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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 (U901E) 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

INTERIM STATUS REPORT
OF SAN DIEGO GAS & ELECTRIC COMPANY (U 902-E)

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September 30, 2016

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INTERIM STATUS REPORT OF SAN DIEGO GAS & ELECTRIC COMPANY (U 902-E)

Pursuant to 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*, dated May 2, 2016, San Diego Gas & Electric Company hereby submits its Interim Status Report concerning Demonstration Project A.

Respectfully submitted,

/s/ Jonathan J. Newlander

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SAN DIEGO GAS & ELECTRIC
DISTRIBUTION RESOURCE PLAN

DEMONSTRATION A

San Diego Gas & Electric
Distribution Resource Plan

Demonstration A – Enhanced Integration Capacity Analysis

Interim Status Report – Methodology, Criteria, and Assumptions

September 2016

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Executive Summary

This document is an interim status report for SDG&E's Integration Capacity Analysis (ICA) Demonstration A "ICA Demo A" as required per 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 (May 2nd, 2016) aka "Ruling". This report details the project execution including criteria, assumptions, and schedule. SDG&E's project team will share this report with the Integration Capacity Analysis (ICA) Working Group as directed in the Ruling to ensure that objectives are being met and adjusted as needed.

For the purposes of Demonstration A, both iterative and streamlined analyses are underway. The iterative analysis performs power flow simulations to model DERs at each node along a circuit, providing accurate hosting capacity results similar to what would be obtained in an interconnection study. The streamlined analysis utilizes a set of algorithms to estimate the hosting capacity at each node after performing an initial baseline power flow simulation to determine the starting point. The streamlined method may offer some reduction in computing time, while the iterative method provides a higher degree of accuracy.

Methodology

The ICA methodology consists of four steps, per the Ruling. These four steps and how they apply to demonstration project A are described in the figure and text below.

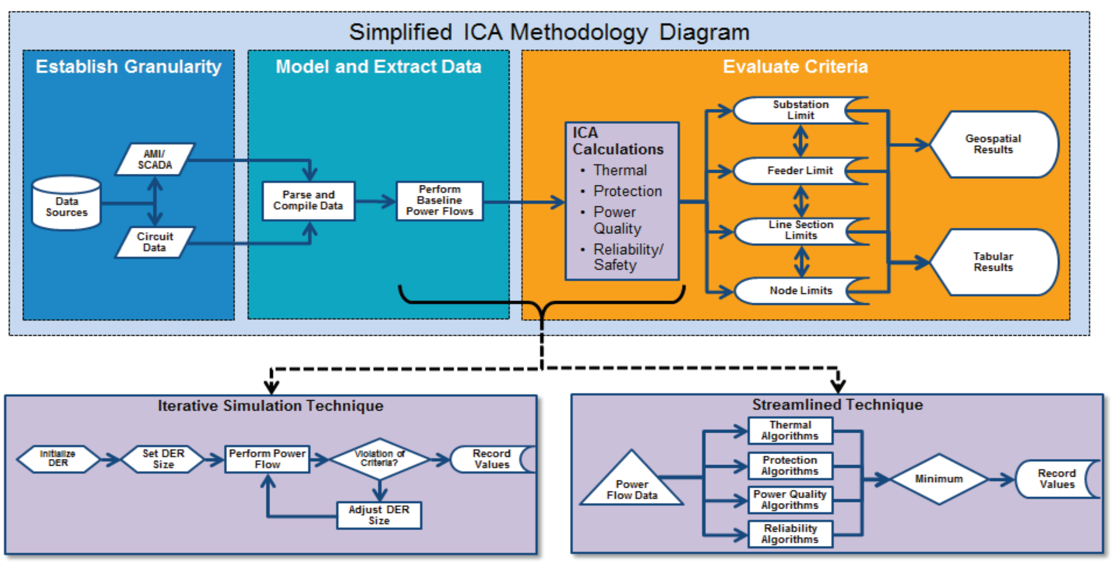

Figure 1: ICA Methodology Diagram

Establish distribution system level of granularity

The first step in performing an ICA is to develop a detailed 12kV distribution circuit model. Synergi imports facilities data from SDG&E's Geographic Information System (GIS). Figure 2 illustrates some of the facility data extracted.

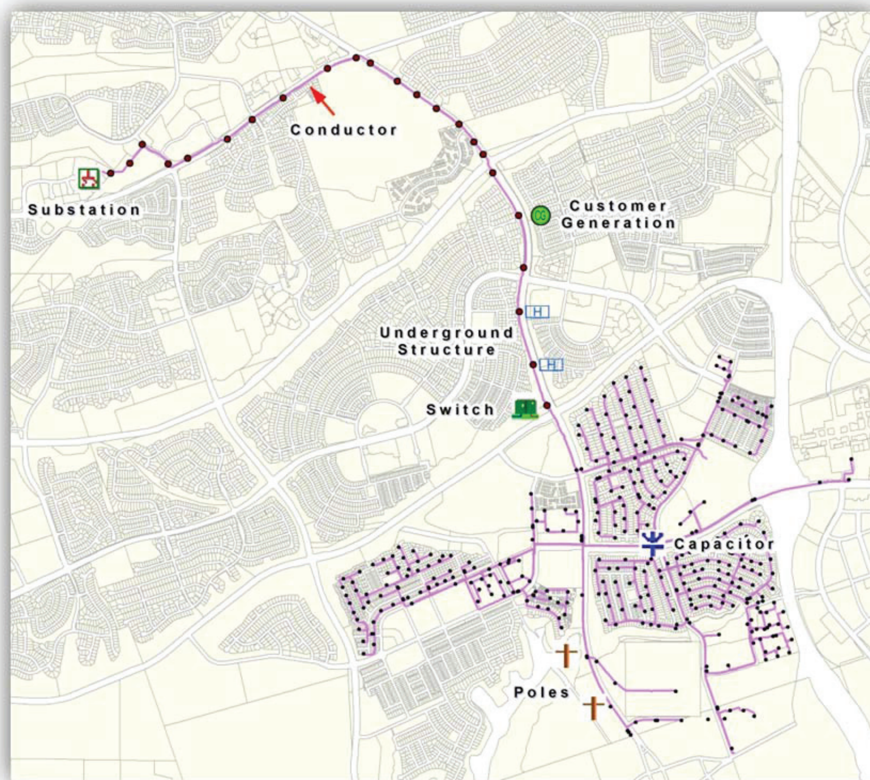

Figure 2. GIS Data Extraction

The extracted data from the GIS includes the material type and length of the conductor, type of switch, structures and subsurface equipment, reclosers, sectionalizers, fuses, capacitors, voltage regulators, generators, connected kVA and type of substation equipment.

Using this level of detailed data allows for a high level of granularity to accomplish an analysis of each line segment. In the GIS model, a line segment represents an electrical path between two points or nodes. A node is defined as a pole or underground structure. The analysis will be applied to all the line segments on the main feeder and branches including three phase and single phase lines. Figure 3 illustrates how the single phase portion of a circuit is identified in the Synergi model

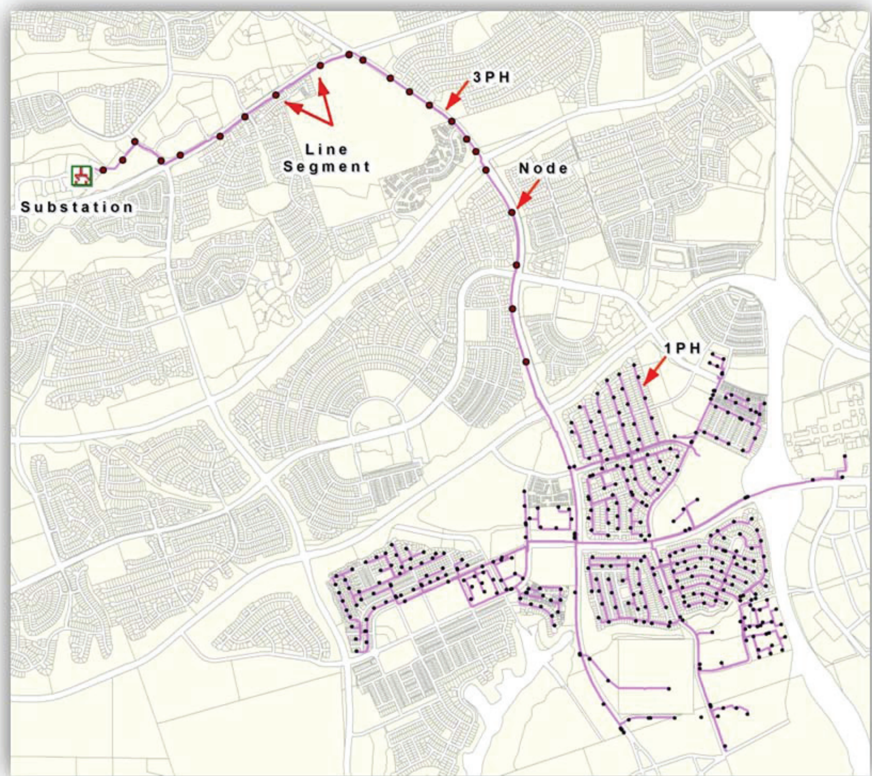

Figure 3. GIS Extraction Including Nodes and Single Phase Lines

For the purposes of operational flexibility, SDG&E analyzes the portion of a circuit between the last remote operated switch or recloser and a remote operated tie switch as a single section. Manual tie switches or sections without a remote operated line switch are not considered in the analysis.

Model and extract power system data

For demonstration project A, SDG&E is performing both an interactive power flow simulation process and streamlined process to perform the ICA. Both approaches start with performing a power flow analysis on the circuit model using Synergi. The analysis is conducted on each line segment up to the substation bus level. The following informational databases are used to build the circuit models.

- **GIS:** The circuit model is built from detailed data, as described in level of granularity.
- **Master Data Warehouse**: A database that contains the DER Profiles[1], Load Profiles, and the thermal ratings for the conductors and devices that Synergi will use for analysis.
- **LoadSEER:** A load forecasting model.

[1] SDG&E is using the DER profile provided by PG&E

- **Supervisory Control And Data Acquisition (SCADA) devices:** SCADA data is leveraged by LoadSEER to develop the demand profile for each circuit, which is then aggregated up to the substation bus level.
- **Customer Information System (CIS):** Customer billing code is acquired to establish customer zones by customer class.
- **Advanced Metering Infrastructure (AMI):** Interval metered load data is recorded for all customers on every circuit and allocated to the circuit model.

Assumptions and Starting Points

Load Profile Development

AMI data and LoadSEER are used to develop demand curves for each circuit based on customer class and historical data. AMI data is used to determine the demand curve at each service transformer. This is done by aggregating the consumption data from each smart meter up to its respective service transformer, as shown in Figure 4 below. Once the loading at each transformer is determined, the circuit load is then allocated to each service transformer based on the AMI information.

Figure 4: Aggregation of AMI Demand Data to Transformer

For the circuit demand profile, SDG&E utilizes LoadSEER to develop its forecasted circuit load shapes that are uploaded to Synergi for the ICA. This tool employs multiple statistical methods including SCADA as well as weather data throughout the SDG&E service territory to derive statistical modeling of peak load history, econometric modeling of energy, and a GIS-based land use simulation analysis (spatial forecasting), all of which are used to develop forecasted load shapes. LoadSEER assigns CEC system level mid case demand to the appropriate substations as well as circuit to establish the growth by utilizing the statistical methods described previously. The two DER growth scenarios (scenario I and scenario III) established by SDG&E with the IEPR forecast mid-energy demand case as the base will also be included in the forecasted load shapes. The final product will be a typical high load forecasted load shape day and a typical low load forecasted load shape day for the three scenarios.

Once the circuit demand profile is created, it is then allocated to each service transformer based on the AMI information.

Generation Profile Development

The DER profiles used in demonstration project A are those that are identified in the ruling, which include:

- EV – Residential (EV Rate)
- EV – Residential (TOU Rate)
- EV – Workplace
- PV
- PV with Storage
- PV with Tracker
- Storage – Peak Shaving
- Uniform Generation
- Uniform Load

These profiles are shown below:

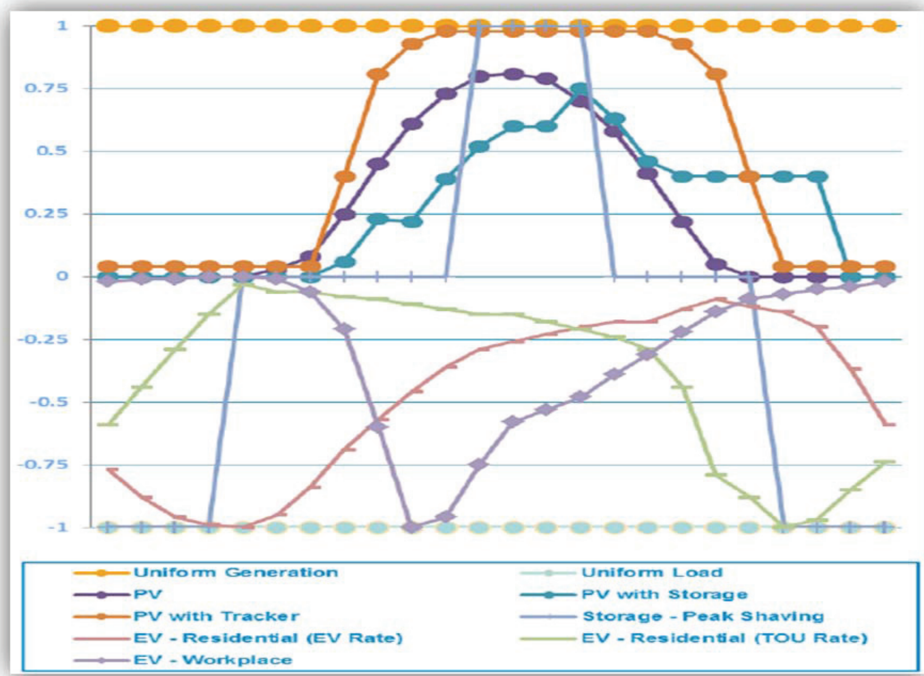

Figure 5. DER Profiles

Power Flow Model Development

As described above, the Synergi model is developed by extracting equipment data from SDG&E's GIS system into Synergi. Once the load and DER profiles are developed, they are imported into the Synergi model. A baseline power flow simulation is then performed on the model and the results are checked and validated. If the model does not converge, or values fall outside the expected range, steps are taken to troubleshoot and remediate any deficiencies in the model.

For the purposes of ICA, SDG&E models circuits in their respective normal configurations only. The number of potential circuit configurations after switching is immense, and typically only used for maintenance or outage restoration purposes. For circuits that do change configuration, future ICA updates will analyze the new configuration and new ICA results will reflect the change. This is in line with current Rule 21 practice that only analyzes normal configuration unless specifically requested by the interconnection customer.

Criteria Limits to determine DER capacity

As required by the Ruling, four general power system criteria were used in the ICA to determine the hosting capacity for DER. Specifically, the Ruling instructs the utilities, as part of Demonstration Project A, to incorporate the list of analyses from PG&E's table 2-4 in its DRP filing to the extent feasible. SDG&E has modified the table to provide the detailed criteria that will be evaluated as part of Demonstration Project A, both for the streamlined and iterative analysis. SDG&E has included most of the criteria identified in table 2-4 in its ICA for Demo A.

Thermal Criteria

Thermal Criteria determines whether the addition of DER to the circuit causes equipment thermal ratings to be exceeded. Thermal limits shall be the rated capacity of the conductor, transformer, cable and line devices established by SDG&E Engineering Standards or equipment manufacturers. The Integration Capacity value is the highest DER value that does not exceed the thermal rating of any piece of upstream equipment on the distribution circuit or substation. The table below shows the equations and flags used to evaluate thermal limitations.

Streamlined	$kW\ Load\ Limit\ [t] = \left(Thermal\ Capability\ - (Load[t] - Generation\ [t])\right)$ $kW\ Generation\ Limit\ [t] = \left(Thermal\ Capability\ + (Load[t] - Generation\ [t])\right)$
Iterative	○ *Flag equipment exceeding its thermal rating in simulation by power flow tool*

Due to the nature of load and generation, the iterative simulation identifies overloads with respect to their impact on the system. Load receives power from the system (forward direction), while generation exports power to the system (reverse direction).

Voltage/Power Quality

Voltage/Power Quality criteria ensure that customer facilities and equipment are not damaged by operating outside of allowable power quality and voltage limits. There are both steady state voltage limits and voltage fluctuation limits established by SDG&E's Rule 2 and SDG&E's Engineering Standards, which are drawn from American National Standard (ANSI) C84.1 - 2011 Range A. For steady state voltage evaluation, below are the equations and flags used to identify violations in demo A.

Streamlined	$kW\ Limit = \frac{\left(Voltage\ Headroom\ (\%)\ * {V_{LL}}^2\right)}{(R * PF_{DER} + X * \sin(\cos^{-1}(PF_{DER})))} * PF_{DER}$ $Voltage\ Headroom = \frac{\lvert Rule\ 2\ Limit - Node\ Voltage \rvert}{Base\ Voltage}$
Iterative	• *Tool flags for steady state over-voltage and under-voltage conditions*

The voltage fluctuation and flicker limit used in Demonstration A is 3%, which is prescribed by SDG&E's design standards, in order to minimize the impact of fluctuations caused by DERs on other SDG&E customers. Below are the flags and equations used to identify voltage fluctuation violations.

Streamlined	$kW\ Limit = \frac{\left(Deviation\ Threshold\ (\%)\ * {V_{LL}}^2\right)}{(R * PF_{DER} + X * \sin(\cos^{-1}(PF_{DER})))} * PF_{DER}$
Iterative	• *This is not a steady state voltage condition and not suitable for iterative steady state power flow simulation* • *Exploring methods if applicable and/or feasible*

To conduct the analysis, SDG&E will set the voltage at the substation bus between within ANSI range A, and allow the LTC to control the voltage at the substation bus.

Protection Criteria

Protection criteria are used to determine if the DER causes problems with the existing protection schemes on the circuits that protect and isolate during system events. There reduction of reach criterion identifies when a generator may impact the ability of the circuit relay to detect and isolate a fault. This reduction of reach could result from the injection of fault current from the generator into the faulted circuit. For inverter based generators, the generator is assumed to contribute 1.2 times the nameplate rating to the fault current during a short circuit. For the reduction of reach criterion, the end of line fault current must remain a prescribed amount above the minimum trip value of the substation relay to ensure coordination. To identify any violations of the reduction of reach criteria, the flags and equations below will be used.

Streamlined	$kW\ Limit = \frac{Reduction\ Threshold\ \% \ * I_{Fault\ Duty} * \ kV_{LL} \ * \sqrt{3}}{\left(\frac{Fault\ Current_{DER}}{Rated\ Current_{DER}}\right)} * PF_{DER}$
Iterative	• *Tool Flags for fault current lower than prescribed limits*

Safety/Reliability Criteria

Operation flexibility limits are a concern with high penetration DER and the impact to abnormal distribution system conditions, circuit transfers and emergency restoration. To mitigate concerns regarding operational flexibility, this criterion will match the generation to the load for the last section between an automated circuit tie and the next automated device on the circuit. The equations and flags below identify when a DER causes the operational flexibility limit to be exceeded.

Streamlined	$kW\ Limit\ [t] = (Load[t] - Generation\ [t])\ \mid\ where\ limit > 0$
Iterative	• *Tool flags for reverse current through device* ○ *Applied only to SCADA capable devices*

Calculate ICA results and display on online map

ICA calculations will be performed using the both a streamlined and iterative simulation process. Each criteria limit is calculated for the most limiting value and is used to establish the integration capacity (IC) limit. The resulting IC data will be publicly available using the Renewable Auction Mechanism (RAM) Program Map. The ICA maps will be available online and will provide a user with access to the results of the ICA by clicking on the map. The capacity limit will be displayed on the ICA maps by clicking on the line segment. The call out box will display the load curve at the feeder and substation bus. SDG&E expects that once the maps are put into use, improvements and refinements to the ICA maps will be developed in conjunction with the ICA working group.

Schedule/Gantt Chart

The schedule for SDG&E's Demonstration Project A is shown in Figure 6 below.

ID		Task Mode	Task Name	Duration	Start	Finish
1			Select DPAs	55 days	Mon 4/4/16	Fri 6/17/16
2			Develop DER profiles	80 days	Mon 5/2/16	Fri 8/19/16
3			Develop DER portfolios	55 days	Mon 6/6/16	Fri 8/19/16
4			**Develop Bus flows**	**71 days**	**Fri 6/17/16**	**Fri 9/23/16**
5			develop substation models	21 days	Fri 6/17/16	Fri 7/15/16
6			Develop load profiles	50 days	Fri 6/17/16	Thu 8/25/16
7			Update to Synergi ICA module	25 days	Mon 8/29/16	Fri 9/30/16
8			Perform Power Flow ICA	30 days	Fri 9/30/16	Thu 11/10/16
9			Perform Streamlined ICA	25 days	Wed 9/7/16	Tue 10/11/16
10			Post Process	20 days	Fri 11/11/16	Thu 12/8/16
11			Qualitatively assess trans impacts	88 days	Thu 9/1/16	Sat 12/31/16
12			**Update ICA maps**	**196 days**	**Mon 4/4/16**	**Sat 12/31/16**
13			Determine new field	79 days	Mon 4/4/16	Thu 7/21/16
14			ICA WG Map meeting	1 day	Mon 7/25/16	Mon 7/25/16
15			Modify map code	60 days	Mon 8/1/16	Fri 10/21/16
16			Update map data with results	10 days	Fri 12/9/16	Thu 12/22/16
17			Comparative Analysis	45 days	Mon 9/5/16	Fri 11/4/16
18			Interim Status Report	0 days	Fri 9/30/16	Fri 9/30/16
19			Final Demonstration A report	0 days	Fri 12/30/16	Fri 12/30/16

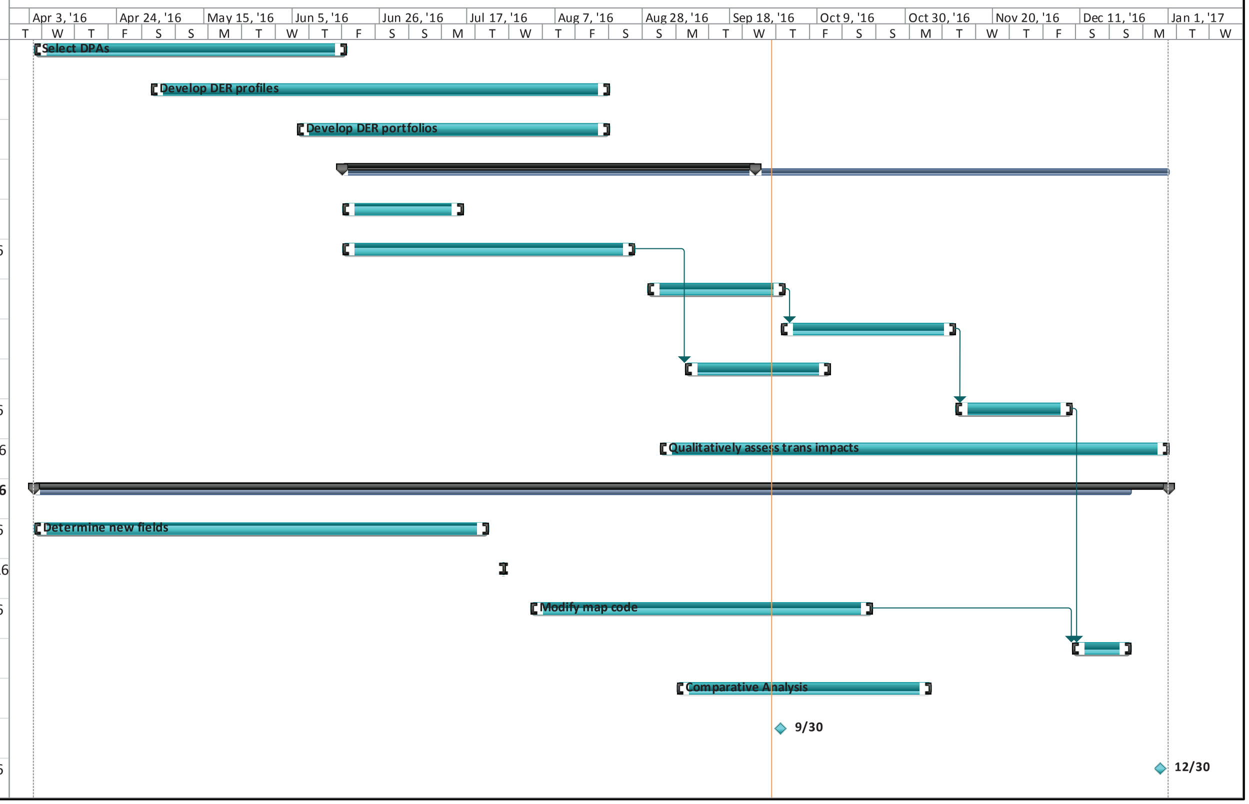

Figure 6. Demonstration Project A Schedule

Demonstration Project A Status

SDG&E's demonstration project A has multiple work streams underway concurrently, and is evaluating each aspect of the ICA to determine efficacy, accuracy, speed, and usefulness to end users.

Iterative Analysis

The iterative methodology SDG&E is implementing includes running power flow analysis that will account for all reactive devices on each distribution circuit and substation bus. SDG&E is already in the process of working with the vendor of Synergi (DNVGL) to properly model substation transformer banks w/ LTC's, substation buses, and substation capacitors. The latest revision to Synergi has incorporated these features into the software, and SDG&E and DNVGL are currently working together to optimize the algorithm to reduce processing time.

Streamlined Analysis

SDG&E's consultant is currently generating streamlined results for all circuits in the Demo A study area for the base planning case. SDG&E's criteria align with the IOU's streamline criteria, including: headroom, voltage fluctuation, short circuit current, upstream regulator, upstream recloser, and thermal limits. Initial results generate data files in excess of 1GB per circuit, highlighting the need for thoughtful data management. The next step for SDG&E's consultant is to report streamline results for the 2 DER growth scenarios.

ICA Computing Time

SDG&E has already undertaken efforts with its power flow software vendor to decrease the computing time of the ICA by performing the analysis within the user interface of the software, rather than as a function call from outside the software. Initial runs show that 24 hour profiles, along with substation modeling, increase computing time substantially. Efforts are underway to modify coding to decrease computing time. The IOUs are also exploring methods of reducing the number of data points required for evaluation, which could potentially reduce the computing time significantly. This may include eliminating redundant simulations for both multiple hours and nodes.

Incremental ICA Computing Needs

To date SDG&E has performed the iterative analysis in house using existing computing resources. SDG&E is currently exploring utilizing a server for various Synergi functions, potentially including ICA. Once the full analysis is complete, SDG&E will evaluate the computing time of both the iterative power flow method and the streamlined method to determine if additional or alternative computing infrastructure is required to perform scenario analysis as well as support ongoing ICA refreshes.

Comparative Analysis

SDG&E, along with the other IOUs, has modeled IEEE reference circuit 123, and performed initial analysis on this circuit. The amount of time and effort needed to not only convert the circuit to Synergi format, but validate that the data is correct and complete, is significant. This calls into question the notion of performing a comparative analysis of multiple circuits before the demonstration project A final report is due. The analysis of multiple circuits can remain a long term objective, but may prove infeasible for the demonstration project.

Progress Toward Learning Objectives

Below is the status of SDG&E's demonstration A with regard to each of the learning objectives identified in the implementation plan.

Objective 1: Study Reverse Flow at T&D Interface	
Description	DER Capacity with and without limiting reverse power beyond substation busbar.
Status	**In Progress.** Substation models have been constructed, and LTCs are operating as expected.
Initial Learnings	Initial runs show a significant increase in processing time when evaluating multiple circuits at one time.

Objective 2: Diverse Locations	
Description	Evaluate two DPAs covering broad range of electrical characteristics.
Status	**Complete.** SDG&E will analyze its Northeast and Ramona districts, which range from long, rural overhead circuits, to short, urban underground circuits. These districts also have circuits with different load characteristics, from residential to commercial/industrial, to some agricultural load.
Initial Learnings	The combination of long rural circuits with short urban circuits provide a good variety of circuits to test the ICA for SDG&E's territory.

Objective 3: Incorporate Portfolios and New Technology	
Description	Methods for evaluating DER portfolios, CAISO dispatch, Smart Inverters, and other technology.
Status	**In Progress.** A DER agnostic ICA curve is under development, and will be modified via post processing to identify specific DER profiles. Smart inverters will be incorporated into analysis of single circuit with voltage limitations after initial analysis is performed.
Initial Learnings	Analyzing portfolios directly in the analysis is time consuming, and post processing may provide a more efficient option.

Objective 4: Consistent Maps and Outputs	
Description	Consistent and readable maps to the public with similar data and visual aspects. SDG&E will work with the other IOUs and the ICA Working Group to develop an interface that is consistent as well as easy to interpret, based on guidance from the working group.
Status	**In Progress.** IOUs and ICAWG have agreed upon map format. IT is in process of coding new interface. Maps will show worst case ICA, downloadable data files will include all results
Initial Learnings	Placing multiple ICA and load curves directly in the maps is confusing and slows down display of results.

Objective 5: Computational Efficiency	
Description	Evaluate methods for a faster and more accurate update process that works for entire service territory. Evaluate hardware/software updates needed to expand and support ongoing refresh cycles.
Status	**In Progress.** The IOUs are also exploring methods to reduce the amount of data points required.
Initial Learnings	Initial ICA runs consumed a considerable amount of time, prompting discussions with software developer regarding code efficiencies.

Objective 6: Comparative Analysis	
Description	Benchmark for consistency and validation across techniques and IOUs. As noted in the comparative analysis section, SDG&E will be running multiple analyses to compare both methodologies on its own system, as well as with the other IOUs for consistency of results.
Status	**In Progress.** IEEE circuit 123 has been converted to Synergi and is being compared across the IOUs.
Initial Learnings	Evaluation of multiple circuits may not be feasible due to complexities inherent in the conversion process, while also developing the tools to complete the ICA for demo A.

Objective 7: Locational Load Shapes:	
Description	Utilize Smart Meters for localized load shapes.
Status	**In Progress.** AMI data has been incorporated into load allocation, LoadSEER shapes are being finalized.
Initial Learnings	The development of load shapes requires significant effort in scrubbing and validation to ensure that bad data is removed, and that circuit transfers are captured in the data.

Objective 8: Future Roadmap	
Description	Determine roadmap and timelines for future ICA achievements based on demonstration learnings.
Status	Part of ICA working group discussions.

Conclusion

While the progress of SDG&E's Demonstration Project A is significant, substantial work still remains to complete the project by end of year 2016. Notably, model conversion, computing time, and sheer volume of data are challenging obstacles to overcome as part of demonstration project A. SDG&E is confident that initial and future learnings from demo A will provide valuable insight into the improvement of the ICA, both for accuracy and speed.