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BEFORE THE PUBLIC UTILITIES COMMISSION OF THE

STATE OF CALIFORNIA

Order Instituting Rulemaking Regarding Policies, Procedures and Rules for Development of Distribution Resources Plans Pursuant to Public Utilities Code Section 769.	Rulemaking 14-08-013 (Filed August 14, 2014)
And Related Matters.	Application 15-07-002 Application 15-07-003 Application 15-07-006

(NOT CONSOLIDATED)

In the Matter of the Application of PacifiCorp (U 901-E) Setting Forth its Distribution Resource Plan Pursuant to Public Utilities Code Section 769.	Application 15-07-005 (Filed July 1, 2015)
And Related Matters.	Application 15-07-007 Application 15-07-008

SOUTHERN CALIFORNIA EDISON COMPANY'S (U 338-E) INTERMEDIATE STATUS REPORT FOR DEMONSTRATION PROJECT A

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Dated: September 30, 2016

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SOUTHERN CALIFORNIA EDISON COMPANY'S (U 338-E)
INTERMEDIATE STATUS REPORT FOR DEMONSTRATION PROJECT A

Pursuant to the May 2, 2016 *Assigned Commissioner's Ruling (1) Refining Integration Capacity and Locational Net Benefit Analysis Methodologies and Requirements; And (2) Authorizing Demonstration Projects A And B* ("May ACR") and the August 23, 2016 *Assigned Commissioner's Ruling Granting the Joint Motion of San Diego Gas & Electric Company, Southern California Edison Company, and Pacific Gas & Electric Company to Modify Specific Portions of the Assigned Commissioner's Ruling (1) Refining Integration Capacity and Locational Net Benefit Analysis Methodologies and Requirements; and (2) Authorizing Demonstration Projects A and B* ("August ACR"), Southern California Edison Company

("SCE") respectfully submits its intermediate status report for Demonstration Project A, attached as Appendix A.

I.

PROCEDURAL BACKGROUND REGARDING IMPLEMENTATION PLANS

On May 2, 2016, the assigned Commissioner issued the May ACR, approving ICA and LNBA methodologies and requirements on an interim basis for use in the Demos A and B. The ACR also directed each IOU to submit "an intermediate status report, due Q3 2016" that "describe[s] the ICA limit criteria and threshold values and how they are applied in the Demonstration A."[1] The August ACR did not modify this requirement.[2]

Attached as Appendix A is SCE's intermediate status report for Demonstration Project A.

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1 May ACR, at Attachment A, p. 13.

2 August ACR, at Attachment A, p. 13.

II.

CONCLUSION

SCE appreciates the opportunity to submit this intermediate status report for Demonstration Project A.

Respectfully submitted,

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Appendix A

Southern California Edison Distribution Resources Plan
Demonstration Project A
Enhanced Integration Capacity Analysis Intermediate Status Report

Southern California Edison
Distribution Resources Plan
Demonstration Project A

Enhanced Integration Capacity Analysis Intermediate Status Report

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1. Summary

On August 14, 2014, the California's Public Utility Commission ("Commission") issued Rulemaking (R.) 14-08-013 which established guidelines, rules, and procedures to direct California investor-owned electric utilities ("Utilities") to develop their Distribution Resources Plan ("DRP"). On February 6, 2015, the Commission issued Final Guidance[1] for the Utilities in filing their DRP. This guidance included a requirement for Utilities to develop a specification for a demonstration project ("Demo A") that performs the Commission approved Integration Capacity Analysis ("ICA") methodology to all line sections or nodes within a Distribution Planning Area ("DPA").

On May 2, 2016, the Commission issued an Assigned Commissioner's Ruling ("May ACR")[2]. On August 23, 2016, the Commission issued an Assigned Commissioner's Ruling[3] granting the joint motion of Utilities to modify specific portions of the ACR. The ACR laid out various prescriptive requirements for the ICA methodologies so that Utilities will perform comprehensive and consistent studies in two of its own DPAs that cover as broad a range as possible of electrical characteristics.

Pursuant to the ACR,[4] Southern California Edison ("SCE") submits this intermediate status report for Demo A. In this status report, SCE describes the methodologies and approach adopted to perform the ICA analysis and publish the ICA results. The status report has been organized in two chapters:

- Chapter 2 presents the current project status of Demo A.
- Chapter 3 describes the methodologies used in Demo A following the baseline ICA methodology steps set forth in the ACR.

[1] Assigned Commissioner's Ruling on Guidance for Public Utilities Code Section 769 – Distribution Resource Planning, ("Final Guidance"), February 6, 2015.
[2] Assigned Commissioner's Ruling (1) Refining Integration Capacity And Locational Net Benefit Analysis Methodologies And Requirements; and (2) Authorizing Demonstration Projects A and B, May 2, 2016 ("May ACR").
[3] Assigned Commissioner's Ruling Granting the Joint Motion of San Diego Gas & Electric Company, Southern California Edison Company, and Pacific Gas & Electric Company to Modify Specific Portions of the Assigned Commissioner's Ruling (1) Refining Integration Capacity And Locational Net Benefit Analysis Methodologies And Requirements; and (2) Authorizing Demonstration Projects A and B, August 23, 2016 ("August ACR").
[4] May ACR, at Attachment A, p. 13. ("Utilities shall provide documentation to describe the ICA limit criteria and threshold values and how they are applied in the Demonstration A Projects, in an intermediate status report, due Q3 2016.").

2. Demo A Project Status

After the Demo A project implementation plan was submitted to the Commission in June 2016, SCE followed the methodologies (both the streamlined and iterative methods) outlined in the Demo A Plan as a guideline to perform the ICA studies on the Johanna and Rector Distribution Planning Areas (*i.e.*, the DPAs). SCE worked closely with Pacific Gas & Electric (PG&E), San Diego Gas & Electric (SDG&E), and the ICA Working Group to ensure the ICA studies are conducted in a consistent and transparent manner. This chapter provides a status update of SCE's Demo A work.

Figure 1 shows the project status chart, which is updated from the schedule chart included in the Demo A implementation plan, to reflect the project progress. Status bars in solid green, light green, and yellow represent completed tasks, in-progress tasks, and yet-to-be-started tasks, respectively.

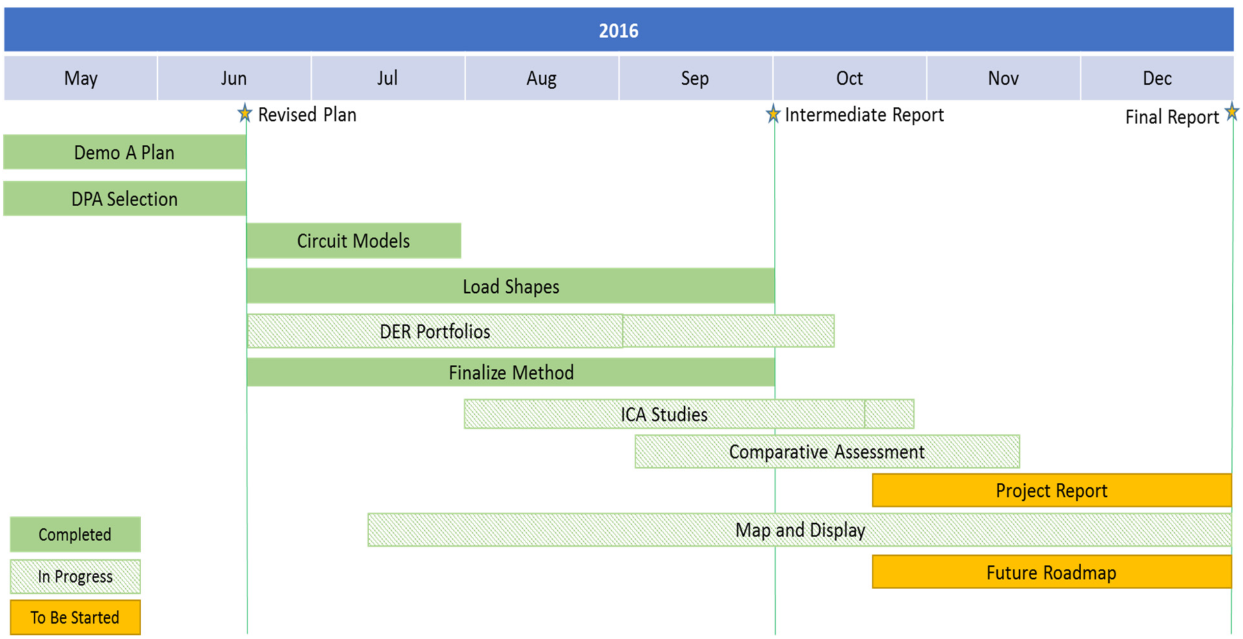

FIGURE 1 PROJECT STATUS CHART

SCE has collected and extracted various power system data to develop and validate circuit models in the selected DPAs and to develop load forecast profiles for each circuit under different DER growth scenarios.

SCE has been working closely with the other Utilities and the ICA Working Group to develop a consistent set of power system limitation criteria that comply with industry standards and individual system designs and to finalize the implementation details of both the streamlined and iterative methodologies.[5] Meanwhile, SCE has developed and has been testing and optimizing the Python scripts for performing the ICA method in a batch process fashion. The production simulation on all the circuits will be conducted in next month.

[5] This work is consistent with the requirements established by the May ACR. *See* May ACR, Attachment A, at pp.1-4, 19-21.

SCE and the other Utilities are currently in the initial stage of conducting comparative assessment, as required by the August ACR,[6] by examining the consistency of Utilities' ICA methodologies and comparing preliminary ICA results on the IEEE circuit in order to ensure the alignments of ICA methods. Details of comparative assessment and other additional studies required in the ACR, such as smart inverter capability investigation, are under discussion and to be finalized in the coming Working Group meetings.

Utilities have reached an agreement on the conceptual design of how the ICA results will be displayed on the publicly available maps, (SCE utilizes DERiM) and how the ICA results will be presented in the downloadable files. SCE is utilizing the test data to develop the platform to ensure an on-time delivery for Demo A project. Mapping is an on-going parallel effort to the DRP Demo A activities.

Table 1 summarizes SCE's status regarding the learning objectives set forth in its implementation plan.

TABLE 1 – SUMMARY OF LEARNING OBJECTIVE STATUS

1. Reverse Flow at T&D Interface	
Description	Assess DER hosting capacity with and without limiting reverse power beyond substation busbar
Status	**In progress**: substation models have been developed in CYMDIST, the operational flexibility criterion that limits the reverse power flow will be enabled and disabled for the two power flow scenarios.
Initial Learning	Including the busbar for evaluating multiple circuits at once will significantly increase the simulation time required.
2. Diverse Locations	
Description	Evaluate two DPAs covering a broad range of physical and electrical characteristics encountered in SCE distribution systems.
Status	**In progress**: Completed the selection and power system modeling of the Johanna (urban) and Rector (rural) DPAs that will be studied as part of DRP Demo A. Evaluation of the ICA Methodologies on this two distinct DPAs is in-progress.
Initial Learning	Two DPAs with different system characteristics, customer mix, load growth pattern provides a good testbed to understand the ICA patterns.
3. Granularity	
Description	Assess the level of granularity necessary and meaningful for the ICA
Status	**In progress**: ICA is being performed on all nodes on the modeled distribution circuits. [7]
Initial Learning	Some nodes are very similar to each other with regard to electrical characteristics such as impedance from substation, it may not be necessary to perform simulation on every single node without losing the resolution of ICA results. This is also part of the computational efficiency objective (No.7)
4. Power System Criteria	
Description	Refine and develop consistent power system limitation criteria and study their impacts
Status	**In progress**: A set of power system limitation criteria has been agreed upon by IOUs and is being implemented in both streamlined and iterative methods.

[6] May ACR, at pp. 1-2.

[7] Nodes are modelled locations where two distinct electrical devices interconnect. For example, a node is the simulated connection between a conductor and a switch.

Initial Learning	Different system designs and operational practice may lead to different limitation among Utilities, such as protection limitation. Operational flexibility system criteria can be excessively complicated and may not be attainable using existing tools if considering all the possible switching scenarios.
5. DER Portfolios and New Technology	
Description	Investigate methods for evaluating DER portfolios, CAISO dispatch, and smart inverters
Status	**In progress**: DER technology agnostic ICA results are being developed, which will likely improve ICA run-time performance and will aid the evaluation of the various DER portfolios; Smart Inverter analysis will be performed on single circuit.
Initial Learning	Current analysis indicates that agnostic ICA results may be an efficient option to derive ICA values for different DER profiles and portfolios. Agnostic ICA results may further help developers to create multiple DER portfolios.
6. Consistent Maps and Outputs	
Description	Ensure consistent and readable maps to the public with similar data and visual aspects
Status	**In progress**: map conceptual design has been developed and agreed upon by IOUs and ICA WG. SCE's IT team is developing the functions and interfaces
Initial Learning	With the projected 10 billion data points to be generated by the ICA process, processing and validation of the data is challenging. Visualization will need to be limited to a subset of the data.
7. Computational Efficiency	
Description	Evaluate methods for faster and more accurate update process that works for SCE's entire service territory
Status	**In progress**: Initial evaluation of required computing efforts has been performed. SCE is exploring various options to reduce the simulations needed without affecting the overall results.
Initial Learning	The system loading condition varies, but similar loading conditions occur across the 576-point profile. SCE may be able to cut down the number of simulations needed.
8. Comparative Analysis	
Description	Develop benchmark for consistency and validation across techniques and Utilities
Status	**In progress**: IEEE 123-node test feeder has been utilized as an initial step to align the methodologies used across three IOUs[8].
Initial Learning	Model conversion between different software is challenging and time consuming.
9. Locational Load Shapes	
Description	Utilize Smart Meters for localized load shapes
Status	**Completed**: Smart Meter data has been collected, aggregated, and incorporated to circuit load allocation process.
Initial Learning	The total aggregated Smart Meter interval demand does not equate to the SCADA reading at the circuit breakers but the Smart Meter data are still adequate for load allocation. Quality check of the Smart Meter data is essential to ensure a proper load allocation under the corresponding circuit configuration. There may be alternative means to provide the same level of results without utilizing the Smart Meter data.

[8] The purpose of the IEEE Test Feeders is to make a common set of data available to verify the correctness of the analysis of distribution feeders: http://ewh.ieee.org/soc/pes/dsacom/testfeeders/index.html

10. Future Roadmap	
Description	Determine roadmap and timelines for future ICA development and improvement based on demonstration learnings
Status	**To Be Started**: IOUs and ICA WG has started initial discussions, but it will need to depend on the Demo A learnings.

3. Methodology

This chapter describes the methodologies that are being implemented as part of DRP Demo A. Some of the contents have been presented in the previous implementation plan such as level of granularity, load forecasting, model development and general power system limitation criteria. This status report is expanded to include the detailed power system limitation criteria, their thresholds, and how these are applied in the project along with the map design that are not previously presented.

Figure 2 illustrates the general ICA methodology process diagram. After the system model data and load data are extracted from various databases, the distribution circuit models are developed in the power flow analysis tool. Several applicable power system criteria are examined based on either pre-defined equations or iterative power flow analyses in order to identify the maximum capacity of hosting Distributed Energy Resources (DERs) at each node. The DER hosting capacity for each criterion is calculated independently and the most limiting values are used to establish the final integration capacity limit for the nodes. In addition to the line section analysis, the feeder level ICA and substation level ICA are also performed. The detailed ICA results will be made publicly available online and in a downloadable format.

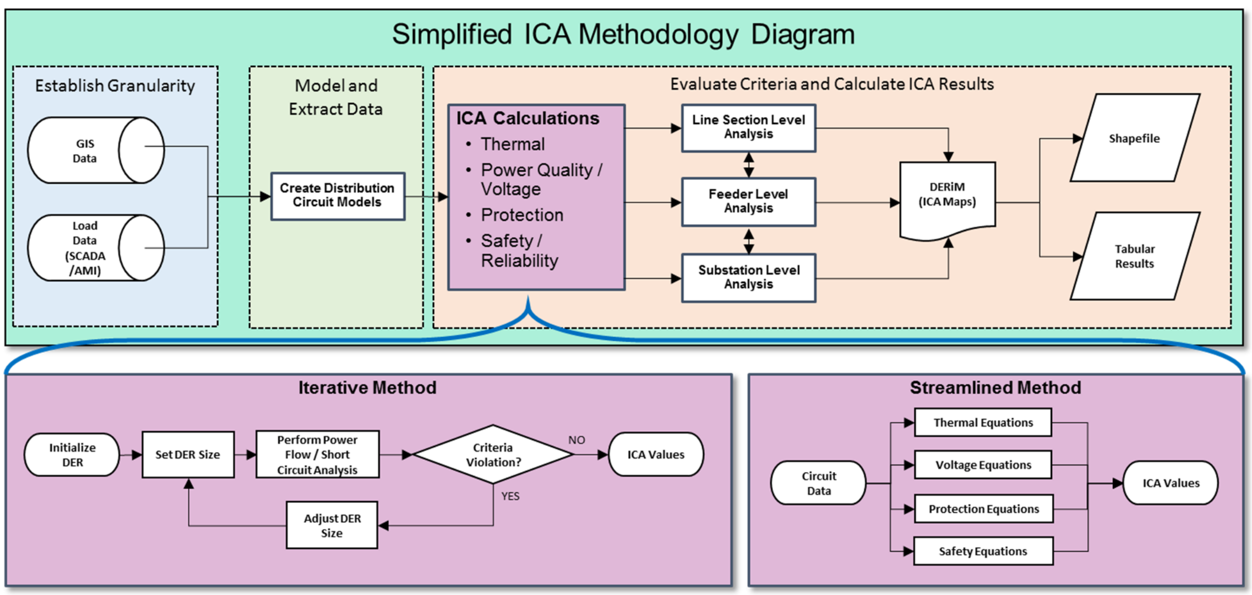

FIGURE 2 ICA PROCESS DIAGRAM

Demo A is a developmental step towards Utilities' final proposals for a common ICA methodology that can be used to update the DER hosting capacity at regular intervals. Being consistent with the ACR requirements, the detailed methodologies used in the Demo A are described below, in four general steps:

1) Establish distribution system level of granularity
2) Model and extract power system data
3) Evaluate power system criterion to determine DER capacity
4) Calculate ICA results and display on online map

3.1 Establish Distribution System Level of Granularity

SCE performs ICA studies, using both the streamlined and iterative methods, down to all the nodes of each primary line section (both three-phase sections and single-phase sections) of individual distribution feeders within the two selected DPAs.

3.2 Model and Extract Power System Data

Two sets of system data are necessary for accurate ICA studies: load/generation profiles and power flow models. Load and generation profiles define various scenarios that the grid may experience; these profiles are developed using SCE's load forecasting analysis tool. Power flow models represent the system electrical connection and device settings so that system behaviors under different DER scenarios can be simulated via power flow analyses; the circuit models are developed in the power flow analysis tool, CYMDIST.

3.2.1 Load and Generation Profile Development

*3.2.1.1 General Methodology for **Profile Development***

SCE utilizes its primary hourly load forecasting tools for deriving normal and scenario based load and generation profiles for its distribution circuits. In the tools, SCE expands its current practices of determining the peak forecast to hourly forecast in order to account for both customer growth and DERs like solar photovoltaics (PV) and electric vehicles (EV), as well as the heat storm sensitivity created by SCE's distribution planners. Figure 3 illustrates SCE's hourly load and generation forecasting methodology. The detailed approach has been explained in SCE's implementation plan, and is not repeated in this report.

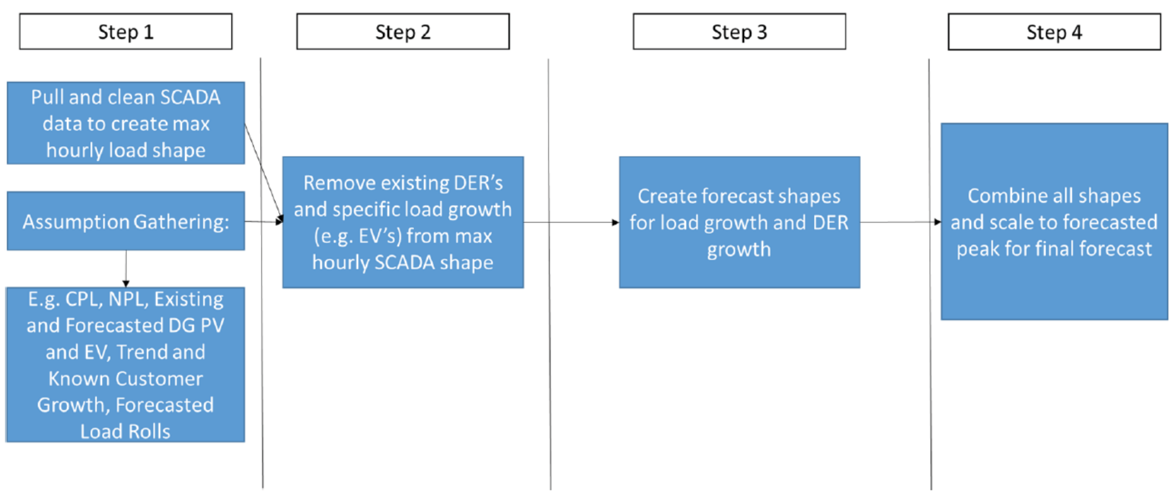

FIGURE 3 SCE HOURLY LOAD FORECASTING METHODOLOGY

3.2.1.2 576-hour Profile Development

In compliance with the ACR, SCE will analyze 576-point profiles as part of DRP Demo A. 576-point profiles are composed of 24-hour hourly typical maximum and minimum profiles for every month ($12\ months \times\ 24\ hours \times\ 2\ profiles\ =\ 576\ loading\ data\ points$). SCE creates these 576-point profile from the forecasted 8760-hour profiles using the 10^{th} and 90^{th} percentile representing typical minimum and typical maximum profiles, respectively. These profiles are then used to initialize the distribution circuit models.

3.2.1.3 Customer Load Allocation

With the significantly different energy consumption patterns, customers from different classes have different load shapes. Customers within the same class may also have very different load shapes. Hourly customer load data from Smart Meter can be aggregated to form a more localized load shapes. To ensure load consistency at different levels, these localized shapes are utilized to allocate the circuit level forecasted load down to service transformer level or individual customer level in a more representative way.

In the project, the aggregated Smart Meter data at different electric structures are scaled to fit the forecasted circuit load profile, before being used for individual customer load assignment in the power flow models. These customer load data enable a more accurate load allocation comparing with the default load allocation mechanism of the power flow analysis tool.

3.2.2 Power Flow Model Development

SCE develops distribution circuit and substation models in the power flow analysis tool, CYMDIST, and validates the parameters to make sure these system models reflect the actual field conditions so that the calculated DER capacity limits are close to real life values.

SCE first uses Python scripts to read latest asset information from its comprehensive Geographic Information System (cGIS) database and builds the initial circuit models in CYMDIST. The circuit models include conductors, line devices, loads and generation components that impact distribution circuit power quality and reliability. The current loading and existing DERs on these circuits are obtained from the Supervisory Control and Data Acquisition (SCADA) system and generation database and are included in the system models to reflect the current level of penetration.

Substation modeling is based on normal substation operating bus-breaker configurations from SCE's Energy Management System (EMS).

In order to ensure the circuit models accurately present the actual system configuration and the consequent ICA studies are representative of the actual system capability, it is essential to perform model validations. Multi-pass network sweep is performed to clean up the potential issues in the initial models such as broken connectivity and missing electric parameters. The model validation utilizes various data sources (such as circuit map, facility inventory map, SAP and DMS) to obtain information and replace the missing parameters with the actual information. The major categories of validation include the type/length/phase of cables and conductors, the size and rated voltage for capacitor banks, and the rating of switches and grid devices.

3.3 Evaluate Power System Criteria to Determine DER Capacity

Power system limitation criteria are the principles that determine whether a specific amount of DER can be interconnected to the system without violating any operation rules and system design criteria. SCE's ICA methodology considers four major categories of power system limitation criteria: 1) thermal, 2) power quality/voltage, 3) protection, and 4) safety/reliability. DER capacity limit against each power system limitation criterion is calculated independently and the most limiting values are used to establish the integration capacity limit.

Table 2 summarizes the power system limitation criteria adopted in Demo A. How these limitation criteria are applied in the Demo A project will be described in the following sections.

TABLE 2 –SUMMARY OF LIMITATION CATEGORIES

Limitation Categories	Limitation Detail
Thermal Criteria	• The amount of power that DERs inject into or draw from the distribution circuits shall not cause the loading of any electrical device on the distribution circuits (such as circuit breaker, cable, conductor, line devices, etc.) and in the substation (such as transformers, breakers, disconnects, etc.) to exceed 100% of equipment's loading limit (thermal ratings or planned loading limits).
Power Quality / Voltage Criteria	• The amount of power that DERs inject into or draw from the distribution circuits shall not cause the steady state voltage at any point on the distribution system to fall outside of Rule 2 voltage specifications (i.e., the voltage shall remain in the range between 0.95pu and 1.05pu); • The amount of power that DERs inject into or draw from the distribution circuits shall not cause voltage fluctuation to exceed 3%, as part of the system design criteria.
Protection Criteria[9]	• The fault contribution of DERs shall not exceed 10% of fault current contributed by SCE system at the point of interconnection (Streamlined method) • The fault contribution of DERs shall not cause a reduction in the relay ability to detect fault. This is accomplished by ensuring the system fault contribution is greater than or equal to 2.3 times the feeder minimum trip (Iterative method)
Safety / Reliability Criteria	• The amount of power that DERs inject into the distribution circuits shall not cause reverse power flow at SCADA controlled switching devices (such as circuit breakers, remote automated reclosers, voltage regulators, remote controlled switches) on the distribution system. This is to ensure the operational flexibility during abnormal circuit operating conditions.

3.4 Calculate ICA Results and Display on Online Map

SCE will perform both the streamlined method and the iterative method to evaluate the system performance against the limitation criteria described above in order to identify the DER capacity limits under different load and DER scenarios.

3.4.1 Scenario Summary

There are various ICA scenarios required by the ACR to investigate in Demo A. These scenarios are summarized below:

Two Power Flow Scenarios:

- The DER capacity does not cause power to flow beyond the substation busbar
- The DERs technical maximum capacity is considered irrespective of power flow toward the transmission system

Three Load Forecasting and DER Growth Scenarios:

- 2-year growth scenario utilities use for distribution planning
- Growth scenario I as proposed in the DRP Applications

[9] The protection criterion used in the streamlined method is consistent with the fast-track interconnection screening process to determine whether a detailed technical study is needed. The protection criterion used in the iterative method is consistent with the detailed interconnection studies which focus on more detailed information.

- Growth scenario III as proposed in the DRP Applications

Eight Typical DER Operational Profiles:

- Inverter based Uniform Generation
- PV
- PV with Tracker
- EV – Residential (EV Rate)
- EV – Workplace
- Uniform load
- Storage – Peak Shaving
- EV – Residential (TOU rate)

Four Representative DER Portfolios:

- Solar and stationary storage
- Solar and residential EV (TOU rate)
- Solar, stationary storage, and load control
- Solar, stationary storage, load control, and EV

The total number of scenarios is 72[10]. In each scenario, ICA capacity limits against four categories of power system limitation criteria are calculated independently and the most limiting values are used to establish the integration capacity limit. In addition, hourly ICA values are generated for the 576 hours analyzed in each scenario. In other words, there will be 207,360[11] data points generated for each circuit section/node. Given that SCE has 78 circuits in the two selected DPAs and the total number of nodes to be examined is approximately 49,000, there will be approximately a total of 10,135,000,000 data points to be generated as the ICA results[12].

3.4.2 Iterative Method

As the name indicates, the iterative method iteratively applies detailed power flow and short circuit analyses to identify the maximum DER capacity that does not violate any power system limitation criteria at each node, at each hour, and under each scenario. Each analysis uses CYMDIST's calculation engines to compute the phase currents and voltages at every node given the feeder device parameters from the model and the load and generation levels under various scenarios. The iterative approach is consistent with engineering technical studies performed on new interconnections, and as expected will return results that most closely resemble a detailed engineering analysis.

Figure 4 illustrates how each power system limitation criterion is evaluated though power flow or short circuit analyses and how the final ICA values are established based on the most limiting individual ICA values. This process will be repeated for every node of each circuit in the two selected DPAs, and repeated for different power flow scenarios and different power flow scenarios. During the reverse power flow scenario, the safety/reliability criterion (i.e., operational flexibility) will be excluded so that the study will allow reverse power flow.

---

[10] [8 (DER profiles) + 4 (DER portfolios)] * 3 (load/DER growth scenario) * 2 (power flow scenario) = 72

[11] 72 (scenarios) * [4 (limitation categories) + 1 (Final ICA value)] * 576 (Hourly ICA value) = 207,360

[12] Since Excel 2007, Microsoft Excel worksheets can accommodate up to 1,048,576 rows.

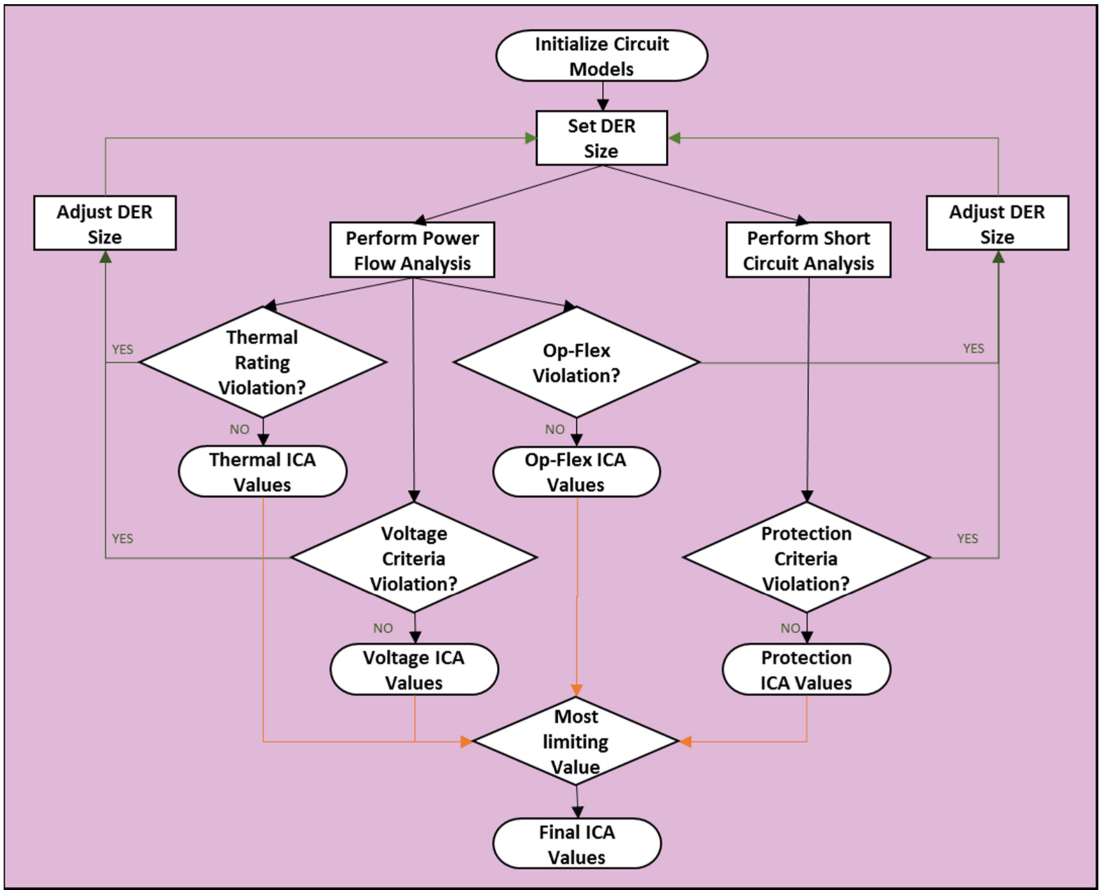

FIGURE 4 ITERATIVE METHOD FLOWCHART

3.4.3 Streamlined Method

The streamlined method applies a set of derived equations for each power system limitation category/sub-category to evaluate the DER capacity limit at any node of the distribution circuits. The load and generation information, under different scenarios (e.g., time of day, time of year, and DER growth scenario), derived from SCE's load forecasting tool and the circuit impedance information extracted from CYMDIST system models using CYME's Python scripting API serve as the inputs to the equations to generate the ICA results.

3.4.3.1 Thermal Criteria:

Thermal criteria determine whether a certain amount of DER causes the power flow to exceed any equipment thermal ratings or the planning loading limits. Equation (1) and (2) are used to determine the capacity of energy consuming DERs and energy producing DERs under the thermal criteria, respectively:

$$\boldsymbol{kW\ Limit}_{\boldsymbol{Load}}[\boldsymbol{t}] = \boldsymbol{Thermal\ Capability} - \left(\boldsymbol{Load}[\boldsymbol{t}] - \boldsymbol{Generation}\ [\boldsymbol{t}]\right) \quad (1)$$

$$\boldsymbol{kW\ Limit}_{\boldsymbol{Gen}}[\boldsymbol{t}] = \boldsymbol{Thermal\ Capability} + \left(\boldsymbol{Load}[\boldsymbol{t}] - \boldsymbol{Generation}\ [\boldsymbol{t}]\right) \quad (2)$$

In the equations, "*Thermal Capability*" refers to the 100% of equipment's loading limit; "*Load[t]*" refers to gross load at hour *t*; "*Generation[t]*" refers to gross generation at hour *t*.

3.4.3.2 Power Quality / Voltage Criteria

Power quality criteria determines whether a certain amount of DER violates the allowable power quality and voltage limits. Equation (3) is used to determine the capacity of DERs under Rule 2 steady state voltage specifications and equation (4) is used to determine the capacity of DERs under the voltage fluctuation limitation criterion.

$$\boldsymbol{kW\ Limit[t]} = \frac{\left(\boldsymbol{Voltage\ Headroom[t]}(\%)\ * \boldsymbol{V_{LL}[t]^2}\right)}{\left(\boldsymbol{R * PF_{DER} + X * \sin(\cos^{-1}(PF_{DER}))}\right)} * \boldsymbol{PF_{DER}}$$

$$\boldsymbol{Voltage\ Headroom} = \frac{|\boldsymbol{Rule\ 2\ Limit} - \boldsymbol{Nodal\ Voltage}|}{\boldsymbol{Base\ Voltage}} \tag{3}$$

In equation (3), "V_{LL}" refers to the actual circuit voltage at hour *t*; "*R*" and "*X*" refer to the line impedance to the node under study, "PF_{DER}" refers to the power factor of DERs, which is assumed at 1 in the study.

$$\boldsymbol{kW\ Limit} = \frac{\left(\boldsymbol{Deviation\ Threshold}\ (\%)\ *\boldsymbol{V_{LL}^2}\right)}{\left(\boldsymbol{R * PF_{DER} + X * \sin(\cos^{-1}(PF_{DER}))}\right)} * \boldsymbol{PF_{DER}} \tag{4}$$

In equation (4), "*Deviation Threshold*" refers to the voltage fluctuation limit, which is 3% of the nominal circuit voltage in the study; "V_{LL}" refers to the nominal circuit voltage; "*R*" and "*X*" refer to the line impedance to the node under study, "PF_{DER}" refers to the power factor of DERs, which is assumed at 1 in the study.

3.4.3.3 Protection Criteria

Protection criteria determines whether a certain amount of DER impacts the protection schemes on the circuit. Equation (5) is used to determine the capacity of energy producing DERs that can be interconnected without violating the reduction of breaker reach criterion.

$$\boldsymbol{kW\ Limit} = \frac{\boldsymbol{Reduction\ Threshold}\ \% * \boldsymbol{I_{Fault\ Duty}} * \boldsymbol{V_{LL}} * \sqrt{\boldsymbol{3}}}{\left(\frac{\boldsymbol{Fault\ Current_{DER}}}{\boldsymbol{Rated\ Current_{DER}}}\right)} * \boldsymbol{PF_{DER}} \tag{5}$$

In this equation, "Reduction Threshold" refers to the threshold of DER contribution, which is 10% in the study; "$I_{Fault\ Duty}$" refers to the maximum fault duty current seen at each node; "V_{LL}" refers to the circuit nominal voltage; "Fault $Current_{DER}$/Rated $Current_{DER}$" refer to DER fault current per unit contribution, which is 1.2 in the study.

3.4.3.4 Safety / Reliability Criteria

Operational flexibility criteria aims to limit the back feed beyond SCADA controlled switching devices so that when a line section is switched over, the amount of generation on that section will only serve the local load and does not generate into the receiving circuit to ensure proper system operations under abnormal conditions. It is the main issue investigated in the safety/reliability criteria category.

$$\boldsymbol{kW\ Limit[t]} = |\boldsymbol{Load[t]} - \boldsymbol{Generation\ [t]}| \tag{6}$$

This equation applies at SCADA controlled switching devices such as such as circuit breakers, remote automated reclosers, voltage regulators and remote controlled switches.

3.4.4 Comparative Assessment

A comparative analysis on selected reference circuits such as the IEEE 123-node circuit is currently under way for methodology alignment among IOUs. The cross-IOU assessment may compare SCE's streamlined and iterative results with the other IOUs' streamlined and iterative results, respectively.

SCE will conduct a comparative analysis between the two ICA methods to understand the difference between these methods.

3.4.5 Results Display

SCE will make the detailed ICA results publicly available within SCE's Distributed Energy Resource Interconnection Map (DERiM)[13] and in a downloadable format.

DERiM is an interactive smart map developed based on ESRI's ArcGIS online platform. It collects and performs calculations using data from the different sources such as generation interconnection tool and cGIS, aiming to connect developers with the SCE system data needed to enable strategic DER siting. Users can click on a feeder segment displayed on the map to obtain the ICA results.

Figure 5 shows an example of the DERiM display which is currently under test. The final map design may change in the final DERiM.

FIGURE 5 DERIM DISPLAY EXAMPLE

3.4.5.1 Results Display Plan

As discussed, the total amount of data to be generated in Demo A is significant. Publishing all these data on the map will require significant computation resources which not only affect the user experience due to longer time required to load information but also impose challenges to the map development. In addition, publishing all the ICA results on the map requires longer learning curves and more efforts for users to correctly retrieve the desired information while navigating through various scenarios. SCE will present the most practical and relevant scenario on the map and provide the data for all the scenarios in

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[13] Users can access DERiM and its associated User Guide at the following location: http://on.sce.com/gridinterconnections.

a download format. All the information published and made available will be subject to Personal Identifiable Information (PII) or Critical Energy Infrastructure Information (CEII) compliance requirements.

The scenario to be presented in the DERiM is the ICA results based on the iterative method, assuming Uniform Generation as the DER type, under the 2-year growth scenario, and with no reverse power flow at the substation busbar. It is assumed that the uniform generation is using inverter-based technology, with a contributing Short Circuit Duty (SCD) value of 1.2 PU. In addition to the Uniform Generation integration capacity value, the Uniform Load integration capacity value will also be published within the interactive maps.

The symbology, also known as the heat map visualization, of the maps will be based on the Uniform Generation integration capacity value described above. The Uniform Generation integration capacity value shown in the map is the "final" ICA results based on the most limiting power system criteria and the most limiting hour. Red colors will be areas of low integration capacity, while green areas will be areas of high integration capacity.

Besides the scenarios shown in the DERiM, users can download the complete Demo A data set through the available links. The complete Demo A data set will include not only all the ICA results but also the relevant information such as typical DER operational profiles and the profiles of representative DER profiles that are used in the ICA analysis; the load profiles at DPA, substation, and circuit levels; and the general system information such as customer type breakdown and existing generations at the circuit level.

As the downloadable data will contain billions of records, the data file will be in a file format that accommodate the amount of data, such as a *.csv. Users can query the dataset to obtain the desired information. For example, the ICA values for a given circuit segment with DER growth scenario III and allowing reverse power flow at the substation busbar can be filtered.

3.4.5.2 Map Design

Demo A ICA map is designed into layers, with each layer showing information at its level of granularity. There are layers for DPAs, substations, circuits, and circuit sections. ICA results at each node is represented by its upstream line section in the map.

When users click a DPA area, the pop-up window will show the DPA type (i.e., rural DPA and urban DPA)[14], 576-point load profile, and the link for downloading the complete Demo A dataset. Similarly, when users click a substation, the pop-up window will show the substation name, 576-point load profile, and the link for downloading the complete Demo A dataset. The load profiles presented in these two layers are 576-point profiles identified for typical high-load days and typical low-load days. These load profiles are aggregated from the circuit load profiles.

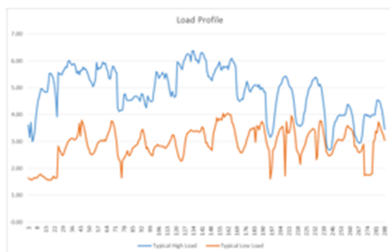
When users click a circuit, the pop-up window (an example shown in Figure 6) will present the circuit name, voltage, customer type breakdown (residential, commercial, industrial, agricultural) in

[14] As DPAs selected for Demo A may not be a complete system, it is proposed to use DPA type instead of actual system names to avoid confusion

percentage[15], existing generation, queued generation, total generation, load profile, and the link for downloading the complete Demo A dataset. The two load profiles presented are for typical high-load days and typical low-load days.

When users click a line segment, the pop-up window (an example shown in Figure 7) will show the associated circuit name, voltage, line section ID, final integration capacity values using the iterative method for uniform generation and uniform load, respectively, and the link for downloading the complete Demo A dataset. As the note shown in Figure 7 indicates, the generation ICA assumes short circuit duty characteristics of inverter-based technology.

Circuit Name	Solitaire
Voltage (kV)	12
Residential Customer (%)	50
Commercial Customer (%)	20
Industrial Customer (%)	10
Agricultrual Customer (%)	20
Existing Generation (MW)	1.02
Queued Generation (MW)	2.00
Total Generation (MW)	3.02
Load Profile (576 data points)	



Note:

Download Complete Demo A Dataset

FIGURE 6 CIRCUIT LAYER INFORMATION[16]

Circuit Name	Solitaire
Voltage (kV)	12
Line Segment Number	2
Integration Capacity, Uniform Generation (MW)	3.00
Integration Capacity, Uniform Load (MW)	4.00
Note:	Generation ICA assumes short circuit duty characteristics of inverter-based technology. Values presented reflect the 2-year growth scenario (utility planning), with no reverse power flow.
Download Complete Demo A Dataset	

FIGURE 7 CIRCUIT SEGMENT LAYER INFORMATION[17]

[15] Using percentage of customer type breakdown, instead of actual customer count, may prevent violating any applicable data sharing limitations to certain extent, but data sharing limitations will still be examined to make sure there are no violations.

[16] This is an example of the current display under test. The final pop-up window design may change in the final version.

[17] This is an example of the current display under test. The final pop-up window design may change in the final version.