Lessons Learned – The EV Project

The EV MICRO-CLIMATE®

Deployment Process in San Diego

Prepared for the US Department of Energy

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List of Acronyms

AC	Alternating Current
ARRA	American Recovery & Reinvestment Act
DC	Direct Current
DCFC	Direct Current Fast Charger
DOE	Department of Energy
ESAC	EV Project Stakeholder Advisory Committee
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
GIS	Geographic Information System
MGRA	Master Geographic Reference Areas
PEV	Plug-in Electric Vehicle
POI	Point of Interest
SANDAG	San Diego Association of Governments
U.S.	United States

1 Company Profile

ECOtality, Inc. (NASDAQ: ECTY), headquartered in San Francisco, California, is a leader in clean electric transportation and storage technologies. Its subsidiary, Electric Transportation Engineering Corporation (eTec) dba ECOtality North America (ECOtality), is a leading installer and provider of charging infrastructure for electric vehicles (EVs). ECOtality has been significantly involved in major EV or plug-in electric vehicle (PEV) initiatives since 1989 in North America and is currently working with major automotive manufacturers, utilities, the United States (U.S.) Department of Energy (DOE), state and municipal governments, and international research institutes to implement and expand the presence of this technology for a greener future.

ECOtality designed and currently manages the world's largest EV infrastructure demonstration - The EV Project. With a budget of over $230 million, The EV Project will deploy and study Level 2 alternating current (AC) electric vehicle supply equipment (EVSE) charging stations for residential use, Level 2 AC EVSE charging stations for commercial and direct current (DC) fast charge (DCFC) stations. This represents thousands of field assets, utilized in concert with the deployment of Nissan LEAF™ vehicles and Chevrolet Volt vehicles.

The EV Project is a public and private partnership administered by the DOE through a federal stimulus grant, made possible by the American Recovery and Reinvestment Act (ARRA) and by the private investment of ECOtality and its partners.

The EV Project is an infrastructure study. The EV Project will deliver to ECOtality, the Government, and the general public a wealth of directly-applicable technical and professional experience for jumpstarting regional EV adoption and replicating business models that lead to sustainable, market-based charge infrastructures.

One purpose of The EV Project is to identify potential barriers to the widespread adoption of EVs and the deployment of EVSE units to support them. This process identifies topics of national interest in the early deployment of EV charging stations in order to facilitate discussion and resolution. This paper documents the considerations associated with and The EV Project's approach to the deployment of these AC Level 2 EVSE units and how the final deployment compares to the planned locations determined by the EV MICRO-CLIMATE® planning process.

2 Statement of Need

The *EV Micro-Climate Planning Process* Lessons Learned document provided the Statement of Need for the planning process itself. ECOtality developed the EV Micro-Climate® planning process as an integrated turn-key program to ensure an area is well equipped with the needed infrastructure to support the consumer adoption of electric transportation. Beginning with extensive feasibility and infrastructure planning studies, the program provided a blueprint to create a rich EV infrastructure.

The EV Micro-Climate process enlisted highly interested stakeholders in the region to provide local context, history, and drive for EV adoption. These stakeholders became the local EV Project Stakeholder Advisory Committee (ESAC) and they were active throughout the planning process. The Micro-Climate process focused the interests of this highly diverse group to produce three major planning documents. The evaluation of the Micro-Climate planning process is available at www.theevproject.com.

The EV Micro-Climate process in San Diego produced three documents: *Electric Vehicle Charging Infrastructure Deployment Guidelines for the Greater San Diego Area* (May 2010), *Long-Range EV Charging Infrastructure Plan for Greater San Diego* (October 2010) and the *EV Micro-Climate Plan for San Diego Region, California* (February 2011).

The *Long-Range EV Infrastructure Plan for Greater San Diego* provides a review of the current behavior of vehicle operators and industry projections of EV sales as a means of understanding the expected EV population in the Greater San Diego area by the year 2020. The Micro-Climate plan utilizes this long range projection, but focuses on the near term, 2 – 3 years, for the immediate deployment of publicly available EVSE units.

The *EV Micro-Climate Plan for San Diego Region* records the process used by The EV Project and the ESAC for distributing, locating, and selecting publicly available EVSE sites. Primary input to this document was the work of the *Long-Range EV Charging Infrastructure Plan for Greater San Diego*. An important output of this document is a series of maps to identify geographic locations for publicly accessible Level 2 EVSE and DCFC equipment. This output is used to find specific EVSE hosts leading to EVSE unit installations.

This paper focuses on an assessment of how the final deployment of the non-residential AC Level 2 EVSE units compare to the results of that planning process.

3 Micro-Climate Plan Methodology in San Diego

The Micro-Climate plan takes the first step in implementing the Long-Range EV Infrastructure Plan for Greater San Diego by determining the general locations for the initial EV charge infrastructure to be deployed within a two-year time horizon. By virtue of focusing on a two-year time horizon, some of the unknowns that are part of the work in the Long-Range EV Infrastructure Plan for Greater San Diego are made more specific and definable. This greater specificity creates a more actionable blueprint for EVSE unit installations in the San Diego region.

Starting with the preparation of *Electric Vehicle Charging Deployment Guidelines for Greater San Diego* and *Long-Range EV Infrastructure Plan for Greater San Diego*, the ESAC member organizations were immersed in PEV and EVSE technology capabilities and function. For EV Micro-Climate planning, this knowledge was specifically augmented with review of recent literature on observed charging behavior and perceived charging needs of PEV drivers or intenders, along with basic Geographic Information Systems (GIS) analysis capabilities. This additional information readied the ESAC to review different data sets available for constructing an EVSE location model and setting reasonable values for the inputs to such location models.

The ESAC established two goals for this effort. The primary goal was:

> *To enable a study of infrastructure deployment and driver behavior, to learn lessons from this study and refine the EV infrastructure deployment methodology.*

The secondary goal was:

> *To place EV Project EVSE units in locations that will serve as the foundation of a rich charging network for all future PEV drivers, where this goal does not conflict with the primary strategic goal.*

All ESAC member organizations were offered an opportunity to provide input on the data that would be used in the Micro-Climate plan. The varied focus, both subject area and geographic, of the ESAC member organizations ensured consideration of a broad set of data, under such general categories as land use, transportation, market research, electric grid capacity, and driver behavior. Each of these functional responsibilities was represented by the ESAC. ESAC organizations also provided access to data available within their organizations to facilitate the Micro-Climate planning process.

ESAC member organizations provided explicit input on the value of certain factors (e.g. trip attraction, employment center, annual EVSE availability, etc.) in the EVSE land use suitability location modeling. The ESAC also outlined four special focus areas for EVSE placement: 1) workplace charging; 2) DCFC corridor planning; 3) non-residential PEV home area charging; and (not as a part of the EV Project) 4) Indian Gaming casino EV charging.

The base unit of geography for the model was Master Geographic Reference Areas (MGRA), a proprietary data unit designed and used by San Diego Association of Governments (SANDAG), who provided the majority of the GIS modeling and mapping support. MGRAs are geographic areas roughly the size of census blocks in urban and suburban areas, and census block groups in rural areas. MGRAs are designed to nest into larger standard geographies, such as census tracts, zip codes, and municipal boundaries. They are delineated in a way to preserve the contiguity of trip producing and attracting land uses. A subset of MGRAs was selected for use in the model, based on the zip codes that were defined as the initial study areas for The EV Project. Trip attractions and total employment were tabulated by MGRA. Land use was also tabulated by category for each MGRA; as it is possible for more than one land use in each MGRA. MGRAs are polygon shapes rather than points, but contain the points of interest (POI) which are expected to attract PEV drivers. An MGRA may contain more than one POI, but this paper will focus on the MGRA level rather than the POI level.

The ESAC was given authority to construct the EVSE location model with the explicit requirement that the model implement the two previously stated strategic goals, and with an understanding of the available data for modeling purposes. Additionally, the ESAC was directed to consider the results of any location selection model, including a map of the MGRAs and a ¼ mile buffer that had the greatest potential of optimum EVSE sites within them.

Optimum Level 2 EVSE locations were defined as those locations with:

- High number of users
  - Integrated into daily life
  - Available to many different users
- High frequency of vehicle turnover
  - Vehicle stay times of 45 minutes to approximately 3 hours
- Significant availability
  - Maximize the number of open days per week and per year
  - Maximize the number of open hours per day

The ESAC members, serving as a focus group, rated the different categories on a 1 to 5 (5 being highest) scale. Additionally, the group provided input on the value (a weight) of each land use suitability factor, which included presence in an Employment Center and the MGRA's trip attraction number.

The weighting factors were applied to all the MGRAs and results normalized to provide a scale of 0 – 10.

Table 1. Number of MGRAs by Normalized Score

Normalized Score	Number of MGRAs
< 0.1	13,178
0.1 – 0.2	2,786
0.2 – 0.3	1,353
0.3 – 0.5	1,355
>0.5	84
Total	18,756

These MGRAs were mapped by this normalized score, as shown in Figure 1. (Note that the blank area in the map is the Miramar Marine Corps Air Station.)

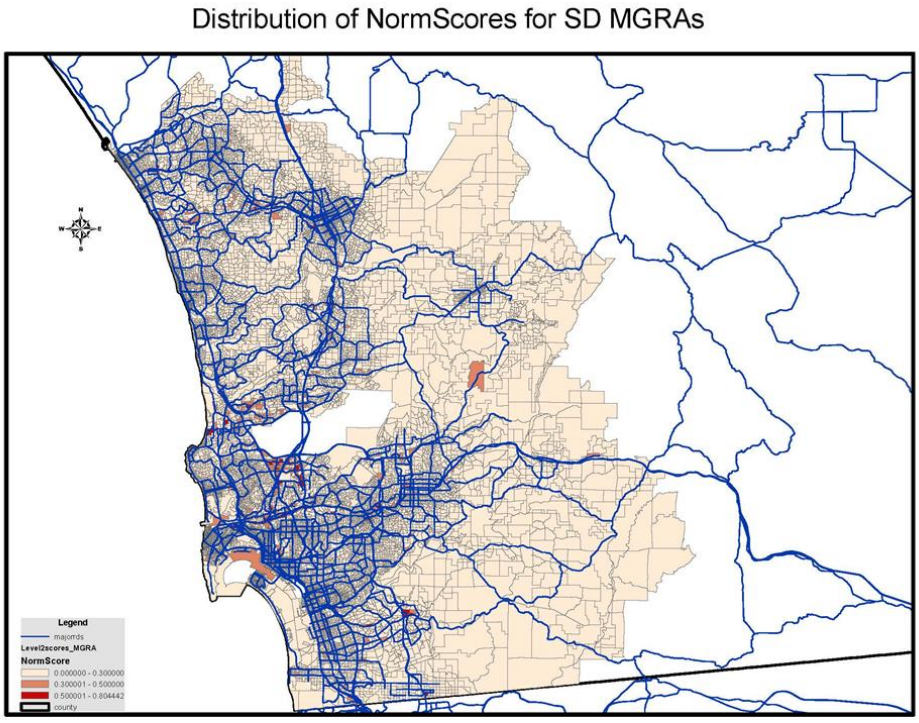

Figure 1. MGRAs Identified by the Normalized Score

The MGRAs were divided into three "Tiers" based upon their normalized score, and only those in Tier 1 (best) and Tier 2 (better) were selected for the final analysis. The Tier 1 and 2 MGRAs were characterized by normalized scores above 1.6 (Figure 2). This was used to show the probable and highly probable potential locations for AC Level 2 EVSE units, shown in Figure 3.

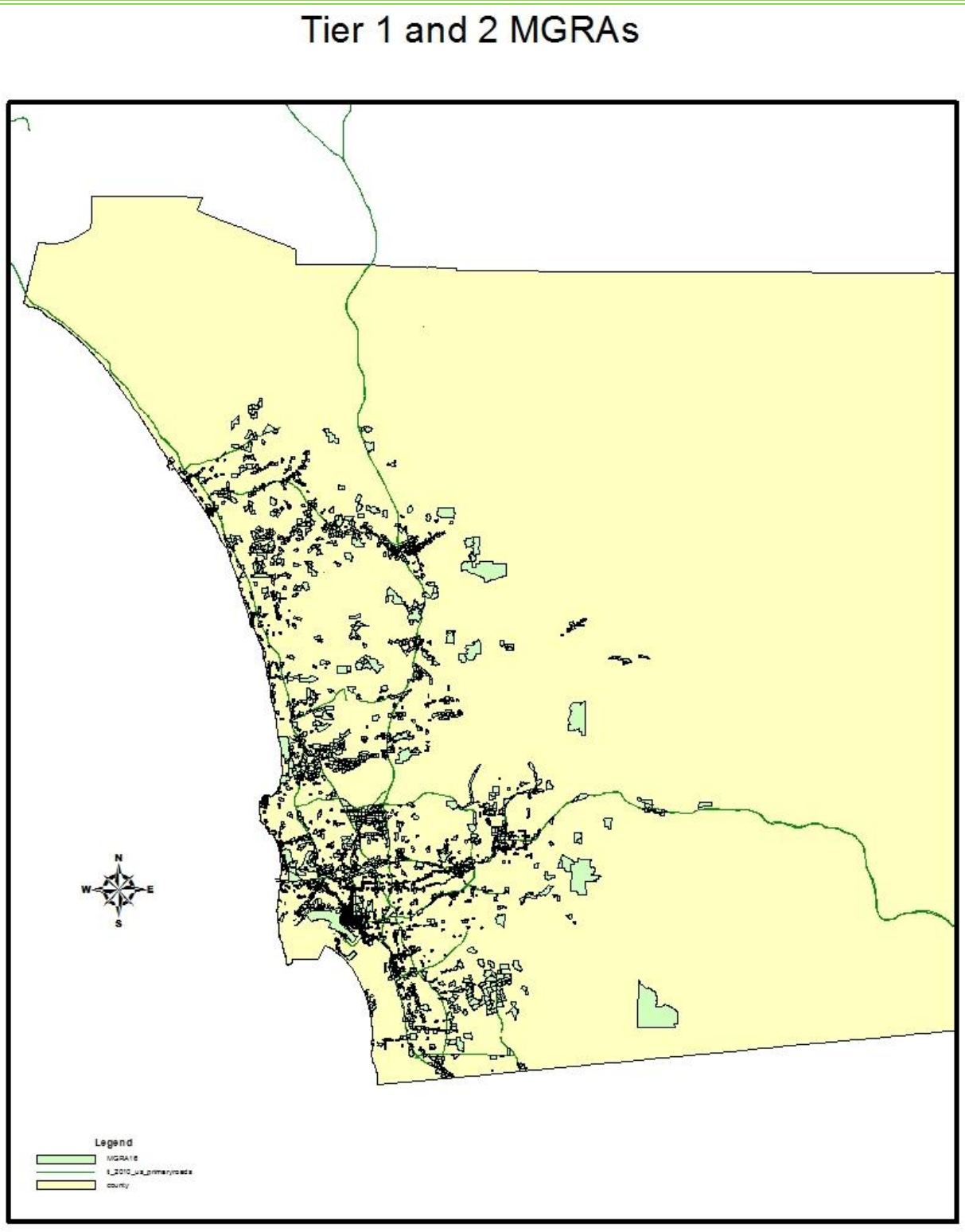

Figure 2. Tier 1 and 2 MGRAs

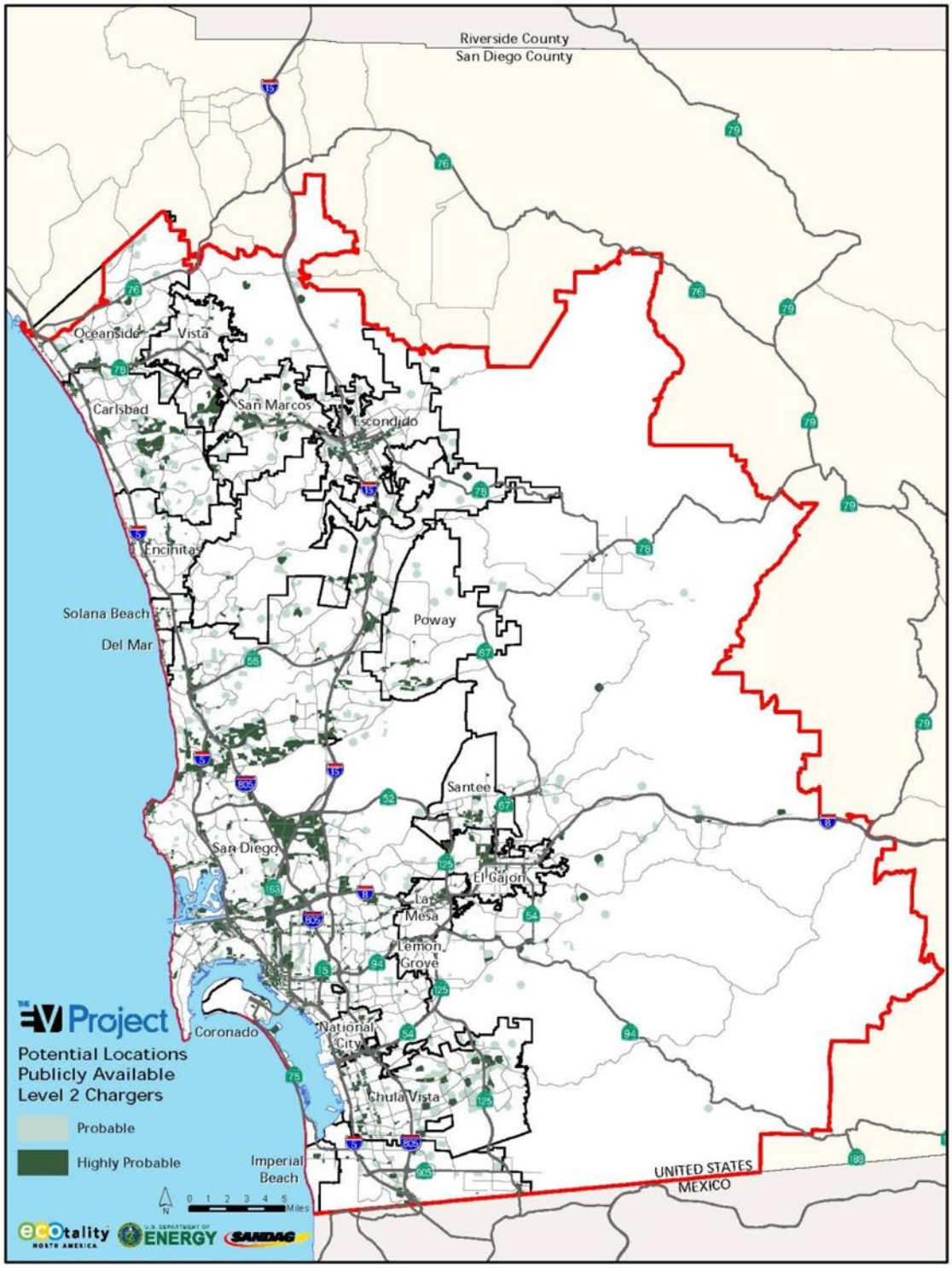

Figure 3. Potential Locations Publicly Accessible AC Level 2 EVSE Units

It is generally accepted practice that a ¼ mile is a reasonable walking distance between a parked PEV charging and the POI. A ¼ mile buffer circle from the center point of the MGRA then provided the target location for a publicly accessible AC Level 2 EVSE unit. After identifying the target Tier 1 and 2 MGRAs, this ¼ mile buffer was identified.

Given the large size of the San Diego region, maps showing this modeling were prepared both at the full region scale and for seven sub-regions, to allow for greater visual detail. Figure 4 shows one of the seven sub-regions. Similar results were developed for the DCFC planning efforts. All sub-region maps were printed and available in the *EV Micro-Climate Plan for San Diego Region, California* document.

The size of the MGRAs are based upon census tracts, so MGRAs within highly populated areas were smaller, which showed overlapping ¼ mile buffers as compared to larger census tracts in less densely populated areas, which showed isolated ¼ mile buffer areas around the point of interest.

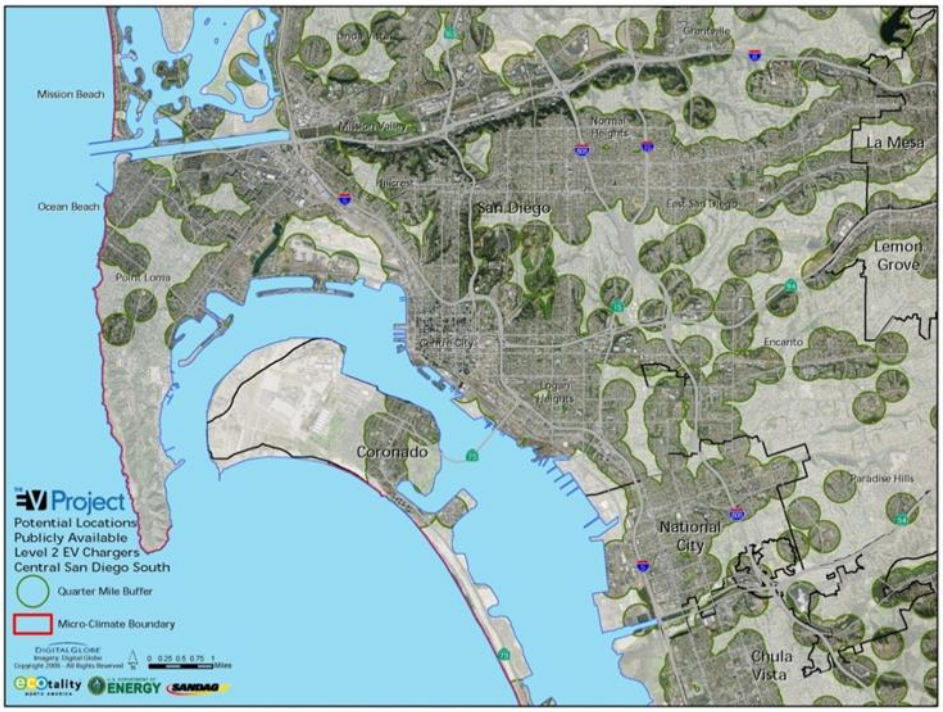

Figure 4. Aerial Imagery Level 2 EV Chargers Central San Diego South Region

4 EV MICRO-CLIMATE® Plan Implementation

Deployment of the non-residential AC Level 2 EVSE units commenced in April 2011, following the initial adoption of PEVs by San Diego residents and the deployment of their residential EVSE units. The deployment process involved the solicitation of charging site hosts who would accept the EVSE unit at their location and take on the obligations to provide this charging service to EV drivers in the San Diego area. The EV Project provided the AC Level 2 EVSE unit at no cost, plus provided installation credit with the agreement that the host would allow The EV Project to collect and analyze data from the equipment for the duration of the Project. Several factors were considered by the host in the decision to accept the EVSE unit offered. These are discussed in another Lessons Learned document, but include installation costs in excess of that credit, impact on the existing parking, ADA compliance requirements, city permitting requirements, wait times and delays in the process, and the host company's internal legal, marketing and strategic planning considerations.

The Micro-Climate Plan was used as the starting point for the deployment of the non-residential EVSE units provided by The EV Project. The target areas developed by the Micro-Climate Plan were investigated and host solicitation commenced. As the deployment progressed, at least two primary phases of lead generation searching for hosts were developed. Phase 1 focused solely within the mapped optimum areas, and Phase 2 expanded outside to increase pace of adoption/installation. The factors considered by the hosts identified above led to slower than desired adoption within the targeted areas. The EV Project also imposed a time schedule for this deployment in order to complete the installation and collect meaningful data prior to the end of the EV Project window.

The EV Project is an infrastructure study. Early on it was determined that non-residential EVSE deployment would concentrate on publicly accessible EVSE units. During the deployment phase, The EV Project was approached by many companies and municipalities who requested EVSE units be placed within their jurisdictions for publicly accessible as well as workplace and fleet vehicle applications. Because several questions related to EV driver behavior surrounding workplace charging and similar questions related to fleet applications exist, The EV Project elected to expand the approach to include a number of workplace and fleet applications for the study. In addition, several EVSE units were installed to provide range extension from regions further from the major metropolitan areas. These EVSE units were not targeted to match the buffer areas of the Micro-Climate Plan.

5 EVSE Deployed Versus Planned Locations

There are 3,333 quarter-mile circle areas developed as buffers around the center point of the Tier 1 and Tier 2 MGRAs which contain POIs. These areas attract EV drivers, and thus are a good choice for the placement of non-residential EVSE units. It is noted that the *Long Range Plan for San Diego* projected that a cumulative total of 80,151 EVs would be sold in the region by 2020 and that approximately 55,000 non-residential EVSE units would be required to support the EV charging away from home. If 2 to 3 EVSE units were placed at every site, approximately 19,000 sites would be required by 2020. These 3,333 initial target locations then provided the initial step toward the final EVSE deployment.

At this time, The EV Project has deployed approximately 435 non-residential AC Level 2 EVSE units in the San Diego region. This includes 321 publicly accessible at 121 sites, and 114 workplace / fleet EVSE units at 39 sites. The final number of EVSE units deployed in the San Diego region is driven by market demographics, as The EV Project was promoting the public EVSE availability across several regional markets in the U.S. to reach the target total of 5,000 non-residential EVSE units.

The deployed EVSE units will then be evaluated to determine:

a) How did the publicly accessible EVSE unit deployed match the planned deployment, and
b) What influenced the placement of the EVSE unit deployed outside the plan's target areas?

5.1 Publicly Accessible EVSE Deployment versus Micro-Climate Plan

The question to be evaluated was: For the quantity of non-residential EVSE deployed, how many are within the ¼ mile buffer of a target MGRA? Again, this ¼ mile distance is established as a reasonable walking distance between a parked PEV charging and POI. It really wouldn't make sense to evaluate how far the EVSE unit was from the nearest POI, since anything more than ¼ mile failed to meet the criteria. EVSE units greater than ¼ mile from a POI were unlikely to encourage EV drivers to walk between the EVSE unit and the POI, except in emergency situations. Such a unit may provide other valuable functions, such as range extension, but failed to support convenient access to the POI.

As seen above, the small census tracts provided overlapping MGRAs, so a single EVSE unit may provide access to several POIs. EVSE units within the buffers of a high number of MGRAs effectively served all these MGRAs.

For example, suppose four adjacent Tier 1 or 2 MGRAs existed, as shown in the Figure 5. Quarter-mile buffers around the center of the MGRAs are shown as overlapping circles. Identified as a red dot, an installed EVSE unit is within the ¼ mile radius of several MGRAs.

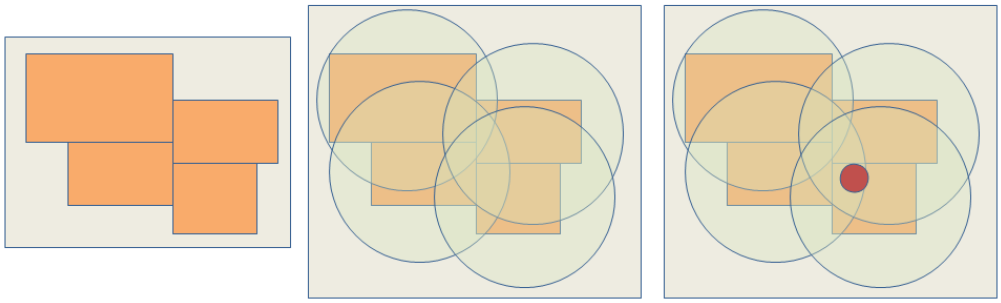

Figure 5. Several POIs Served by a Single EVSE Unit

5.1.1 Workplace and Fleet EVSE Units

The 114 workplace and fleet (restricted use) EVSE units at 39 sites were installed as a small subset of EVSE units outside the Micro-Climate plan for publicly accessible EVSE units for San Diego. As noted earlier, ESAC outlined special focus areas for EVSE unit placement, and suggested that a portion of the AC Level 2 EVSE units be made available in order to gain additional information of value to The EV Project. In most cases, these EVSE units were not available to the general public, but reserved for use by employees. While location near a targeted MGRA was not the primary factor for the selected sites, it was of interest to see whether these units actually fell within the buffers of MGRAs. Workplace hosts may allow the public to use the EVSE unit during off hours and restricted its use to employees during normal business hours. Table 2 provides the results of this evaluation, including the number of MGRAs served by these EVSE units. For example, there were three EVSE units each of which fell within the ¼ mile buffer zone of more than 125 MGRAs.

Table 2. Number of Restricted use EVSE Units in Targeted MGRAs

Number of MGRAs	Number of EVSE Units	Percent of Total EVSE Units
>125	3	3%
101 - 125	38	33%
76 - 100	0	0%
51 - 75	0	0%
26 - 50	4	4%
21 - 25	0	0
16 - 20	4	4%
11 - 15	17	15%
6 - 10	24	21%
1 - 5	22	19%
0	2	2%
Total	**114**	

Figure 6 shows the location of the restricted use EVSE units. Only two of these restricted use EVSE units fall outside a targeted MGRA. This may not be surprising, since employment centers were a consideration in the land use criteria.

5.1.2 Deployed Publicly Accessible EVSE Units in MGRA Buffers

As there were 3,333 targeted MGRA locations and a much smaller number of EVSE units available, the number of these MGRAs served by a deployed EVSE unit was of interest.

EVSE units that did not fall within the ¼ mile buffer of a MGRA were identified and considered not installed per the Micro-Climate plan.

Table 3. Number of Publicly Accessible EVSE Units in Targeted MGRAs

Number of MGRAs	Number of EVSE Units	Percent of Total EVSE Units
101 - 125	8	2%
76 - 100	5	2%
51 - 75	5	2%
26 - 50	30	9%
21 - 25	12	4%
16 - 20	3	1%
11 - 15	41	13%
6 - 10	88	27%
1 - 5	119	37%
0	10	3%
Total	**321**	

In summary, eight deployed EVSE units were in an area where each was within ¼ mile of more than 100 targeted MGRAs. Only 10 publicly available EVSE units were outside targeted MGRA zones.

Of the 3,333 targeted MGRAs, 1,138 (34%) were served by a deployed publicly accessible EVSE unit.

Figure 6 shows the location of the deployed non-residential publicly accessible EVSE units, as they related to the Tier 1 and Tier 2 MGRAs.

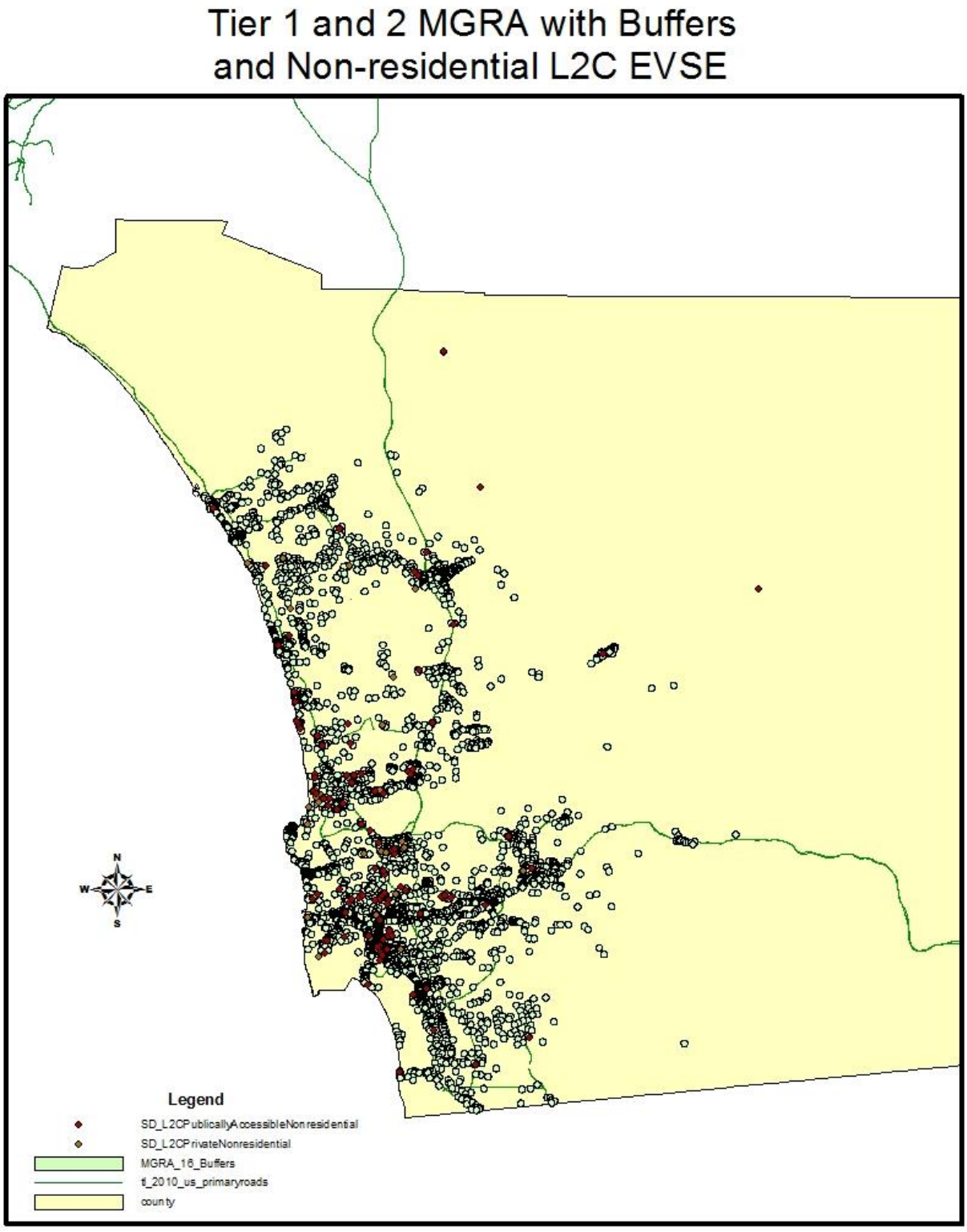

Figure 6. Tier 1 and Tier 2 MGRA Buffers with Deployed Non-residential EVSE Units

5.2 EVSE Units Serving One or More MGRAs

As shown in Figure 6, 97% of the deployed publicly accessible EVSE units provided services to targeted MGRAs. Notwithstanding the functionality or desired purpose for the 10 deployed outside the targeted areas, this constituted a very successful deployment of EVSE units with respect to the plan.

The fact that 34% of the targeted MGRAs were served by these EVSE units was also significant. If the non-residential, non-restricted EVSE units were installed in single MGRA buffers, the available 321 EVSE units would have satisfied just 9.6% of the targeted areas. The placement amplified the suitability and functionality of these EVSE units and satisfied an average of 3.5 MGRAs each.

5.3 EVSE Units Deployed Outside the Micro-Climate Plan

Some of the publicly accessible EVSE units deployed outside the Micro-Climate plan are shown in Figure 7.

Most of the EVSE units that are outside targeted MGRAs are close to a buffered MGRA. However, three are clearly identified as significantly away from the nearest MGRA. Their purpose was to provide trip continuation and extension to more remote parts of the County.

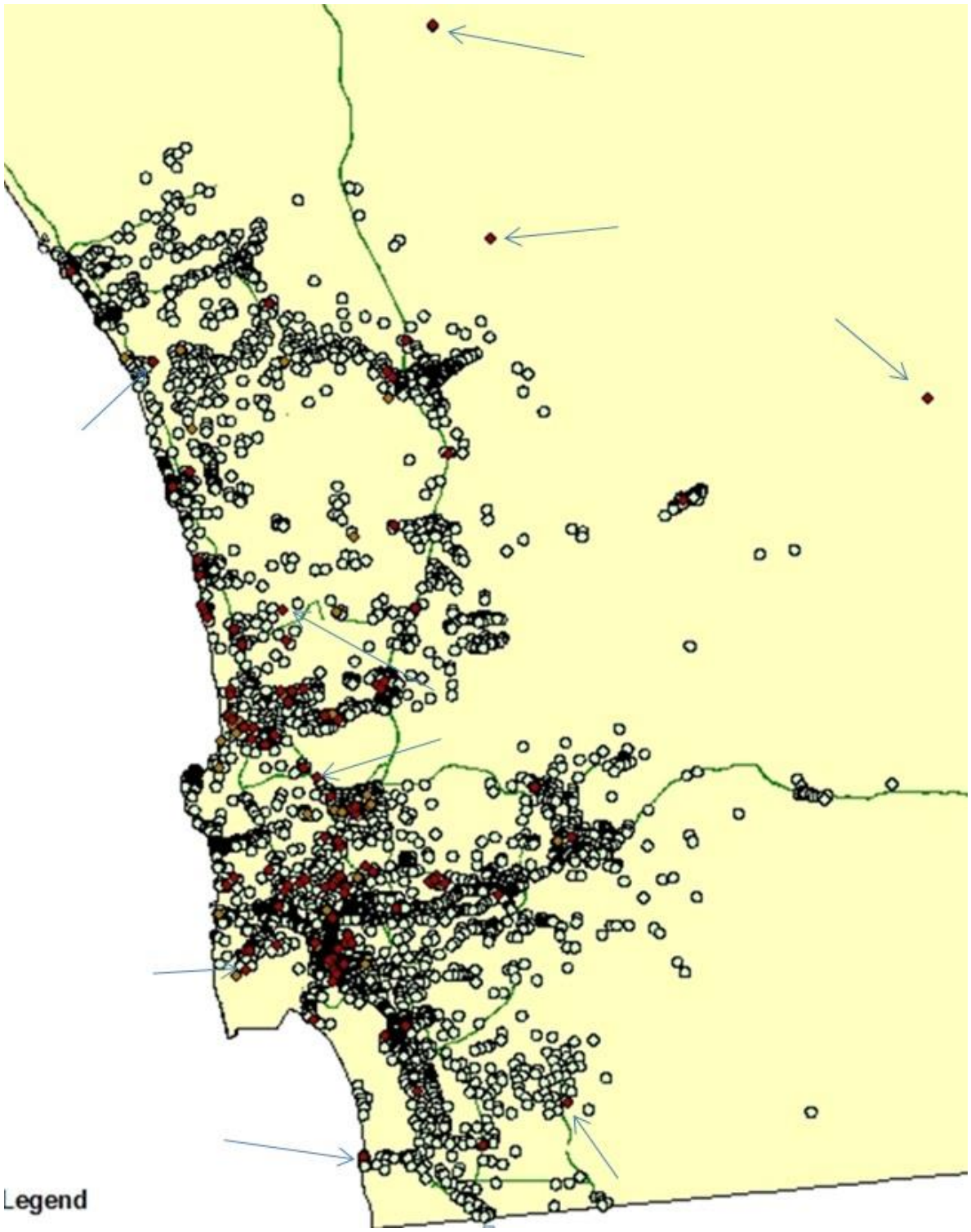

Figure 7. Publicly Accessible EVSE Units outside Target MGRAs

6 Recommendation/ Conclusion

6.1 Overall Conclusion

Section **Error! Reference source not found.** identified the planning methodology used in San Diego to develop target areas for the deployment of publicly accessible EVSE units. Section 4 identified other factors involved in the final deployment of the available EVSE units. Section 5 provided the evaluation of how the EVSE units deployed met the plan objectives and which did not, for various reasons.

In summary, 97% of the deployed EVSE units are in locations that are in the target MGRA buffer zones. In addition, the 321 publicly accessible AC Level 2 EVSE units serve 1,138 (34%) of the 3,333 targeted MGRAs. Greater effectiveness is demonstrated in the installations because of the multiple MGRAs served by a single EVSE unit.

The EV Project is an infrastructure study. The placement of every EVSE unit, whether workplace, fleet, or publicly accessible, provides information for analysis as part of this study. In that sense, there are no poor locations. In addition, Section 4 identified that there are additional considerations for deployment that may not have to do with EVSE unit utilization or the frequency of connect events.

6.2 Documentation

The EV Project Micro-Climate plans are documents approved by ECOtality and locally by the Stakeholder Advisory Committees (SAC) and made public documents. The documents for Arizona, Oregon, Tennessee, Central Puget Sound & Olympia Areas of Washington State, and San Diego, California are posted on The EV Project website.

6.3 Time and Schedule Impact

The overall planning process was found to be an eight to nine month process. This does not add time or cost to The EV Project, because it was conducted in parallel with the data-capable charge equipment development for the Project and ahead of actual PEV availability. The final EV MICRO-CLIMATE® planning phase was completed coincident with the availability of residential Blink EVSE units and the delivery of the first Nissan LEAF vehicles. This also preceded the delivery and installation of the first publicly available EVSE unit by approximately six months.

6.4 Future Work

The evaluation of the EV Micro-Climate Planning Process involves three steps: 1) Evaluation of the planning process, 2) Evaluation of the deployment per the plan, and 3) Evaluation of the EVSE unit utilization installed within or outside the plan. This evaluation shows a very successful deployment, according to the plan. Other regions of The EV Project will be similarly evaluated. The final step to evaluate utilization is the subject of another Lesson Learned document.