTC) controls require fixed settings based on the load and DER connected to the voltage regulators. Thus, allowing reverse power flow on voltage regulators without verification of regulator's capability to accept reverse power flow may cause power quality issues for load and DER customers.

First System Rollout Recommendations

The WG agrees and recommends that the operational flexibility criterion based on no reverse power flow across SCADA-operated devices is a reasonable short-term solution to the preservation of operational flexibility. Therefore, the WG recommends that the IOUs calculate the ICA values both with and without this constraint in the first system-wide rollout of the ICA without waiting for further refinement of the criterion. The WG recommends that in the first system-wide rollout of ICA results, two sets of values be published (for reference to sets of ICA values, please see Section 9: Presentation of ICA Values):

1. Set of ICA values as applied in Demo A with operational flexibility limitations on SCADA devices
2. Set of ICA values allowing reverse power flow across the SCADA devices up to the substation low-side busbar and without allowing reverse power flow to the high-side busbar across the substation transformer towards the transmission system

Publishing both values will better indicate the hosting capacity where this factor could be mitigated or determined to be non-constraining through Supplemental Review in the Rule 21 process. It is important to note that this second value differs from the second value tested in Demo A in accordance with ACR requirements.

Considerations for Long-Term Refinement

The WG engaged in discussions regarding means to improve how operational flexibility is addressed within ICA. Many WG members place high priority on development of an improved operational flexibility criterion as a key long-term refinement item. These WG members envision that the WG develop an improved, less heuristic approach based on engineering analysis that evaluates whether a limit on operational flexibility results in any safety or reliability impacts. This new approach may be enabled by an improved understanding of the ICA's ability to evaluate a large number of scenarios and configurations or by a discussion of how the utilities study the operational flexibility impact of an interconnection application that requires such a study. This improved value is expected to replace Screen P (the Safety and Reliability Screen) within the Rule 21 process.

These WG members additionally recognize that one possible solution to this restriction could be that utility may in the future utilize communication means to send commands directly to DER systems or may send communication through third-party aggregators to DER systems as to mitigate the issues related to operational flexibility. However, that capability will only be available after the CPUC develops rules for contractual relationships between utilities and DER system owners through a stakeholder process, or such contracts are found mutually agreeable to counterparties and do not violate existing regulations.

Finally, these WG members feel that further refinement of the operational flexibility criterion will include differentiating between different types of SCADA-operated devices, and recommend that IOUs include this data in their efforts to clean up data in preparation for the first system-wide rollout.

The IOUs would also like to examine whether the operational problem may be solved in future years through the implementation of other potential solutions. Such solutions include the implementation of future DERMS, which would provide high levels of visibility and control and would mitigate the system flexibility limitation. Some WG members are also open to these types of solutions, but would like both to be considered going forward. The WG will determine a more detailed priority list of items in the beginning stages of the long-term refinement process.

Some WG members recommend that the CPUC consider the following questions about the interplay between ICA and operational flexibility:

1. If increased DER adoption has the potential to become a consideration in operational flexibility, how can we quantify the impact of the change in operational flexibility?
2. What kind of change in operational flexibility is appropriate to reach policy goals related to DER adoption?
3. Are there technical and/or policy solutions to expand ICA while still preserving operational flexibility?

The utilities view any reduction of operation flexibility which impacts customer service reliability in favor of increasing ICA as contrary to the goals of DER implementation. Further understanding of these questions may require a separate research initiative or pilot project.

10.3 Circuit models

The IOUs have not historically created computer models of their substations and distribution circuits such that engineering analyses such as power flow and short-circuit analyses can be performed. PG&E models are complete but additional work to enhance the gateway to incorporate requirements set forth by WG recommendations will be needed. SDG&E modeled its distribution system as part of Demo A. SCE modeled 83 of its circuits as part of Demo A, is currently modeling the balance of its system, and expects to complete this process in approximately 8 months. While the IOUs built these models using the best available data, the models and underlying data may require adjustment if power flow models do not converge on a solution during ICA analysis. In the streamlined analysis, only one power flow analysis is performed and model adjustment is only required once, except when circuits change (as discussed below). With the iterative method, additional model adjustments may be required during any of the hundreds or thousands of power flow analyses performed for each circuit, as adding DER in each location has different impacts.

Separately, IOU distribution circuits are constantly changing due to circuit reconfigurations, new utility equipment, new or modified loads, and DER additions. IOU circuit models must be routinely updated and vetted for ICA values to be current and accurate. IOUs have confirmed that they will update their circuit models as part of the implementation work in advance of system-wide ICA implementation. Some stakeholders expressed that ICA cannot be deployed on a system wide basis until each IOU develops a means to adequately incorporate changes in distribution circuits and loads. Tweaks to circuit models in CYME and Synergi required for model convergence are currently lost when new data from GIS and other data sources is incorporated into the power flow model. In addition to details provided in the Final Demo A Reports, the IOUs have provided the following proposals for how models may be updated and remaining work before system-wide implementation:

- PG&E has a gateway tool for incorporating circuit updates into its circuit models on a weekly basis. PG&E also creates yearly planning models from a snapshot of the gateway model which contains specific modifications and planned worked on the circuits. Recommendations from the WG would require additional work to merge the planning models with the gateway models.
- SCE reiterates that it would incorporate significant changes to new circuit models on a monthly basis. SCE is currently developing automated processes to maintain the accuracy of network models and data as changes on the distribution system occur, as part of full system-wide deployment of ICA.
- SDG&E currently automatically updates its models daily, but those are not currently validated for ICA purposes. SDG&E would need to validate those models that have monthly changes for the ICA update.

10.4 Pre-existing conditions

The WG identified a challenge whereby circuit models sometimes display violations of one or more power system criteria before the DER is modeled, resulting in a hosting capacity of zero (i.e., a pre-existing condition on the circuit is responsible for the violation). A targeted DER solution may not impact the existing violation criteria, and in some cases, could even improve the existing violation criteria. However, it may be difficult to automatically determine whether adding a DER solution worsens a violation criteria or creates an entirely new violation.

To address this condition, the WG recommends that (1) ICA should be limited by pre-existing conditions when adding DER degrades the pre-existing condition; and (2) that ICA should not be limited by a pre-existing condition when adding DER improves the pre-existing condition. For example, in a situation when low voltage exists in an area, adding generation may improve the low voltage condition but adding load may degrade the pre-existing conditions. In this example, the ICA for new generation would not be limited by the pre-existing condition but the ICA for new load (i.e. electric vehicles) would be limited by the pre-existing condition. It should be noted that in some cases, such as substations with load tap changer (LTC) control, adding generation to a low voltage pre-existing condition may further degrade the low voltage condition rather than improve the low voltage condition. These refinements should be included within the first system-wide rollout of ICA.

To implement this recommendation, the IOUs will need to create automated processes as part of the ICA implementation plan to efficiently evaluate the feeders and substations for pre-existing conditions. These processes would need to determine if any pre-existing conditions exist and to determine if adding DER would improve or degrade the detected pre-existing condition and take the necessary action to determine when ICA can be allowed or when ICA must be limited by the pre-existing condition. The IOUs expect that this process will require significant IT resources to automate and/or significant engineering resources to properly consider evaluate pre-existing conditions on a regular basis. These additional costs were included in the utilities' costs estimates.

11 Short-term WG Activities as Outlined by ACR

The ACR outlines seven discrete activities for WG consultation related to Demo A (ACR Section 3.1). The IOUs consulted with the WG on each of these topics in 2016. A summary of those topics, discussions, and recommendations are included below.

11.1 ACR Section 3.1.b: Recommend methods for evaluation of hosting capacity for the following resource types: i) DER bundles or portfolios, responding to CAISO dispatch; ii) facilities using smart inverters

11.1.1 With regards to DER bundles or portfolios responding to CAISO dispatch

For Demo A, the IOUs generated technology-ICA results in consultation with the ICA WG, given that assumed DER operational profiles do not accurately represent variations due to locational and technology specifications. It was also determined that it would be difficult to accurately define the ICA in a meaningful way for hypothetical DER bundles, without knowing the specific operational profiles and combination of the DER in the bundle.

The WG agrees with use of a technology-agnostic approach to determine ICA values in the full system-wide rollout and not be required to determine ICA values based on technology specific DER bundles or portfolios, or through assumptions about CAISO dispatch.

11.1.2 With regards to smart inverters

The WG envisions that smart inverters can influence the ICA in that smart inverters may, in certain conditions, support greater hosting capacity.

Within Demo A, the IOUs did not recommend methods for evaluation of hosting capacity with regard to smart inverters. However, the IOUs did conduct analysis to start understanding the impact of smart inverters on ICA, and recommended to the WG that integration of smart inverters be considered as a future enhancement building upon Demo A results, at the August ICA WG meeting. The WG accepted this in the development of ICA as a reasonable first step. IOUs limited their Demo A study to the Smart Volt/VAR function which, when used properly, may have the ability to reduce steady state voltage rise. These capabilities were tested on a limited basis by each utility using either the streamlined method or the iterative method.

The utilities performed ICA calculations applying a limited set of smart inverter capabilities on one distribution feeder to determine how smart inverters may be able increase the integration capacity. The capabilities tested were a static volt/VAR curve (SCE) and fixed power factor (PG&E and SDG&E). The studies indicated that smart inverter may be able to support higher levels of ICA in certain system conditions.

The WG recognizes that universal reactive power priority cannot be incorporated into the ICA until standards are improved and compliant inverters are widespread. Additional methodology development and software enhancements are required as the WG determines how smart inverters may be incorporated in the near term. Currently, smart inverter functions are being finalized, while understanding how to study the functions within ICA requires additional research and development – while CYME and Synergi already contain the ability to include some advanced inverter functionality, but the WG must agree on assumptions of how smart inverters will operate before the software vendors incorporate that capability into the ICA modules.

The ICA WG agrees that smart inverter functionality be included in ICA calculations when the functional methodology has been agreed and developed and tools are capable of implementing smart inverter technology in automated and efficient manner. The WG will do this as part of long term enhancement to ICA, and if methodologies and tool enhancements are developed in time for inclusion to the first system wide roll out, then those functions of smart inverters will be added to the first system wide roll out; otherwise, the IOUs will include the agreed upon-smart inverter functions in subsequent iterations of the ICA as methodologies are developed and tools are enhanced.

The WG also identified additional studies that would inform the understanding of the impacts of smart inverters on hosting capacity, including static volt/VAR and fixed power factor functions, as inverter standards are finalized through the IEEE process and as smart inverters begin to proliferate in the market. While important, is also acknowledged that significant resources may be required to determine an appropriate methodology for smart inverter inclusion in ICA, given that complex studies will require significant engineering resource which will need to be prioritized based other ICA study requirements (such as Single phase, transmission impacts, etc.). These studies should consider two overarching questions: 1) at what point can smart inverters be expected to have an impact on increasing hosting capacity? 2) once smart inverters are implemented as common practice, how much will they impact hosting capacity? The WG identified the following areas of additional evaluation for consideration, pending prioritization of all long-term refinement items and resource availability

- How the various smart inverter functions and applicable function ranges affect ICA values
    1. Volt/Var
    2. Fixed Power Factor
    3. Volt/Watt
    4. Function prioritization (what Brad is interested in ->)
    5. Phase II communication implications
    6. Phase III advanced functions implications
    7. Future IEEE 1547 oversizing implications, if approved
- Determine the range of settings and curves that can provide maximum ICA without negatively affecting the distribution system
- Determine the effects of the application of smart inverter functions to the distribution system reactive capacity and system efficiency

Finally, some stakeholders would like to understand how ICA may consider dynamic inverter functions, which may include settings to be changed by season, TOU period, and weekday vs. weekend, and in response to price signals and temperature forecasts. These stakeholders would like to evaluate this capability in coordination with a need for Rule 21 to include verification of operating profiles before systems can be approved based on dynamic functions. However, it is noted that further research of dynamic inverter functions is not within the scope of the ICA WG, and therefore not a research study appropriate for the IOUs to take on.

11.2 ACR Section 3.1.c: Recommend a format for the ICA maps and downloadable data to be consistent and readable by all California stakeholders across the utilities service territories with similar data and visual aspects (Color coding, mapping tools, etc.).

The WG discussed ICA map formats in the July WG meeting. The ACR specifies requirements for how ICA results shall be available via utility maps. To reach common fundamental principles guiding the ICA map formats, the joint IOUs presented a proposal for displaying ICA results, including the structure of mapping layers (substations, circuits, line segments all visible) and which information will be viewable in map format and which will be included in the downloadable data set.

The WG agrees and recommends that the IOUs should continue to standardize to a common mapping structure and mapping functionality while using what was developed for Demo A for first system rollout. Additional proposed modifications are discussed below; some have WG consensus, while others may require further discussion. The IOUs recommend that additional enhancements to maps for the full system roll-out may be added by the utilities as allowed by their tools and respective limitations.

As a long-term refinement, and as discussed earlier in Section 9: Presentation of ICA Values, the WG would like to consider how the map may provide verification that available capacity has not been absorbed by another interconnection application submitted since publication of the ICA value. This factor will be reduced as utilities get closer to real-time ICA updates. Much of the coordination work will need to be done within the context of the Rule 21 proceeding.

11.2.1 ICA Maps

The WG agrees that the following attributes should be available across all three IOU maps: 1) circuit; 2) section ID; 3) voltage (kV); 4) substation; 5) system[15]; 6) customer breakdown percentage (agriculture, commercial, industrial, residential, other); 7) existing generation (MW); 8) queued generation (MW); 9) total generation (MW); 10) ICA with uniform generation (MW); 11) ICA with uniform load (MW); 12) integration capacity of a generic PV system (MW).

The WG will develop assumptions for a standard PV generating profile that is sufficiently conservative to be relied upon for interconnection approval, as a long-term refinement item. Within the current value, it is assumed that a solar system produces its maximum rated power every hour of the year and is consequently treated as uniform generation within the ICA. As hosting capacity will be measured on an hourly and seasonal basis, the hourly and seasonal profiles of DERs should be considered.

The WG identifies incorporation of single phase line sections as another high priority item for long-term refinements beginning Q1 2017, and discussed the inclusion of identifying the location of single phase line sections within the first system-wide rollout of ICA to support the interconnection use case. The WG agrees that the IOU online maps should display all single phase line sections with a unique color in the first system-wide rollout. Until the ICA WG develops a methodology for inclusion of single phase line

[15] System data was not required under Demo A. SCE's RAM map includes system data. PG&E's and SDG&E's maps do not currently include system data.

sections, the reflected ICA value will not be of the single phase line section, but rather indicate their location and point of connection to a three phase feeder. In addition, it is recommended that IOUs continue to further develop their gateway and circuit modeling with the understanding that single phase line sections will eventually be incorporated.

The IOUs agree on the potential value of identifying single phase line sections on a map separate from determining their actual ICA value, but additionally note that determining accurate single phase ICA would require significant investment in the development of comprehensive single phase network models. This is because the IOUs do not currently have a complete source of single phase information for their network models. The IOUs agree that the WG should continue to explore the applicability of single phase ICA values taking into account the cost to develop the single phase ICA values against the efficiencies gained from ICA values in the interconnection use case.

No cost estimates have been developed on this topic at this time.

11.2.2 Downloadable data sets

All IOUs make the following information available via downloadable data set from their Demo A projects: 1) Demo A final report; 2) ICA Translator; 3) load profiles; 4) customer type breakdown; 5) detailed ICA results by circuit.

The WG envisions that there may be some differences between the interconnection use case and planning use case with regards to map and dataset needs, and so far, have only discussed data within the context of the interconnection use case. Given the amount of data produced in calculating ICA results and size of data files, the IOUs recommend limiting future downloadable data to only actionable data based on use cases. Additional downloadable data should be discussed with WG to determine which data should be downloadable for system wide implementation and the associated requirements and costs.

The WG has already identified issues related to data access as an important long-term refinement item to be addressed in the next six months, some of which are detailed in the Interim ICA Long-Term Refinement Report filed December 2016. Some WG stakeholders place a high value on providing data in machine readable formats. IOUs express that data security issues may need to be clarified and vetted, and recommend that discussion on details of how this functionality may be implemented should be deferred to future enhancements within long-term refinement discussions.

11.3 ACR Section 3.1.d: Evaluate and recommend new methods that may improve the calculation of ICA values using computational efficiency method to calculate and update ICA values across all circuits in each utility's service territory

The IOUs presented three proposed methods to improve ICA computational efficiency at the September and October WG meetings, with the purpose of reducing the number of data points needed to calculate in ICA without reducing the quality of results. These methods focus on 1) hourly reduction and mapping, 2) node filtering, and 3) criteria bounding. Each IOU employed different levels of computational efficiency methods in their Demo projects (see the Final Reports for a full discussion). The WG is in consensus with regards to the methodology underlying these computational efficiency refinements and agrees that the methods for node reduction and limitation category reduction are appropriate for use within the IOUs' first system-wide rollout (with differing opinions on whether hourly load profile reduction should be used), though as computing power and other factors change, this may need to be reevaluated to seek the most precise ICA over time and that modifications, adjustments, or additions may be needed for future ICA iterations.

i. **Hourly load profile reduction methods analyze fewer loading conditions**. For example, an ICA using a 576 hourly profile (which uses minimum and maximum load days for every month, for 12 months – 24 x 2 x 12) may be efficiently reconstructed by reducing the number of hours analyzed with similar loading conditions.
    a. The WG has different recommendations on whether this method should be used. The IOUs tested the use of load profile reduction within their Demo A projects. The IOUs presented to the WG on whether ICA can be run using a reduced profile while maintaining the ability to represent a 576 hourly profile. Full discussion of separate IOU viewpoints on whether and how this method should be used can be found in separate IOU Final Demo A reports.
    b. After reviewing Demo A Final Reports, stakeholders of the WG recommend the continued use of a 576 profile, as was tested under Demo A as representative hours of the entire year.

ii. **Node filtering methods** improve efficiency by limiting the number of nodes analyzed – when nodes are within close proximity to each other with no customer loads in between, or nodes exists only for simulation purposes, those nodes have the same level of ICA due to similar levels of impedance and loading conditions.
    a. The WG is in consensus with the use of node filtering methods in the first system-wide rollout of ICA.

iii. **Reduction of limitation categories for feeders with a high short circuit duty.** For those specific feeders, the voltage fluctuation screens and protection limitation screens do not need to be evaluated, as they will not affect the final ICA value.
    a. The WG is in consensus with the use of reducing limitation categories in the first system-wide rollout of ICA.

11.4 ACR Section 3.1.e: Evaluate ORA's recommendation to require establishment of reference circuits and reference use cases for comparative analyses of Demo Project A results.

The CPUC directed the IOUs to work towards additional consistency between IOUs' methodology and assumptions, for both the iterative and streamlined approach. To ensure a common approach between IOUs, the Commission asked the IOUs to compare methodologies against reference circuits, for discussion and approval by the WG.

The IOUs used the IEEE 123 test feeder as the reference circuit for comparative analysis as it employs a public data set of power flow results. The IOUs first compared power flow results between the power system analysis tools (PG&E and SCE employ CYME, and SDG&E employs Synergi), and then within each IOU for the Demo A test feeder.

The IOU Demo A reports include a joint report component. Within that joint report, the IOUs conclude that overall, the ICA results do not have significant variation across the IOUs for both the iterative and streamlined methodologies, with the slight variations attributed to how power flow models are treated between CYME and Synergi.

Another comparative assessment in IOUs Demo A projects evaluated the difference between iterative and streamlined methods. This assessment was used to determine which of the two methods would be most appropriate for the use cases and for implementation of first system wide roll out. Full exploration of these differences are detailed in the separate IOU Final Demo A Reports.

The WG recommends exploration of the utilization of more representative circuits from California feeders, and will prioritize this future testing alignment against other competing resources and cost considerations through full WG discussions, within ICA long-term refinement. This recommendation should be part of the long-term future enhancements to ICA.

The Office of Ratepayer Advocates (ORA) included 12 metrics of success for evaluating ICA. ORA provided the WG with a table of these criteria on January 10, 2017, with a brief description of whether the IOUs have met the criteria. IOUs have additionally detailed individual responses to ORA's 12 metrics in their Final Demo A reports. The most recent version of the table is provided below:

Table 3: ORA 12 Criteria or Metrics of Success

ORA Criteria	SCE	SDG&E	PG&E	Comments from ORA
1. Accurate and meaningful results				
A. Meaningful scenarios				Need to verify if reverse flow at substation busbar is correctly modeled.
B. Reasonable technology assumptions				Need plan to incorporate smart inverter data.
C. Accurate inputs (i.e. load and DER profiles)				Track 3.

D. Reasonable tests (i.e. voltage flicker)				No concerns/alternatives from working group.
E. Reasonable test criteria (i.e. 3% flicker allowed)				No concerns/alternatives from working group.
F. Tests and analysis performed consistently using proven tools, or vetted methodology				Tools being developed as part of Demo A and LT refinements.
2. Transparent methodology				IOUs have been open to information requests.
3. Uniform process that is consistently applied	LT Item	LT Item	LT Item	QA/QC of custom Python scripts TBD.
4. Complete coverage of service territory				Not required at this point.
5. Useful formats for results				PG&E is continuing to work on making the map more functional. This includes upgrading the server to improve map loading speeds, which will enable PG&E to adopt tools such as an ESRI tool to enhance usability. All utilities should include the "system" attribute in the full circuit deployment. SDG&E has not provided access to results.[16]
6. Consistent with industry, state, and federal standards				No concerns/alternatives from working group.
7. Accommodates portfolios of DER on one feeder				Uniform Gen map, plus DER translator. Need to ensure DER translator will work independent of the map showing uniform generation or PV profile.
8. Reasonable resolution				
–Spatial				Optimal (lower) resolution TBD; nodal reduction proposal.
–Temporal				Optimal (lower) resolution TBD; 576 vs. 24 hours.
9. Easy to update based on improved and approved changes in methodology				QA/QC of custom Python scripts TBD.

[16] SDG&E provided access to online results on 3/10/17. SDG&E realizes that this does not provide sufficient time for stakeholders to review the results prior to submission of the Final ICA WG Report. SD&E also should not have to provide a "system" field. SDG&E's transmission system is a single interconnected system, and therefore believes the requirement to provide a "system" field for each substation and/or circuit should not apply.

10. Easy to update based on changes in inputs (loads, DER portfolio, DER penetration, circuit changes, assumptions, etc.)				Tweaks to circuit models in CYME/Synergi required for convergence are currently lost when new data from GIS and other data sources is incorporated into power flow circuit model.
11. Consistent methodologies across large IOUs				
12. Methodology accommodates variations in local distribution system				
Legend				
Criteria met, OK to proceed				
Must be resolved before full scale deployment, but ORA believes they will be resolved by ongoing WG activity.				
Important issues have not been resolved to ORA's satisfaction, and it is not certain whether they will be before full scale deployment. Delay full scale deployment until resolved.				

Explanation Text Provided From ORA:

The legend describes how close to the IOUs are to meeting the Criteria.

- Green means that the IOUs have met the criteria, so it is ok to proceed with full scale circuit modeling.
- Yellow means that these are areas that have been identified as criteria that must be resolved before full scale deployment, but current WG activity will resolve them.
- Red means that these are issues that the utilities have not been adequately resolved, and it is not certain whether they will be resolved before full scale deployment. Full scale deployment of the ICA should be delayed until these criteria are met.

The WG understands that not all of the requirements can or need to be met in order to begin performing the full-scale circuit modeling. However, the WG expects the IOUs to meet these criteria as the ICA is refined over time.

In regards to Criteria 10, SCE agrees that maintaining accurate circuit models and related data is of extreme importance for the development of ICA values and one that the WG should continue to monitor. SCE is currently developing automated and engineering in the loop processes to maintain the accuracy of network models and data as changes on the distribution system occur. While SCE does not object to the color red for criteria 10, SCE does not agree that it cannot commence with the full-scale system-wide circuit modeling, as SCE will create the necessary steps to maintain accuracy of the network models as part of its deployment. Preventing SCE from commencing of full scale-wide deployment of circuit models will delay the implementation of ICA system wide as required the WG members which will ultimately will delay future modifications to Rule 21 to allow timely interconnection.

11.5 ACR Section 3.1.f: Establish a method for use of Smart Meter and other customer load data to develop more localized load shapes to the extent that is not currently being done

In reviewing Final Demo A Reports, WG stakeholders requested further clarification on the use of advanced metering infrastructure within ICA methodology. This application is detailed further by the utilities:

SCE and PG&E aggregated smart meter measurements to their corresponding distribution transformers. That is, the loading of a distribution transformer for a certain hour is characterized by

$$Transformer\_loading=\sum_{i=0}^{n} Customer_i$$

where $Customer_i$ represents a customer served by the transformer and n is the number of customers served by the transformer. By performing this analysis for each hour, load shapes and patterns are generated for each transformer. These localized shapes in combination with the circuit level loading profile were utilized to allocate the feeder level forecasted loading down to the service transformer level or individual customer level. This allowed SCE to more accurately geographically allocate feeder level forecasted loading values down to specific regions on the circuit.

SDG&E brings AMI data at the time of the peak for each customer to establish the demand. Then SDG&E leverage its AMI data to develop different customer classes load profiles. Each customer class has its profile and is created per substation bus. The profile curve adding all the customers consumption on each customer class by hour for that specific class and bus. LoadSeer creates monthly profiles curves per circuit for peak and minimum day (48 points per month) using SCADA data at the breakers. These curves get imported into Synergi and the load gets allocated on the feeder using the combination of Customer class's curves at the transformer level and Feeder profile curves at the breaker level.

It is recommended that the IOUs continue to utilize customer level load data as used in Demos A for first system wide roll out, and the WG would like to further explore reasons for divergence, as well as trade-offs between methods, as part of long-term refinement.

11.6 ACR Section3.1.g: Establish definite timelines for future achievement of ICA milestones, including frequency and process of ICA updates

Please refer to *Section 6: Schedule and Timelines* for discussion on ACR Section 3.1.g.

12 Additional Cost Recovery

The WG acknowledges that continued deliberation with regards to cost impacts and cost recovery will likely occur in a separate forum. It is also acknowledged that the IOUs can continue to engage in some work related to the full system roll-out, such as data clean-up efforts, independent of a CPUC Proposed Decision.

Depending upon the implementation requirements adopted by the Commission, additional cost recovery may be necessary. The WG therefore recommends that CPUC adopt a process to facilitate IOU requests for additional funding to support ICA implementation.

13 Recommendation Summary Table for First System-Wide Implementation of ICA

Table 4: Summary of Recommendations for Interconnection Use Case and First System-Wide Roll Out
For full detail, please reference specific report sections.

Component	Consensus?	Recommendations	WG activity on Long-Term Refinement (6 months)	Refer to Report Section
1. Methodology	Non-Consensus	SCE, SDG&E, WG stakeholders: iterative method PG&E: “blended” approach (see Final Demo A Report)	See other sections	Section 5: Methodology
2. Update frequency	Non-Consensus	Non-IOU stakeholders: weekly SCE and SDG&E: no more than monthly PG&E: dictate updates by conditions, not time frame		Section 7: Review of Cost Estimates Section 8: Frequency of Updates
3. Hourly profile	Non-Consensus	PG&E, SCE, SDG&E: see Final Demo A Reports Non-IOU stakeholders: 576 hour profile		Section 7: Review of Cost Estimates Section 11.3: ACR Section 3.1.d
4. Circuit models	Consensus	Incorporate changes to circuit models in advance of full system implementation is needed.		Section 10.3: Circuit Models Section 11.4: ACR Section 3.1.e
5. Pre-existing conditions	Consensus	ICA should be limited by pre-existing conditions when additional DER degrades the pre-existing condition.		Section 10.4: Pre-existing conditions

		ICA should not be limited by a pre-existing condition when adding DER improves the pre-existing condition.		
6. Voltage regulating devices	The WG is in consensus with allowing devices to "float" within power flow models. There is non-consensus with regards to process and implementation. Based on Demo A implementation: **SCE & PG&E** - Locked **SDG&E** – Float. SCE & PG&E use CYME software. SDG&E uses Synergi software.	PG&E, SCE, and SDG&E recommend operations as applied in Demo A, and will continue to work with software vendors to encourage the development of an additional "unlock" function. Currently, CYME software does not support this option. Requiring the inclusion of this function may delay the 12 month implementation timeline proposed. Non-IOU stakeholders encourage IOUs to work with software vendors to include this feature within the first rollout, if feasible.		Section 10.2.1: Power quality/ voltage criteria
7. Operational flexibility	Consensus	Publish two ICA values: 1) no reverse flow across SCADA operated devices, 2) reverse flow up to substation low voltage busbar with no export to the high side busbar towards the transmission system	Continued discussion on improving operational flexibility criterion, using non-heuristic values	Section 10.2.2: Safety and reliability
8. Smart inverters	Consensus on recommendation, non-consensus on process and timing	WG agreement to include smart inverter functionality within ICA. Given that assumptions and functionalities need to be developed, there are two separate recommendations on process and timing: IOUs recommend that smart inverters not be included in first system roll out until further methodologies and modification to tools are developed and implemented. IOUs will begin work with software vendors to determine best means of incorporating smart inverter data when methodology is developed. Other stakeholders recommend that IOUs endeavor to work with software vendors to include, if possible, in the first-system rollout.	Develop assumptions for smart inverter operating behavior Consider additional studies	Section 11.1: ACR Section 3.1.b
9. Maps and Published Values	Consensus	Set of ICA data: Publish uniform generation ICA, uniform load ICA, and a PV ICA value based on common PV shape	Develop standard PV generation	Section 9: Presentation of ICA Values

		2 sets of ICA data should be published, addressing two different operational flexibility constraints. In total, 6 values are published.	profile Continued discussion on downloadable data sets	Section 11.2: ACR Section 3.1.c
10. Computational efficiency	Consensus approval for use of methodologies in Demo A	IOUs may utilize the methods of computational efficiency to reduce nodes and reduce limitation categories, as tested in Demo A in the first system roll-out. There is non-consensus with regards to whether hourly profile reductions should be used to reduce the 576 profile as tested under Demo A.		Section 11.3: ACR Section 3.1.d
11. ORA success criteria and reference circuits	See Section 11.4	See Section 11.4	Consider additional reference circuit	Section 11.4: ACR Section 3.1.e
12. Smart meters	Consensus	Utilize customer level load data as used in Demos	Explore further reasons for divergence and comparison between methodology	Section 11.5: ACR Section 3.1.f
13. Timelines	Non-consensus	PG&E, SCE and SDG&E: 12 months from PUC Final Decision CALSEIA: 12 months from filing of ICA WG Final Report		Section 6: Schedule and Timelines

14 Next Steps for the ICA WG

The WG looks forward to continuing improvement and development of additional methodological components for the ICA, and has developed an additional list of items to begin working on within the next long-term refinement phase of the ICA WG after its review of Demo A Final Reports, given that some recommendations are potentially considered for the first system-wide rollout of ICA if necessary methodology and studies are developed. This table is meant to complement those topics already identified in the Interim ICA Long-Term Refinement Report[17] (e.g., data access, single phase line sections, etc.). This table does not re-iterate those topics.

The WG aims to create a proposed working schedule as a priority item once work on long-term refinement items begin.

Table 5: Additional topics for Long-Term ICA Refinement

Topic	Section
Use cases: further development of planning use case, with CPUC guidance and in accordance with further development of Track 3 of DRP proceeding	Section 4: Use cases
Development of standard PV generation profile for published ICA value	Section 9: Presentation of ICA values
Development of operational assumptions for voltage regulating devices	Section 10.3: Voltage regulation
Continued discussion of how to improve the operational flexibility criteria	Section 10.4: Safety and reliability
Integration of smart inverter technology, potential additional studies	Section 11.1.2: Smart inverters
Additional reference circuit	Section 11.4: Reference circuits
Further review of underlying assumptions (e.g., weather) with consideration of parallel Track 3 activities	Section 10.1: Modeling and extracting power system data
Smart meters: additional discussion comparing methodology	Section 11.5: smart meters

[17] http://drpwg.org/wp-content/uploads/2016/07/R.14-08-013-ICA-Status-Report.pdf

15 Appendix

15.1 Acronyms

ACR: Assigned Commissioner's Ruling
CPUC or Commission: California Public Utilities Commission
DER: Distributed Energy Resources
DRP: Distribution Resources Plan
ICA: Integration Capacity Analysis
IOU: Investor Owned Utilities
IRP: Integrated Resources Proceeding
LNBA: Locational Net Benefits Analysis
PG&E: Pacific Gas & Electric
SCADA: Supervisory control and data acquisition
SCE: Southern California Edison
SDG&E: San Diego Gas and Electric
WG: Working Group

15.2 Working Group Meetings and Topics

Meeting Date	**Topic(s)**
May 12 – 1:00pm-3:00pm Webinar	Opening meeting
May 18 – 10:30am-12:00pm Webinar	Seeking input regarding 1) use of power flow analysis and 2) level of granularity
June 1- 9:00am-3:00pm In person	First discussion of demonstration implementation plan before June 16th submission
June 9 – 9:00am-3:30pm In person	Second discussion of demonstration implementation plan before June 16th submission
July 5 – 2:00pm-4:00pm Conference call	Call to discuss submission of demonstration implementation plan
July 25 – 9:00am-3:30 pm In person	Discussion of submitted stakeholder comments on demonstration implementation plans Use cases 3.1.c/3.2.c – data and maps 3.1.b – portfolio analysis
August 31 – 9:00am – 4:15pm In person	Use cases 3.1.b – smart inverters 3.1.f – smart meter/customer load data Data access
September 30 – 9:00am-4:00pm In person	3.1.e – comparative analysis 3.1.b.i – portfolio analysis 3.1.d – computational efficiency Data access
October 17 – 9:00 am-4:00pm In person	Demo A update 3.1.d – computational efficiency

	3.1.f – smart inverters 3.1.e – comparative analysis 3.1.b.i – DER portfolios 3.2.a-g – long-term scoping discussion
November 18 – 9:00am-4:00pm In person	Review of Working Group short term final report outline Long-term scoping discussion of 3.2.a-g plus other topics Data
December 13 – webinar	Review of Working Group interim long-term report topics
January 6 – 9:00am – 4:00pm In person	Review of Final IOU Demo A Reports
January 17 – 9:00am – 4:00pm In person	Review of Final IOU Demo A Reports
January 20 – 9:00am – 4:00pm In person	ICA Recommendations
February 2 – 2:00pm-4:00pm Webinar	ICA Recommendations and development of report
February 14- 9:00am – 1:00pm Webinar	ICA Recommendations and development of report
February 27 – 11:30am – 1:00pm Webinar	Review of IOU cost estimates
March 9 – 9am -1pm	Final ICA discussion before WG report

15.3 Working Group Participants

The following stakeholder groups attended at least one meeting or webinar of the ICA WG:

- ABB Group
- Advanced Microgrid Solutions
- Alcantar & Kahl
- AMS
- Artwel Electric
- Bloom Energy
- CAISO
- California Energy Storage Alliance
- California Energy Commission
- CPUC Office of Ratepayer Advocates
- California Solar Energy Industries Association
- City of Burbank
- Clean Coalition
- Community Choice Partners
- Community Environmental Council
- Comverge
- DNV GL
- ECCO International Inc.
- Energy and Environmental Economics
- Electric Power Research Institute
- Energy Foundation
- Environmental Defense Fund
- Gratisys Consulting
- Greenlining Institute
- Helman Analytics
- ICF International
- Independent Energy Producers Association
- Independent advocates
- Independent consultants
- Integral Analytics
- Interstate Renewable Energy Council
- Kevala Analytics
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- Natural Resources Defense Council
- Northern California Power Agency
- NextEra Energy

- New Energy Advisors
- Nexant
- Open Access Technology International
- Pacific Gas & Electric
- PSE Healthy Energy
- Quanta Technology
- Sacramento Municipal Utilities District
- San Diego Gas and Electric
- Siemens
- Smart Electric Power Alliance
- SoCal REN
- Solar Energy Industries Association
- SolarCity
- Solar Retina
- Southern California Edison
- Stem Inc.
- Strategy Integration
- Sunpower
- Sunrun
- The Utility Reform Network
- UC Berkeley
- Vote Solar

15.4 WG Materials

All ICA WG materials, including meeting materials (participant lists, agendas, presentation materials, meeting summaries if available, and webinar recordings if available), and WG member comments and responses to materials may be found at the DRP WG website: http://www.drpwg.org.

IOU Final Demo A Reports may be found at the following links:

- PG&E: http://drpwg.org/wp-content/uploads/2016/07/R1408013-PGE-Demo-Projects-A-B-Final-Reports.pdf
- SCE: http://drpwg.org/wp-content/uploads/2016/07/R1408013-SCE-Demo-Projects-A-B-Final-Reports.pdf
- SDG&E: http://drpwg.org/wp-content/uploads/2016/07/R.14-08-013-DRP-Demos-A-B-Reports-SDGE.pdf