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Clean Transportation Program

FINAL PROJECT REPORT

North Coast Plug-in Electric Vehicle Charging Network

Prepared for: California Energy Commission

REDWOOD COAST EnergyAuthority

Schatz Energy Research Center SERC

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Project Partners:

- California Department of Transportation, District 1
- Colburn Electric
- GHD
- McKeever Energy & Electric
- OurEvolution Energy & Engineering
- Pacific Gas and Electric
- Pierson's Building Company
- The Local Government Commission
- Trinidad Coastal Land Trust

Site Hosts:

- Arcata Technology Center Partners
- Brown Rental
- City of Ferndale
- City of Fortuna
- City of Rio Dell
- City of Trinidad
- L and A Enterprises
- North Coast Unified Air Quality Management District
- St. Joseph Hospital
- Willow Creek Community Services District

PREFACE

Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007) created the Clean Transportation Program. The statute authorizes the California Energy Commission (CEC) to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state's climate change policies. Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) reauthorizes the Clean Transportation Program through January 1, 2024, and specifies that the CEC allocate up to $20 million per year (or up to 20 percent of each fiscal year's funds) in funding for hydrogen station development until at least 100 stations are operational.

The Clean Transportation Program has an annual budget of about $100 million and provides financial support for projects that:

- Reduce California's use and dependence on petroleum transportation fuels and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Produce sustainable alternative and renewable low-carbon fuels in California.
- Expand alternative fueling infrastructure and fueling stations.
- Improve the efficiency, performance and market viability of alternative light-, medium-, and heavy-duty vehicle technologies.
- Retrofit medium- and heavy-duty on-road and nonroad vehicle fleets to alternative technologies or fuel use.
- Expand the alternative fueling infrastructure available to existing fleets, public transit, and transportation corridors.
- Establish workforce-training programs and conduct public outreach on the benefits of alternative transportation fuels and vehicle technologies.

To be eligible for funding under the Clean Transportation Program, a project must be consistent with the CEC's annual Clean Transportation Program Investment Plan Update. The CEC issued PON-13-606 to fund electric vehicle charging infrastructure in several categories that will support growth of electric vehicles as a conventional method of transportation and adoption of plug-in electric vehicles over a wide range of California's population and socio-economic classes. In response to PON-13-606, the recipient submitted an application which was proposed for funding in the CEC's notice of proposed awards on April 4, 2014 and the agreement was executed as ARV-13-029 on June 1, 2014.

ABSTRACT

The purpose of the North Coast Plug-In Electric Vehicle Charging Network project was to facilitate plug-in electric vehicle travel in the region. This project represents the implementation of extensive planning efforts completed as part of the North Coast Plug-in Electric Vehicle Readiness Project. Key tasks included installing ten electric vehicle charging stations at nine locations in Humboldt County, the successful demonstration of a not-for-profit electric vehicle charging stations owner/operator model, the development of a novel hardware and software solution to address parking scarcity at St. Joseph Hospital, and data collection from network operations.

Important lessons were learned in the process of designing, installing, and operating the network. Specific site-host requirements for electric vehicle charging stations installation added cost and complexity. A more thorough exploration of site-host requirements during the site selection process would have changed site rankings. Stations provided by electric vehicle supply equipment with LLC have proven to be unreliable. Choosing electric vehicle charging stations with a simpler design is critical for network sustainability, especially in rural communities.

Even with these challenges, the first phase of the North Coast Plug-In Electric Vehicle Charging Network has been a success. The unique, not-for-profit owner/operator model has been essential in building a network of electric vehicle charging stations in areas most critical for sustainability of the network, not just in areas with the strongest business case. Continued funding for projects with a similar ownership model will be critical to sustained plug-in electric vehicle adoption in rural and hard-to-reach areas.

Keywords: North Coast Plug-In Electric Vehicle Charging Network, electric vehicle charging, Humboldt County, not-for-profit, electric vehicle charging stations, electric vehicle supply equipment

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EXECUTIVE SUMMARY

This project resulted in the installation of ten dual-port Level 2 Electric Vehicle Charging Station, and six single-port Level 1 Electric Vehicle Charging Station, at nine different sites in the North Coast Region. These installations increased regional charging capacity by 20 Level 2 ports and 6 Level 1 ports. This primary objective, as well as additional project objectives, were met by finalizing arrangements between site hosts and the Charging Network Administrator, completing final design, bidding, and construction, and completion of related Plug-in Electric Vehicle charging, parking policies/systems, and network startup activities.

There were several steps in the successful completion of this project. The first was the finalization of agreements between site hosts and Redwood Coast Energy Authority as Charging Network Administrator. Memorandums of Understanding were developed and signed by Redwood Coast Energy Authority and each site host. These Memorandums of Understanding delineated each party's responsibilities, described a revenue-sharing plan, and established Redwood Coast Energy Authority as the owner/operator.

The next step was to conduct final selection of Electric Vehicle Charging Station. The project team analyzed Electric Vehicle Charging Station from multiple manufacturers by developing criteria and a comprehensive decision matrix. Electric Vehicle Supply Equipment, LLC was selected as the Level 2 Electric Vehicle Charging Station manufacturer, and Clipper Creek was selected as the Level 1 Electric Vehicle Charging Station manufacturer.

Multiple steps were required for construction of the project. The first was the completion of the final civil and electrical engineering. Civil Engineering was provided by OurEvolution Energy and Engineering. Electrical Engineering was provided by the Schatz Energy Research Center. Next was to conduct construction project bidding. For the main project, Schatz Energy Research Center prepared a bid package including general conditions, engineering plans, and specifications. The bid opportunity was advertised locally. The final step in construction was to build all sites. McKeever Energy & Electric was selected as the contractor for the main project, which included seven sites. Colburn Electric was selected for the St. Joseph Hospital site, and the Pierson Company was selected for the McKinleyville site.

Next, the project required the establishment of network operations and pricing. The first part was the development of an economic model to assess different pricing schemes. The selected pricing scheme, \$0.48/session and \$0.18/kilowatt hours allows for limited cost recovery and a cheaper cost per mile over gasoline. The next part in network development was to upload all locations to internet sites, navigation systems, and apps. All Electric Vehicle Charging Station sites were uploaded to Electric Vehicle Charging Station mapping sites and apps. The most commonly used mapping sites, Plugshare and the Alternative Fuels Data Center, are updated regularly. Thirdly, we developed a Plug-in Electric Vehicle parking management policy and system. In collaboration with facilities personnel, Schatz Energy Research Center developed a novel hardware and software solution to address parking scarcity at St. Joseph Hospital. Funding will be pursued to install the system. The final step was to collect and analyze data on network usage. Schatz Energy Research Center analyzed charging data recorded by Greenlots, the network service provider for the Level 2 stations. Useful statistics were generated, including average charge duration, projected future demand, and the distribution of demand across the network.

CHAPTER 1: Introduction

1.1 Problem Statement

Plug-In Electric vehicles (PEVs) are arriving on California's North Coast in significant numbers. As of March 2017, there are over 670 PEVs in Humboldt County.[1] To support existing PEV drivers and encourage continued adoption of PEVs locally, funding was needed to construct a local network of publicly accessible Electric Vehicle Charging Stations (EVCS) to address a critical barrier to market demand for EVCS services. This barrier is a "cart before the horse" issue where the market-driven supply of EVCS requires market demand of EVCS services, while a publicly accessible supply of EVCS is critical to facilitate PEV adoption and initiate market demand. This project addresses this market barrier by kickstarting the supply of publicly accessible EVCS.

By installing publicly accessible EVCS in the region, this project addresses three additional critical barriers. The first is a socioeconomic barrier created by the geographically isolated, economically disadvantaged nature of the North Coast. The second barrier is a lack of institutional experience with permitting the installation of EVCS, and with regulating and enforcing the unique parking requirements of PEV drivers. The third critical barrier is a lack of experience in administering and maintaining a network of EVCS. This project will directly impact the lack of institutional and administrative experience and will make a significant step towards tackling the socioeconomic barrier.

1.2 Goals and Objectives

The primary goal of this project was to implement 10 Level 2 Electric Vehicle Supply Equipment (EVSE) installations at 9 different sites in the North Coast Region as Phase 1 of building out the North Coast Plug-In Electric Vehicle Charging Network.

Additional objectives of this project were to:

- Increase PEV travel in the North Coast region and thereby reduce greenhouse gas (GHG) emissions from vehicle miles travelled;
- Establish the first phase of a well-planned, locally-controlled, affordable, and economically sustainable network of EVSE installations in the North Coast Region;
- Demonstrate a non-profit EVCS network administrator business model that includes:
    - Cost recovery for site hosts providing electricity for EVCS,
    - Maintenance of a network administration and operations fund to ensure network reliability, and
    - A reasonable pricing structure aimed at offering lower local "fuel" costs for PEVs as compared to non-PEVs on a dollar per mile basis;

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1 RCEA analysis of Pacific Gas and Electric residential EV rates. There were 674 homes on an EV rate as of 3/31/2017.

- Develop a hardware and software application concept designed to address the issue of fairness for PEV charging and non-PEV parking in an environment of parking scarcity at St. Joseph Hospital;
- Collect operational data from the project and analyze that data for economic and environmental impacts.

1.3 Project Metrics

Table 1 shows several measurable metrics that would determine project success.

Table 1: Objectives and Outcomes

Objective	Measurable Outcome
Increase PEV travel in the North Coast region and thereby reduce greenhouse gas emissions.	Cumulative increase in EVCS utilization, measured in session count and duration. Cumulative increase in GHG savings.
Establish the first phase of a well-planned, locally-controlled, affordable, and economically sustainable network of EVSE installations in the North Coast Region.	Fully functioning Electric Vehicle (EV) network deployed at all key locations. Overall positive customer feedback on EV mapping sites.
Demonstrate a non-profit EVSE network administrator business model.	Non-profit network business model fully implemented. Business model projected to function beyond grant funding period.
Develop a hardware and software application concept designed to address the issue of fairness for PEV charging and non-PEV parking in an environment of parking scarcity at St. Joseph Hospital.	Dynamic parking management system concept developed and presented to facilities personnel. Drawings and cost estimates developed will be used to pursue funding for installation.
Collect operational data from the project and analyze that data for economic and environmental impacts.	Data for 2016 and Q1 of 2017 collected and analyzed, useful conclusions drawn.

Source: Redwood Coast Energy Authority

1.4 Project Team

The project team is a public-private partnership whose core members have solid track records of success on a range of relevant work.

The Redwood Coast Energy Authority (RCEA) was formed in 2003 to develop and implement sustainable energy initiatives that reduce energy demand, increase energy efficiency, and advance the use of clean, efficient, and renewable resources available in the region. RCEA is a public Joint Powers Authority, representing all incorporated cities in Humboldt County, the County of Humboldt, and the Humboldt Bay Municipal Water District. As a Joint Powers

Authority, RCEA is governed by a board composed of representatives from each of the jurisdictions and is authorized to plan and implement a sustainable energy vision for Humboldt County. In the last few years RCEA has led efforts in the region to develop a renewable energy strategic plan, a plug-in electric vehicle readiness plan, and climate action plans and general plan energy elements for Cities and the County.

The Schatz Energy Research Center at Humboldt State University was founded in 1989 with a mission to promote the use of clean and renewable energy resources. Over the years Schatz Energy Research Agency has been involved in extensive research, planning, design, and analysis activities for the development and implementation of sustainable energy systems. Schatz Energy Research Agency's work has included energy and sustainable transportation planning for the local region; design, permitting, installation, and operation of hydrogen fueling EVCS; emergency first responder trainings for hydrogen vehicles and fueling EVCS; and outreach and education efforts targeted to both key decision makers and the general public in support of the development and installation of hydrogen fueling infrastructure.

GHD is an engineering consulting firm established in 1928 with over 5,500 people working in five continents and with specific expertise in water, wastewater, energy, environment, and transportation. The local office has provided engineering services for 60 years. Their expertise includes civil, electrical, mechanical and structural engineering, as well as environmental, surveying, construction, and sustainable building design services. GHD's Eureka office has staff with expertise in the deployment of PEVs and EVSE. GHD has partnered with both Schatz Energy Research Agency and RCEA on the regional readiness plans for PEVs for both the North Coast and Upstate regions.

Our Evolution Energy & Engineering is an engineering consulting firm based in Arcata California. Our Evolution Energy & Engineering specializes in clean energy engineering and electrical vehicle infrastructure and also provides civil and electrical engineering as well as bidding and project management services

RCEA served as the project lead, and provided oversight, administration, and network ownership and operation. RCEA sub-contracted with Schatz Energy Research Agency as the technical lead for the project, including parking management system design and data and policy analysis. Schatz Energy Research Agency also acted as the Owner's Engineer for RCEA leading the design, preparing the construction documents, bidding the project, and providing construction management services. Our Evolution Energy & Engineering completed the civil engineering for the project and assisted with construction management. RCEA sub-contracted with GHD to provide electrical engineering review for the project.

1.5 Background

PEV adoption in Humboldt County has increased by 111 percent since 2015.[2] Supporting this rapid growth requires the development of a robust network of publicly accessible EVCS. However, the rural nature of the North Coast poses barriers to EVCS infrastructure development. Due to a weak business case for EVCS in rural areas, there has been little private investment. The majority of existing public and workplace charging locations in the

2 RCEA analysis of increase in Pacific Gas and Electric residential EV rates. There were 319 homes on an EV rate on 12/31/2015, and 674 homes on an EV rate on 3/31/2017.

region are owned by local governments or small businesses, and these entities have limited funding and capacity to help locally implement the need for statewide charging infrastructure.

An analysis conducted by Schatz Energy Research Agency, as part of the North Coast EV Readiness Plan, identified 41 charging locations as the minimum number of EVCS needed to accommodate the expected penetration of 3000 PEVs in Humboldt County by 2025.[3] To address this gap in critical infrastructure, RCEA responded to PON-13-606 issued by the California Energy Commission. RCEA was awarded funding through ARV-13-029 to construct the first phase of a locally-controlled, not-for-profit EVCS network in Humboldt County. This not-for-profit model provided an innovative solution to a weak business case in rural areas and consequent lack of private investment.

3 Zoellick, Jim, David Carter, Colin Sheppard, Jerome Carman. 2014. North Coast Plug-in Electric Vehicle Readiness Project. California Energy Commission. Publication Number: CEC-ARV-11-006.

CHAPTER 2:
Project Activities and Results

2.1 Charging Network Planning and Design

2.1.1 Site Selection

The North Coast Plug-In Electric Vehicle Readiness Planning Project developed guidelines for the implementation of infrastructure to support charging throughout Humboldt, Del Norte, and Trinity Counties. Within the plan, sites for EVCS were identified in a systematic two-step process.

The first step was a macro-siting analysis conducted by Schatz Energy Research Agency. Schatz Energy Research Agency developed the PEV Infrastructure model to identify the best locations for the required charging infrastructure in Humboldt County. Transportation demand, travel analysis, census data, PEV adoption estimates, and relative cost of charging technologies were all used as inputs. To support a PEV penetration of 2 percent, the model identified 37 travel-zone sub-areas in which to locate EVCS.[4] The nine sites selected for this project are located in top-priority travel zones identified by the model.

The second step involved translating the results of the macro-siting analysis into actual locations within those larger geographic areas. The second step has been referred to as the micro-siting analysis. Site assessments were conducted for a variety of alternative host locations and those sites were ranked according to a decision matrix. The following design criteria, with weighted values based on level of importance, were included in the decision-matrix:

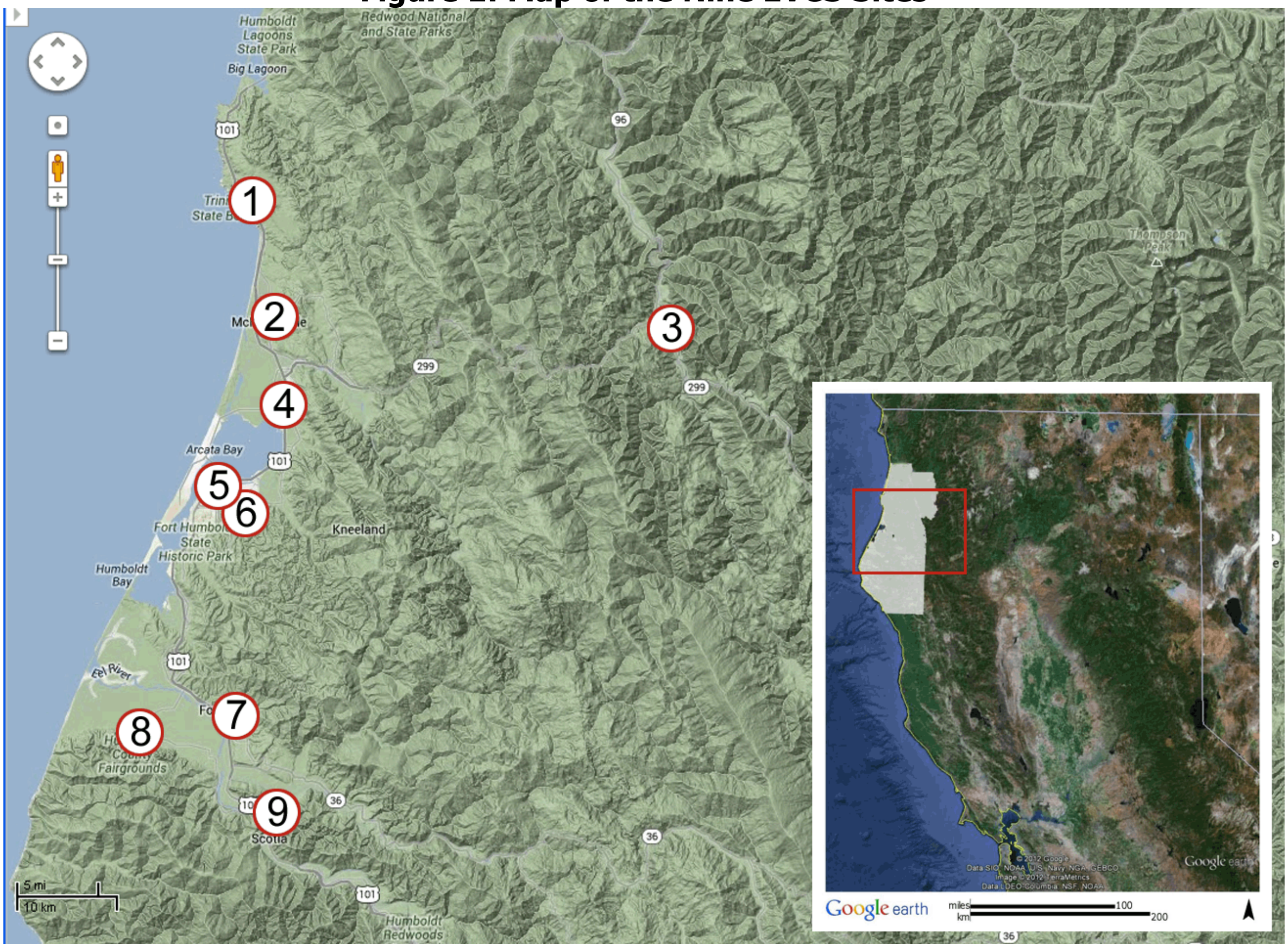
- Willing owner/operator or host (pass/fail screening criteria)
- Americans with Disabilities Act accessibility potential (pass/fail screen criteria)
- Potential for minimizing delays experienced by drivers as determined by modeling analysis
- Close proximity to suitable electrical point of connection
- Minimal trenching required through paved areas
- High visibility
- Within 1/2 mile of at least 10 Basic Services as per Leadership in Energy and Environmental Design 2009
- Within 1/2 mile of connection points to other modes of transportation
- Suitable for block of multiple chargers
- Low risk of public backlash from converting significant numbers of high-demand conventional parking spaces
- Site is well lit without the addition of dedicated lighting installed with EVCS
- Potential for long duration charge (1 hour or more)

[4] Zoellick, Jim, David Carter, Colin Sheppard, Jerome Carman. 2014. North Coast Plug-in Electric Vehicle Readiness Project. California Energy Commission, Grant ARV-11-006.

- Site appears to support workplace and/or fleet charging in addition to public commerce charging
- Site appears to be suitable for use by residents of a multi-family housing development

Over 100 candidate sites across the region were identified for consideration, and 70 of those were assessed using the decision matrix rubric and site owner consultations were initiated at 44 sites. This process led to a final list of top-priority sites, and nine of these were selected for inclusion in this project as Phase 1 regional network sites, shown in Figure 1 and listed in Table 2.

Figure 1: Map of the Nine EVCS Sites



Source: Redwood Coast Energy Authority

Table 2: Final EVCS Sites

Site # on Map	Site	Site Address	Number of Level 2 Ports
1	Trinidad Museum/Library Complex Parking Lot	400 Janis Court, Trinidad, CA 95570	2
2	McKinleyville Shopping Center Parking Lot	1505 Central Avenue, McKinleyville, CA 95501	2
3	Bigfoot Museum Parking Lot	28949 CA Highway 299, Willow Creek, CA 95573	2
4	Arcata Technology Center Parking Lot	1835 8th Street, Arcata, CA 95521	2
5	NCUAQMD Headquarters Parking Lot	707 L Street, Eureka, CA 95501	2
6	St. Joseph Hospital Parking Lot	2700 Dolbeer Street, Eureka, CA 95501	4
7	Fortuna Public Parking Lot	621 11th Street, Fortuna, CA 95540	2
8	Ferndale City Parking Lot	4th Street at Main Street, Ferndale, CA 95536	2
9	Rio Dell Public Parking Lot	675 Wildwood Drive, Rio Dell, CA 95562	2

Source: Redwood Coast Energy Authority

2.1.2 Site Host Agreements

RCEA developed Memorandums of Understanding for each of the nine sites hosts. These Memorandums of Understanding were created to ensure site host participation and to delineate responsibilities between sites hosts and RCEA. The Memorandums of Understanding designates RCEA as the owner/operator, responsible for installation, maintenance, pricing, and collection of revenues. The site host's responsibilities include the dedication of parking spaces and provision of electricity. Each Memorandum of Understanding was signed by both the site host and RCEA and was provided to the CEC.

Included in the Memorandum of Understanding is a revenue sharing plan that described how any revenues would be spent. The following list of revenue goals is included in the revenue sharing plan:

- Generate sufficient funds to pay for routine operating and maintenance costs of the
- electric vehicle infrastructure;
- Maintain an electricity price at or below conventional gasoline costs for an equivalent
- distance traveled;
- Build a contingency fund for unplanned costs such as from power disruption, accidents, vandalism, and other unforeseen situations.

- Generate shared revenue, assuming other pricing goals are met. Site hosts will be informed in advance of any price changes.

In addition to these goals, the revenue sharing plan outlines the order of priority for revenue spending. It clarifies that recovering costs from operation of the Network is the top priority and that any financial shortfalls are RCEA's responsibility. Any revenue above costs is to be shared equally among site hosts in the Network.

2.1.3 EVCS Selection

Selecting the most suitable EVCS was an important decision for the project. The team developed a plan for the EVCS selection process. The plan consisted of the following components for selecting a Level 2 EVCS:

- Development of weighting criteria
- EVCS research
- Rubric to score each EVCS
- Economic model
- Discussion over highest scored EVCS

While developing civil and electrical designs for each site, a need was identified for Level 1 courtesy chargers to satisfy Americans with Disabilities Act requirements. The courtesy charger selection process included EVCS research and a discussion focusing on quality and cost.

2.1.3.1 EVSE Selection Matrix

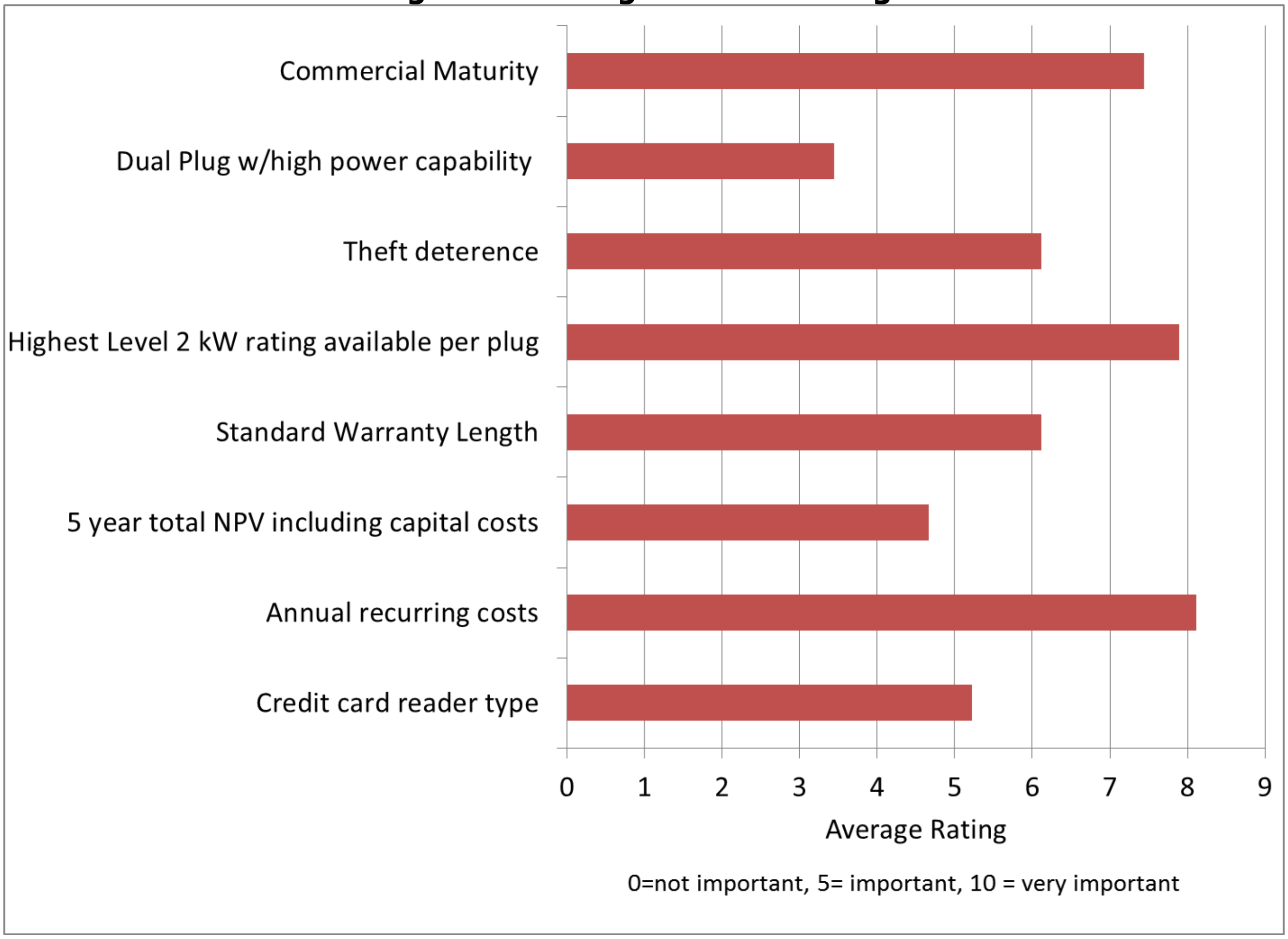
The EVSE selection matrix compared each researched Level 2 EVCS based on weighted criteria and requirements.

The EVCS requirements were:

- Includes energy and use data measurement
- Does not require subscription fee or membership
- Uses open standard network protocol
- Has credit card payment capability
- UL listed
- Provides dedicated 30 Amperage output minimum per plug.

The weighted criteria were scored by nine members of the project team. The average weighting for each criterion is shown in Figure 2. The criterion "annual recurring costs" was shown to be most important to the team while dual port with high power capability was shown to be of the least importance. A total of eight weighted criteria were included in the EVCS assessment.

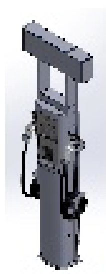
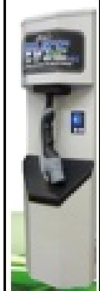
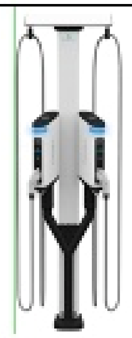
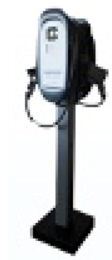
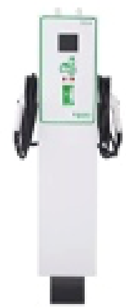
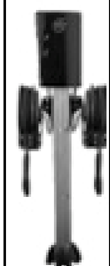
Figure 2: Average Criteria Ratings



Source: Redwood Coast Energy Authority

Upon researching nine leading EVCS manufacturers, the EVCS highlights and drawbacks were recorded, as well as scores for the eight weighted criteria. During the research process, quotes specific to the project were obtained. A summary of the final scores is shown in Figure 3.

Figure 3: EVSE Selection Matrix Results

EVSE Models	BTC Power Chargion EVP	EVSE, LCC	Charge Point CT 4021-GW1	Eaton Dual	Sema Connect ChargePro	Clipper Creek HCS w/ LAT Hydra-R	Schneider Evlink	Evo Charge	OpConnect Mark II
Total Score	3.6	5.5	4.2	4.2	4.6	4.9	4.0	4.0	3.7
Images									

Source: Schatz Energy Research Center

After completing the selection matrix, additional research was conducted on the highest scored EVCS to compare the following characteristics:

- Remote management capability and data access,
- allows variable pricing/demand response capability,
- reference checks,
- cable management,
- aesthetics, and
- bundled network capabilities.

Comparison of the EVCS based on the additional research was assessed. A summary memo explaining the final selection is included as Appendix A.

2.1.3.2 Courtesy Charger Selection Matrix

As mentioned previously, during the design process the realization was made that most sites would require a Level 1 courtesy charger to be located at an existing Americans with Disabilities Act stall. While Americans with Disabilities Act regulations for EVCS had yet to be finalized in building code, best practice and feedback from the County Building Inspector led the project team to incorporate the use of Level 1 EVCS at some existing Americans with Disabilities Act parking spaces.

Similar to the Level 2 EVCS selection process, a matrix was developed for the Level 1 EVCS selection process. After all of the research was collected, it was evident which EVCS was appropriate for the application. Only one EVCS met the Level 1 courtesy charger requirements at a reasonable price.

The Level 1 courtesy charger requirements were:

- 120 Volts Alternating Current

- Hardwires
- J1772 connection.

2.1.4 Economic Model

To most accurately assess the differences between Level 2 EVCS options, an economic model was developed. This model was designed to assess both the operation and maintenance costs associated with the top four Level 2 EVCS, along with universal costs that would apply regardless of the EVCS chosen. The purpose of the model was to compare the $/kilowatt hours (kWh) charged to the customer that was necessary to pay for the ongoing operation and maintenance costs of different EVCS. The following costs were taken into account for each of the four EVCS manufacturers:

- Service charges, including network, gateway, cellular, and internet fees
- In addition to costs unique to each EVCS manufacturer, the model accounted for the following universal costs associated with operating the Network:
  - The price of electricity by the host site
  - RCEA management, including the cost to administer, insure, and maintain the Network

Table 3 provides these estimated costs per month and the resulting price per kWh required to recoup these costs.

Table 3: Monthly costs per EVCS, predicted $/kWh needed to recoup those costs, and the comparison of this $/kWh to the price of gasoline

EVCS Model	RCEA Management Costs	Electricity Costs	EVCS Service Charges	Monthly Annualized Marginal Capital Cost	$/kWh required	% of Price of Gasoline
BTC Power	$116	$98	$28	$0	$0.24	66%
EVSE, LLC	$116	$98	$14	$55	$0.28	78%
ChargePoint	$116	$98	$19	$112	$0.37	102%
Eaton	$116	$98	$24	$0	$0.24	66%

Source: Redwood Coast Energy Authority

As shown in Table 3 above, a comparison was made to the price of gasoline for each EVCS. Note that local gasoline prices have dropped since the time the analysis was conducted; therefore the "percent of Price of Gasoline" values in Table 3 are outdated. A more recent analysis by RCEA determined full cost recovery, while keeping the cost per mile lower than gasoline, was not feasible. A more thorough discussion of this conclusion is contained in Section 2.2.3, Pricing for PEV Charging. An Interim Consultant's Report more thoroughly describing the methodology behind the EVCS Economic Model is included as Appendix B.

2.1.4.1 Final Selection

The final selection for the Level 2 EVCS was challenging. Based on the EVCS selection matrix, the EVSE, LLC stations obtained the highest score. However, the EVSE, LLC stations were more expensive than originally assumed in the project proposal.

For the final selection, requirements for the number of EVCS, EVCS power rating, warranty, 3-year network plan, etc., were finalized and used to obtain quotes for the EVSE, LLC stations and ChargePoint stations. The EVSE, LLC stations had an 8 percent higher cost compared to the ChargePoint stations. The total cost for the EVSE, LLC stations was $94,234 while the total cost for the ChargePoint stations was $87,194. The project team determined that the advantageous characteristics of the EVSE, LLC stations (cable management, magnetic strip, Americans with Disabilities Act considerations, etc.) justified the higher cost.

For the Level 1 courtesy charger, only two of the six models identified met all three criteria: the Clipper Creek ACS-20 and the Eaton EVSE Level 1 16 HLBW. These two models appeared similar in quality. The Clipper Creek model had a longer warranty (three years as opposed to one year) and also had a lower cost ($495 as opposed to $824). Due to these reasons, the Clipper Creek ACS-20 was selected as the Level 1 courtesy charger for the project.

2.1.5 Civil and Electrical Engineering

This project involved three discrete construction projects:

- The main project involved constructing EVCS at the following locations: Trinidad Library and Museum, Bigfoot Museum in Willow Creek, Greenway Building in Arcata, North Coast Unified Air Quality Management District in Eureka, Fortuna City Hall, a public parking lot in Rio Dell, and a public parking lot in Ferndale.
- A separate project was executed to install an EVCS at the McKinleyville Shopping Center in McKinleyville.
- Another separate project was executed to install two EVCS at St. Joseph Hospital in Eureka.

Each of these projects was completed by a different contractor for reasons described in Section 2.1.6.

Civil Engineering for the main project was provided by Andy Sorter of OurEvolution Energy and Engineering. Electrical Engineering was provided by David Carter of Schatz Energy Research Agency, and Eric Penn of GHD Inc. David Carter acted as Owner's Engineer for RCEA and coordinated the development of the design plans and specifications. The plans and specifications were developed in three review stages: 30 percent, 60 percent, and 95 percent. At each review stage the plans were reviewed by stakeholders and comments were provided. The comments were incorporated into the subsequent revision up to the point where the plans were put out to bid. Also at each review stage, Mr. Carter revised the Engineer's Opinion of Probable Costs and checked to see if the project could reasonably be completed within the grant budget.

For the McKinleyville Shopping Center and St. Joseph Hospital projects, Mr. Carter completed the civil and electrical engineering and acted as the Owner's Engineer.

2.1.6 Construction Project Bidding

For the main project, Mr. Carter prepared a draft bid package including general conditions, engineering plans, and specifications for review by RCEA. RCEA provided legal review of the terms and conditions for the construction project. Upon finalization of the bid package, Mr. Carter circulated the bid package among several local contractors and posted it at the Humboldt Builder's Exchange.

During the bid period contractors were able to ask questions and Mr. Carter produced three addenda to clarify the contract requirements. At the end of the bid period, three bids were received. After review, Mr. Carter deemed all three bids to be complete, responsible, and responsive.

Mr. Carter then provided a recommendation to award the construction contract to the lowest responsible, responsive bidder, which was McKeever Energy and Electric.

For the McKinleyville Shopping Center Project, the owner of the shopping complex required that RCEA use their preferred electrical contractor for the work. Mr. Carter prepared a construction contract consisting of General Conditions and construction plans. The Pierson Company provided a price, which was reviewed by Mr. Carter. RCEA and the Pierson Company then executed a contract for the work.

For the St. Joseph Hospital Project, the hospital required that RCEA use their electrical contractor for the work since the hospital site is highly regulated by the Office of Statewide Planning and Development. Colburn Electric has been the only electrical contract to complete electrical work on the St. Joseph Campus for years and given their familiarity with the campus electrical system and the regulatory framework for the campus, RCEA elected to use Colburn Electric for the work at this site. Mr. Carter prepared a construction contract consisting of General Conditions and construction plans. Colburn Electric provided a price for the work, which was reviewed by Mr. Carter. RCEA and Colburn Electric then executed a contract for the work.

2.2 Charging Network Construction & Operations

2.2.1 Construction Contract Administration

Mr. Carter administered the three construction contracts for the work completed under the project. The process for each contract was similar and is described below.

A Notice of Award was issued to each contractor. A conformed set of construction plans was issued to each contractor that showed all of the changes that were incorporated by addenda into their construction contract prior to award. A Notice to Proceed was issued to each contractor. Submittals were reviewed for materials such as wire, conduit, electrical panels, pull boxes, etc. Prior to breaking ground at each site Mr. Carter met with the contractor, RCEA, Pacific Gas and Electric, and the site host to go over the scope of work and schedule. At the end of construction for each site Mr. Carter met with the contractor to confirm that the work was completed according to the contract. When the work was deemed complete by Mr. Carter, a Release of Liability and a Notice of Completion was signed by all parties.

2.2.2 Construction Observation

During the work Kristen Radesky, Jerome Carman, and David Carter from Schatz Energy Research Agency and Andy Sorter from OurEvolution Energy and Engineering performed periodic construction observation. Observation was generally limited to the first and last day of work at each site as well as at significant milestone events or when a contractor specifically requested direction from the Owner’s Engineer. Observers checked for the following types of things:

- Materials used were as per the approved submittals
- Conduit, wire, and circuit breakers were correct
- The depth of cover over conduit was correct

- Signage installed was correct
- The striping of the charging stalls was correct
- The placement of the bollards and wheel stops were correct
- The location and number of expansion stub outs was correct
- The quality of the workmanship was adequate

2.2.3 Pricing for PEV Charging

To determine the optimal pricing structure for the Redwood PEV Charging Network, RCEA matched different pricing structures to the historic usage of previously installed EVCS in the RCEA Network. After subtracting reoccurring costs like monthly network and cellular connection fees, payment processing fees, EVCS maintenance, and warranty costs, RCEA determined revenue neutrality was not feasible. Instead, a limited cost recovery strategy was adopted. The final pricing structure provides limited cost recovery, transparency to customers, and a lower cost per mile versus gasoline.

However, this pricing structure does not reflect the actual cost of electricity at each EVCS. Because site hosts have unique Pacific Gas and Electric tariff rates, a tool had to be developed to ensure each site host sharing a meter with an EVCS is reimbursed correctly. RCEA developed the Site Host Reimbursement Calculator tool to account for unique tariff rates and peak times when providing reimbursement to site hosts.

2.2.3.1 Pricing Methodology

In 2015 RCEA developed a rate analysis using data from existing EVCS deployed and administered by RCEA. This analysis was updated in March 2016 once construction and activation was completed on the nine new EVCS locations covered under Grant ARV-13-029. The goal of this analysis was to use real-world data to better estimate ongoing administrative costs and inform price setting to achieve cost neutrality.

The rate analysis documented charging events during 2015, capturing the number of charging events and the total sum of energy delivered for the total year and selected months, shown in Table 4.

Table 4: 2015 Charging Statistics

Site Address (pre-grant locations)	Sum of Energy (kWh)	# of charge events, Dec 2015	Sum of Energy (kWh)	Total # of charge events, 2015	Total Sum of Energy (kWh), 2015
4 C STREET #1	322.37	18	141.65	154	1646.18
BL CITY HALL		1	8.15	19	122.61
BL RANCHERIA 1	196.99	16	118.78	179	1379.73
BL RANCHERIA 2	76.27	10	102.56	98	632.49
CITY OF ARCATA	443.64	68	472.41	583	4317.96
GHD INC.		16	106.34	172	1052.26
Grand Total	1039.27	129	949.89	1205	9151.23

Source: Redwood Coast Energy Authority

The analysis next set various prospective rates and calculated the estimated annual revenue based on a linear projection of December 2015 activity. Various schemes were considered based on session fees and kWh costs. These annual values were also multiplied by 3x and 10x to compare several potential utilization rates, shown in Table 5.

Table 5: Potential Utilization Rates

Prospective Rate	12-Dec	Annual Revenue	Multiply by 3	Multiply by 10
$0.20/kWh	189.98	1,830.25	5,490.74	18,302.46
$0.75 flat + $0.20/kWh	286.73	2,734.00	8,201.99	27,339.96
$0.50 flat + $0.20/kWh	254.48	2,249.72	6,749.16	22,497.22
$0.25 flat + $0.20/kWh	222.23	2,131.50	6,394.49	21,314.96
$0.22/kWh	208.98	2,013.27	6,039.81	20,132.71
$0.24/kWh	227.97	2,196.30	6,588.89	21,962.96
$0.26/kWh	246.97	2,379.32	7,137.96	23,793.20

Source: Redwood Coast Energy Authority

Based on the rate analysis, it was determined that the Network is unable to deliver cost neutrality when the fee is capped to achieve an equal or better driver "cost per mile" using electricity instead of gasoline. The leading factors contributing to this include:

- Recurring monthly network connection fees: The original proposal included using a site host internet connection for network communications. This consistently proved unattractive or infeasible for all sites. The alternative is dedicated cellular communication, which incurs monthly recurring fees.
- Payment processing fees: the ability to accept credit card payment results in service fees. In the selected Greenlots network, this is structured as a fixed $0.50 charge for every charging session. This fee structure adds a significant, unavoidable cost at the start of each session, similar to an ATM banking service charge.
- Field maintenance costs: These have not yet been factored in since data is still being collected, but during EVCS deployment it was apparent that the increased complexity of payment and cell networking and hardware requires significant field support. This can be partially alleviated with more robust remote diagnostics to minimize costly onsite service calls.
- Extended warranties: typical manufacturing warranties are one year, so additional years can have a meaningful impact on total annual EVCS cost.

Note that these fees are associated with the specific network and payment offerings established with EVSE, LLC and Greenlots for this particular implementation. Other configurations will vary based on their product and service offerings. For example, to cover similar network services, ChargePoint applies a 10 percent surcharge based on the total cost to the customer for each session. Note that ChargePoint uses a network or loyalty card system to manage payment, so are unaffected by credit card processing fees.

The project team determined it was important that the EVCS allowed PEV drivers to pay a cost that was equal to or less than a traditional “cost per mile” using gasoline. The team concluded that PEV charging needed to promote electric driving that is consistently cheaper than using fossil fuels. This requires a subsidy, such as a discount, to contain costs borne by customers. A future price sensitivity analysis would help to validate market response to price increases.

As a result of the rate analysis and recurring connectivity and payment costs, the team elected to replace revenue neutrality with a partial cost recovery model. In this model:

- Electricity and recurring transaction costs are passed through directly to the consumer. Electrical rates are determined as a fixed, non-tier rate using the typical Tier 1 price. No demand charges, peak day, or other time-of-use variables are applied, although this could be revisited as Network services add flexibility to pricing features.
- A discount is applied to promote travel distance cost parity between electric and fossil fueled vehicles. Defining an explicit discount makes at least some of the cost subsidy visible and can be adjusted as fuel costs fluctuate.
- Maintenance costs will be absorbed by the Network administrator as part of the local initiative to promote alternative fuels.

The pricing methodology formula is:

($kWh x discount rate) + ($session fee x discount rate)

Using $0.20/kWh, $0.50 session fee, and a 10 percent discount rate selected for the 2016 Network launch, the formula is:

($0.20/kWh x 0.9) + ($0.50/session x 0.9) = $0.18/kWh + $0.48 session fee

A distinction of this model is to maintain transparency on actual costs and subsidies. A debate is underway evaluating the merits of smart, networked chargers with their increased cost and complexity when compared to basic, non-networked chargers. There is a compelling argument that, at least for Level 2 chargers, it may be cheaper to provide electricity at no cost than to pay recurring fees for cellular and payment services over a full-time networked charger. The project team recommends a follow-up study to determine the break-even point between these two system designs, now that both charging configurations are available in the real world for study.

Since RCEA has a heterogeneous network with both Greenlots and ChargePoint networked systems, RCEA decided to set up identical cost structures on both types of EVCS. This is to provide users with a consistent, predictable experience while using the EVCS. The additional revenue collected at ChargePoint EVCS (which do not incur credit card transaction fees) will help to offset some of the operating deficit.

2.2.3.2 Quarterly Reports

RCEA developed a quarterly reporting template which gives EVCS site hosts a clear picture of how their EVCS is being used. Reports provide site hosts with the reimbursement amount (if applicable), the total number and daily distribution of charge events and kWh consumed, and the average time users were plugged in. These reports are distributed to site hosts quarterly along with applicable reimbursement checks.

To generate useful statistics for site hosts, RCEA developed the Site Host Reimbursement Calculator. Two versions of this Excel-based tool were created to process raw session data from both ChargePoint's and Greenlots' online management systems. Each vendor's system tracks and generates slightly different data, so the Reimbursement Calculator was designed to generate consistent reporting metrics for both EVCS types.

The output provided by ChargePoint and Greenlot's online management systems consists of detailed data on every charging session in a given quarter. The location, date, time, duration, energy consumption, GHG reduction, fee charged, and other descriptors are provided for each session. Along with session data, both systems generate detailed usage charts. Users can view and download charts with energy consumption, number of sessions, charge duration, and revenue, broken down by user-defined time frames. Daily energy consumption and session count charts generated by these systems are provided to site hosts in the quarterly reports.

The detailed session data from the online management system is converted by the Reimbursement Calculator into meaningful statistics that site hosts can use to compare EVCS usage over time. At sites where the EVCS shares a meter with the site host, the Reimbursement Calculator is used to determine accurate reimbursements for electricity consumed. The EVCS installed at the following locations through ARV-13-029 share a meter with the site host:

- Trinidad Library
- North Coast Unified Air Quality Management District Office
- St. Joseph Hospital
- The Arcata Technology Center

The Reimbursement Calculator accounts for each site host's unique Pacific Gas and Electric tariff rate and assigns each session to Peak, Off-Peak, or Part-Peak rates based on the time the charging session was initiated. Seasonal adjustments of Tariff rates and peak times are also accounted for. Accurate quarterly reimbursements are then calculated based on the site host's actual costs for electricity.

At the sites where RCEA owns the meter, RCEA receives energy bills and pays Pacific Gas and Electric directly. Quarterly reports distributed to these site hosts include all of the statistics mentioned above, with the exception of the cost of electricity consumed and the reimbursement amount. RCEA owns the meter at these EVCS sites:

- City of Fortuna Public Parking
- City of Rio Dell Public Parking
- McKinleyville Shopping Center
- The China Flat Museum in Willow Creek

To date, site hosts have received four quarterly reports from RCEA. Distribution of these quarterly reports will continue as long as the Memorandums of Understanding between the site host and RCEA remains in effect. A quarterly report for St. Joseph hospital is included for example as Appendix C.

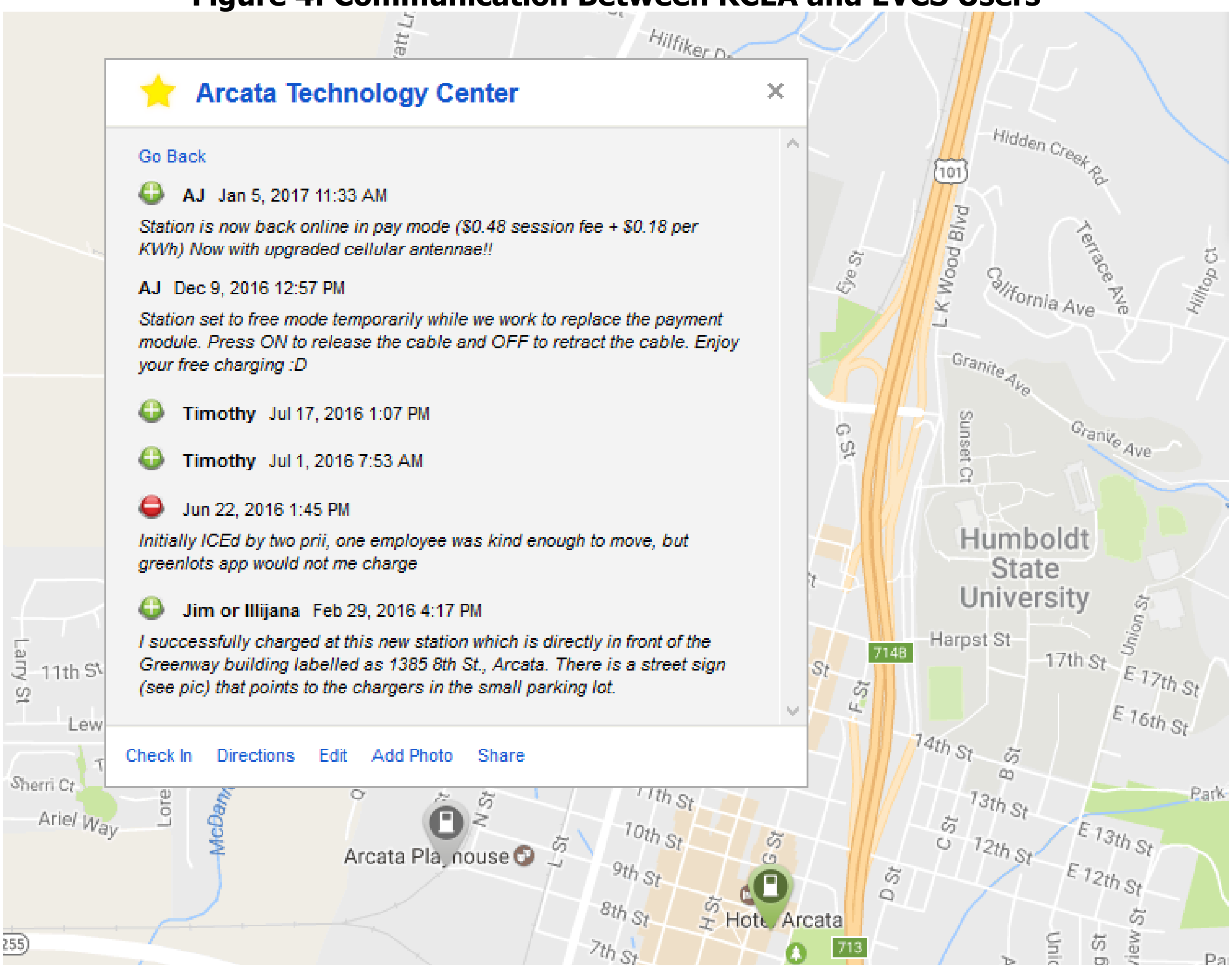
2.2.4 Posting on Internet Sites, Navigation Systems, and Apps

PEV drivers rely on internet mapping sites and apps to locate EVCS. Up-to-date maps allow drivers to plan out routes in advance, ensuring adequate fueling opportunities exist. These maps are also accessed through vehicle navigation systems and on smart devices, allowing drivers to locate EVCS in real-time.

These online maps allow drivers to input their location and determine how many EVCS are within a certain distance of their location, or along a planned route. Many mapping services differentiate EVCS based on levels (i.e. Level 1, Level 2, Direct Current Fast Charger and Tesla), showing different colored pins above EVCS levels and allowing users to filter EVCS by level. Some mapping services also include non-standard EVCS, such as residential EVCS owners have made available for free, or National Electrical Manufacturers Association outlets at RV parks.

Through research comparing different mapping services, along with feedback received from PEV drivers, RCEA concluded that Plugshare and the Alternative Fuels Data Center are the two mapping services used by the majority of PEV drivers. Plugshare allows users to comment on EVCS status and experience, a feature RCEA has used to learn about user's experiences and to communicate with users on the status of EVCS repairs. See Figure 4 for an example of communication between RCEA and users through comments on Plugshare:

Figure 4: Communication Between RCEA and EVCS Users



Source: Plugshare

While Plugshare and AFDC serve the majority of PEV drivers, RCEA uploaded EVCS locations installed through ARV-13-029 to all known EVCS mapping services to ensure the maximum number of PEV drivers would be able to locate the new installations.

EVCS mapping services are provided by government, private, and non-profit entities. The new EVCS were added to the following online maps:

- Alternative Fuels Data Center, available at afdc.energy.gov
- NREL, available at maps.nrel.gov
- Car Charging, available at carcharging.com
- Open Charge Map, available at openchargemap.org
- Plugshare, available at plugshare.com
- Chargemap, available at chargemap.com
- Clean Fuel Connection, available at cleanfuelconnection.com
- Car EVCS, available at carevcs.com

The new EVCS stations were also added to the following smartphone Apps:

- Greenlots App (private)
- ChargePoint App (private)
- Plugshare App (private)

2.2.5 PEV Charging Parking Management System

One of the EVCS installation locations for this project, St. Joseph Hospital, operates in an environment of parking scarcity. Demand for parking spots in the St. Joseph Hospital parking lot is high, and the four dedicated PEV charging parking spaces were frequently used by conventional vehicles during the first few months after installation. The development of a novel hardware/software application concept was included in this project to provide a solution to increased parking scarcity caused by the dedication of PEV only parking spaces at St. Joseph Hospital.

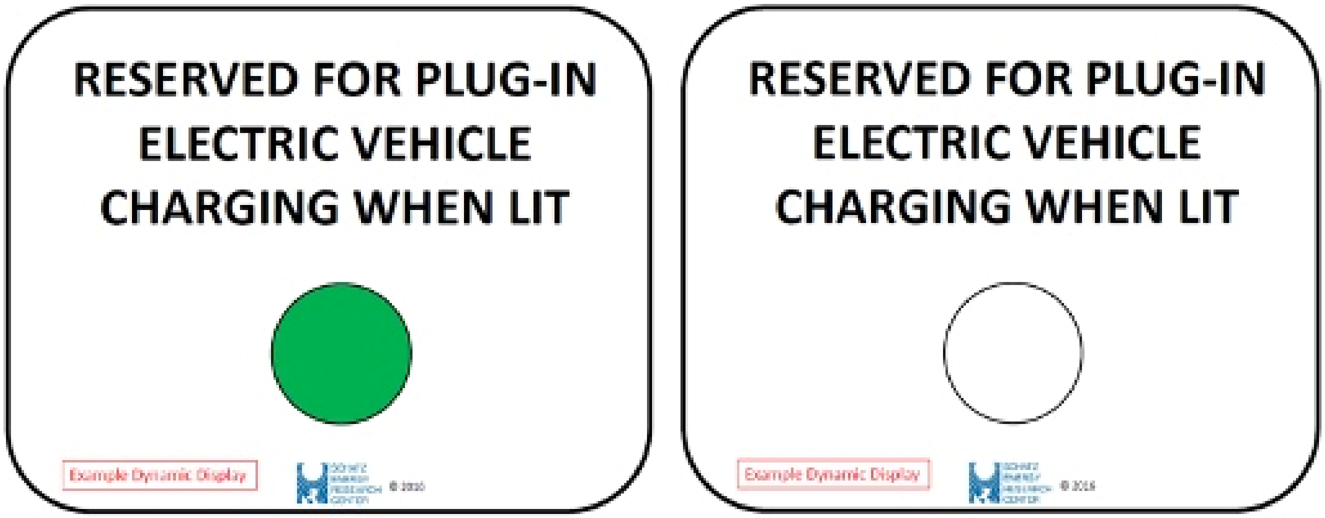
David Carter of Schatz Energy Research Agency met with St. Joseph facilities personnel to discuss their parking policy in regards to the PEV charging parking spots. Due to the high instance of conventional vehicles violating the PEV-only parking requirement, facilities personnel began a parking enforcement policy. This policy constituted a series of escalating warnings to violators:

- If a conventional vehicle is found to be parked in a PEV stall, a note is placed on the car notifying the driver that the stall is for PEV charging only and the license plate number is recorded.
- In a case where the same conventional vehicle parks in a PEV stall three or more times, a parking boot is placed on one of the vehicle's wheels.
- The driver has to talk to facilities personnel to get the boot removed, and he/she is warned not to park in the stall again unless charging a PEV.

In addition, facilities personnel expressed interest in learning more about a dynamic parking management system that ensured one parking space was always available for PEV drivers.

To this end, Mr. Carter developed the system concept, along with conceptual drawings and a cost estimate. The system consists of dynamic signage placed in front of each PEV parking space, shown in Figure 5; the signage would be connected to occupancy sensors and a microcontroller.

Figure 5: Example Dynamic Display



Source: Schatz Energy Research Center

As shown in Figure 5, LEDs on the signs would turn on and off, indicating if the space was reserved for PEV use. The microcontroller would make the decision to light an LED depending on the occupancy of the remaining parking spaces and whether vehicles in those spaces were charging. A presentation on Mr. Carter's completed work was given to St. Joseph facilities personnel. The concept was well received and acknowledged as the best solution to the current parking congestion. Both organizations intend to pursue funding for the installation of the system.

A memo outlining St. Joseph's current parking policy, presentation on the concept, conceptual drawings, and cost estimate is included as Appendix D.

2.3 Data Collection and Analysis

2.3.1 Data Collection Plan

The data collection plan consists of at least six months of throughput, usage, and operations data from the project for the Level 2 EVCS. The data is downloaded from the Greenlots network portal and includes the following parameters:

- EVCS name
- Charge event start and stop times
- Total energy usage
- Total revenue per charge event
- Payment type (i.e., RFID or credit card)
- Battery full time (only for selected vehicle types)

The previously existing RCEA ChargePoint data also included GHGs avoided and total energy usage per charging event. The ChargePoint data uses 0.42 kg GHGs avoided/kWh electricity consumed by vehicle. This ratio is used to determine the additional parameter "avoided GHGs per charging event" for the new Greenlots data set.

The targeted outcomes from the data include:

- Cumulative usage by all EVCS over time
- Individual EVCS usage over time
- Frequency of charging duration
- GHG emissions reduction by all EVCS over time

Upon each EVCS's connection with Greenlots, followed by a brief testing period, start dates where established, shown in Table 6, for data analysis purposes.

Table 6: Start Date by Location For Data Analysis Purposes

EVCS Location	Level 2 Charging Ports	Level 1 Charging Ports	Start Date For Data Analysis
Trinidad Library	2	1	28-Jan-16
Arcata Technology Center	2	0	27-Feb-16
Eureka AQMD	2	0	29-Feb-16
Fortuna Public Lot	2	1	30-Jan-16
Willow Creek Museum	2	0	15-Apr-16
Eureka St. Joseph Hospital	4	1	23-Feb-16
McKinleyville Shopping Center	2	1	4-Apr-16
Rio Dell Public Lot	2	1	28-Apr-16
Ferndale Public Lot	2	1	n/a

Source: Schatz Energy Research Center

2.3.2 Data Analysis

2.3.2.1 Bird's-eye View of Data

Select useful metrics were calculated for each EVCS location, shown in Table 7, with the exception of Ferndale since the EVCS was not yet communicating with the Greenlots' network portal. Appendix I includes refreshed data covering Q1 of 2017 and data from the Ferndale station. Over the duration of the data analysis, EVCS were in use for between 8 and 11 months.

For a charge event to be considered successful, the event must have a duration greater than 0 seconds and a usage greater than 0 kWh. Only successful charge events were used in the following data analysis. One reason for an unsuccessful charge event is that the driver may require multiple attempts at commencing a charge prior to starting a successful charge due to not understanding how to work the EVCS. Since each new EVCS's start date, 91 percent of the charge events were successful. This does not mean that 9 percent of the events ended with the driver not receiving a charge; more likely the driver needed multiple attempts prior to commencing a successful charge. As drivers become more familiar with the EVCS type, a higher percentage of successful charge events is likely.

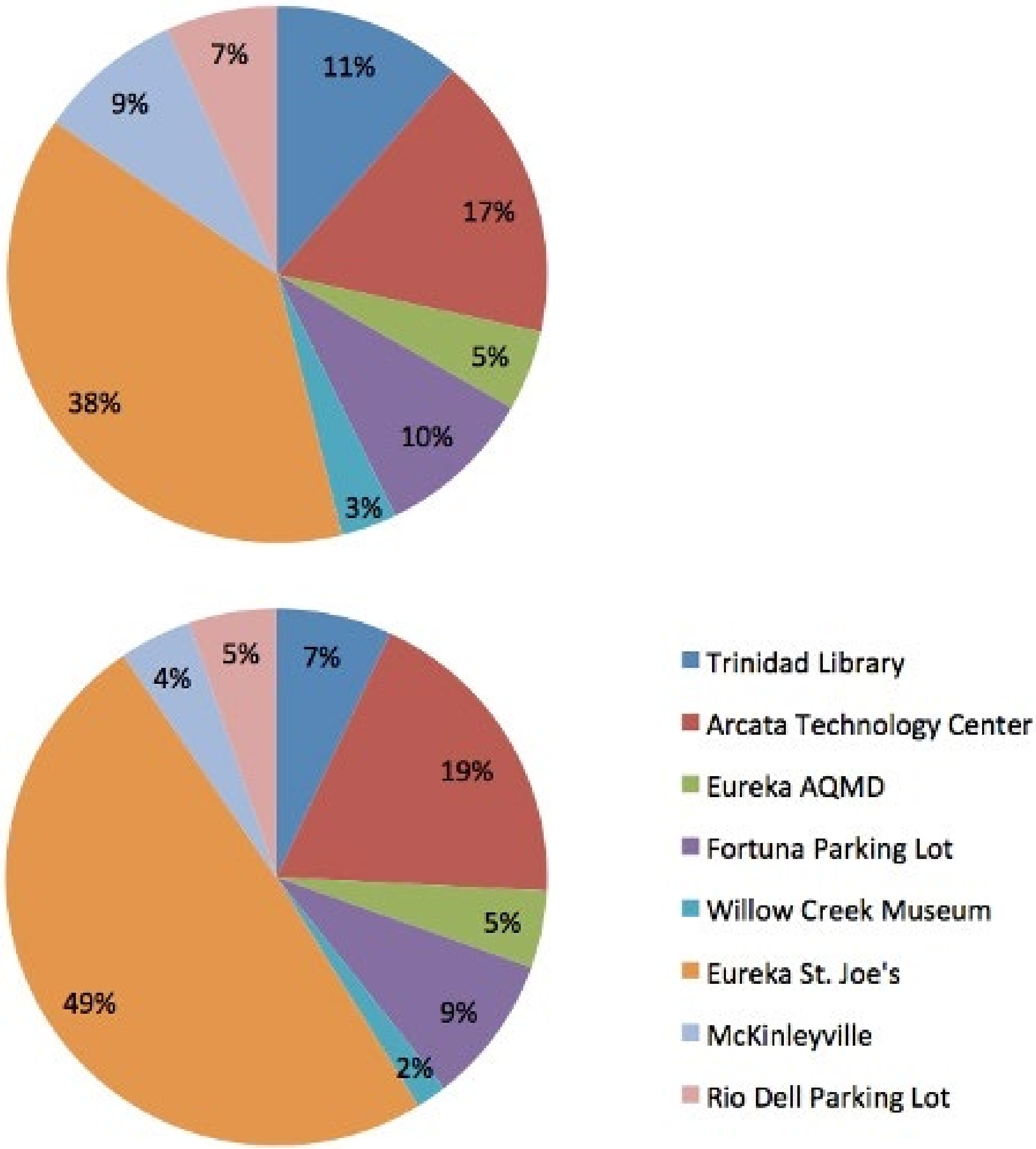
Table 7: Useful Metrics by EVCS Location

Location	Level 2 charging ports per location	Total number of successful charge events	Number of successful charge events per charging port	Fraction of successful events	Average duration per charge event (hours)	Average usage per charge event (kWh)	Fraction of overnight events
Trinidad Library	2	87	44	90%	1.7	5.4	4%
Arcata Technology Center	2	121	121	94%	4.0	9.7	12%
Eureka AQMD	2	34	17	65%	2.5	8.4	2%
Fortuna Public Lot	2	73	37	90%	2.4	8.3	10%
Willow Creek Museum	2	20	10	80%	1.2	4.8	8%
Eureka St. Joseph Hospital	4	275	69	95%	3.6	11.3	1%
McKinleyville Shopping Center	2	54	54	86%	1.4	4.4	2%
Rio Dell Public Lot	2	38	19	93%	2.4	6.9	5%

Source: Schatz Energy Research Center

Some EVCS locations exhibited a higher volume of charge events, such as Eureka St. Joseph Hospital, as seen in Table 7 and Figure 6. This is partly because St. Joseph Hospital has more charging ports. Per charging port, Arcata Technology Center exhibits the highest volume of EVCS use by event. Moreover, the higher number of charge events per EVCS location coincides with higher total usage per location, suggesting that drivers are in fact receiving a charge while parked in the PEV charging stall.

Figure 6: Percentage of Successful Level 2 EVCS Charge Events per Year by EVCS Location (top); Percentage of Energy Usage per Year by EVCS Location (bottom)



Source: Schatz Energy Research Center

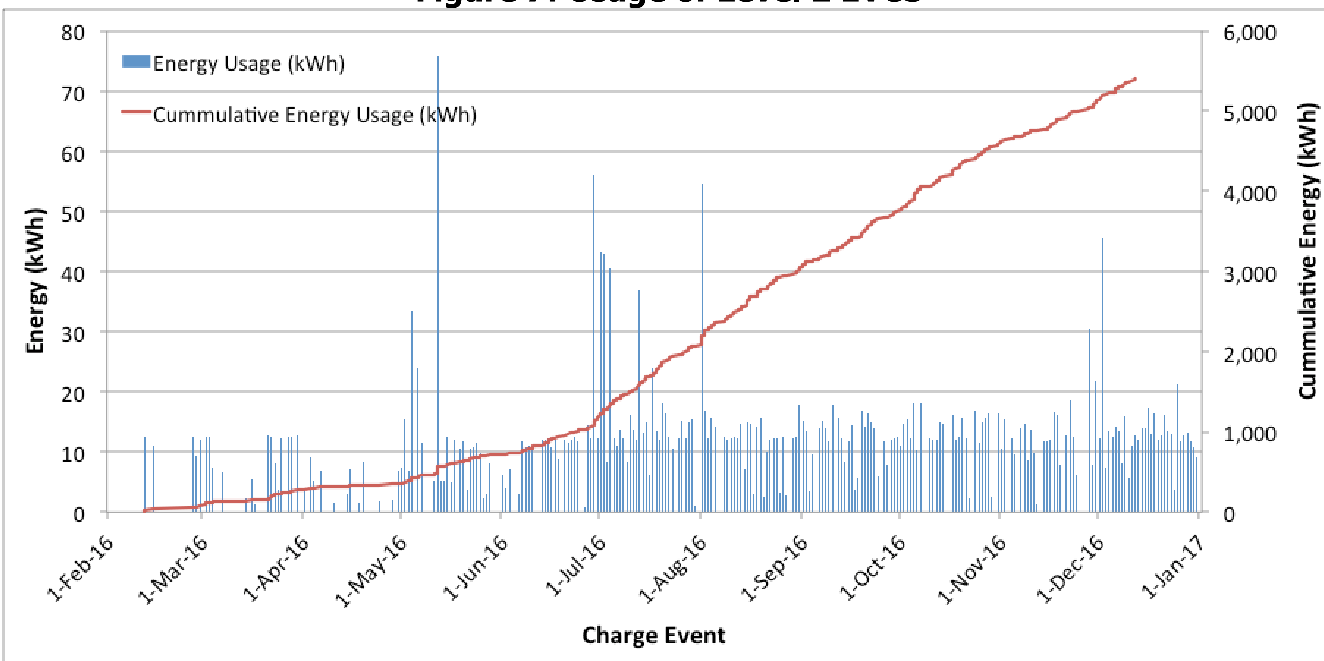
Additional useful outcomes shown in Table 7 are the variation on average duration per charge location and average usage per charge location. The Arcata Technology Center and Eureka St. Joseph Hospital EVCS exhibit the longest charge event durations and highest charge event usages. This is likely because the majority of charge events are by employees at the two locations; drivers are charging while they are at work. The McKinleyville Shopping Center and Willow Creek Museum EVCS exhibit the shortest charge event durations and lowest charge event usages. This is likely because these locations came online later, and drivers are still discovering their existence. As shown in the plots in Appendix E, some time is required for drivers to become aware of new EVCS before their usage increases. The average charge duration over all new EVCS events is 3.0 hours and the average usage is 8.9 kWh.

Interestingly, a notable fraction of charging events at the Arcata Technology Center occur overnight. The project team has yet to understand who is charging overnight and why. The remaining locations exhibit a lower overnight charging fraction. A charging event is considered overnight if the charging event spans over multiple days, i.e. including midnight.

2.3.2.2 EVCS Usage Over Time

Figure 7 below shows the 702 successful charging events that have occurred in 2016. The figure also illustrates the accumulated energy usage over all the EVCS together. It is evident that as more EVCS came online, there was a jump in the rate of energy usage. All of the online EVCS were in use by the end of April; a notable rate of increase in the cumulative energy curve occurred 2 months in early July, likely due to drivers discovering the new EVCS. Appendix E provides plots like Figure 7 for each individual location.

Figure 7: Usage of Level 2 EVCS

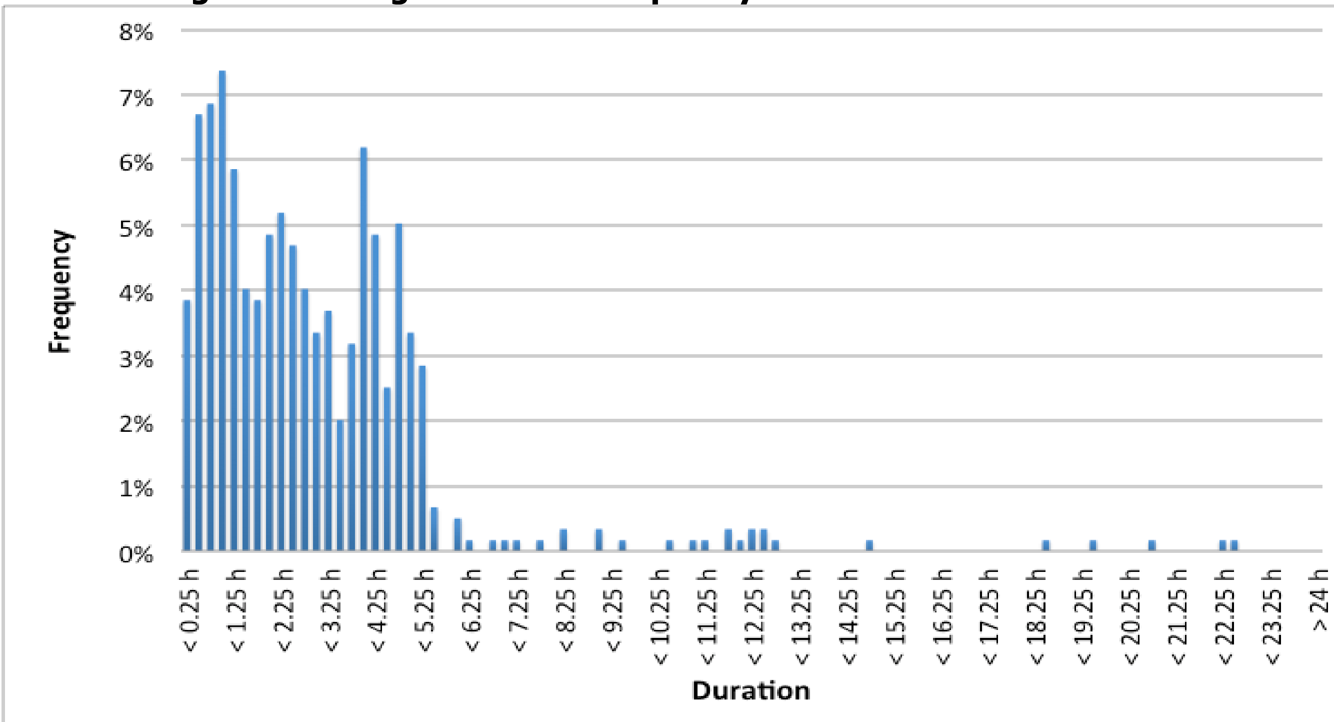


Source: Schatz Energy Research Center

2.3.2.3 Frequency of Charging Duration

Another interesting outcome is the frequency of charge event durations. Figure 8 shows a histogram of the Level 2 charge event durations in 15-minute intervals. The majority of charge events at 94 percent have duration less than 5.25 hours. The average duration of the charge events is 3.0 hours and the median is 2.4 hours.

Figure 8: Charge Duration Frequency Distribution for New EVCS

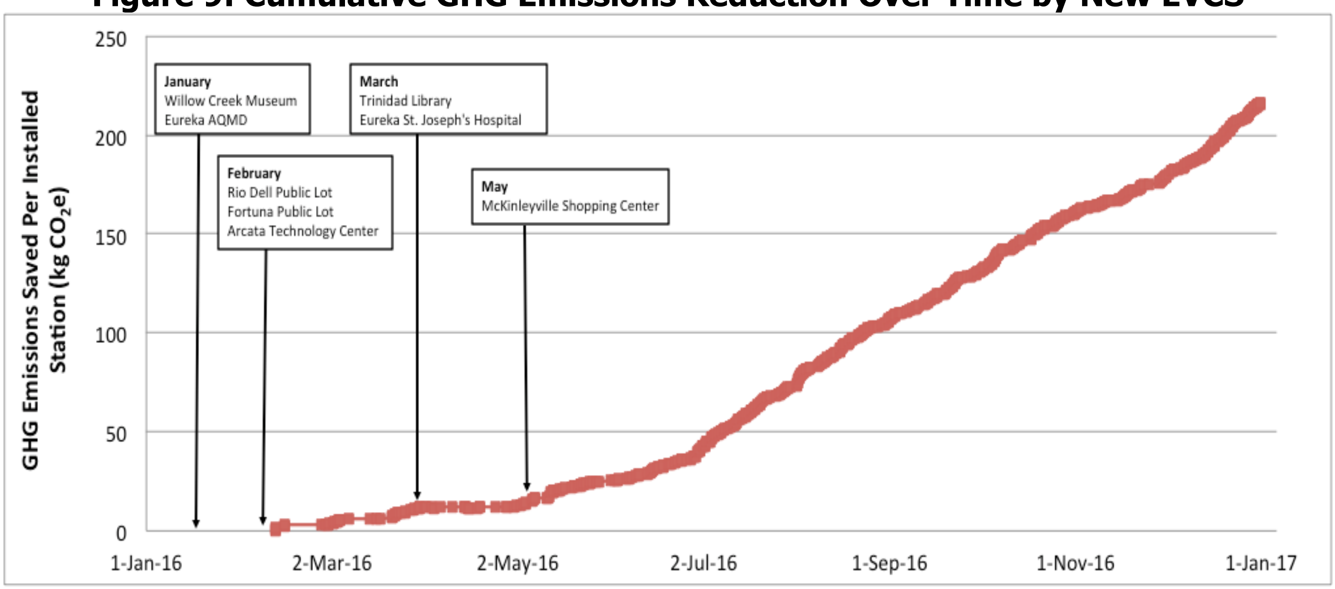


Source: Schatz Energy Research Center

2.3.2.4 GHG Emissions Reduction

It is noticeable that as more EVCS became available, there was an approximate 1-month delay in observing a boost in the EVCS' rate of use, as depicted as GHG emissions reduction, shown in Figure 9.

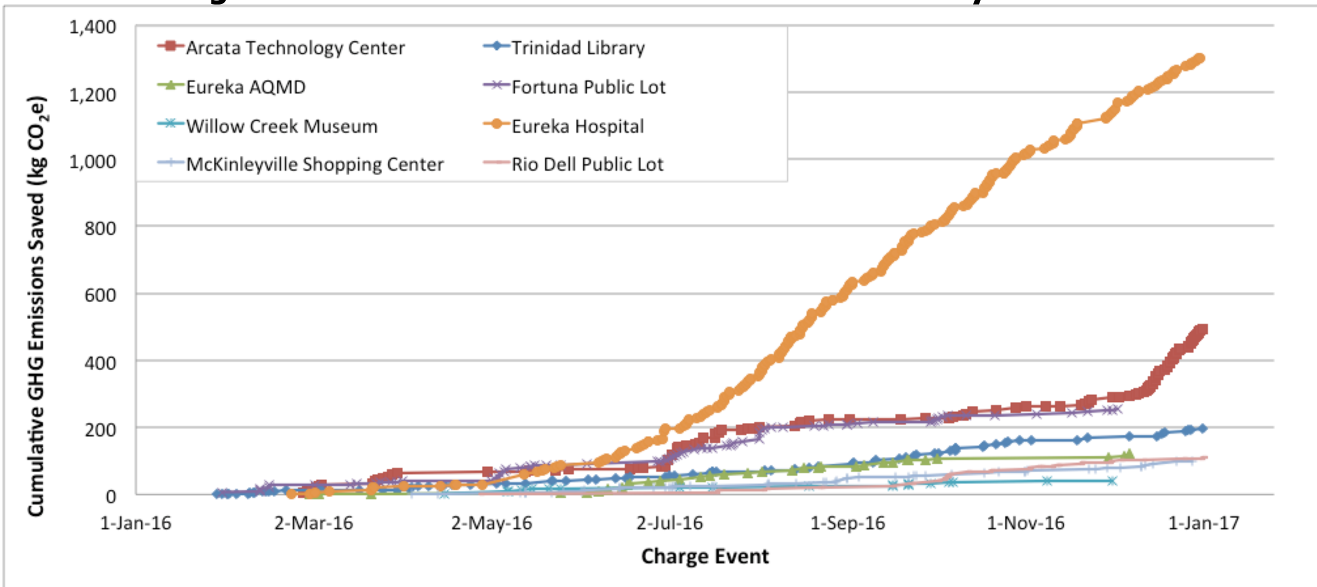
Figure 9: Cumulative GHG Emissions Reduction Over Time by New EVCS



Source: Schatz Energy Research Center

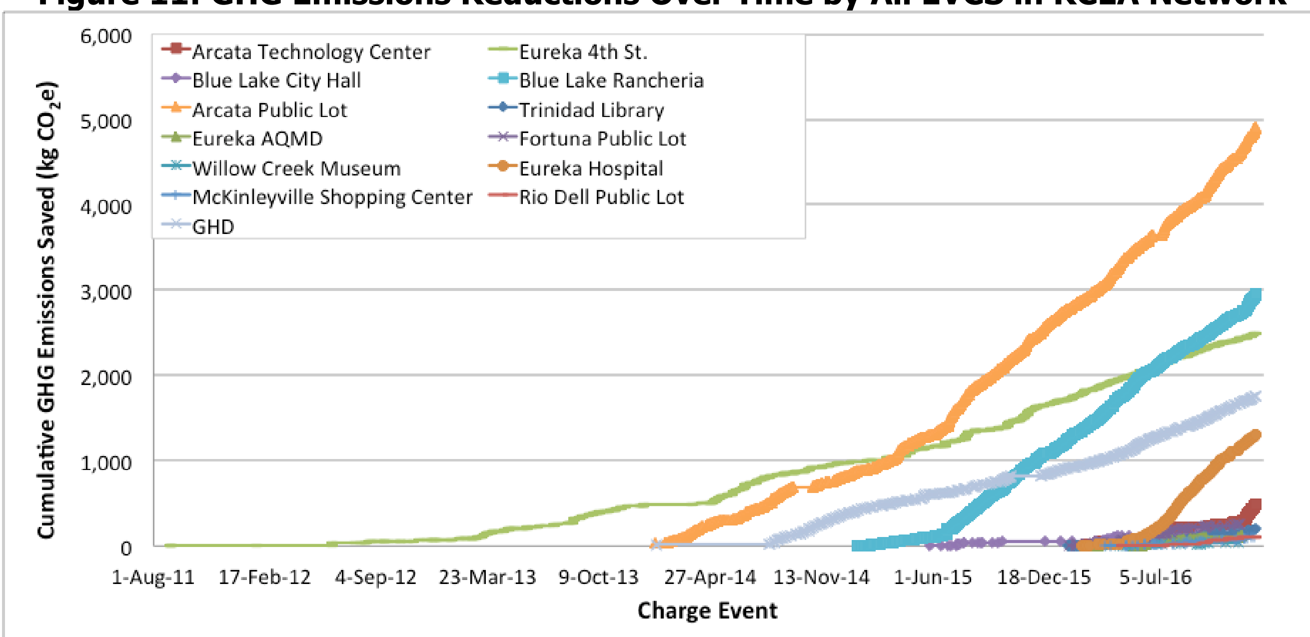
Figure 10 and Figure 11 show the GHG emissions reductions by location. Figure 10 focuses on the new Level 2 EVCS while Figure 11 includes all the online EVCS in the Network. It is notable that some locations exhibit higher cumulative GHG emissions reductions, due to number of EVCS per location, duration of the location hosting EVCS(s), and number of PEV adopters near the location.

Figure 10: GHG Emissions Reduction Over Time by New EVCS



Source: Schatz Energy Research Center

Figure 11: GHG Emissions Reductions Over Time by All EVCS in RCEA Network



Source: Schatz Energy Research Center

An important goal is to provide charging over a wide set of locations to minimize range anxiety and increase PEV adoption. This implies that EVCS in rural areas may see less use; however, they are an important piece in the larger picture of increasing PEV usage and reducing GHG emissions.

2.3.3 Projected Usage Over Time

In order to estimate the project's success over time, in terms of GHG emissions reduction and EVCS usage, a projection of Network usage needed to be made. Two main factors were identified that contribute to the increased usage rate of EVCS: (1) drivers discovering the EVCS and (2) increased public adoption of EVs.

The usage projection method is composed of two parts – one to project through 2017 and the other to project from 2018 through 2020. For the first part, the rate of usage increase by month per location was determined and continued over 2017. It was assumed that the rate pattern obtained from the 2016 data includes both main factors identified as contributing to the increased usage rate of EVCS. By 2018, it was assumed that drivers will have discovered the new EVCS. Consequently, rate will be influenced solely by increased adoption of PEVs. The California Air Resources Board estimated rates for Humboldt County electric vehicle adoption were used to extend the projected EVCS usage through 2020.

Another consideration is that between 2017 and 2020, additional EVCS are likely to be installed in Humboldt County; California Air Resources Board's projected increased PEV population's EVCS usage was distributed to include 2 new EVCS per year starting in 2017. See Table 8 for the projected usage for the EVCS for this project and see Appendix F for a detailed explanation to determine the projected usage.

Table 8: Projected Network Energy Usage Through 2020

Year	2017	2018	2019	2020
Total Projected Usage [kWh]	17,380	23,170	32,200	44,130

Source: Schatz Energy Research Center

2.3.3.1 Carbon Intensity Values for Life-Cycle Greenhouse Gas Emissions

Substituting driving internal combustion engine vehicles with PEVs reduces GHG emissions by over 30 percent, according to ChargePoint's GHG emissions reductions estimates. Appendix G provides a detailed explanation of ChargePoint's calculations, supporting the claim that with every kWh of energy used by PEVs, 0.42 kg GHG is reduced. Based on ChargePoint's 0.42 kg GHG/ kWh estimation, Table 9 estimates the GHG reduction from the projected usage for project EVCS.

Table 9: Projected GHG Emissions Reduction by the Level 2 Stations Through 2020

Year	2017	2018	2019	2020
Total Projected Usage [kWh]	17,380	23,170	32,200	44,130
Total GHG Emissions Reduced [kg CO_2 e]	7,310	9,740	13,530	18,550

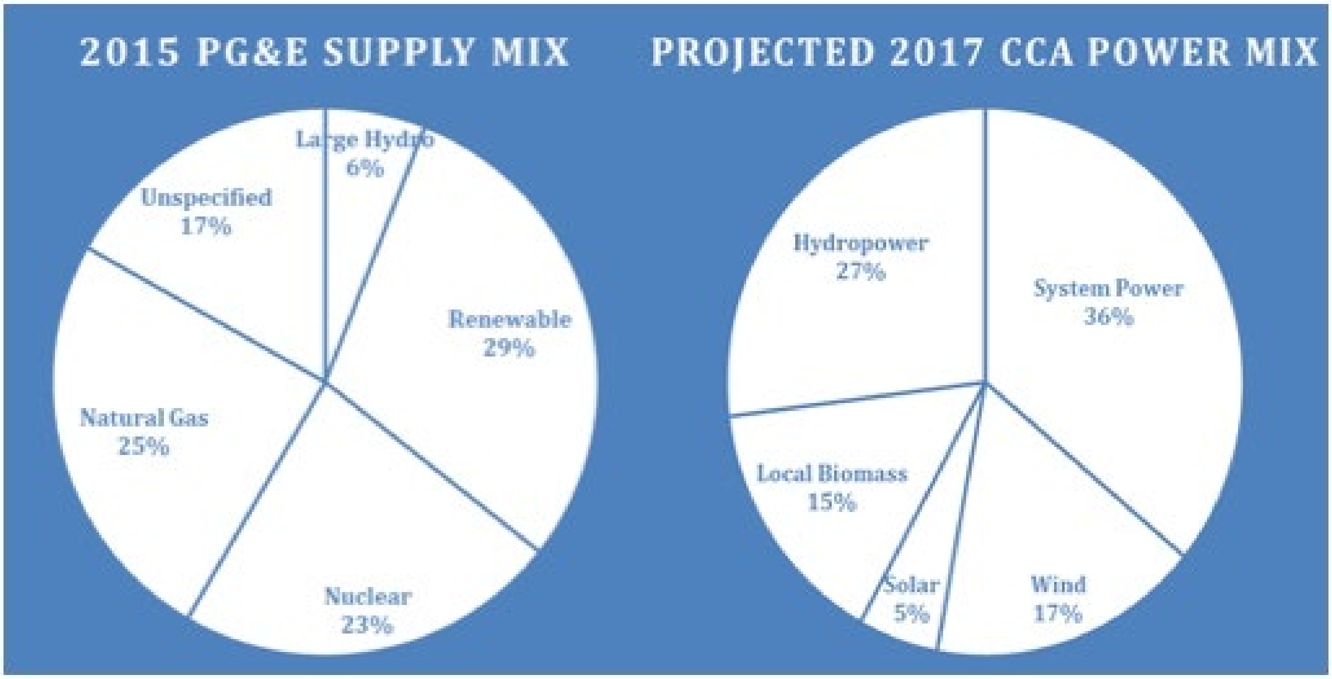
Source: Schatz Energy Research Center

From 2016 through 2020, an estimated 51,740 kg of GHG will have been reduced as a result of this project; this is equivalent to approximately 15,500 gallons of gasoline avoided.

2.3.3.2 Current and Planned Use of Renewable Energy

All of the EVCS installed through this project are grid-tied and distribute power supplied by Pacific Gas and Electric. Pacific Gas and Electric's 2015 power mix (the most recent power mix breakdown provided by Pacific Gas and Electric) was 30 percent renewable. However, starting in May of 2017, RCEA will be taking over Pacific Gas and Electric's current responsibilities for power procurement in Humboldt County. Through the Community Choice Aggregation program, RCEA will be providing more renewable energy to customers compared to Pacific Gas and Electric. Consequently, all of the EVCS installed under ARV-13-029 will be distributing electricity that will be produced using at least 37 percent renewable sources. Additionally, any project site hosts that opt up to the Community Choice Aggregation program's "RePower+" option will be providing 100 percent renewable electricity. Figure 12 provides a comparison of Pacific Gas and Electric's current power mix with the 2017 planned Community Choice Aggregation power mix.

Figure 12: Comparison of Pacific Gas and Electric's 2015 Power Mix and the Projected 2017 Community Choice Aggregation Power Mix



Source: Pacific Gas & Electric and the Redwood Coast Energy Authority

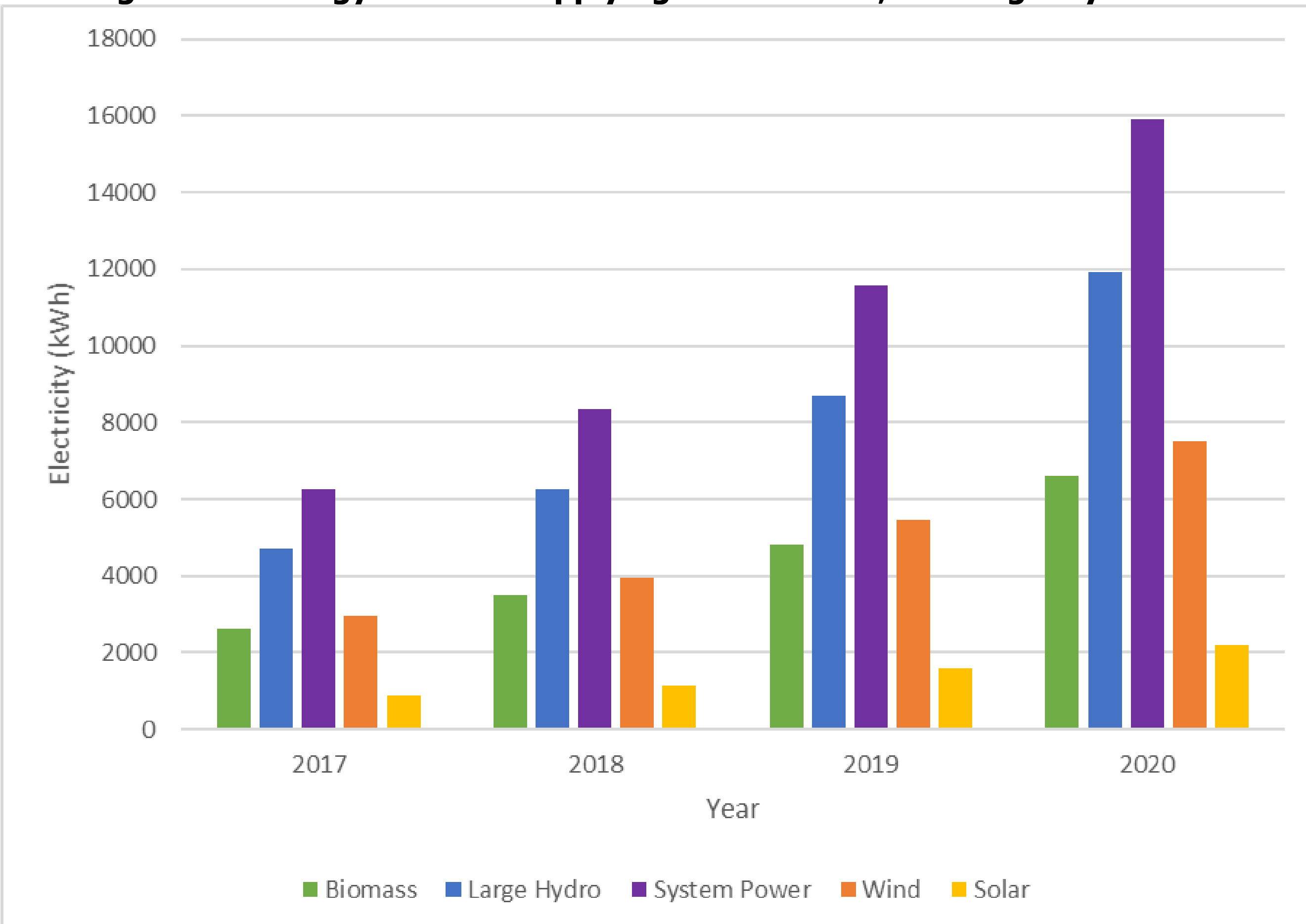
The percentage contribution of different generation sources in the projected 2017 Community Choice Aggregation power mix was applied to the growth forecasts in Table 8 to determine the proportion of Network electricity being generated from each source. Table 10 and Figure 13 provide the amounts of electricity generated from different sources for the Network:

Table 10: Energy Sources Supplying the Network, Starting May of 2017

Source (in kWh)	2017	2018	2019	2020
Biomass	2,607	3,476	4,830	6,620
Large Hydro	4,693	6,256	8,694	11,915
System Power	6,257	8,341	11,592	15,887
Wind	2,955	3,939	5,474	7,502
Solar	869	1,159	1,610	2,207
Total:	17,380	23,170	32,200	44,130

Source: Redwood Coast Energy Authority

Figure 13: Energy Sources Supplying the Network, Starting May of 2017



Source: Redwood Coast Energy Authority

In addition to a cleaner power mix through the Community Choice Aggregation, the electricity distributed from the Arcata Technology Center EVCS is offset by a 126-kW solar array installed on the facility's roof. This array was completed in 2016 and produces enough power to offset all of the energy consumed at the facility.[5]

2.3.3.3 Future Expansion

Most sites were intentionally designed for future expansion in the event funding becomes available. The expansion capacity of the nine new sites hosting EVCS is provided in Table 11 below. Factors that enable expansion include suitable additional parking availability, conduit size, and wire size. All sites have at least one dual Level 2 EVCS, each plug able to supply 30 Amperage at 240 Volt simultaneously; most sites have capacity to add another dual Level 2 EVCS. Some sites have a Level 1 (120 Volt, 16 Amperage) EVCS designated for persons with disabilities only; these EVCS can be swapped out for a Level 2 EVCS with the maximum current rating specified in Table 11, if desired.

5 Information on Large Scale Solar, available at http://greenwaypartners.net/project/large-scale-solar-design-efficiency-upgrades-and-construction-management.

Table 11: EVCS Site Expansion Details

EVSE Location	Expansion Capacity	Technical Expansion Description
Trinidad Library	Add up to 2 x 240 Volt, 30 Amperage EVCS Courtesy charger upgrade from 120 Volt, 16 Amp to 240 Volt, 18 Amp	Adding 2 x 240 Volt, 30 Amp EVCS: existing 1.5” conduit can accommodate 4 additional #4 wires, additional wires can be guided through conduit using existing pull tape between load center and existing 240 Volt EVCS. Upgrading courtesy charger: existing ¾” conduit and #10 wires can accommodate a 240 Volt, 18 Amp EVCS.
Willow Creek Museum	Add up to 2 x 240 Volt, 30 Amp EVCS	Existing 1” conduit installed, capped, and buried within 5 feet of meter pedestal, sized to accommodate 4 additional #8 THHN/THWN wires.
McKinleyville Shopping Center	No expansion – 100 A service limit, fully in use with current design	
Arcata Greenway Building	No expansion – no additional available parking stalls	
Eureka AQMD	Add up to 2 x 240 Volt, 30 Amp EVCS	Existing 1” conduit can accommodate 4 additional #8 THHN/THWN wires
Eureka St. Joseph Hospital	No expansion – currently using full 200 A capacity	
Fortuna Parking Lot	Add up to 2 x 240 Volt, 30 Amp EVCS Courtesy charger upgrade from 120 Volt, 16 Amp to 240 Volt, 25 Amp	Adding 2 x 240 Volt, 30 Amp EVCS: existing 1” conduit can accommodate 4 additional #8 THHN/THWN wires, capped stub out buried as indicated in drawing within storm water drainage basin. Upgrading courtesy charger: existing 1” conduit and #12 wires can accommodate a 240 Volt, 25 Amp EVCS.
Ferndale Parking Lot	Add up to 2 x 240 Volt, 30 Amp EVCS Courtesy charger upgrade from 120 Volt, 16 Amp to 240 Volt, 28 Amp	Adding 2 x 240 Volt, 30 Amp EVCS: existing 1” conduit can accommodate 4 additional #8 wires, capped stub out buried as indicated in drawing. Upgrading courtesy charger: existing 1” conduit and #10 wires can accommodate a 240 Volt, 28 Amp EVCS.

EVSE Location	Expansion Capacity	Technical Expansion Description
		Existing 200 Amp service can accommodate the additional EVCS and courtesy charger upgrade.
Rio Dell Parking Lot	Add up to 2 x 240 V, 30 Amp EVCS Courtesy charger upgrade from 120 V, 16 A to 240 V, 25 A	Adding 2 x 240 Volt, 30 Amp EVCS: existing 1” conduit can accommodate 4 additional #6 THHN/THWN wires, capped stub out buried as indicated in drawing. Upgrading courtesy charger: existing 1” conduit and #12 wires can accommodate a 240 Volt, 25 Amp EVCS. Existing 200 Amp service can accommodate the additional EVCS and courtesy charger upgrade.

Source: Schatz Energy Research Center

2.3.3.4 Economic Impact

Taking advantage of the expansion opportunities referenced above would produce both near and long-term economic benefit. Due to the Community Choice Aggregation program’s purchase of local, renewable power, increased consumption of electricity will result in more money staying in the community. As the Network expands, more people will feel comfortable purchasing PEVs, which will increase the utilization of current EVCS and spur demand for new stations.

As mentioned in the preceding section, additional EVCS can be easily installed at many sites that currently host project EVCS. The total expansion potential, based on existing conduit size and site configuration, is an additional 16 Level 2 EVCS ports.

To determine the economic impact of expansion by 16 EVCS ports (six dual-port Level 2 EVCS and four single-port Level 2 EVCS), a cost per installation was calculated. The ten dual-port EVCS installations had an average cost of $11,065. Due to extensive pre-work completed for the expansion opportunities, only construction costs are included in the estimates. Table 12 lists the estimated cost to install per EVCS for this project.

Table 12: Installation Cost per EVCS

EVCS	Installation Cost
Trinidad Museum/Library Complex Parking Lot	$15,927
McKinleyville Shopping Center Parking Lot	$9,999
Bigfoot Museum Parking Lot	$12,903
Arcata Technology Center Parking Lot	$10,989
NCUAQMD Headquarters Parking Lot	$9,274
St. Joseph Hospital Parking Lot 1	$7,832
St. Joseph Hospital Parking Lot 2	$7,832
Fortuna Public Parking Lot	$10,028
Ferndale City Parking Lot	$14,099
Rio Dell Public Parking Lot	$11,768
Average Cost:	$11,065

Source: Redwood Coast Energy Authority

Applying this average cost for a dual-port EVCS installation to the addition of ten EVCS comes out to $110,650. These funds would be paid to local contractors and represent and immediate economic benefit.

In addition to the initial boon from EVCS installation, the community benefits from the lower cost per mile from driving a PEV. Table 13 includes the electric vehicle miles travelled enabled by the Network, along with an estimate of cost savings over gasoline. Over four years, the network provides an estimated $4,469 in savings over gasoline. The electric vehicle miles travelled were calculated assuming an efficiency rating of 34 kilowatt-hours per 100 miles (the efficiency rating of a Nissan Leaf), and the savings over gasoline assumes a cost per mile of 10 percent below the local average cost of gasoline per mile of $0.13.

Table 13: Electric Vehicle Miles Travelled and Savings Over Gasoline Estimates

Year	2017	2018	2019	2020
Total Electric Vehicle Miles Travelled (miles)	51,118	68,147	94,706	129,794
Savings Over Gasoline* ($)	$665	$886	$1231	$1687

Source: Redwood Coast Energy Authority

Displacing gasoline use as a transportation fuel not only provides cost savings, it reduces negative health impacts as well. According to the American Lung Association, there is a health and environmental cost of $1.19 per gallon of gasoline consumed. To assign this cost, the American Lung Association assessed public health, global warming and societal costs and impacts from burning fossil fuels. Assuming 3 miles/kWh for a PEV and 23 miles per gallon for internal combustion engine vehicle, this project will have offset 15,500 gallons of gasoline through 2020. According to American Lung Association's calculation, this will avoid $18,445 in health and environmental damage.

2.3.4 Cost of Operations

Unfortunately, performing maintenance on the EVSE, LLC stations (owned by Control Module, Inc.) has proven to be prohibitively expensive. Equipment failures have required frequent site visits and dedication of staff time. Table 14 captures a conservative snapshot of required maintenance trips and associated costs.

Table 14: Maintenance Log for Project EVCS and Associated Costs

Date	EVCS	Malfunction	Travel Expense ($0.54/ mile)	Cost of Staff Time ($45/hour)	Combined Total Cost
1/13/2016	Rio Dell	Stock cabinet screw stripped	$29.48	$94.50	$123.98
1/18/2016	Arcata	Payment module power frozen	$9.07	$45.00	$54.07
1/19/2016	Willow Creek	Screw stuck on base of West unit	$51.30	$127.50	$178.80
2/3/2016	Multiple Sites	Magtek card reader recessed	$51.30	$127.50	$178.80
2/6/2016	NCUAQMD	Payment module malfunction	$0.54	$22.50	$23.04
4/21/2016	St. Joseph	Credit card payment not working	$2.81	$22.50	$25.31
4/28/2016	St. Joseph	Credit card payment not working	$2.81	$22.50	$25.31
6/16/2016	Trinidad	Cables forcibly retracted	$24.73	$85.50	$110.23
7/12/2016	Ferndale	Cable retraction error	$20.63	$91.50	$112.13
7/13/2016	Rio Dell	Cable retraction error	$29.48	$72.00	$101.48
7/21/2016	Rio Dell	Installation of replacement ZigBee	$29.48	$94.50	$123.98
9/14/2016	Rio Dell	Cable retraction error	$29.48	$72.00	$101.48
10/19/2016	Trinidad	Cable retraction error	$24.73	$94.50	$119.23
10/24/2016	Ferndale	Cable retraction error	$20.63	$91.50	$112.13
10/31/2016	Trinidad	Communication error	$24.73	$94.50	$119.23
11/1/2016	Trinidad	Communication error	$24.73	$94.50	$119.23
11/22/2016	Arcata	Credit card payment not working	$9.07	$45.00	$54.07

Date	EVCS	Malfunction	Travel Expense ($0.54/ mile)	Cost of Staff Time ($45/hour)	Combined Total Cost
11/28/2016	Arcata	Credit card payment not working	$9.07	$45.00	$54.07
12/5/2016	St. Joseph	Cable retraction error	$2.81	$22.50	$25.31
1/9/2017	McKinleyville	Communication error	$14.36	$82.50	$96.86
1/20/2017	Trinidad	Installation of replacement ZigBee	$24.73	$87.00	$111.73
1/23/2017	Ferndale	Replacement payment module	$20.63	$88.50	$109.13
2/6/2017	St. Joseph	Cable retraction error	$2.81	$22.50	$25.31
2/15/2017	Trinidad	Installation of replacement ZigBee	$24.73	$87.00	$111.73
3/13/2017	Willow Creek	Communication error	$51.30	$105.00	$156.30
3/29/2017	Trinidad	Cable and communication error	$24.73	$87.00	$111.73
3/29/2017	Willow Creek	Replacement payment module	$51.30	$127.50	$178.80
4/5/2017	Trinidad	Installation of replacement ZigBee	$24.73	$87.00	$111.73
4/17/2017	Willow Creek	Cable and communication error	$51.30	$127.50	$178.80
4/20/2017	Trinidad	Cable retraction error	$24.73	$87.00	$111.73
4/25/2017	Trinidad	Installation of replacement ZigBee	$24.73	$87.00	$111.73
4/25/2017	Willow Creek	Installation of replacement ZigBee	$51.30	$127.50	$178.80
Total:					$3,356.26

Source: Redwood Coast Energy Authority

The project team selected EVSE, LLC primarily due to their feature-rich EVCS. The stations have class-leading cable management systems and have the ability to accept both mag stripe and radio frequency identification credit cards. However, the two primary maintenance needs of these stations have resulted from failures in these systems – 32 percent of maintenance trips have been necessitated by a failure in the cable management system, while 29 percent have been necessitated by a failure in the payment processing system.

Ensuring station uptime at this early stage in EV market development is essential. Going forward, RCEA will need to devise a strategy to ensure station uptime while significantly reducing costs.

A possible solution would be to require Control Module, Inc. to provide maintenance for its stations with high downtime. An agreement could be reached where Control Module, Inc. is required to repair each station at its own cost within a designated time period. For example, if a station is down for over 10 percent of time within the last 60 days, Control Module, Inc. at its own cost would restore the station to full operation within 72 hours. Once greater EVCS reliability is achieved, RCEA would continue routine care.

To avoid the issue of excessive maintenance costs in future agreements with EVCS manufacturers, an uptime performance clause could be included in a service contract. A clause like this would require minimum repair turn-around and escalating fines, similar to how other businesses address cost impacts from service providers.

2.3.5 Site Host Surveys

In addition to analyzing data on charging station usage, data captured from interviewing site hosts was also analyzed. It is important to gauge the level of effort required to host stations as well as level of happiness in hosting the stations.

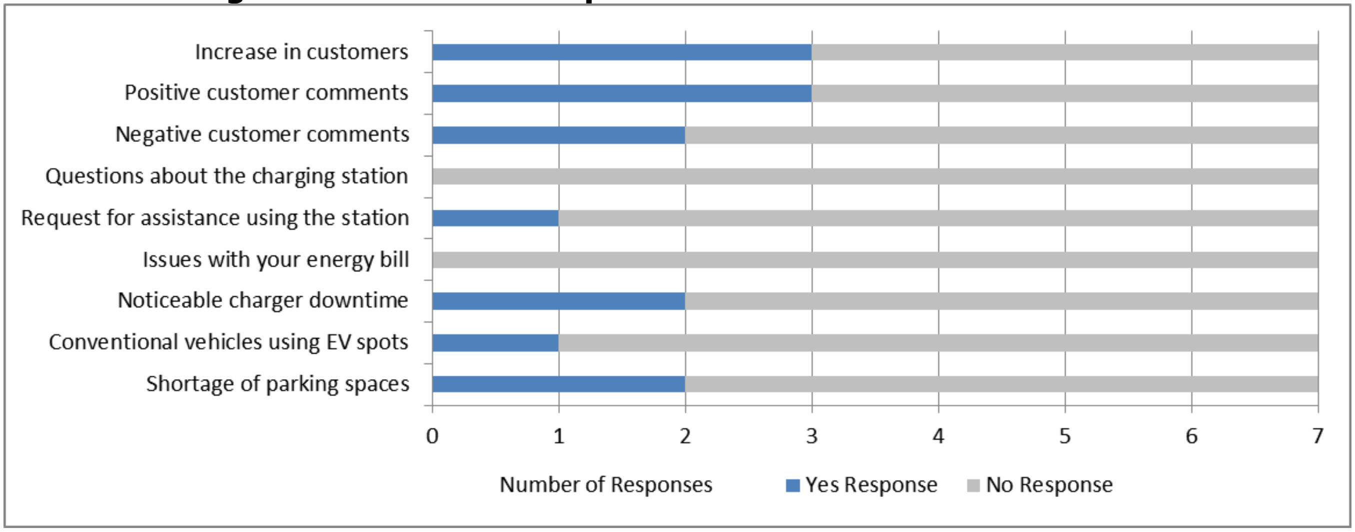
2.3.5.1 Survey Results

The project team conducted site host surveys over February and March 2017. Seven of the nine site hosts participated in the survey. The raw data from the survey can be viewed in Appendix H. The survey aimed to capture the following information:

- Improvement to site host business
- Drawbacks
- Time requirement by site host
- Overall level of happiness

The first set of questions was yes/no and focused on business improvement and drawbacks. See Figure 14, which summarizes site host responses; the blue bars indicate the number of “yes” responses out of the seven site hosts surveyed. Close to half of the surveyed site hosts believe that hosting an EVCS has increased visitors to their facility. The negative customer feedback was minor; one person noted the temporary bags placed over the station between installation and networking were not aesthetically pleasing. Little assistance was needed from EVCS users; one site host mentioned a request for assistance but only just after the charging station was installed. Two site hosts observed shortage of parking spaces: Ferndale public lot and Eureka St. Joseph Hospital. The Ferndale public lot site host further explained that the shortage of parking stalls is not an everyday occurrence. The St. Joseph Hospital site host further explained that conventional vehicles parking in the PEV stalls has become an issue.

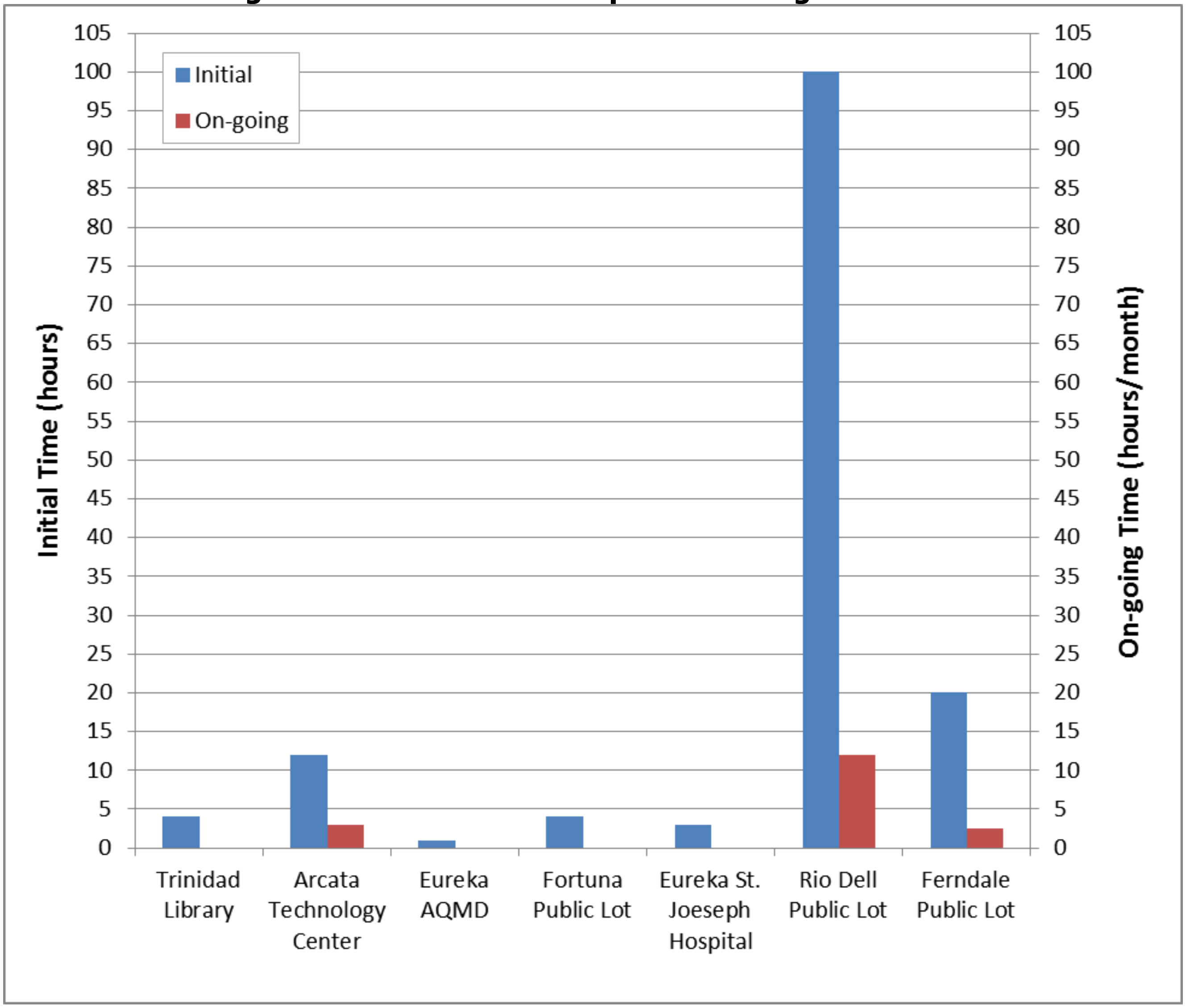
Figure 14: Site Host Responses to Station Use Observations



Source: Schatz Energy Research Center

The second set of questions focused on time required by the site host. See Figure 15 showing site host responses. The blue columns indicate site host estimated initial time spent during the EVCS installation process, e.g. paperwork, communications, meetings. The red columns indicate site host estimated ongoing time spent after the EVCS installation process, e.g. assisting drivers and dealing with vandalism. The Rio Dell public lot site host indicated a notably high initial time requirement; the site host commented that upgrading the parking required a significant time investment. The parking lot upgrade was originally in the city's plans but was pushed to happen at a sooner date prior to the EVCS installation. The majority of site hosts spent less than 5 hours during the initial installation process. In addition, the majority of site hosts indicate that there are no ongoing time requirements with hosting an EVCS. Table 15 provides the average and median initial and ongoing time requirements over the seven site hosts surveyed. During the survey, no site hosts mentioned vandalism; one site host noted that "the area is well lit and there is a security camera."

Figure 15: Site Host Time Spent Assisting with EVCS



Source: Schatz Energy Research Center

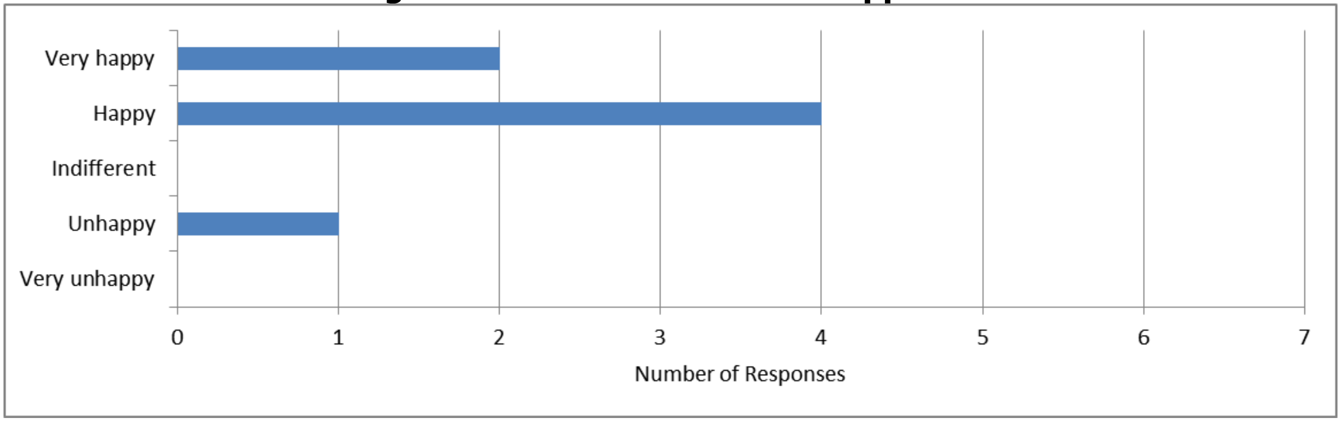
Table 15: Installation and Maintenance Time

Time Requirements	Initial (hours)	Ongoing (hours/month)
Average	20.6	2.5
Median	4.0	0

Source: Schatz Energy Research Center

The final survey question asked was in regards to the site host's level of happiness with hosting an EVCS. Six of the seven site hosts surveyed indicated they were happy with their decision to host. See Figure 16 for a breakdown of the responses. The one site host indicating they were unhappy with their decision to host cited lack of use.

Figure 16: Site Host Level of Happiness



Source: Schatz Energy Research Center

2.3.5.2 Survey Take-Away Points

Conducting the surveys approximately one year past the installation date was good timing – the site hosts had time to see the EVCS in use and discovered by PEV drivers. The main take-away points from the survey are summarized below:

- The time requirement to host an EVCS is minimal, i.e. the majority of site hosts spent less than 5 hours during the initial installation process and estimate no time in ongoing maintenance.
- Close to half the surveyed sites experienced an increase in customers from hosting an EVCS.
- More PEVs were purchased by site location employees, as indicated by the Arcata Technology Center and St. Joseph Hospital.
- The stations were self-sufficient; little assistance was required by the site host from PEV drivers using the stations.
- Conventional vehicles parking in PEV charging stalls is a common issue.

CHAPTER 3: Conclusions and Recommendations

3.1 Assessment of Project Success

The project team successfully installed 10 EVCS at the nine locations identified at the beginning of the project. The Network has seen steadily increasing usage, which aligns with the dramatic rise in PEV adoption in Humboldt County. Successful installation and operation of this Phase 1 Network will encourage the build out of more infrastructure and attract more funding. In addition, the project team has successfully provided a proof of concept for a not-for-profit owner/operator model, which can be replicated in other areas. This model provides convenient charging opportunities even in areas where no business case exists and can be a solution for lagging PEV adoption in rural communities.

The set of bulleted points that follow evaluate project success based on the objectives that are stated in Section 1.2 of this report.

- Increase PEV travel in the North Coast region and thereby reduce GHG emissions from vehicle miles travelled. From the agreement start in June of 2014 to March of 2017, Humboldt County has seen a staggering 1,270 percent increase in PEVs.[6] In addition, EVCS installed through this project have offset an estimated 9603 kg. of CO2, as of April 2017. Access to public EVCS at convenient locations throughout the region will be critical to maintaining this momentum.
- Establish the first phase of a well-planned, locally controlled, affordable, and economically sustainable network of EVCS installations in the North Coast Region. All ten EVCS at the nine sites identified at the start of the project were installed successfully. Extensive planning efforts were leveraged to site the EVCS in areas most critical to PEV adoption.
- Demonstrate a non-profit EVCS network administrator business model. RCEA has been successfully operating the network; responding to customer inquiries and providing station maintenance. Thorough analysis produced a pricing scheme for the Network which keeps the cost per mile below that of gasoline and allows for limited cost recovery.
- Develop a hardware and software application concept designed to address the issue of fairness for PEV charging and non-PEV parking in an environment of parking scarcity at St. Joseph Hospital. A novel parking management concept, including engineering drawings and cost estimates, was developed for St. Joseph Hospital. Implementing this system would satisfy St. Joseph facility's requirement that at least one parking spot is made available at all times for PEVs, while freeing up remaining parking for conventional vehicles. Additional funding will be pursued to install this system.
- Collect operational data from the project and analyze that data for economic and environmental impacts. A thorough analysis of EVCS usage data was conducted for this

6 RCEA analysis of increase in Pacific Gas and Electric residential EV rates. There were 49 homes on an EV rate on 6/31/2014, and 674 homes on an EV rate on 3/31/2017.

project. Useful information on charging session characteristics, the distribution of usage across the Network, EVCS usage over time, GHG emissions reductions, and economic impacts are detailed in Section 2.3.

3.2 Conclusions and Lessons Learned

3.2.1 Better Site Selection Screening

During the bid process for construction, new information surfaced that significantly affected the bid structure and final selection process:

- One site, being a hospital, presented additional conditions for construction. The hospital is in a long-standing relationship with an existing electrical contractor. While the contractor and hospital were open to accepting another contractor for the EVCS installation, the team elected to respect the existing relationship since the:
  - Site host and electrician already has a pre-existing, long-term relationship,
  - Existing contractor has critical institutional knowledge about the site;
  - Existing contractor is intimately familiar with ongoing upgrades and therefore optimal control over scheduling, capacity, interconnections, and so on;
  - Existing contractor is well-versed in hospital-specific code and safety requirements, something that would involve a learning curve for other contractors.
- Another site at a shopping center is owned by a building construction firm. Again, the construction firm understood that we were pursuing a single bid, but the team elected that it was in the best interest for the firm to install the EVCS on its own property.

Although these were judged as the best business decisions by the team, the consequence was three separate construction contracts and a significant increase in administrative and oversight costs. To avoid this in the future, site host selection needs more comprehensive screening for unique code and safety issues, ownership implications, and existing relationships with service providers.

3.2.2 Predicting Costs

Installing, operating, and maintaining the Network has incurred costs above those initially accounted for. Rural, isolated communities like Humboldt County pose unique challenges and additional costs for network management. RCEA encountered the following additional costs:

- EVCS network service providers structure costs with the expectation that these costs can be spread over multiple ports. In rural communities, expansion at a single site may not be feasible, given limited parking or low demand. Cost structures like this may make single or dual port installations infeasible.
- The project team's original intent was to share site host's hard-wired internet connection, as opposed to using a cellular modem. However, sharing this connection proved to be difficult. A few reasons the project team opted away from site host's internet connection included: assessing a fair fee for shared use of the site host's internet would be difficult, wireless internet connections are notoriously insecure, and relying on the site host's routers, service provider, etc. could impact network reliability.
- While a cellular connection addressed many of the issues faced by sharing the site host's hardwired internet connection, it still had its challenges. When siting the EVCS in Ferndale, cellular connectivity was confirmed using a cell phone, as suggested by Greenlots as a means for confirmation. However, after installing the EVCS, it was

determined the station required a stronger connection than a cell phone; therefore, Greenlots was not initially able to communicate with the EVCS. It took the manufacturer more than eight months to provide a stronger antenna.

- Installation of the project EVCS took place before accessibility requirements were finalized in the 2016 California Building Code. However, best practices for accessibility were applied. Level 1 EVCS were placed at existing Americans with Disabilities Act parking spaces in select locations. The 2016 building code now requires the dedication of a van accessible space and access aisle. This adds extra cost and may cool infrastructure development in rural areas as site hosts with small parking lots will be reluctant to sacrifice limited parking.
- While feature-rich, the selected EVSE, LLC stations have proven to be problematic. The more sophisticated retracting cable management system and universal payment system are unreliable. Cable retraction and communication errors have necessitated frequent and costly site visits.
- When evaluating different network service providers, the project team discovered each company structures its fee schedule slightly differently. It is essential to ask network service providers to divulge all cost-recovery mechanisms. For example, percent fee per kwh, session fees, etc.

3.3 Recommendations

The following recommendations are made for improving the build out of EVCS infrastructure in the North Coast and beyond:

- Include mechanisms such as an uptime performance clause with minimum repair turn-around times in contracts with EVCS providers.
- Retractable cable management systems in EVCS may assist with some issues, like improving accessibility, but are less reliable than more traditional cable management systems. Distance to EVCS in rural areas adds to the cost of maintenance visits. Simple, maintenance-free EVCS units, especially in rural areas, are more desirable.
- Universal payment systems are cumbersome, but so is carrying multiple loyalty cards. As previously mentioned, simplicity is key when selecting EVCS. Dispensing with universal payment systems may be required to improve reliability.
- Promote networked EVCS to have robust remote diagnostics and self-repair routines to avoid costly field visits. This is particularly important in rural areas where cell signals are intermittent and service calls may be some distance from support centers.
- The installation of independent meters is more expensive, but the benefits outweigh the cost. Reimbursement of site hosts is cumbersome and adds administrative load.
- Conduct an economic analysis to compare real-world costs of basic vs. smart/networked Level 2 EVCS. The combination of higher upfront hardware costs, reoccurring fees, and frequent service visits may make administering "smart" EVCS costlier than providing free electricity at a non-networked EVCS.
- Continue to provide funding for publicly owned EVCS. The not-for-profit owner/operator model will be critical to PEV market growth in rural and hard-to-reach areas.

GLOSSARY

CALIFORNIA ENERGY COMMISSION (CEC)—The state agency established by the Warren-Alquist State Energy Resources Conservation and Development Act in 1974 (Public Resources Code, Sections 25000 et seq.) responsible for energy policy. The CEC's five major areas of responsibilities are:

1. Forecasting future statewide energy needs.
2. Licensing power plants sufficient to meet those needs.
3. Promoting energy conservation and efficiency measures.
4. Developing renewable and alternative energy resources, including providing assistance to develop clean transportation fuels.
5. Planning for and directing state response to energy emergencies.

Funding for the CEC's activities comes from the Energy Resources Program Account, Federal Petroleum Violation Escrow Account, and other sources.

ELECTRIC VEHICLE (EV)—A broad category that includes all vehicles that are fully powered by electricity or an electric motor.

ELECTRIC VEHICLE CHARGING STATION (EVCS)–Infrastructure used to supply electricity for the recharging of Plug-in Electric Vehicles

ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE)—Infrastructure designed to supply power to EVs. EVSE can charge a wide variety of EVs, including BEVs and PHEVs.

GREENHOUSE GAS (GHG)—Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include water vapor, carbon dioxide (CO2), methane (CH4), nitrous oxide (NOx), halogenated fluorocarbons (HCFCs), ozone (O3), perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs).

KILOWATT-HOUR (kWh)—The most commonly used unit of measure telling the amount of electricity consumed over time, means one kilowatt of electricity supplied for one hour. In 1989, a typical California household consumed 534 kWh in an average month.

PLUG-IN ELECTRIC VEHICLE (PEV)—A general term for any car that runs at least partially on battery power and is recharged from the electricity grid. There are two different types of PEVs to choose from—pure battery electric and plug-in hybrid vehicles.

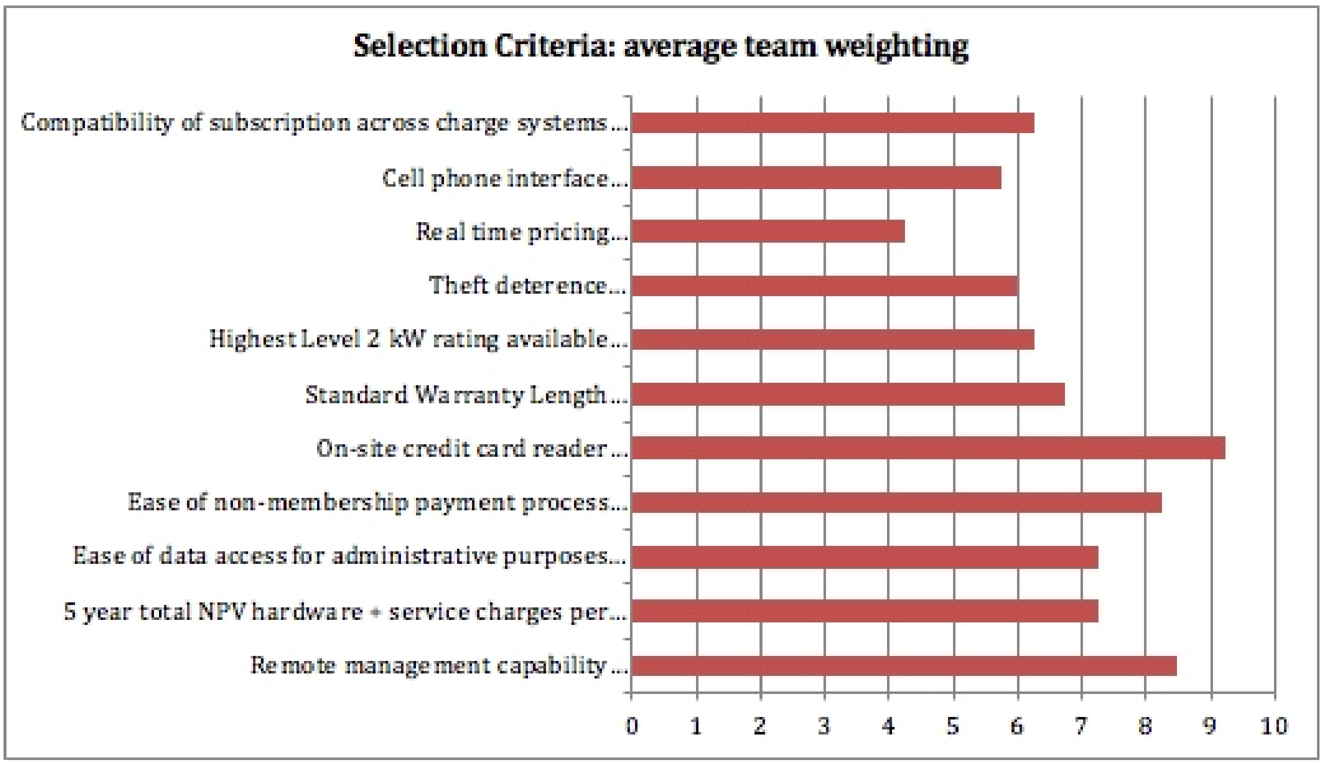
REDWOOD COAST ENERGY AUTHORITY (RCEA)–A local government Joint Powers Authority whose purpose is to develop and implement sustainable energy initiatives that reduce energy demand, increase energy efficiency, and advance the use of clean, efficient and renewable resources available in the region for the benefit of the Member agencies and their constituents.

APPENDIX A: Memo Explaining Final EVSE Selection

In May 2015, the RCEA as the prime on contract agreement ARV-13-029, finalized the EVSE selection process. This memo summarizes the process to identify, compare, and select a final EVSE for this project.

The first step was to identify EVSE available on the market. As an implementation project, the team only considered currently available equipment. To consistently compare EVSEs, the team developed a rubric. This involved a brainstorming exercise to identify a range of potential criteria. The team reviewed this list and identified criteria that were explicitly required within the grant, such as open payment options, or were deemed essential for other factors such as safety and reliability. The team then individually scored the remaining criteria. The participant scores were averaged and used as a weighting value for each criterion, shown in Figure 17.

Figure 17: Average Weighting Values of EVSE Selection Criteria



Source: Redwood Coast Energy Authority

The available EVSE models were then compared using the criteria. The first pass was to confirm availability and compliance with mandatory criteria, and eight candidates passed this stage; see Table 16.

Table 16: Initial Evaluation of EVSE Based on Availability and Mandatory Criteria

EVSE Manufacturer, model	Available	Meets mandatory criteria	Pass
AeroVironment eVse-rs Dual	Yes	No OCPP; subscription required	
Blink Level 2	Yes	No OCPP	
BTC Power Chargion EVP	Yes	Yes	Yes
ChargePoint CT 4021-GW1	Yes	Yes	Yes
ClipperCreek HCS w/ LAT Hydra-R	Yes	No UL listing (ECL)	
DBT-USA GNS Premium	No	n/a	
Eaton Dual	Yes	Yes	Yes
EVCharge America	Yes	Yes	Yes
EVoCharge	Yes	Yes	Yes
EVSE(LLC)	Yes	Yes	Yes
GE Durastation	Yes	No OCPP	
GE Watt Station	Yes	No OCPP	
GRIDbot	No	n/a	
Leviton EVR-Green 4000	Yes	No OCPP	
OpConnect Mark II	Yes	Below 30A output per plug	
Schneider Evlink	Yes	Yes	Yes
Sema Connect ChargePro	Yes	Yes	Yes

Source: Redwood Coast Energy Authority

The next pass was to compare the candidate EVSEs against the weighted criteria. Manufacturers were contacted for details on their products, and once preliminary data was examined, several additional rounds of dialog were required to establish comparable information across vendors. Through the data collection phase, additional information arose that caused the team to re-evaluate their criteria choices and weights. For example, in some cases an EVSE did well overall, but was weak in a single factor such as power rating or payment options. The team evaluated these on a case-by-case basis to determine if an exception was appropriate.

In the results from the quantitative exercise, a shortlist arose with EVSE (LLC) as the clear leader, followed by a three-way tie between BTC, ChargePoint, and Eaton; see Figure 18. The key differentiators were payment options, highest charge rate capacity, and theft deterrence. These factors were ranked high in the criteria weighting, and this combination gave EVSE (LLC) the advantage.

Figure 18: Shortlist of EVSE Following Quantitative Assessment

3			EVSE Models					
4	All EVSE highlighted in red are presumed not available anymore (company out of business)	Criteria Weight	Put EVSE Model Name Here	BTC Power Chargion EVP	EVSE(llc)	ChargePoint CT 4021-GW1	Eaton Dual
5	Includes energy and use data measurement	Reqd.	Y or N	Y	Y	Y	Y
6	Does not require subscription fee or membership	Reqd.	Y or N	Y	Y	Y	Y
7	Uses Open Charge Point Protocol (OCPP)	Reqd.	Y or N	Y	Y	Y	Y
8	Has credit card payment capability	Reqd.	Y or N	Y	Y	Y	Y
9	Is UL Listed	Reqd.	Y or N	Y	Y	Y	Y
10	Provides dedicated 30A (or 32A) output minimum per plug	Reqd.	Y or N	Y	Y	Y	Y
11	On-site credit card reader 0=no reader, 4=swipe only, 8=RFID only, 10=RFID+swipe	5	rate 0 through 10	10	10	8	4
12	Annual Recurring Costs (per plug) 0 = highest, 5 = middle, 10= lowest	8	rate 0 through 10	0.0	2.0	3.3	2.1
13	5 year total NPV including capital costs (per plug) 0 = highest, 5 = middle, 10= lowest	5	rate 0 through 10	3.9	1.5	2.0	2.4
14	Standard Warranty Length 0=no warranty, 1=1 year, 5=3 year, 10=5 or greater	6	rate 0 through 10	10	1	1	1
15	Highest Level 2 kW rating available 1 = 7.2kW, 5 = 13.2kW, 10=19.2kW or greater	8	rate 0 through 10	2.5	8	1	7.5
16	Theft deterence (Locked Cable Retraction) 0=no theft deterence, 10=excellent theft deterence	6	rate 0 through 10	0	10	2	0
17	Dual Plug Option 0= no dual plug option, 5 = dual plug at one power level, 10 = dual plug at multiple power levels	3	rate 0 through 10	7.5	5	7.5	5
18	Commercial Maturity of Network 0= less than 100 installations, 5= more than 500 installations, 10= more than 1000 installations (Source: DOE Alternative Fuels Data	7	rate 0 through 10 (see NumStations tab)	4	6	10	10
19	Total EVSE Score:			4.2	5.5	4.2	4.2

Source: Redwood Coast Energy Authority

Once the quantitative assessment was complete, the team held discussions to consider qualitative criteria. These included remote management capability and data access, variable pricing and demand response capability, cable management (beyond theft deterrence), aesthetics, network bundling, and reference checks. To maximize equitability, this exercise was performed for all eight candidates identified in the preliminary screening. At the conclusion of this exercise, EVSE (LLC) retained the top score and was chosen for this project.

A number of lessons were learned through this process, such as developing comparable metrics across EVSE offerings, considering future capabilities particularly for payment options and charge rate capacity, and addressing localized issues such as vandalism. These lessons will be documented in the final report.

APPENDIX B: Economic Model

Introduction

An analysis of characteristics and economics was required to select the EVCS infrastructure that would be installed, operated, and maintained by the RCEA for the North Coast Plug-in Electric Vehicle Charging Network. As part of the comparison and selection process, an economic model was developed to assess the operation and maintenance cost associated with the top four EVCS that were born out of the selection process. This informed the final decision on the most appropriate EVCS model for the Network in Humboldt County.

Economic Model Methodology

This section outlines the methodology and procedures of running the economic analysis to evaluate estimated EVCS monthly operating costs. We used projected monthly operation costs and revenue to determine a break-even point and profitability thresholds based on user fees.

The economic model was developed in Microsoft Excel. The inputs for the model are used to derive an estimated end-user price per kWh that will fund projected Network expenditures. The Network business model is designed to be non-profit such that revenue will meet but not exceed expected short- and long-term maintenance and operation of the Network.

Price per kWh is a primary constant in the model design and distinguishes the model from fixed-rate mechanisms such as an hourly or per-session fee. A key reason for this approach is to provide a more equitable pricing structure for the range of vehicles and their different charge rates. The approach also provides increased pricing flexibility, such as the ability to link fees with dynamic pricing during peak demand events and to accommodate time-of-use rate schedules.

Prior to the development of the economic model, numerous commercially available EVCS were compared and rated via a selection criteria matrix. This selection process narrowed down the number of EVCS choices to four. The economic model was then one factor used to choose the final EVCS manufacturer and model for the Network.

The four EVCS systems identified for this study are shown in Table 17. Each station has two plugs and is mounted on a pedestal. The Network design used for this analysis is the installation of 10 EVCS of the same manufacturer and model at the nine locations identified for this project.

Table 17: EVCS Products Compared in Economic Model

Company	Product	Contact Name	Phone Number	Email Address
BTC Power	Chargion EVP	Donald Jarecki	(847) 374-8840	djarecki@4fmi.com
EVSE (LLC)	3704 AutoWind	Daniel J. Shanahan Data	(860) 916-7162	dshanahan@controlmod.com
ChargePoint	CT 4021-GW1	Our Evolution Energy and Engineering	(360) 791-3259	info@ourevolution.com
Eaton	Level 2 AC-Commercial	Christy Cunningham	(916) 717-2080	christycunningham@eaton.com

Source: Redwood Coast Energy Authority

The ten sites considered for this study are shown in Table 18. Note that there are two charging stations at the St. Joseph's Hospital location. The rate schedule for each site varies depending on the particular setup of each site. Some sites will have the EVCS tie in directly to the host's meter, and other sites will have a separate meter installed, the account for which will be owned by RCEA.

Table 18: List of Network EVCS sites and Expected Electricity Rate Schedules

Location	City	Owner of Electricity Meter Account	Expected Future Rate
Trinidad Library	Trinidad	Host Site	HA1X
McKinleyville Pierson Shopping Center	McKinleyville	RCEA	HA1X
Willow Creek Chamber of Commerce	Willow Creek	RCEA	HA1X
Arcata Technology Partners	Arcata	Host Site	HA10SX
Northcoast Unified Air Quality Management District	Eureka	Host Site	HA1X
St. Joseph's Hospital (x2)	Eureka	Host Site	HA10S
Fortuna across from City Hall	Fortuna	RCEA	HA1X
Ferndale City parking lot – 4th Street	Ferndale	RCEA	HA1X
Rio Dell City parking lot–Wildwood Drive	Rio Dell	RCEA	HA1X

Source: Redwood Coast Energy Authority

Economic Model Inputs

The following subsections describe the key inputs for the model and how they were derived.

Gasoline Prices

On a three-year average basis from 2012-2015, the price of gasoline for the city of Eureka was $3.55.[7] This value was then divided by 33.41 kWh/gallon factor and multiplied by an efficiency factor of 3.4 to derive an equivalent $/kWh charge of $0.36:

($3.55 / 33.41) * 3.4 = $0.36

This cost is compared with the economic model results to see if the goal of charging less than the price of gasoline is possible given projected charging network costs.

Host Electricity Prices

Host electricity pricing data was determined by analyzing rate schedules from the Pacific Gas & Electric Company. The rate schedules are identified by an alphanumeric code which is defined on the Pacific Gas and Electric website.[8] The three rate schedules currently used by the nine sites analyzed are the time-of-use A1, A10 and E19 rates. When the EVCS are installed the rates tied to some of the EVCS will differ from the host site rate since the EVCS will be tied to a separate meter account which will be owned by RCEA. Other sites will have the EVCS tied directly to the host site's existing meter account such that the host site's rate schedule will determine the actual cost of the energy used by Network customers. Table 18 shows the expected rate schedules for each EVCS site.

Each time-of-use rate schedule differentiates between peak, partial-peak and off-peak hours and the schedule. All three of the time-of-use schedules are defined by the same timelines but have different costs associated with each time segment. This model uses historic vehicle charging data from ECVS currently operating in the Network[9] to estimate the percentage of energy consumed over different time-of-use periods.

Estimated Total Network kWh Consumption

This economic model estimated total revenue generation by an estimated public consumption of kWh after the network is fully built and the Humboldt County region has reached a 2 percent on-road electric vehicle adoption. Previous work under CEC contract ARV-11-006 developed an agent-based transportation model that estimated total kWh required via public charging (i.e. not including the kWh consumed during home charging which is assumed to power roughly 80 percent of miles driven by EV owners) based on region-specific trip and mileage data from the transportation model developed for the Humboldt County Association of

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7 Eureka Gas Prices, available at http://www.californiagasprices.com/Eureka/index.aspx

8 Pacific Gas and Electric Tariff Rates, available at http://www.pge.com/tariffs/ERS.SHTML

9 RCEA has an existing small EVCS network in the Humboldt Bay region as a result of several parallel grant activities, with roughly one year of preliminary data.

Governments. The total annual kWh distributed by the Network is estimated to be 126 megawatt hours[10] at the 2 percent adoption rate.

EVCS Service Charges

Each EVCS has monthly and/or annual service charges associated primarily with data access and billing capabilities. The service charges for each of the EVCS models were determined by receiving quotes from either the manufacturer or distributor of the EVCS. Monthly service charges include:

- Network fees: Costs associated with accessing the data and financials of each charging station. This fee is charged by either the EVCS manufacturer or a third party such as Greenlots.
- Gateway fees: EVCS manufacturers may also charge gateway fees which provide equipment to access the cellular network so that customers can access the station with their smart phones. This is necessary where physical internet connection is infeasible.
- Cellular fees: For cell-based telemetry, the cost for connecting to a wireless network so that the EVCS can send and receive data and complete billing services. Except for ChargePoint, the cellular fees are based on whatever plan the EVCS owner sets up with their respective telecommunication provider.
- Internet service fees: This is the cost to supply a physical internet connection for EVCS.

In addition to the monthly service costs, the economic model took into account an annualized marginal capital cost for those EVCS models that would cost more to install than the grant funds available in this contract. This additional cost was modeled as a 0 percent loan taken from RCEA's general fund, paid back over five years assuming a discount rate of 5 percent.

RCEA Management Costs

The monthly overhead budget for the EVCS stations will be provided by RCEA and is broken out into eight categories as described below.

- **Network Administrative Oversight**: administrative oversight will require two hours of work per month each for an energy specialist and a Network manager with a fully loaded rate of $80.88 and $37.46/hour respectively[11].
- **Site Host Reimbursement**: it is assumed that reimbursement of electricity costs to sites where the EVCS is tied to the site host's electricity meter will require eight hours of work quarterly each for a contract support person and a program assistant, both at a fully loaded rate of $37.46/hour. This includes time necessary to perform data validation and calculation updates.
- **Network Management**: Network management would be supported by RCEA’s IT department and is budgeted for eight hours per month at a fully loaded rate of $37.46/hour.

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10 Zoellick, Jim, David Carter, Colin Sheppard, Jerome Carman. 2014. North Coast Plug-in Electric Vehicle Readiness Project. California Energy Commission. Publication Number: CEC-ARV-11-006.

11 Rates apply to 2015 fully-loaded staff costs.

- **Physical Location Check**: Sites will be inspected at least once every quarter by the Network manager. This model assumes each station check will take 15 minutes at a rate of $37.46/hour. Additionally, a cost adder is included which assumes 20 miles of travel per station per visit at a rate of $0.58 per mile.
- **General Maintenance**: average maintenance for the EVCS is presumed to be similar to that of metered parking lot payment kiosks. Based on this assumption, maintenance rates for parking kiosks in San Diego were used as an estimate. In San Diego, the total cost of maintenance per month is $93 per pay station including labor and materials[12].
- **Vandalism Adder**: based on past experience with the existing Network and given the remoteness of the location of some of the EVCS in the Network, it is assumed that one charging cable will be replaced per year for the ten stations at a cost of $395/cable. It is also assumed that this replacement would take four hours at a fully loaded rate of $50/hour. It is hoped that this is a very conservative estimate.
- **Insurance**: conversations with the insurance agent confirmed no adjustment is needed to RCEA's insurance rates associated with assuming responsibility for the Network.
- **Plug Degradation Adder**: based on communication with some EVCS suppliers from an inquiry into warranty cost justifications, it is expected that the J1772 connector at the end of each charging cable of each EVCS will fail from normal use roughly every five years. Plug replacements are assumed to be every five years at a cost of $395 per plug. The labor for this is assumed to be four hours to replace each plug every five years at a fully loaded rate of $50/hour.

Results

The purpose of this study is to estimate the $/kWh charges for the stations necessary to pay for the ongoing operation and maintenance costs associated with the Network. Table 19 provides these resulting estimated costs and shows how they compare to the assumed Eureka city gasoline price for each EVCS model. On a per kWh basis, it appears possible to recoup all short- and long-term operation and maintenance expenses for price that is competitive with gasoline.

12 Final Report - Downtown Multi-space Parking Station Pilot Project. Revenue Collections Division, City Treasurer's Department report to the Downtown Parking Management Group. City of San Diego, April 4th, 2007, available at http://www.sandiego.gov/parking/pdf/20070404_finalrpt.pdf

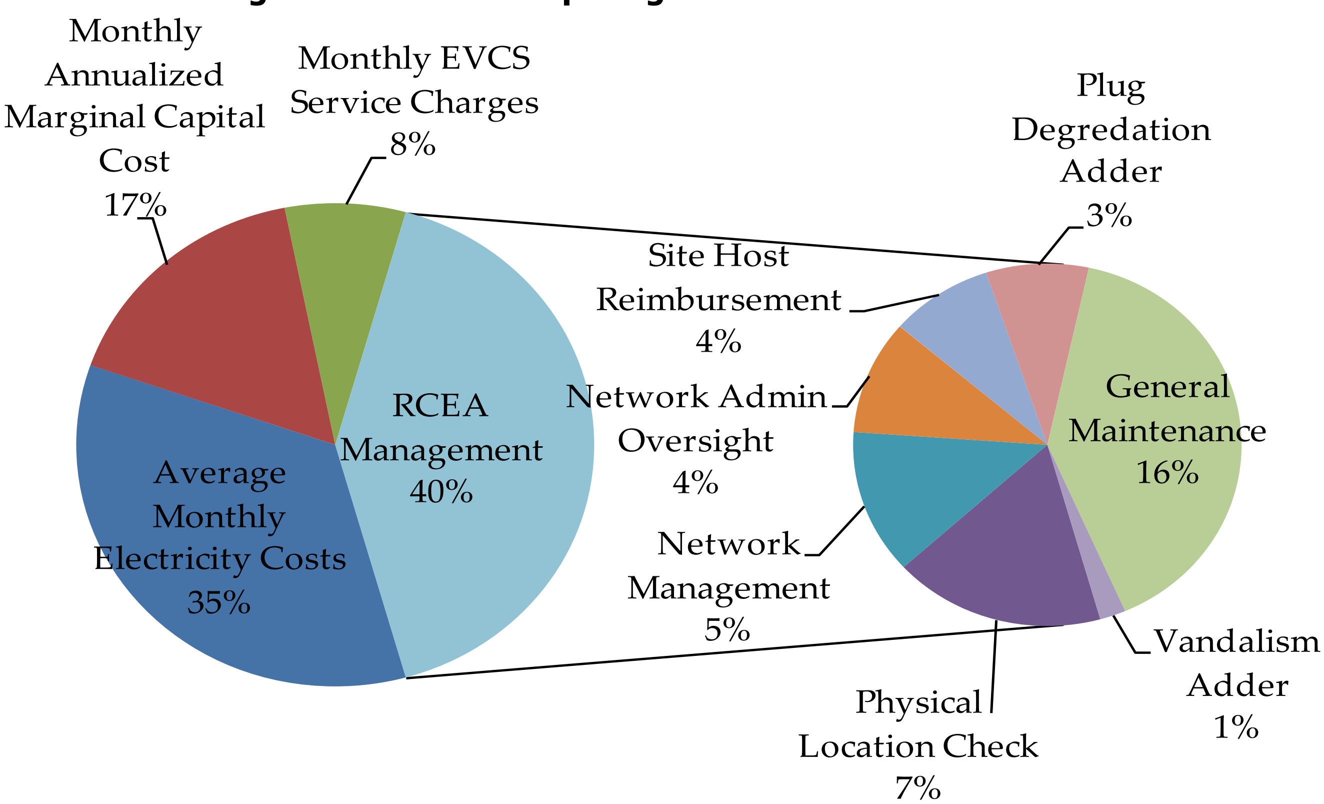
Table 19: Monthly Costs Per Station, Predicted $/kWh Needed to Recoup Those Costs, and the Comparison of this $/kWh to the Price of Gasoline

EVCS Model	RCEA Management Costs	Electricity Costs	EVCS Service Charges	Monthly Annualized Marginal Capital Cost	$/kWh required	% of Price of Gasoline
BTC Power	$116.17	$97.99	$28.20	$0	$0.24	66%
EVSE (LLC)	$116.17	$97.99	$14.33	$54.91	$0.28	78%
ChargePoint	$116.17	$97.99	$18.67	$112.43	$0.37	102%
Eaton	$116.17	$97.99	$23.83	$0	$0.24	66%

Source: Redwood Coast Energy Authority

The pie chart in Figure 19 shows how each of these costs contribute to the overall monthly costs for running ten EVCS stations, averaging between the results of the four EVCS models shown in Table 19. Total expected monthly revenue is about $6,000 with a 2 percent EV adoption rate and the planned Network of 10 dual plug stations.

Figure 19: Chart Comparing All Modeled Network Costs



Source: Redwood Coast Energy Authority

Interpreting Cost

The findings from this analysis show that rates for the EVSE LLC and ChargePoint models are more expensive because the monthly cost calculations take into account the additional capital cost needed to purchase these models. Network management costs are expected to be the bulk of Network operation and maintenance expenses. Once the marginal capital costs are paid off, RCEA management costs represent 50 percent of total Network costs, electricity costs 41 percent, and Network fees 9 percent.

Another perspective on these costs is to consider the additional costs above the electricity cost as the price for providing the public service. This works out to be about 200 percent of the cost of electricity when the marginal capital costs are included, and 140 percent of the cost of electricity after the marginal capital cost is paid off.

Note that there is an economy of scale as more EVCS are added to the Network. With the management costs representing the majority of the costs, the cost per station decreases significantly with each additional station. The monthly cost per station for the 10-station Network is about $470, not including the marginal capital cost. If the number of stations is doubled to 20, the monthly cost per station drops to about $330.

Cable Management

Part of the increased cost is to include retractable cord reels to decrease damage and to improve cord longevity and safety.[13] The network is located in a maritime environment, and some existing EVCS have observed vandalism in recent history. Beyond retractable reels, the economic model includes conservative estimates to include repair costs following potential vandalism. Plug degradation is also considered based on dialog with manufacturers regarding warranty offerings. Cord management improves the ability to address Occupational Safety and Health Administration and Americans with Disabilities Act regulations as they develop. However, these systems increase complexity and moving parts, which will incur maintenance costs.

Americans with Disabilities Act Accessibility

Although the Americans with Disabilities Act does not yet provide design standards for EVCS, these are available through several industry guidelines, and are adopted for this project as a best practice. One consequence is that the physical placement of charging stations must now consider the location of Americans with Disabilities Act parking, which typically increases design complexity. This is particularly true where future EVCS expansion is in direct conflict with premium parking. These tradeoffs are not specifically built into this economic model as they are driven by design choice but deserve consideration particularly since Americans with Disabilities Act will likely develop future EVCS regulations.

Future Considerations

During site development, additional topics arose that weren't apparent during initial micro-siting activities. These include site expansion, network accessibility, and metering.

Site Expansion

The economic model considered a fixed population of ten stations and doesn't address future expansion. Observations on manufacturing pricing structures suggest that installations are expected to spread recurring costs across more than one or two ports. This is particularly true for network gateways, which can be shared across many station ports as long as they are

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13 Early station designs often result in cables lying on the ground, causing issues with safety and cleanliness. Regarding safety, regulations may emerge that address better cable management.

within signal range. This scaling has a disproportionate economic effect on small installations. Rural installations are likely to be restricted in their ability to grow, such as from limited parking capacity, or demand at any one location. This restricts the ability for rural sites to spread installation and recurring costs across multiple stations. If manufacturers explicitly set service fees with the expectation that operators can allocate costs across multiple stations, single-station installations will observe decreased viability.

Network Accessibility

The initial network design included physical internet access to avoid cellular fees, but this proved unrealistic for several reasons. Internet availability would be the responsibility of the site host, potentially impacting EVCS availability based on connectivity issues and so on. It would be difficult to assess a reasonable fee for the shared service. Also, network changes would require close coordination and scheduling between site and EVCS administrators, likely causing delays. Where outages required coordination with site host staff, delays may also result if issues occur outside of normal business hours. Internet cable would require physical routing when wireless solutions were infeasible, and wireless solutions are inherently more vulnerable to malicious activities.

The alternative networking option is cellular service, which addresses most of the issues with internet connectivity. The most obvious tradeoff is cost, since cellular service noticeably increases monthly recurring costs. This increases the required station utilization rate to break even on recurring costs. Additionally, cellular service can be marginal or absent in various locations, so it isn't a complete solution.

Electric Metering

Initial design criteria chose to use the existing site host electrical service to feed the EVCS. Follow-up dialog with site hosts required a new approach for more than half the sites regarding access to electricity. The primary concerns involved potential demand charges and related rate increases, current and future service capacity, cost outlays and associated reimbursement mechanisms, and complexity of sharing a utility service. The solution was to install new meters under the network administrator's responsibility, in this case RCEA. This eliminated the need to calculate electric consumption and associated reimbursements and created a distinct ownership and control boundary around the utility service. An added benefit is total control for the network administrator to monitor electric service and maximize uptime. New, stand-alone service also increases onsite electric capacity for future expansion.

These benefits are significant enough to be considered a best practice for future installations. The major downside, particularly regarding the economic model, is the increased cost to install new electric service at each site. Pacific Gas and Electric required an engineering advance to assess onsite electrical service and utility interconnection constraints, as well as the cost of a new meter and potentially a meter pedestal and pad. These incremental costs can be reduced by coordinating the work with the EVCS trenching, conduit, and related construction tasks. Note that the cost of new electrical service is diminished substantially when multiple charging stations are installed, which may be the default situation in any case depending on electrical service capacity at the site. Whenever, possible, site plans included stub-outs to support future expansion and provide an opportunity to allocate installation and maintenance costs among multiple charging stations.

APPENDIX C:
St. Joseph Hospital Quarterly Report

Figures 20 and 21 show the St. Joseph Hospital Quarterly report and St. Joseph's Energy Consumption.

Figure 20: St. Joseph Hospital Quarterly Report

RCEA EV Network Site Report

Date Range:	1/1/2017-3/31/2017
Reference Number:	REVN-0065
Total Reimbursment:	**$509.44**

Site Host

St. Joseph's Hospital, Eureka
Attn: Sherie Henderson-Bialous
2700 Dolbeer Street
Eureka, CA 95501

Charging Station Location

Station IDs:
013-EUR-STJ-021
013-EUR-STJ-022
013-EUR-STJ-023
013-EUR-STJ-024

Reimbursment Calculations*

Electricity Distributed to Charging Station Customers (kWh):	2358
Average Cost Per kWh:	$0.216
Total Reimbursment for Electricity Used:	$509.44

Charging Statistics*

Total Number of Charge Events	252
Average Time Plugged In:	3:52
GHG Emissions Saved (MT CO2):	2.09489
Gallons of Gas Saved:	193.92

*No-cost fleet vehicle charging statistics are not included in the reported values above

The RCEA EV Network is a not-for-profit initiative to develop a locally managed, affordable, and economically sustainable network of publically available electric vehicle charging stations in the North Coast region. The goals of this initiative are to accelerate electric vehicle adoption, promote equitable access to charging stations in the region, and reduce greenhouse gas emissions associated with vehicle travel.

REDWOOD COAST EnergyAuthority
Phone: (707) 269-1700 www.redwoodenergy.org
Billing questions: evadmin@redwoodenergy.org
All other questions: ev@redwoodenergy.org

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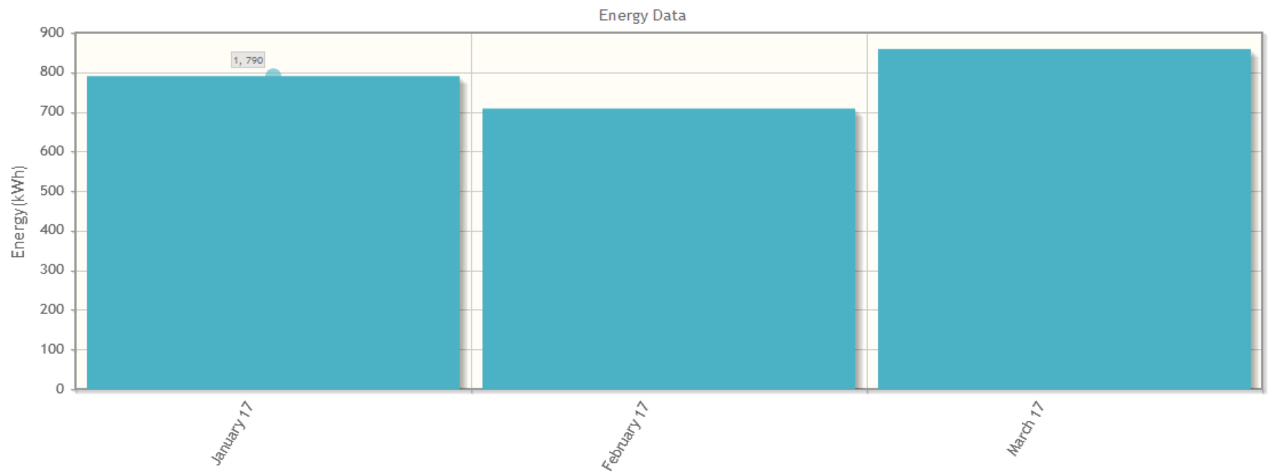
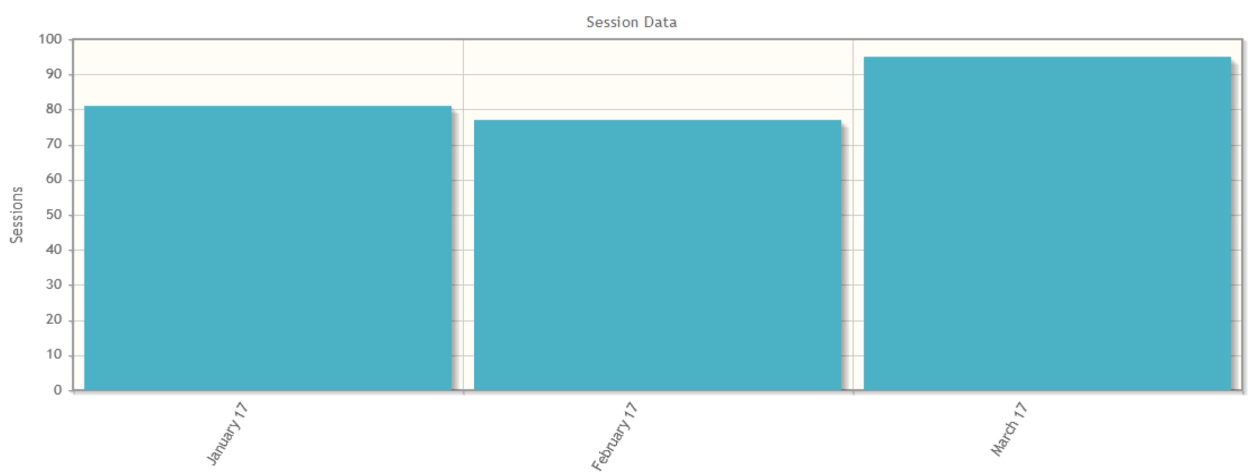
Figure 21: St. Joseph Hospital Energy Consumption

Energy Consumed per Month (Jan 1, 2017 - Mar 31, 2017)



Number of Sessions per Month (Jan 1, 2017 - Mar 31, 2017)



Source: Redwood Coast Energy Authority

APPENDIX D: St. Joseph Parking Concept and Policy

To: Pierce Schwalb, Program Specialist, Redwood Coast Energy Authority From:
From: David Carter PE, Senior Research Engineer, Schatz Energy Research Center
Re: Parking and Charging Policy for St. Joseph Hospital

The purpose of this memo is to provide the deliverables for Task 3.3 under the agreement between the RCEA and the Schatz Energy Research Center (Sponsor Award #AR-13-029PT). Task 3.3 involved developing, implementing, and evaluating a PEV Charging Parking Management Policy and System at St. Joseph Hospital in Eureka, CA.

Below you will find a summary of the policy used by St. Joseph Hospital to manage the competing parking and charging demand in the four EV charging stalls that were installed under this project. Attached to this memo you will find the following documents:

1. A document showing a concept for an automated parking and charging system that I developed and that has been discussed with staff at St. Joseph's Hospital.
2. Conceptual Plans for the installation
3. My opinion of probable cost for the installation.

Summary of Parking and Charging Policy at St. Joseph Hospital

The parking lots at St. Joseph's hospital are under pressure from heavy usage and the decision to allocate four stalls for EV charging was not taken lightly. Initially the two of the four stalls were marked "EV Charging Only" and the other two were marked "EV Charging." The thought behind this was to allow

some of the spaces to be used for parking if demand for EV charging was low. Relatively soon after the EV charging stations were installed, hospital administrators decided to mark the other two stalls "EV Charging Only" due to demand for charging.

There have been consistent incidences of conventional vehicles parking in the EV charging stalls. To address this hospital administrators instituted the following policy:

- If a conventional vehicle is found to be parked in an EV stall a note is placed on the car notifying the driver that the stall is for EV charging only and the license plate number is recorded.
- In a case where the same conventional vehicle parks in an EV stall three or more times, a parking boot is placed on one of the vehicle's wheels.
- The driver has to talk to facilities personnel to get the boot removed and they are warned not to park in the stall again unless they are charging an EV.

This policy has been working reasonably well to date. Facilities personnel report that the stalls are being used regularly and that on average the stalls appear to be about half full with EVs charging during business hours. They would like to always have at least one stall open for EV charging and they would also like to be able to make the most use of those parking spaces in charging demand is low. Facilities personnel have expressed interest in learning more about an automated parking and charging management system such as is described in the attached document.

To: Pierce Schwalb, Program Specialist, Redwood Coast Energy Authority
From: David Carter PE, Senior Research Engineer, Schatz Energy Research Center
Re: Parking and Charging Policy for St. Joseph Hospital

The purpose of this memo is to provide the deliverable for Part 3 of Task 3.3 under the agreement between the RCEA and the Schatz Energy Research Center (Sponsor Award #AR-13-029PT). Task 3.3 involved developing, implementing, and evaluating a PEV Charging Parking Management Policy and System for the St. Joseph Hospital in Eureka CA.

Below you will find the results from the implementation of the parking policy at St. Joseph Hospital. This parking policy was implemented to manage the competing parking and charging demand in the four EV charging stalls that were installed under this project.

Results from Implementing the Parking and Charging Policy at St. Joseph Hospital

Due to heavy demand for parking, there have been consistent incidences of conventional vehicles parking in the EV charging stalls at St. Joseph Hospital. For this reason, facilities personnel implemented the parking policy which is outlined in the Memo deliverable for Part 1 of Task 3.3.

The parking policy has been working reasonably well to date. Facilities personnel made the following observations about the policy's effectiveness:

- Placing standard parking violation stickers on internal combustion engine vehicles has been an effective deterrent. The number of repeat violations has decreased dramatically since the policy was initiated. The stickers contain standard language and are used for all other parking violations across the campus. They are backed with a special adhesive which makes them difficult to remove.
- There were three recorded parking violations in the month of March, which exceeds the current average of two parking violations per month.
- Doctors and employees of the Hospital are no longer violators. The parking policy has been effective in deterring regular users of the parking lot from parking in the EV only spaces. Most violators are Hospital visitors.

While this policy has been successful in reducing the number of violations by repeat offenders, facilities personnel still need to place violation stickers on two to three internal combustion engine vehicles per month. In addition, multiple commenters on the EV charging map website Plugshare.com have complained about the presence of internal combustion engine vehicles in EV only parking spaces at the Hospital. Implementation of the automated parking and charging management system developed by Dave Carter for Part 2 of Task 3.3 would solve the issue of ongoing violations by first time offenders. Schatz Energy Research Agency, RCEA, and St. Joseph Hospital intend to pursue funding for the installation of this automated parking and charging management system.

Figure 22 shows a PowerPoint presentation on the St. Joseph Hospital parking layout concept.

Figure 22: St. Jospeh Hospital Parking Concept

Plug-In Electric Vehicle (PEV) Charging/Parking Management for St Joseph Hospital, Eureka CA

- Contents:
  - – Challenge
  - – Solution Concept
  - – Technical Readiness
  - – Policy Enforcement

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707-826-4345

SCHATZ ENERGY RESEARCH CENTER

Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

Challenge

- Coincident demand for parking and charging leads to tension
- Facility managers are unsure about how many chargers to install
  – Goals are to maximize charger utilization and minimize stranded assets (parking stalls and chargers)
- How to enforce a fair policy that make the best used of available stalls?

Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

Solution Concept: Automated PEV charging hub

- A set of parking stalls
- One PEV charger per stall
- One dynamic display per stall
- One vehicle sensor per stall

Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

Parking-Charging Policy

- Maintain one stall available for EV charging whenever possible.
- Place note on vehicle upon violation
- After 3 violations on same vehicle install parking boot on offender's vehicle

Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

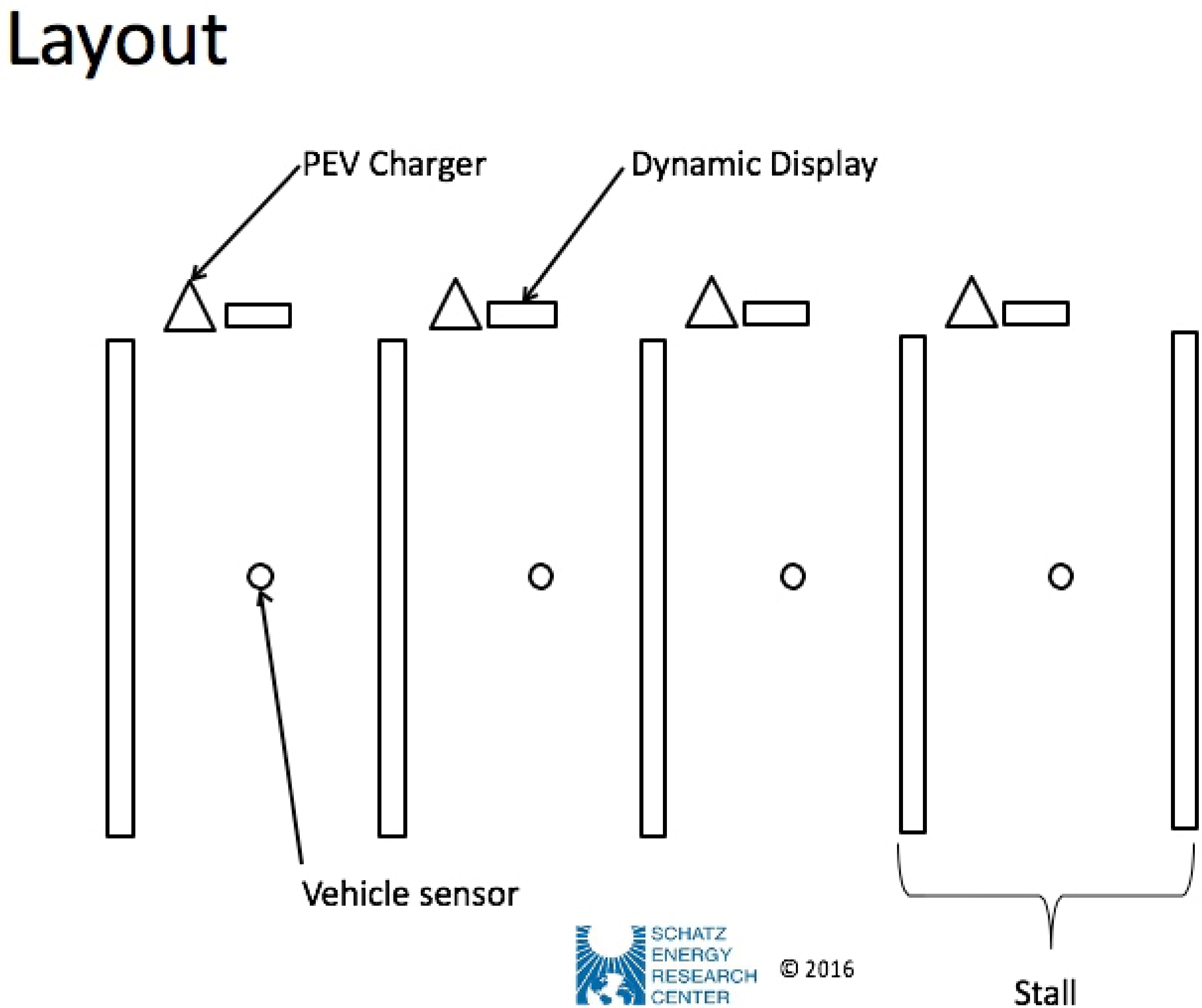


Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

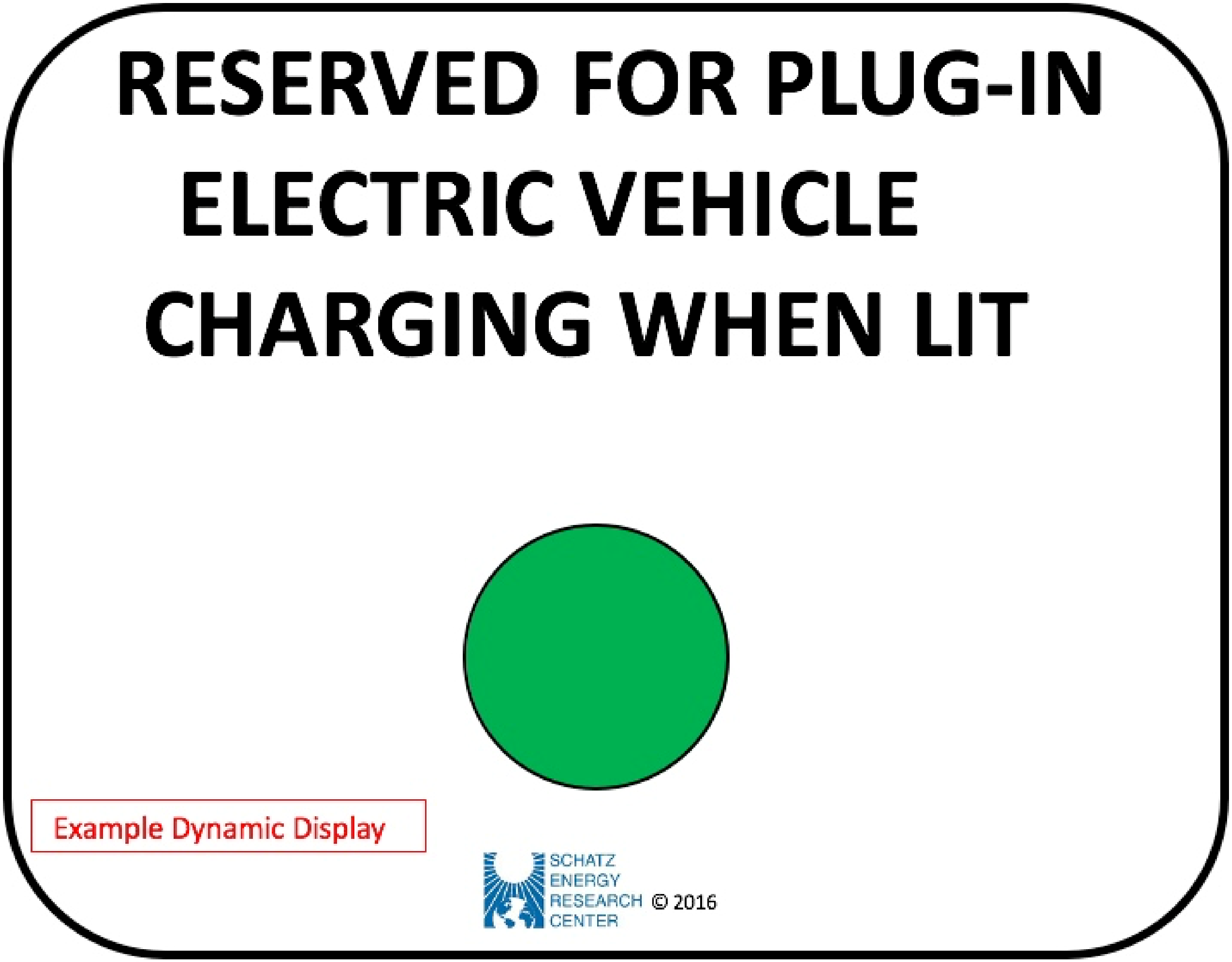


Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

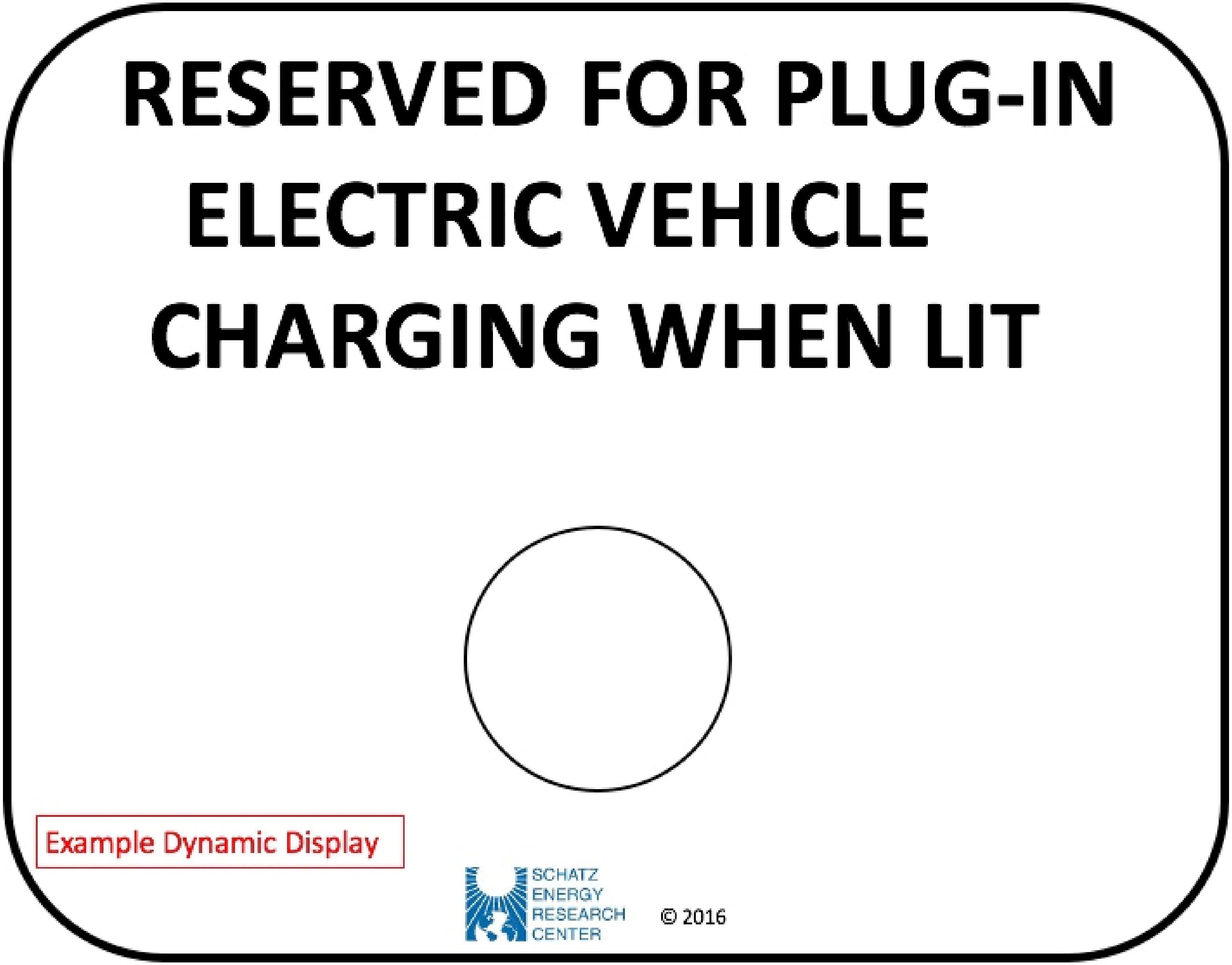


Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

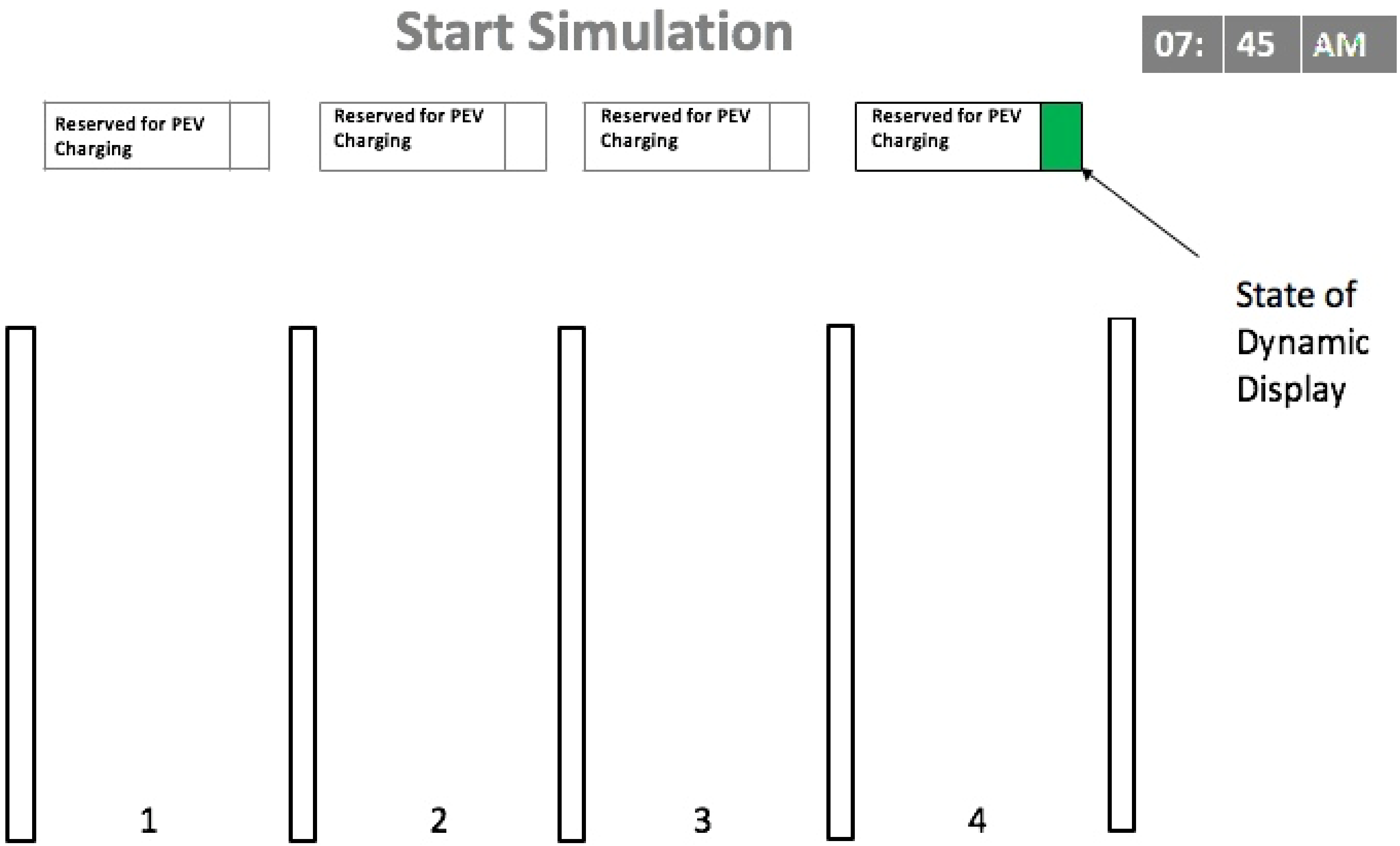


Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

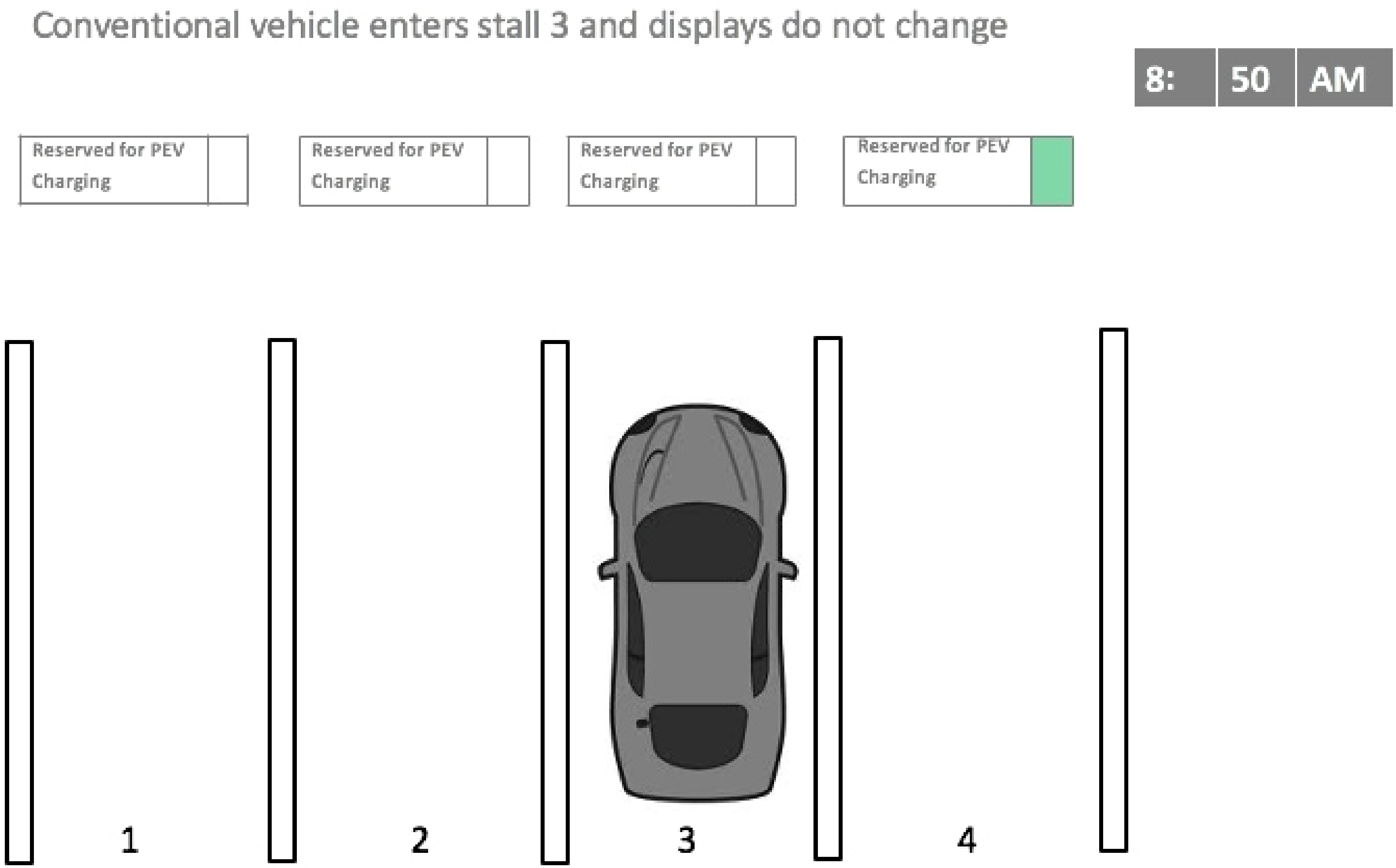


Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

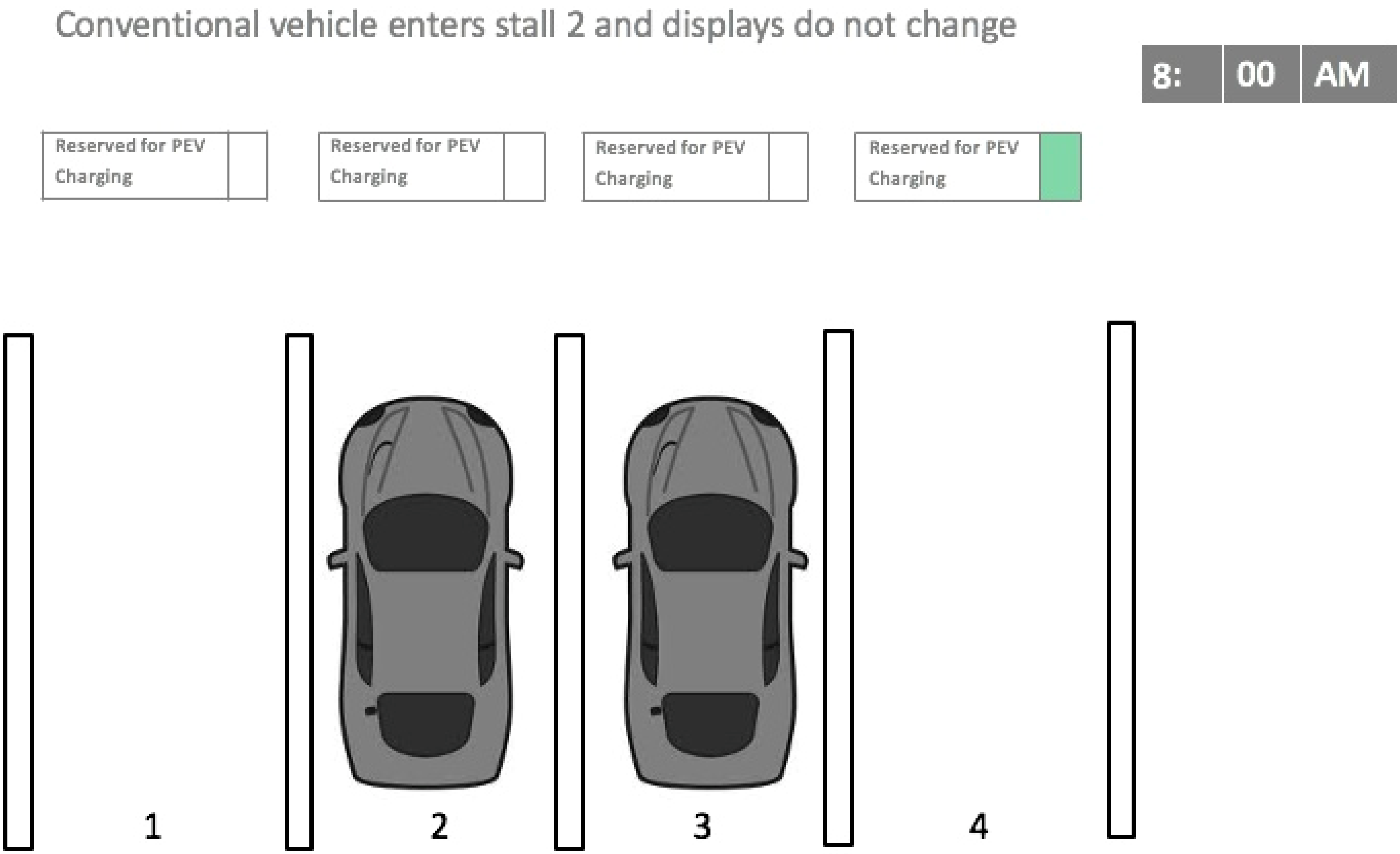


Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

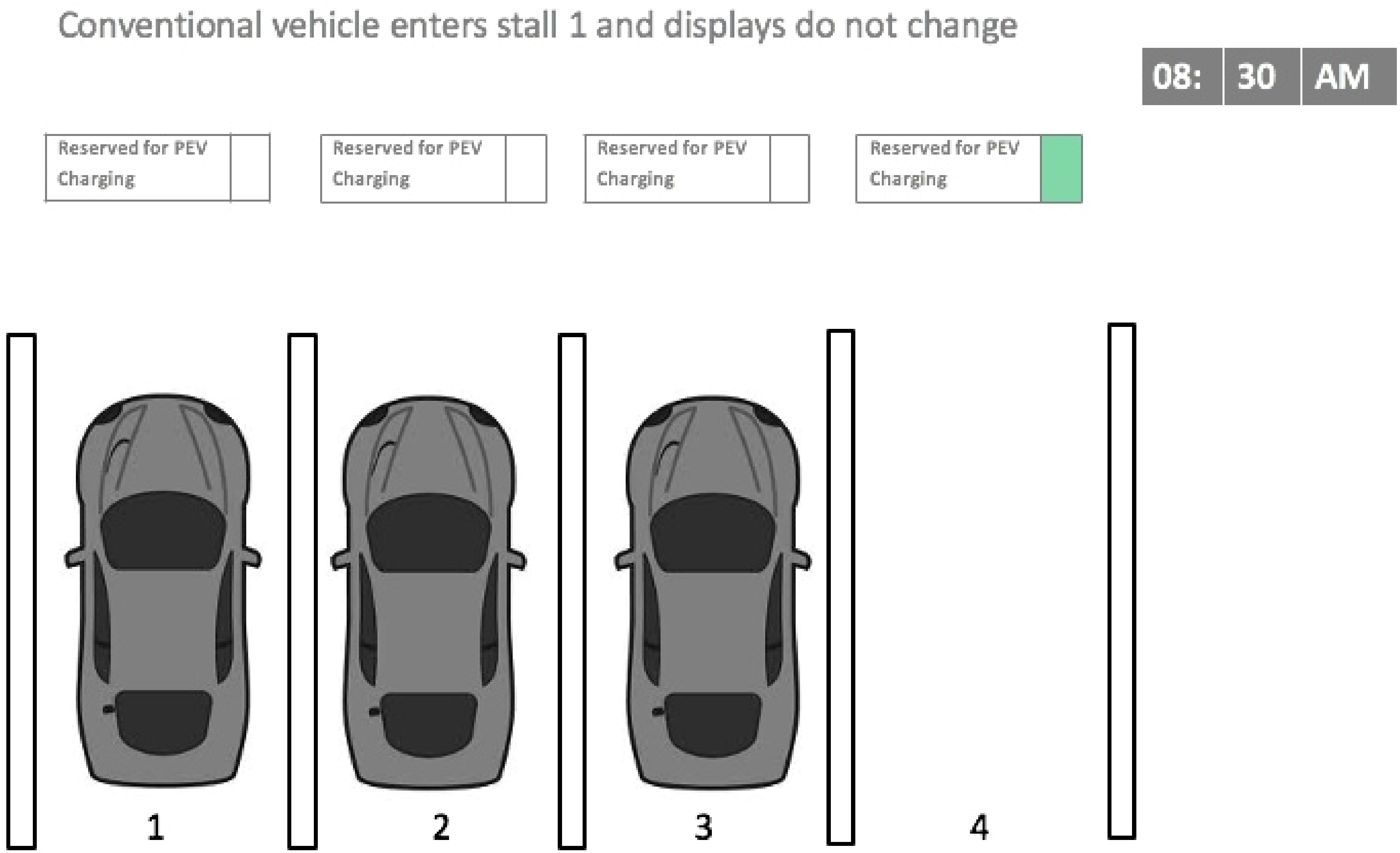


Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

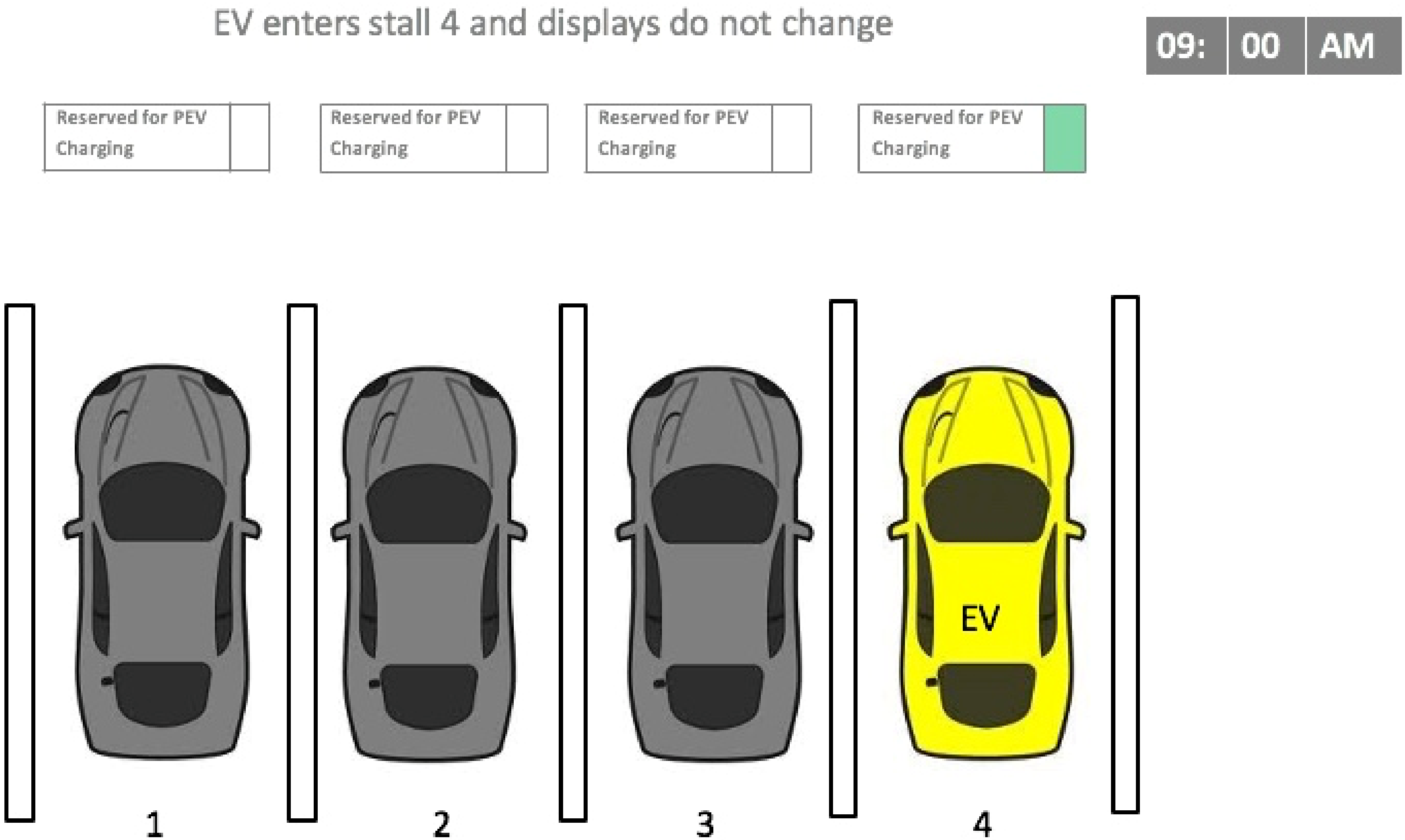


Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

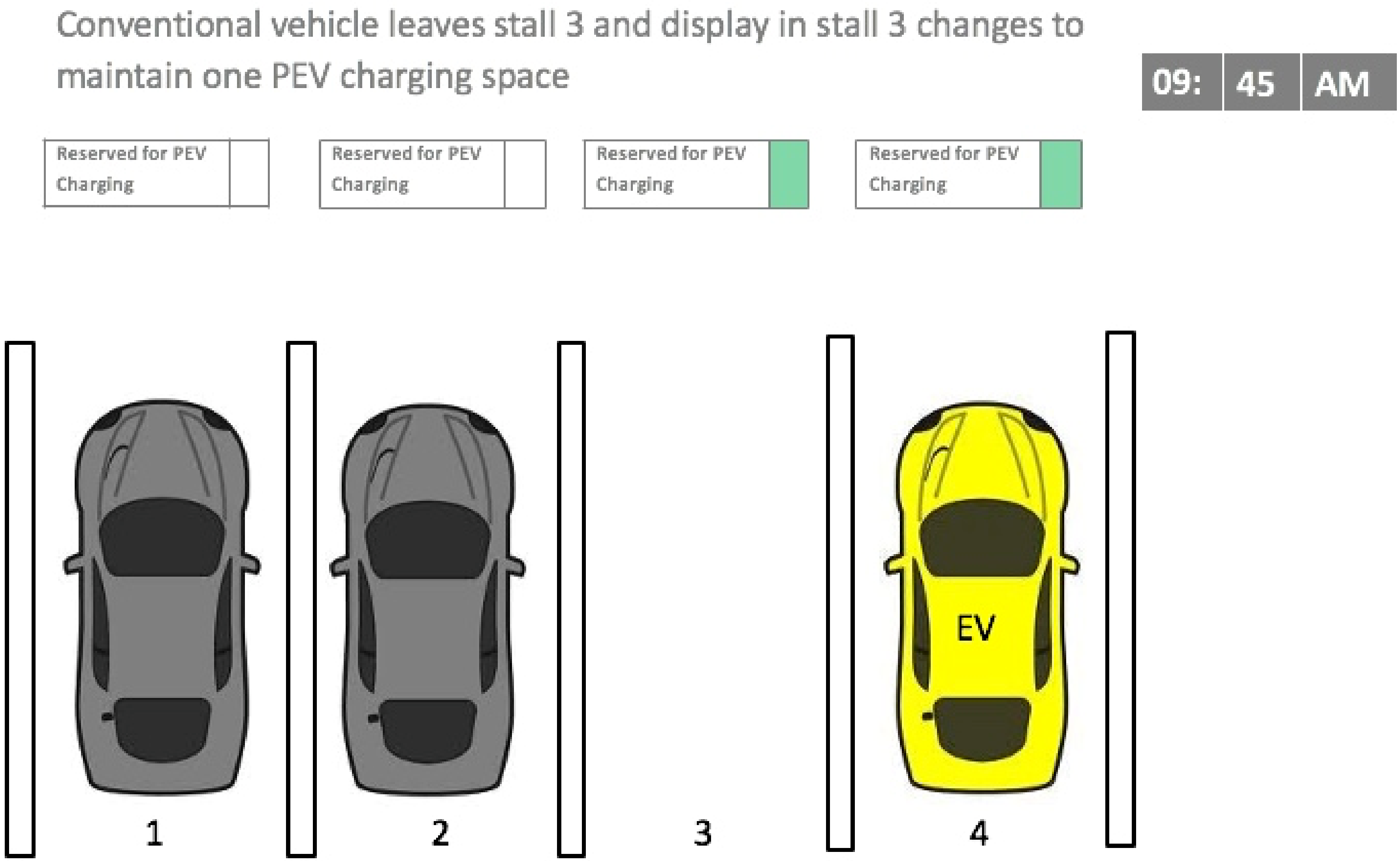


Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

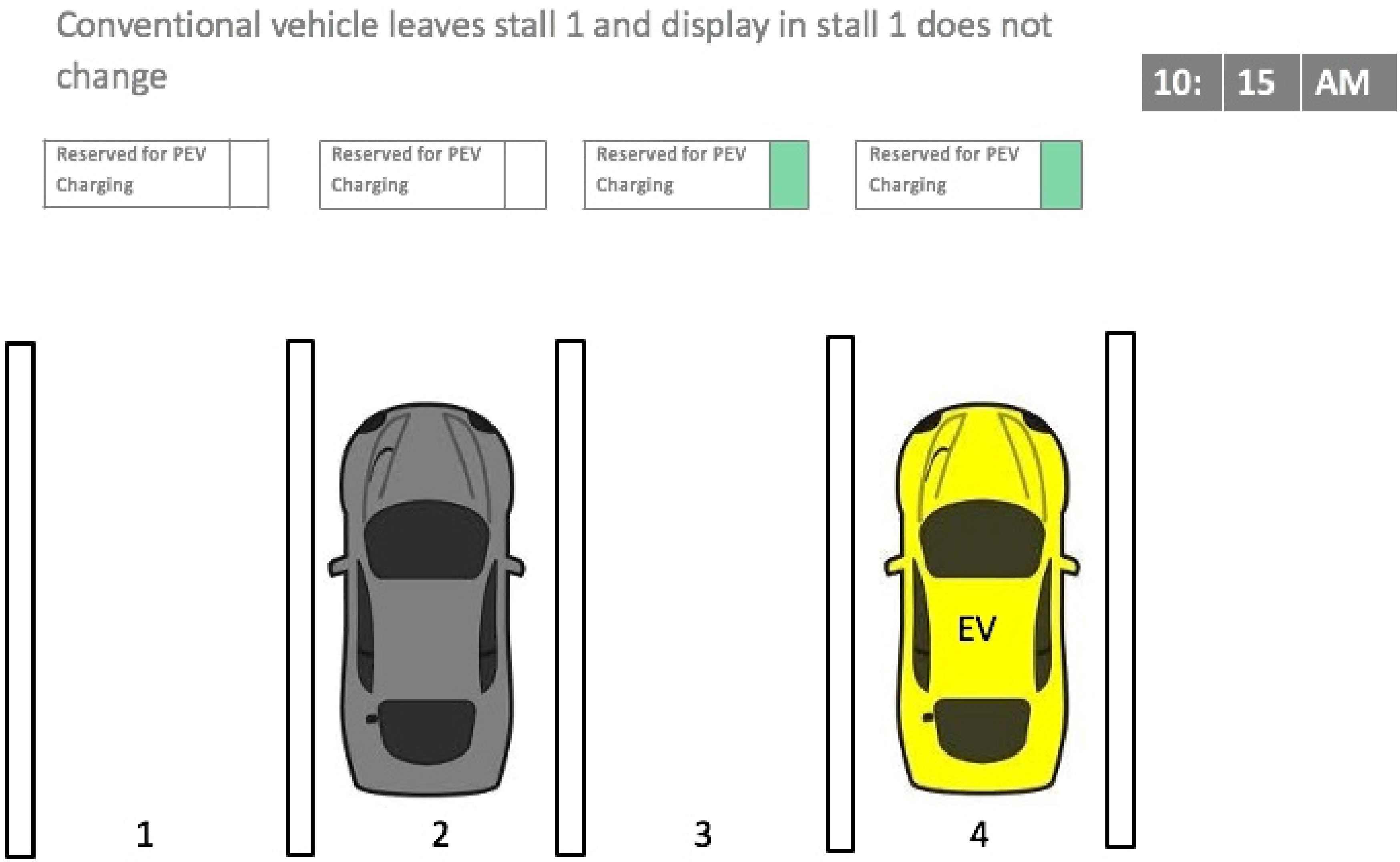


Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

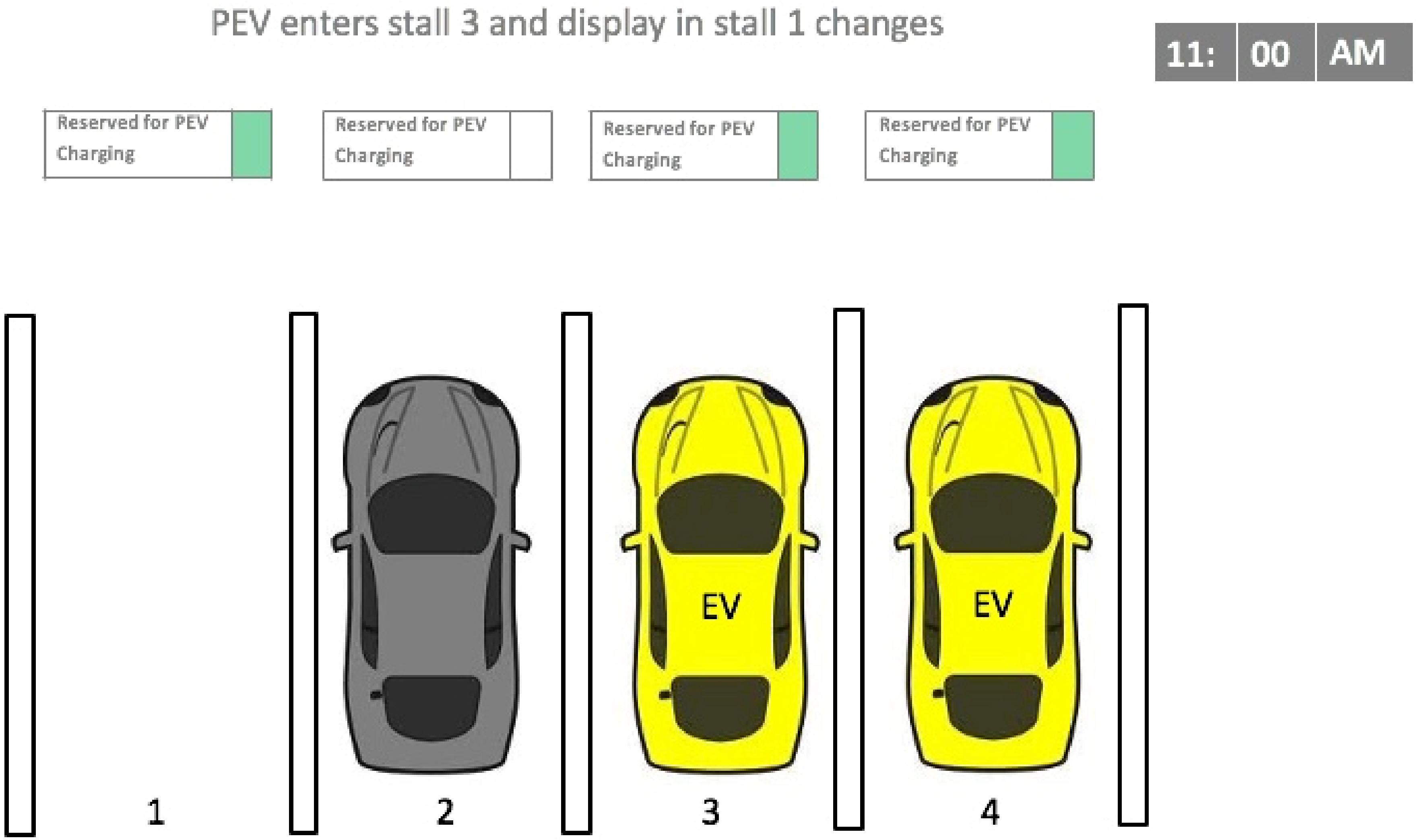


Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

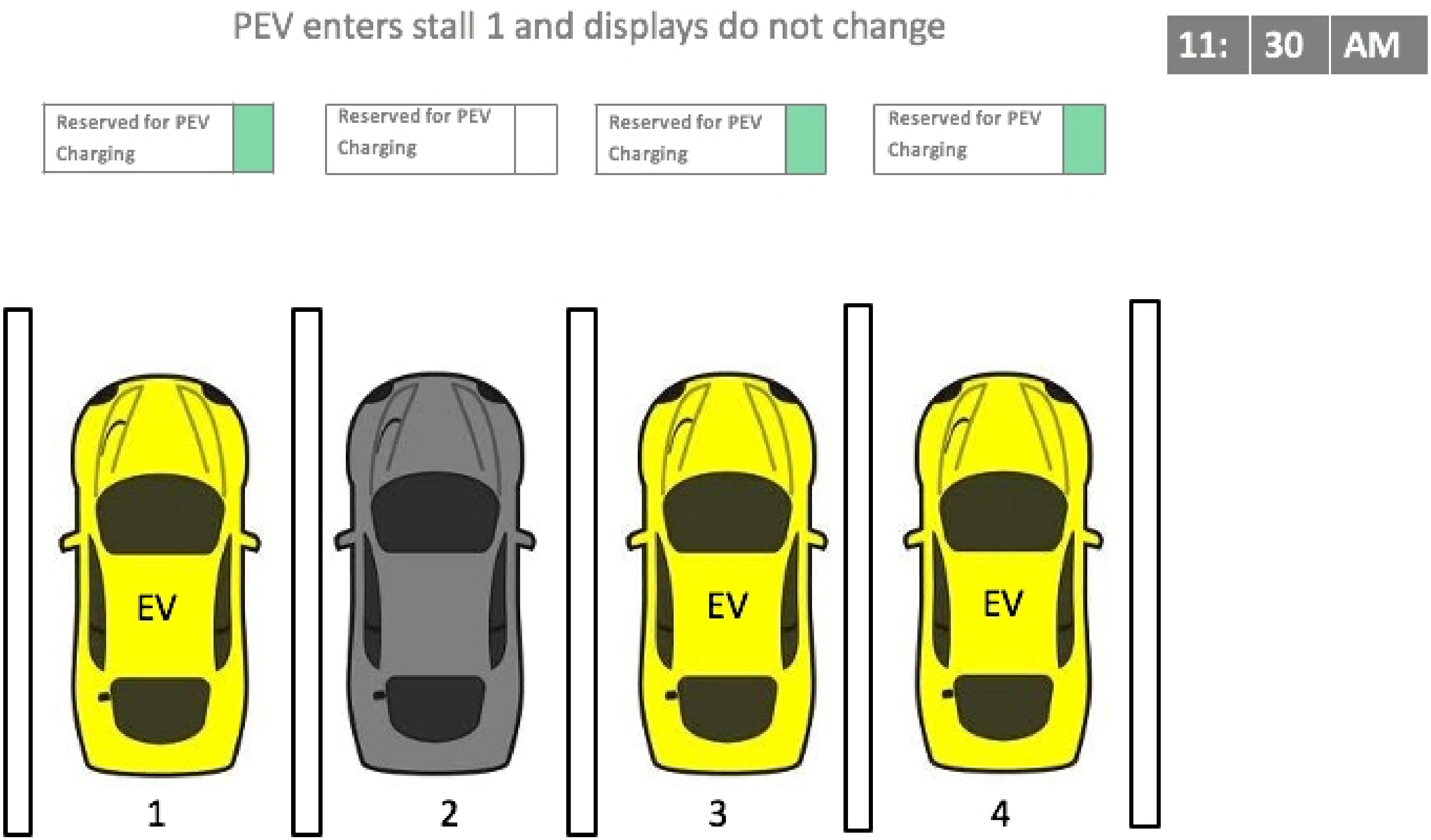


Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

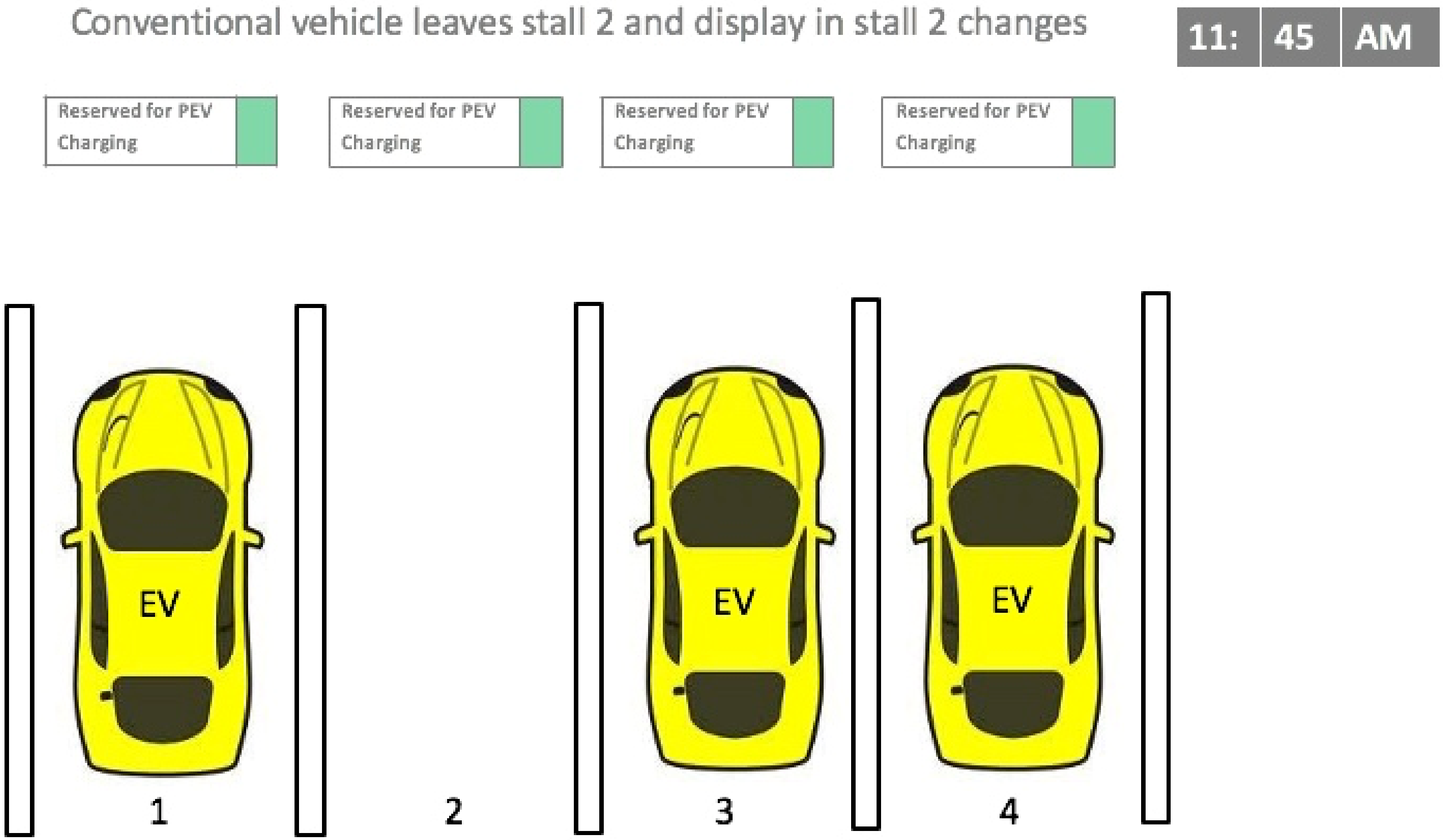


Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

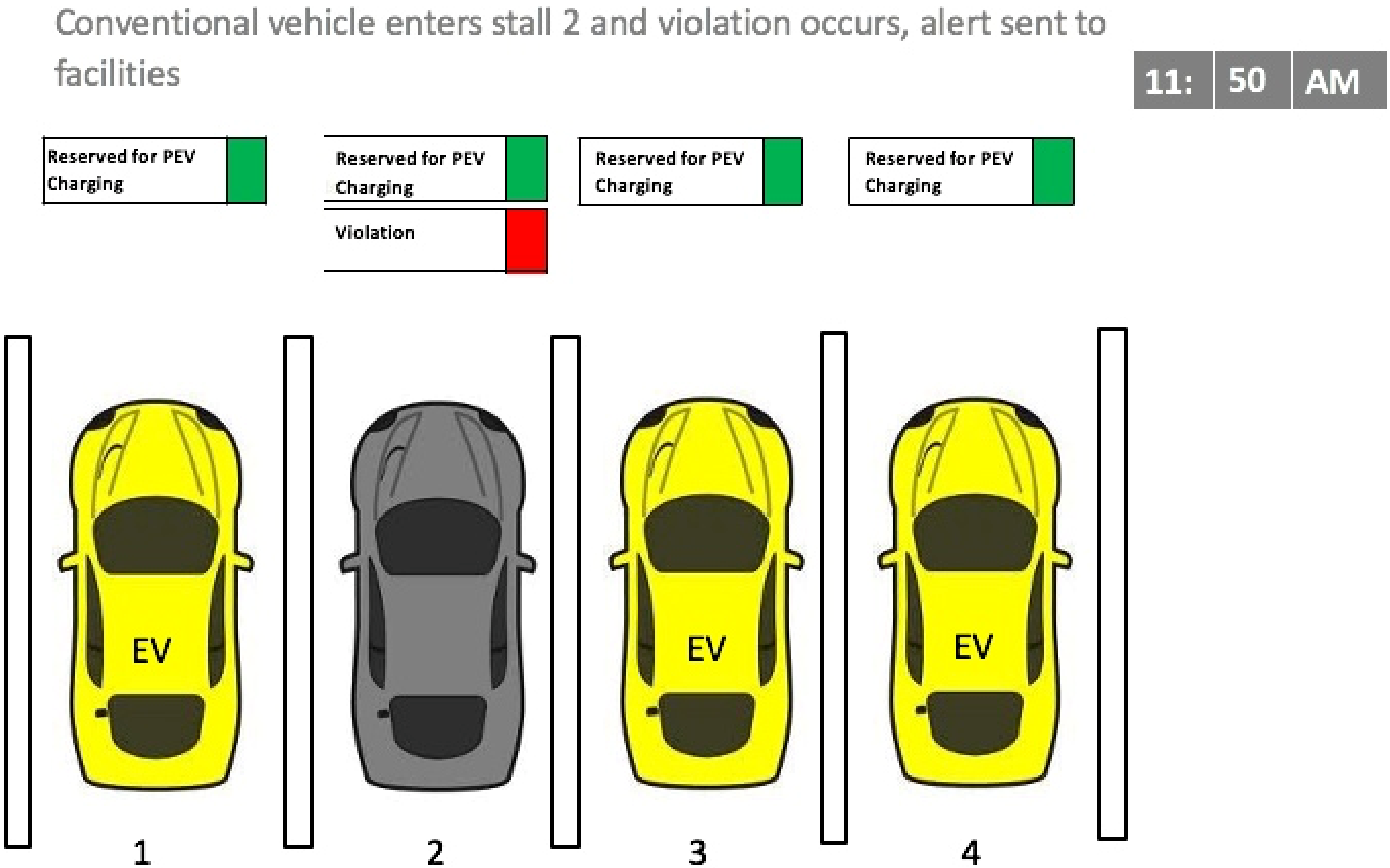


Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

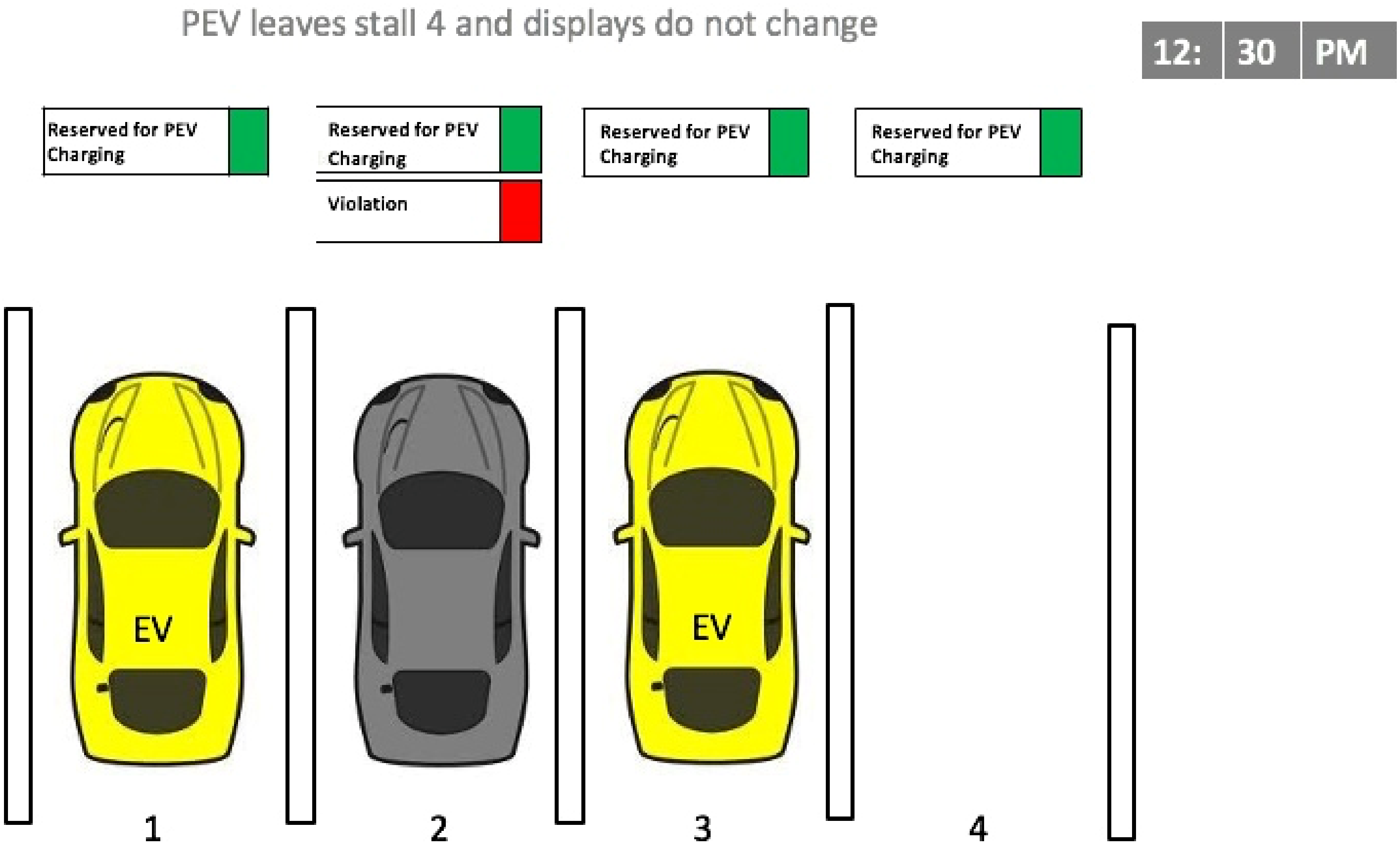


Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

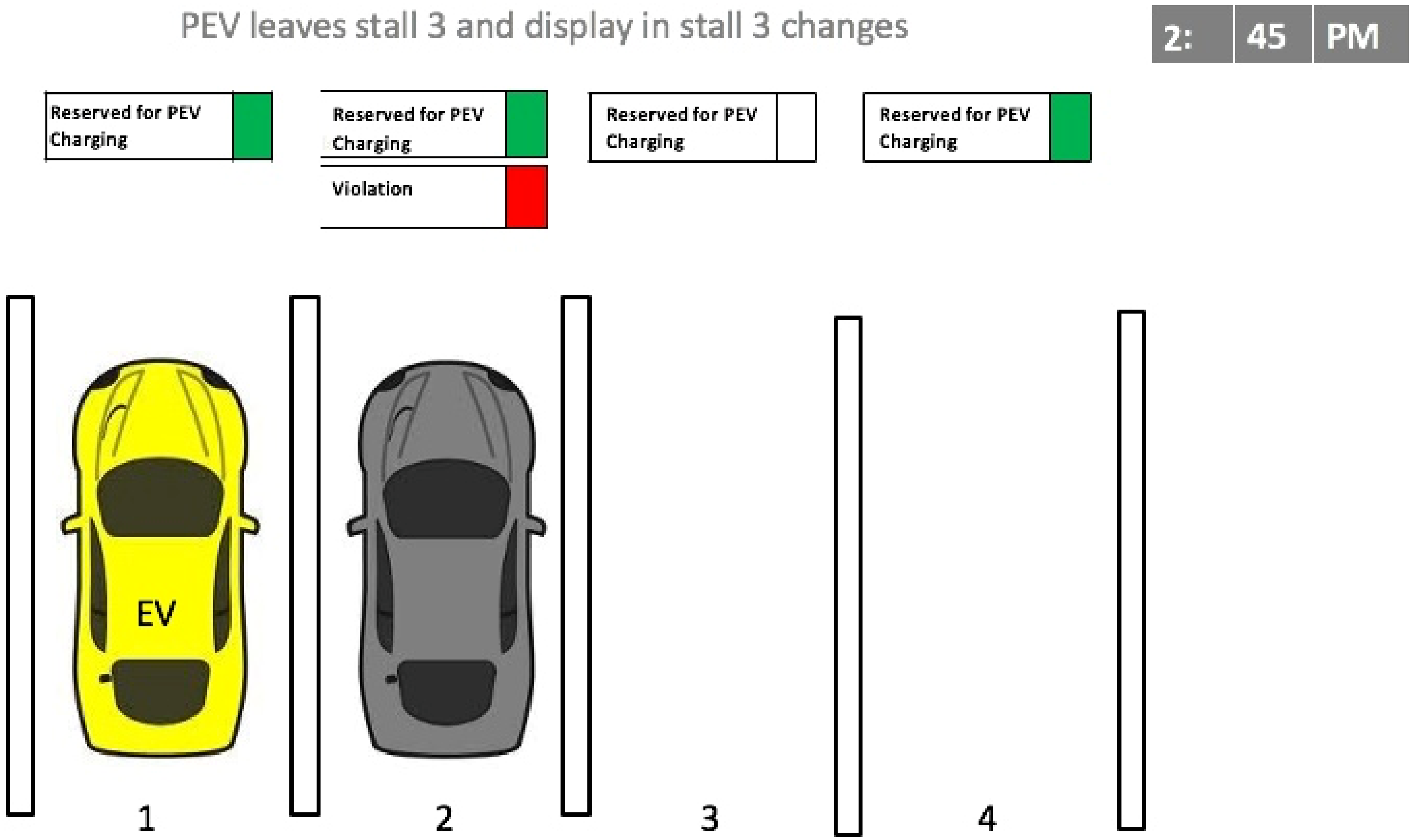


Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

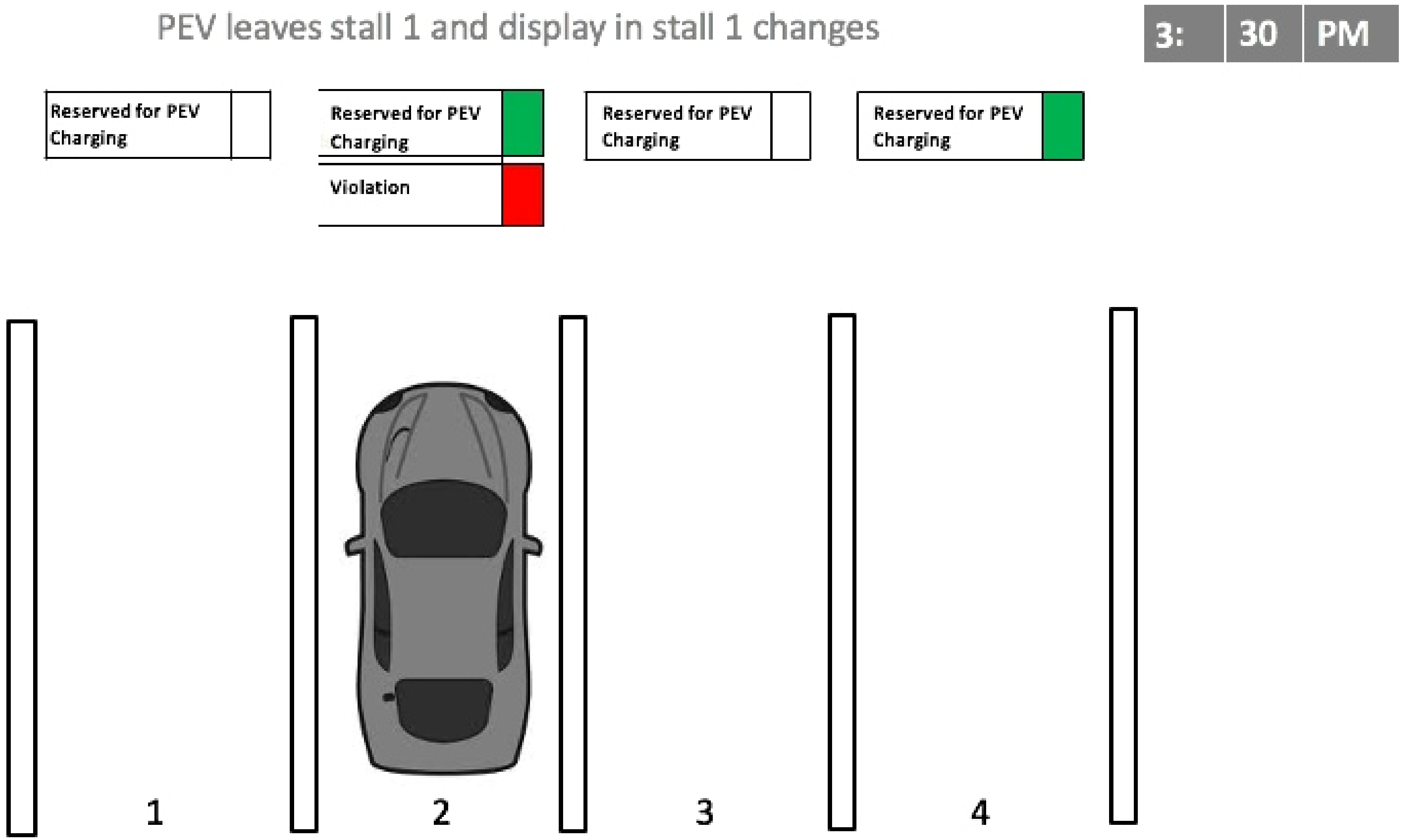


Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

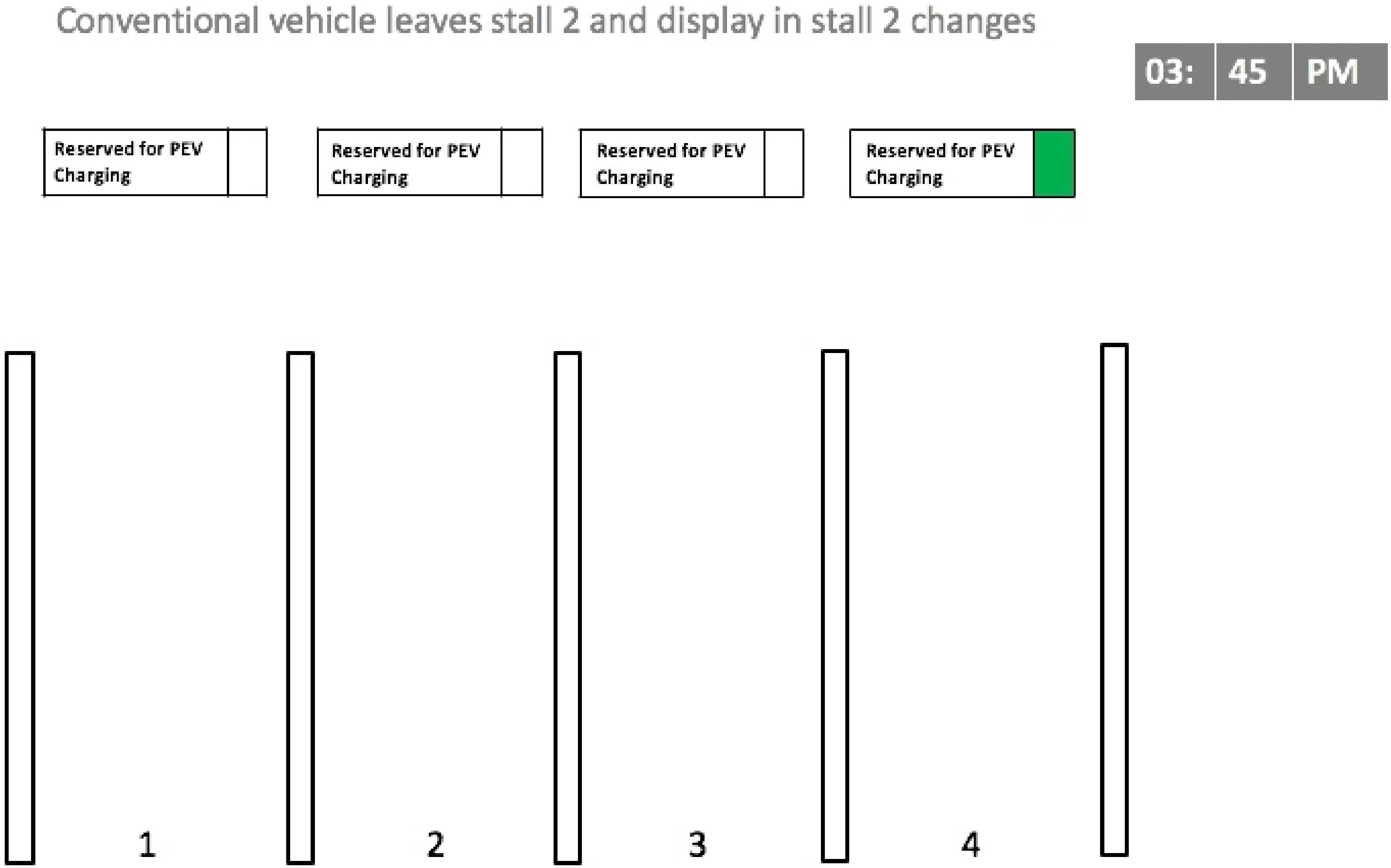


Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

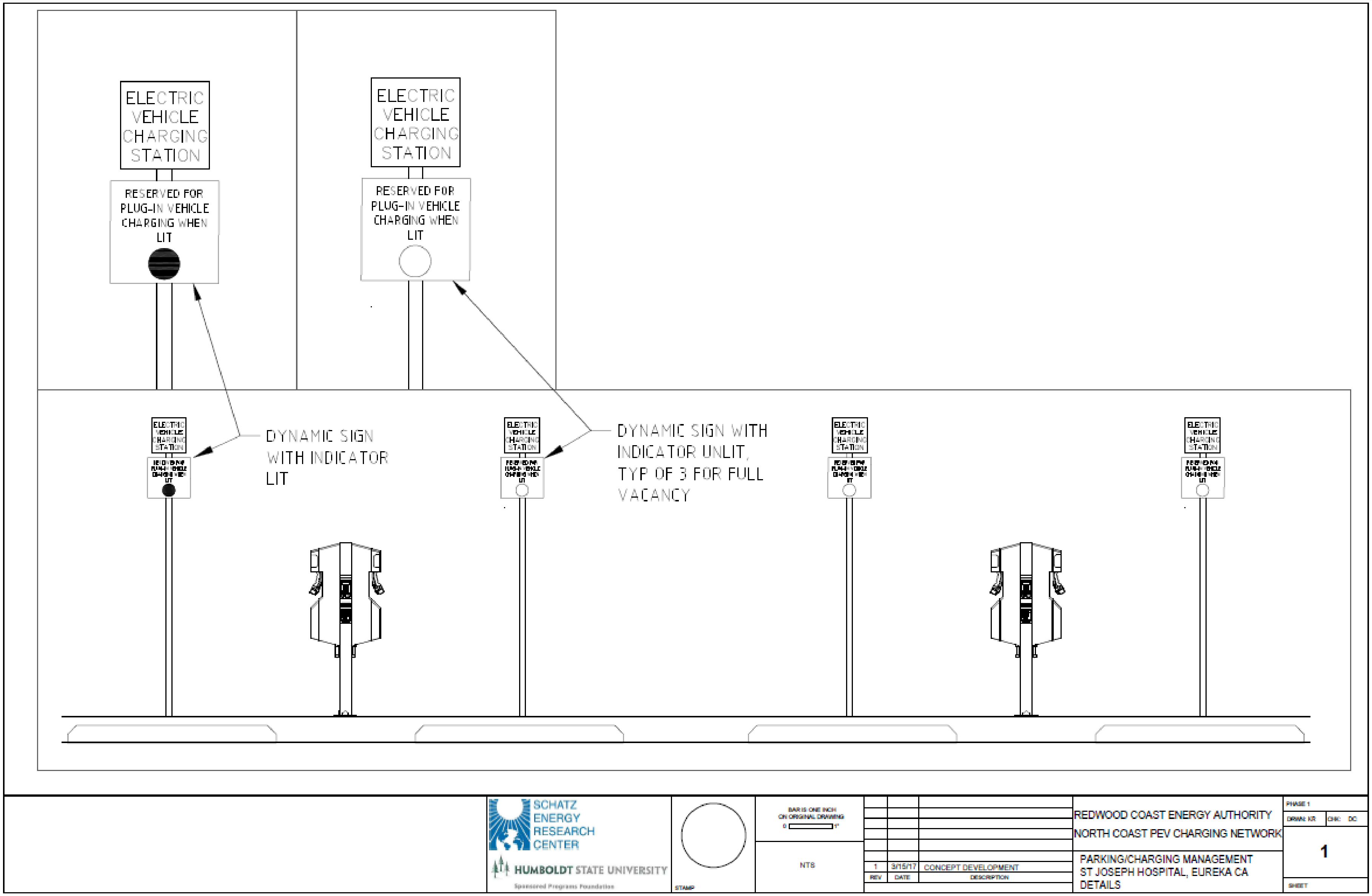
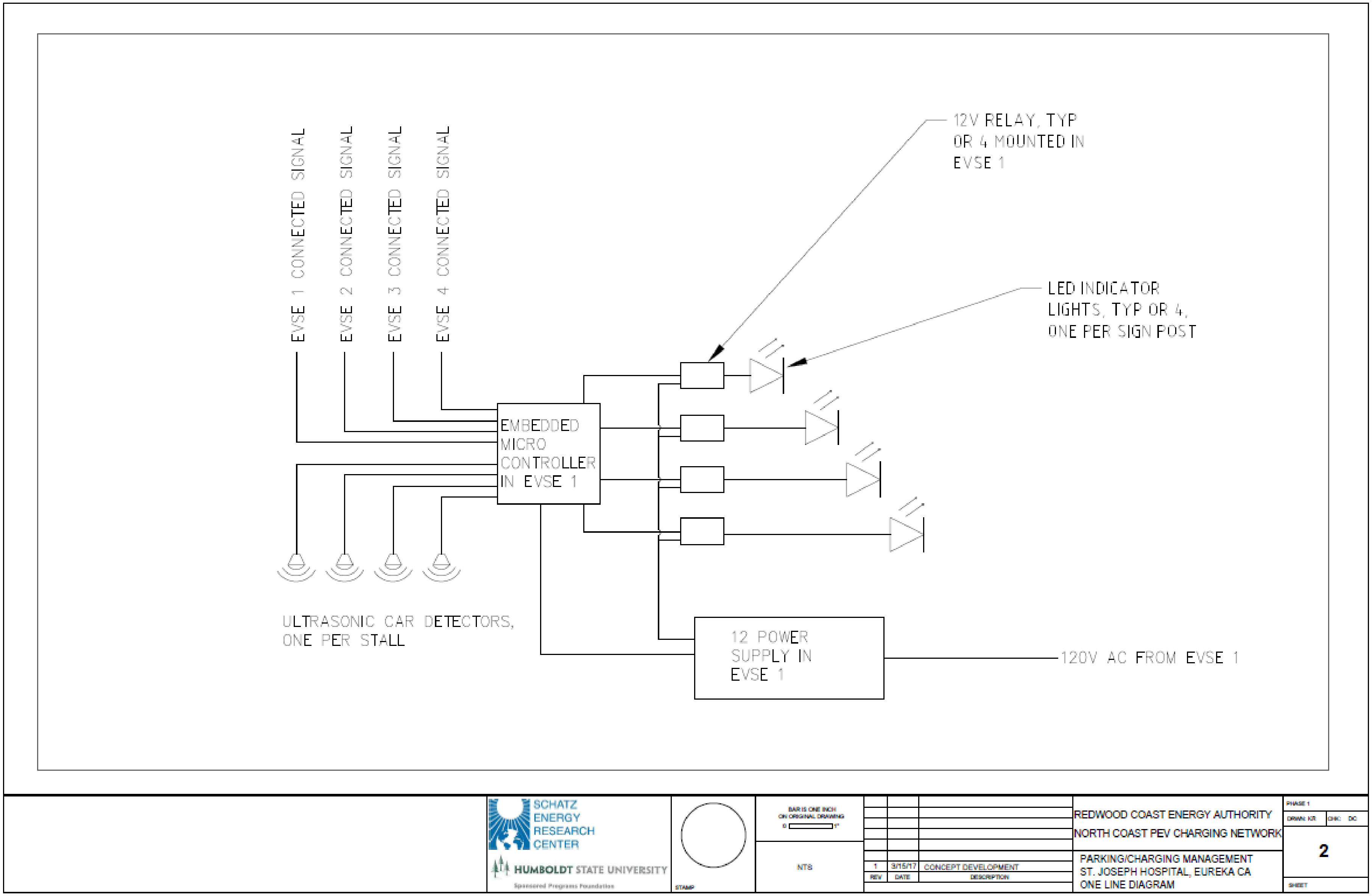


Figure 22: St. Jospeh Hospital Parking Concept (cont'd)

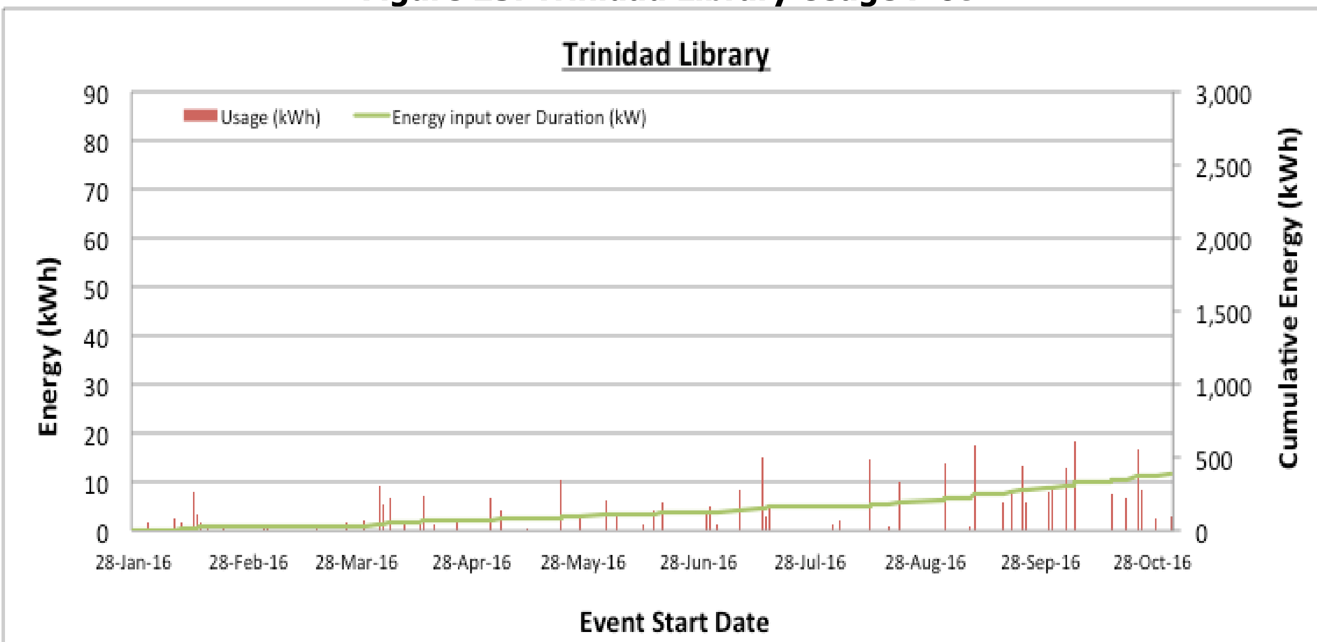


Source: Schatz Energy Research Agency

APPENDIX E: Usage Plots for Each EVCS

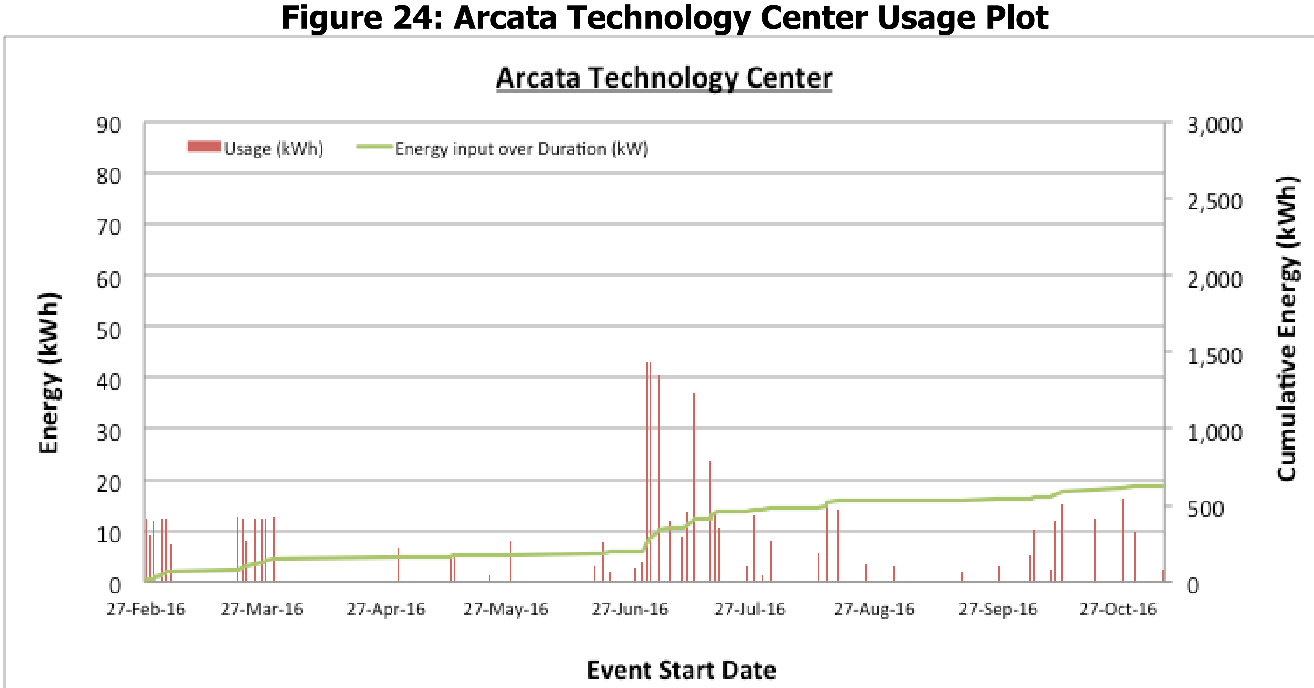
Figures 23 through 30 represent usage plots for each new EVCS through 2016. These usage plots include the energy usage and the cumulative energy usage per EVCS location over time. The plots represent "raw" data in an easy-to-read fashion prior to analysis.

Figure 23: Trinidad Library Usage Plot



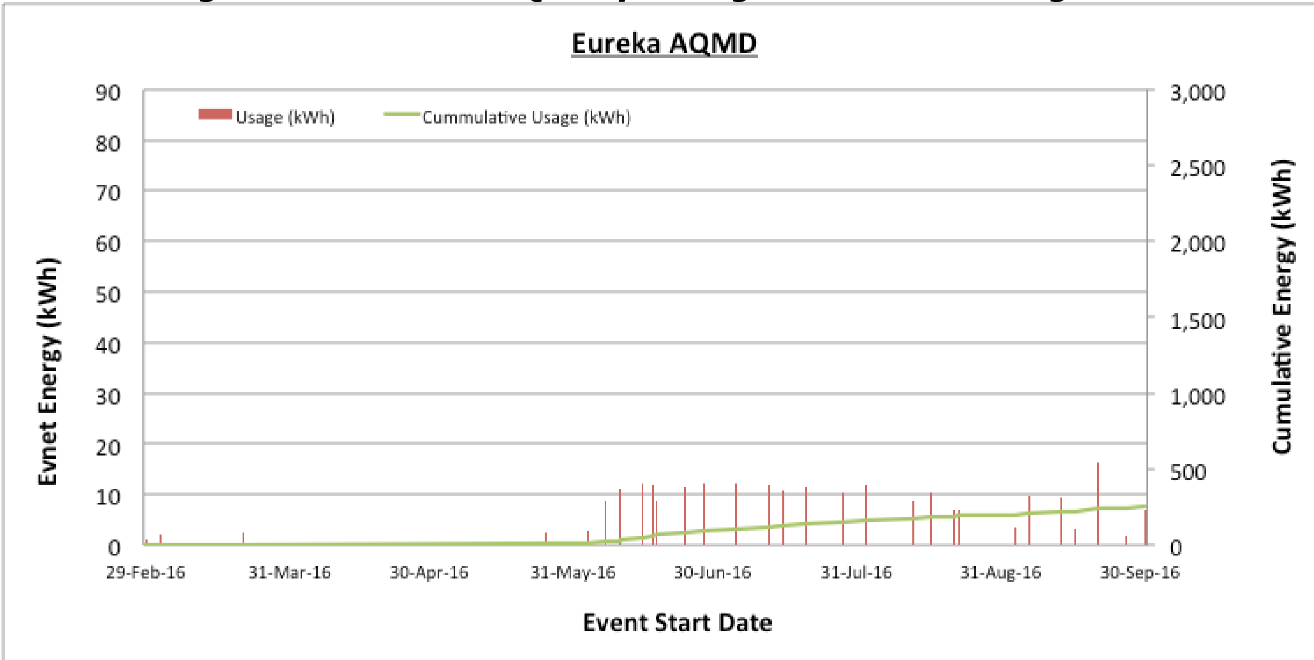
Source: Schatz Energy Research Agency

Figure 24: Arcata Technology Center Usage Plot



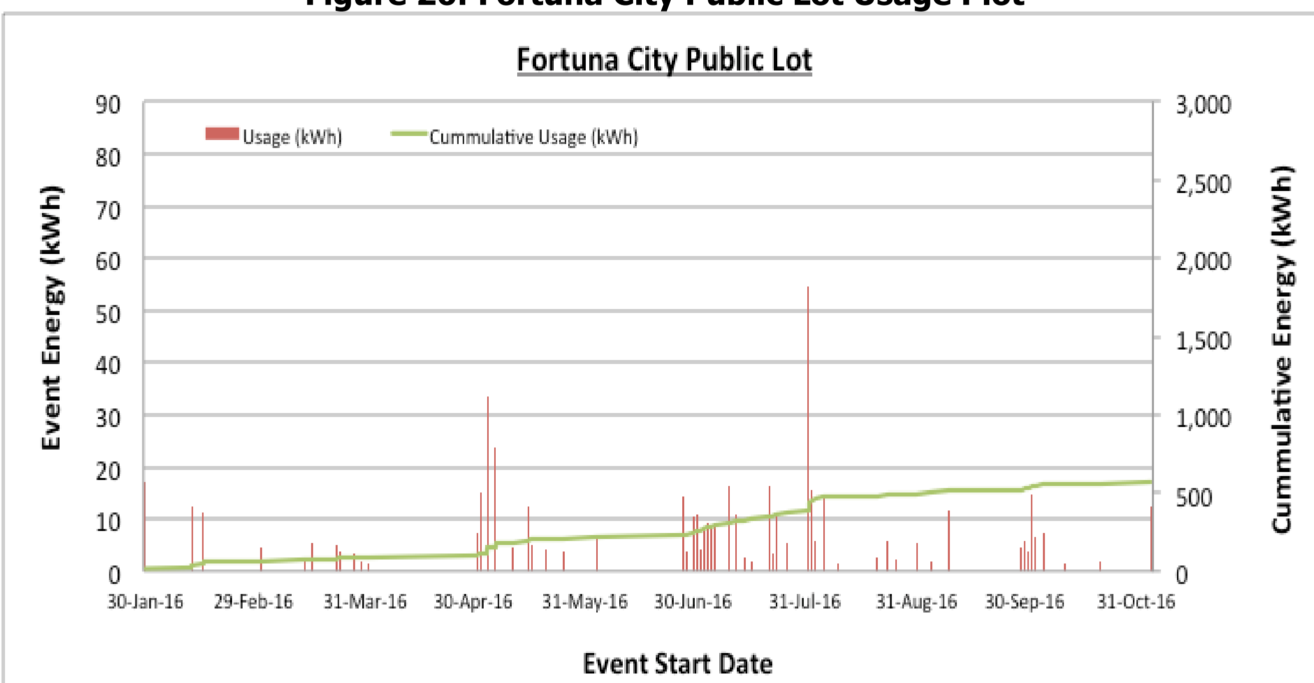
Source: Schatz Energy Research Agency

Figure 25: Eureka Air Quality Management District Usage Plot



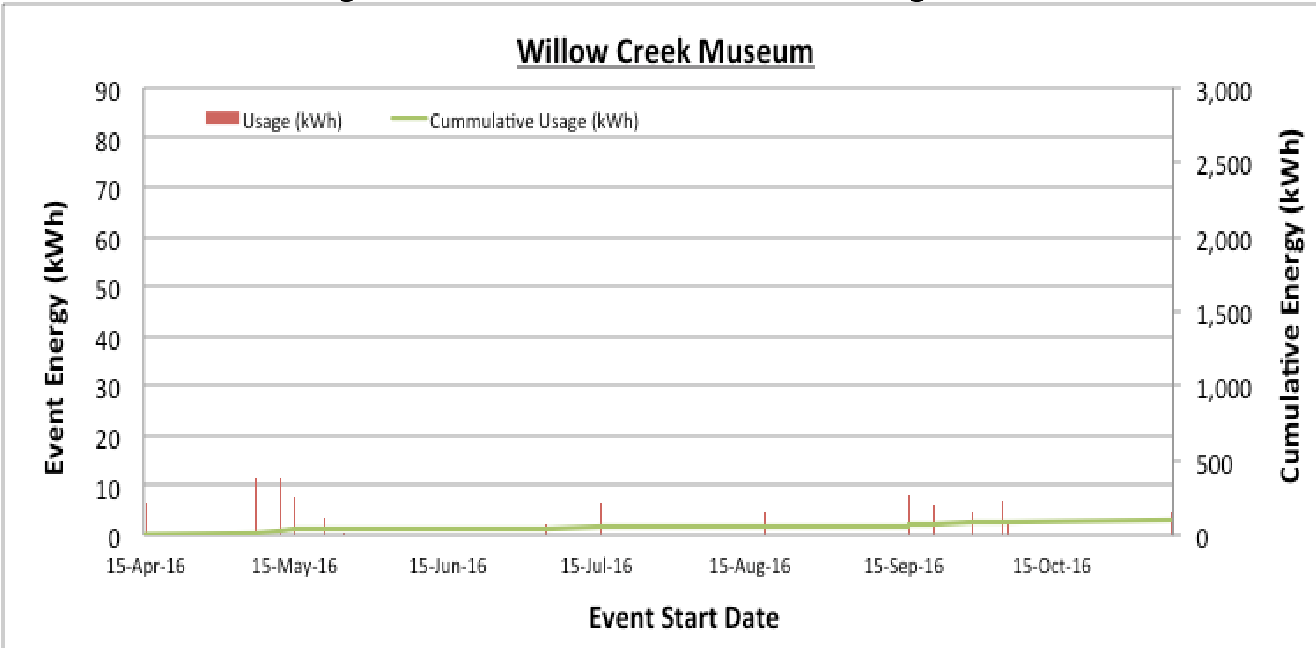
Source: Schatz Energy Research Agency

Figure 26: Fortuna City Public Lot Usage Plot



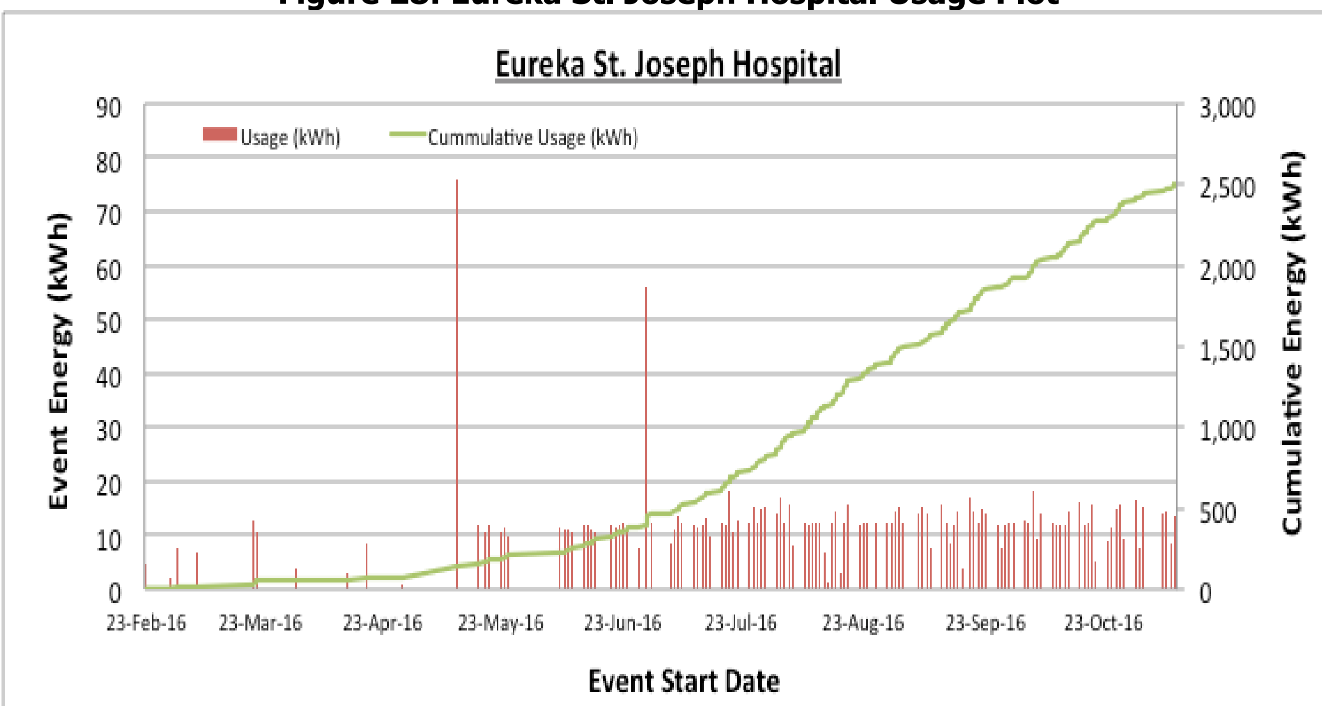
Source: Schatz Energy Research Agency

Figure 27: Willow Creek Museum Usage Plot



Source: Schatz Energy Research Agency

Figure 28: Eureka St. Joseph Hospital Usage Plot

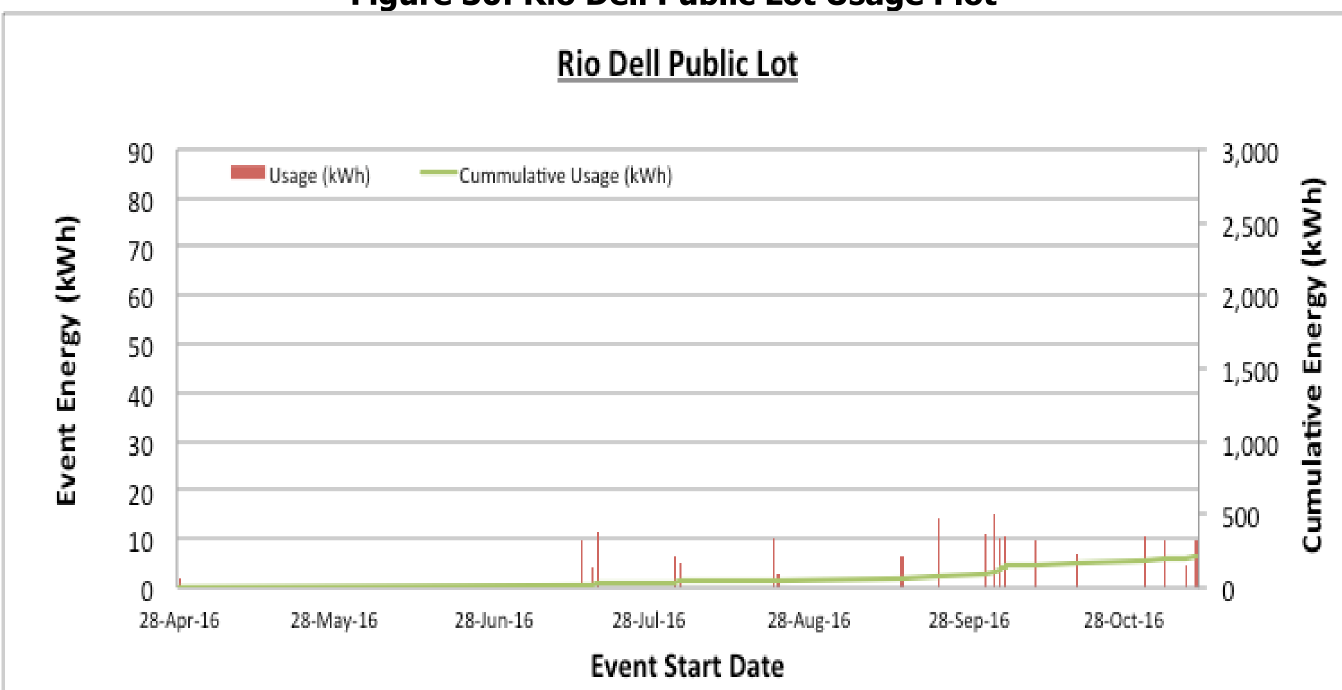


Source: Schatz Energy Research Agency

Figure 29: McKinleyville Shopping Center Usage Plot

Source: Schatz Energy Research Agency

Figure 30: Rio Dell Public Lot Usage Plot



Source: Schatz Energy Research Agency

APPENDIX F: Details of Projecting Future Energy Usage

This appendix explains the details for projecting future energy usage of the project's Level 2 EVCS.

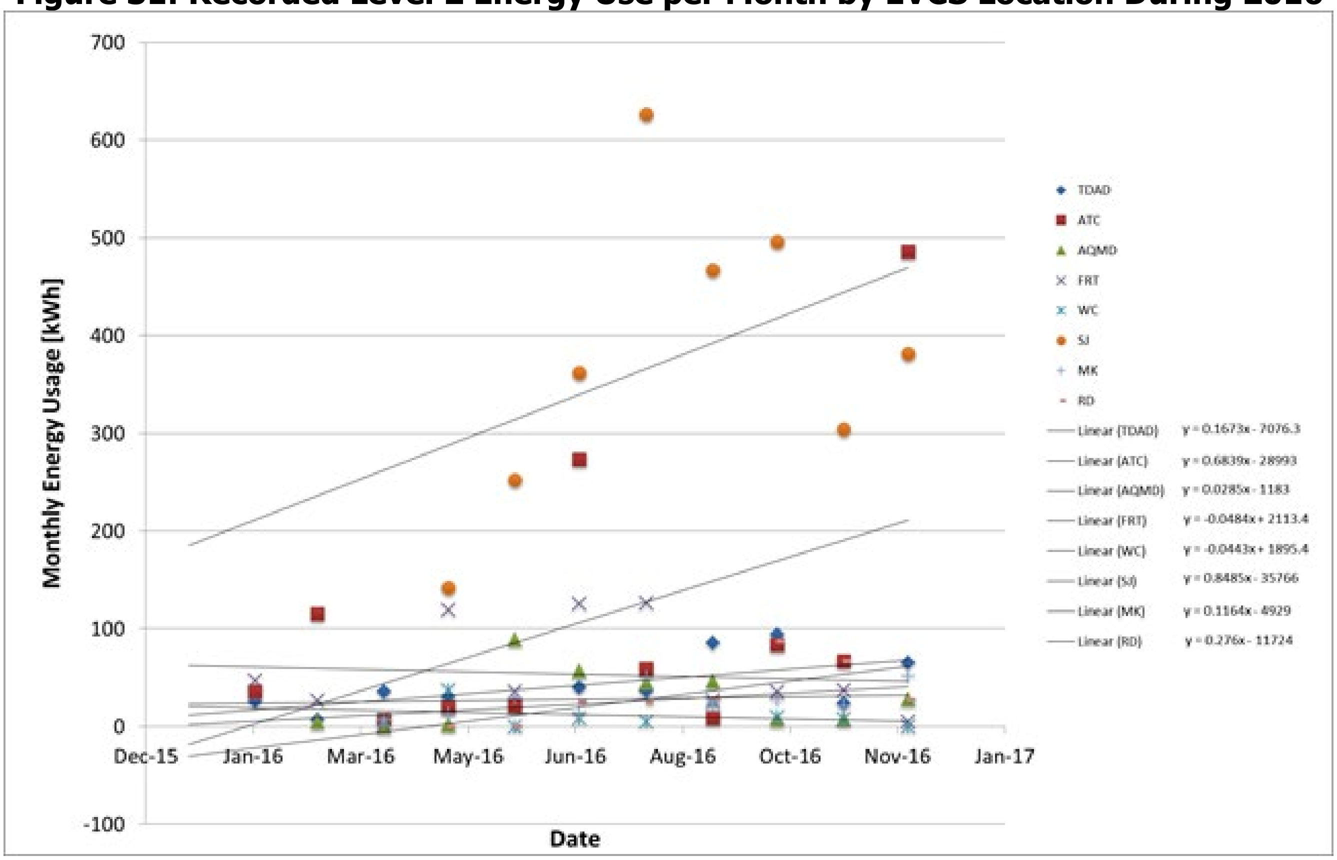
The following information was considered when projecting the Level 2 EVCS energy usage:

- Rate of drivers discovering new EVCS,
- Rate of EV adoption in Humboldt County, and
- Installation of new EVCS.

Projecting for 2017

The rate of drivers discovering the new EVCS was determined using existing data from 2016. This rate was applied to Level 2 EVCS energy usage for 2017; after 2017 it is assumed that most EV drivers will have discovered the EVCS. In addition, it is assumed that this rate is inclusive of EV adoption for 2017. To determine the rates, each location's energy usage per month was plotted and a linear trend line estimated, shown in Figure 31. Based on the trend line equations, each location's energy usage per month was projected over 2017.

Figure 31: Recorded Level 2 Energy Use per Month by EVCS Location During 2016

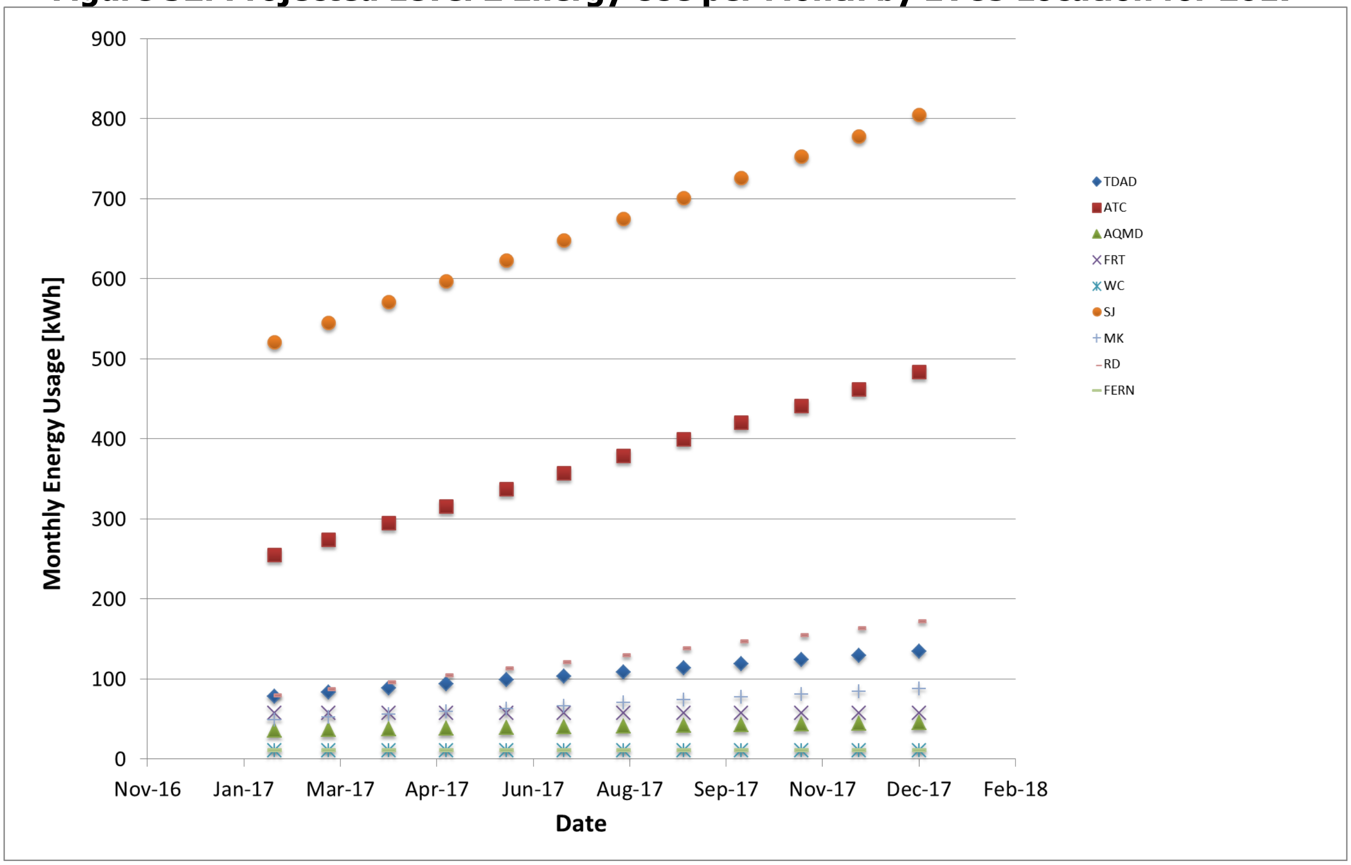


Note: TDAD = Trinidad Library, ATC = Arcata Technology Center, AQMD = Eureka AQMD, FRT = Fortuna Public Lot, WC = Willow Creek Museum, SJ = Saint Joseph Hospital, MK = McKinleyville Shopping Center. RD = Rio Dell Public Lot

Source: Schatz Energy Research Center

It is noted from the trend line equations that two locations had negative slopes indicating their rate of use was declined over 2016 - Willow Creek and Fortuna. This may be due to reduced driving during the rainy season in remote locations. For these two cases, a single average monthly energy use was determined for their 2017 monthly estimates. On a similar note, since data was unavailable for Ferndale EV chargers, the assumption was made that their use was comparable to the least used location, which was Willow Creek. Figure 32 shows the projected monthly energy uses by location over 2017. The total estimated energy usage for 2017 is a summation of the energy usage per month over all locations, or 17,380 kWh.

Figure 32: Projected Level 2 Energy Use per Month by EVCS Location for 2017



Note: TDAD = Trinidad Library, ATC = Arcata Technology Center, AQMD = Eureka AQMD, FRT = Fortuna Public Lot, WC = Willow Creek Museum, SJ = Saint Joseph Hospital, MK = McKinleyville Shopping Center. RD = Rio Dell Public Lot

Source: Schatz Energy Research Center

Projecting for 2018-2020

In projecting for 2018-2020, it was assumed that most EV drivers will have already discovered the EVCS. The rate of EV adoption in Humboldt County was determined using projected EV population data by the California Air Resources Board, the most recent PlugShare EV charger map, and an estimate that two new Level 2 EVCS would be installed in Humboldt County per year starting in 2017.

California Air Resources Board’s projected EV growth for Humboldt County is captured in Table 20. The electric vehicle population includes both light duty automobiles and light duty trucks. The percent increase is determined for each year based on the year prior.

Table 20: California Air Resources Board's Projected EV Population for Humboldt County

Year	2016	2017	2018	2019	2020
Population	178	232	326	477	687
Percent increase per year	--	31%	41%	46%	44%

Source: Schatz Energy Research Center

If it is assumed projected energy usage directly follows projected EV population, usage of future EVCS would be neglected. According to PlugShare's most recent mapping, 34 public Level 2 J1772 EVCS are in Humboldt County, 18 of which were installed through this project (just over 50 percent). If it is assumed that two new public Level 2 J1772 EVCS will be installed in Humboldt County per year, the fraction of the total energy usage against total energy demand by EV drivers will likely decrease. The estimated annual decrease values are provided in Table 21; they are determined by dividing the number of project EV chargers (always 18) by the number of total EV chargers in Humboldt County (increasing by 2 per year).

Using the project 2017 energy usage for this project EV chargers, California Air Resources Board's projected increased EV population rates, and the percentage of energy usage by project chargers per year (described in the latter paragraph), projected energy usage for 2018-2020 was determined for the project's EV chargers.

The annual projected energy use values were determined using the following steps.

1. Estimate the 2017 total energy usage by multiplying the 2017 project charger's estimated energy usage (17,380 kWh) by the percentage of energy usage by this project's chargers over all Humboldt County chargers, considering that two chargers are to be added during 2017.
2. Estimate the 2018 total energy usage by multiplying the 2017 total energy usage by California Air Resources Board's 2018 EV population percent increase for Humboldt County.
3. Estimate the 2018 project charger's energy usage by multiplying the 2018 total energy usage by the percentage of energy usage by this project's chargers over all Humboldt County chargers, considering that two chargers are to be added during 2018.
4. Repeat steps 2 and 3 through for 2019 and 2020.

Table 21: Projected Number of EV Chargers in Humboldt County, Charger Energy Usage, and Decreasing Fraction of Total EV Charger Usage by this Project's Chargers

Year	2016	2017	2018	2019	2020
Total charger count	34	36	38	40	42
Project charger count	18	18	18	18	18
Percentage of energy usage by project chargers over total chargers	--	50%	47%	45%	43%
Estimated total charger energy usage [kWh]	34,760	48,900	71,550	102,960	134,760
Estimated project charger energy usage [kWh]	17,380	23,170	32,200	44,130	57,380

Source: Schatz Energy Research Center

Through the 2018-2020 projections, we assume that

- The average Humboldt County public Level 2 J1772 EVCS not included in this project experience the same level of energy usage as the average of this project's Level 2 EVCS
- As new EVCS are installed in Humboldt County, each new EVCS will provide a fraction of the total EV charger energy usage proportional to the total number of EVCS, i.e. we estimate there will be 36 public Level 2 J1772 EVCS in Humboldt County in 2017, each of the two new EVCS installed in 2017 will provide 1/36, or 3 percent, of the total energy demand for the year.

APPENDIX G: GHG Calculations

This appendix explains the calculations that ChargePoint made to estimate the GHG avoided by EV energy usage. Table 22 shows the assumptions with sources used for the calculations. The main source is the Environmental Protection Agency. Table 23 shows the calculations step-by-step made to determine the GHG avoided by EV energy usage and percentage of GHG reduction by switching to an EV from an internal combustion engine.

Table 22: Assumptions Provided by ChargePoint to Determine GHG Avoided by EV Energy Usage

Item	Value	Units	Source			
Internal Combustion Engine vehicle emissions	8.8	kilograms carbon dioxide per gallon gasoline	Emission Facts: Average Carbon Dioxide Emissions Resulting from Gasoline and Diesel Fuel	U.S. EPA	2005	Emission Facts available at https://na.chargepoint.com/UI/downloads/help/420f05001.pdf
Internal Combustion Engine vehicle efficiency	23.9	Miles per gallon gasoline	Emission Facts: Greenhouse Gas Emissions from a Typical Passenger Vehicle	U.S. EPA	2005	Emission Facts available at https://na.chargepoint.com/UI/downloads/help/420f05004.pdf
EV efficiency	3	Miles per kilowatt hour electricity	ChargePoint's estimate based on several types of EVs			
Electricity generation emissions	0.706	Kilogram carbon dioxide per kilowatt hour electricity	eGRID2012 Version 1.0: Year 2009 Summary Tables	U.S. EPA	2012	eGRID2012 available at https://na.chargepoint.com/UI/downloads/help/eGRID2012V1_0_year09_SummaryTables.pdf
Fraction of Internal Combustion Engine vehicle GHG emissions that is carbon dioxide	95%	--	Emission Facts: Greenhouse Gas Emissions from a Typical Passenger Vehicle	U.S. EPA	2005	Emission Facts available at https://na.chargepoint.com/UI/downloads/help/420f05004.pdf

Source: Schatz Energy Research Center

Table 23: Calculations for Determining GHG Avoided by EV Energy Usage and Percentage of GHG Reduction by Switching to an EV from an ICE

Calculations		
CO_2 emitted per distance traveled with ICE vehicle	8.8 kg CO_2/gal gasoline ÷ 23.9 mi/gal gasoline	0.368 kg CO_2/ mi traveled
CO_2 emitted per distance traveled with EV	0.706 kg CO_2/kWh electricity ÷ 3.0 mi/kWh electricity	0.235 kg CO_2/ mi traveled
CO_2 displaced by traveling with EV instead of ICE vehicle	0.368 kg CO_2/mi traveled – 0.235 kg CO_2/ mi traveled	0.133 kg CO_2/mi traveled
Total GHG emissions displaced by traveling with EV instead of ICE vehicle per distance traveled	0.133 kg CO_2/mi traveled ÷ 95 %	0.140 kg GHG/mi traveled
Total GHG emissions displaced by traveling with EV instead of ICE vehicle per electricity usage	0.140 kg GHG/mi traveled x 3.0 mi/kWh electricity	0.420 kg GHG/ kWh used
Percentage of GHG reduction by switching to an EV from an ICE	0.368 kg CO_2/mi traveled ÷ 0.133 kg CO_2/mi traveled	36%

Source: Schatz Energy Research Center

APPENDIX H:
Raw Data from Site Host Surveys

Figure 33 provides the raw data from the site host surveys. The survey consisted of yes/no questions, site host time requirements, and level of happiness hosting.

Figure 33: Site Host Survey

Site	Trinidad Library	Arcata Technology Center	Eureka AQMD	Fortuna Public Lot	Eureka St. Joeseph Hospital	Rio Dell Public Lot	Ferndale Public Lot
1. Which of these situations have you observed for your site:							
Increase in customers	No	Yes	Yes	No	Yes	No	No
Notes:	--	A few people who work in the building have purchased Evs because the stations are there.	--	Not much activity at the station.	Lots of use by physicians, they've purchased Evs because of the stations	--	--
Positive customer comments	No	Yes	No	No	Yes	Yes	No
Notes:	--	Multiple people have told Sara they are glad the station is there.	--	--	--	--	--
Negative customer comments	Yes	Yes	No	No	No	No	No
Notes:	Some complaints about the way the bags looked that were placed over them right after installation.	One negative comment from Roger, a local DIY EV driver. Said the voltage was to low.					
Questions about the charging station	No	No	No	No	No	No	No
Notes:	--	--	--	--	--	--	--
Request for assistance using the station	No	No	No	No	Yes	No	No
Notes:	--	--	--	--	Only a few when the station first went in. A few customers asked how to use the station.	--	--
Issues with your energy bill	No	No	No	No	No	No	No
Notes:	--	--	--	--	--	--	--
Noticeable charger downtime	No	Yes	No	No	No	No	Yes
Notes:	--	Charger was in free mode during November.	--	--	--	--	--
Conventional vehicles using EV spots	No	No	No	No	Yes	No	No
Notes:	--	--	Only once - Brian just went over and spoke with the owners of the conventional vehicle.	--	Frequent use by gas vehicles. Expressed interest in	--	--
Shortage of parking spaces	No	No	No	No	Yes	No	Yes
Notes:	--	--	--	--	Yes, and very interested in the dynamic parking management solution we are working on.	--	Yes, but it isn't a daily occurance

Figure 33: Site Host Survey (cont'd)

2. We are interested in gauging the time required to host a charging station. Please estimate the time you and/or your organization spent in the following aspects of hosting a charging station:							
Initial installation process, e.g. paperwork, communications, meetings [h]	4	12	1	4	3	100	20
Notes:	--	--	--	Building permit and site visits.	--	Upgrading the parking lot took up a lot of time.	--
On-going maintenance, e.g. assisting drivers, vandalism [h/mo]	0	3	0	0	0	12	2.5
Notes:	--	--	The area is well lit and there is a security camera.	--	--	--	--
3. In general, are you happy with your decision to host an EV charging station?							
Response	Happy	Happy	Very happy	Unhappy	Very happy	Happy	Happy
Why/why not?	Its been good, though wasn't crazy about parking availability during construction.	It's been good to have - the owner would like a free charging card (I am investigating this)	--	--	--	Would like to see it get used more.	Happy, but would like to see it get used more/was difficult during installation due to pushback from local businesses. RCEA has been great to work with.
4. What advice would you give to a future EV charger site host?							
Response	--	Install more than one charging station.	Install in a well-lit location with a security camera	Install stations near workplaces. The Riverlodge area in Fortuna would be a good future spot.	Just do it!	Make sure the specific site location is nailed down way in advance. Had some issues with moving the location back and forth from City Hall to downtown.	--

Source: Schatz Energy Research Center

APPENDIX I: Data Analysis - Extended Through May 2017

More data has been collected since drafting the data analysis section of this report, and most notably, the remaining station in Ferndale has now been connected to the Greenlots portal network with a start date of January 1, 2017. Therefore, this appendix provides updated plots and commentary for the project's Level 2 EVCS.

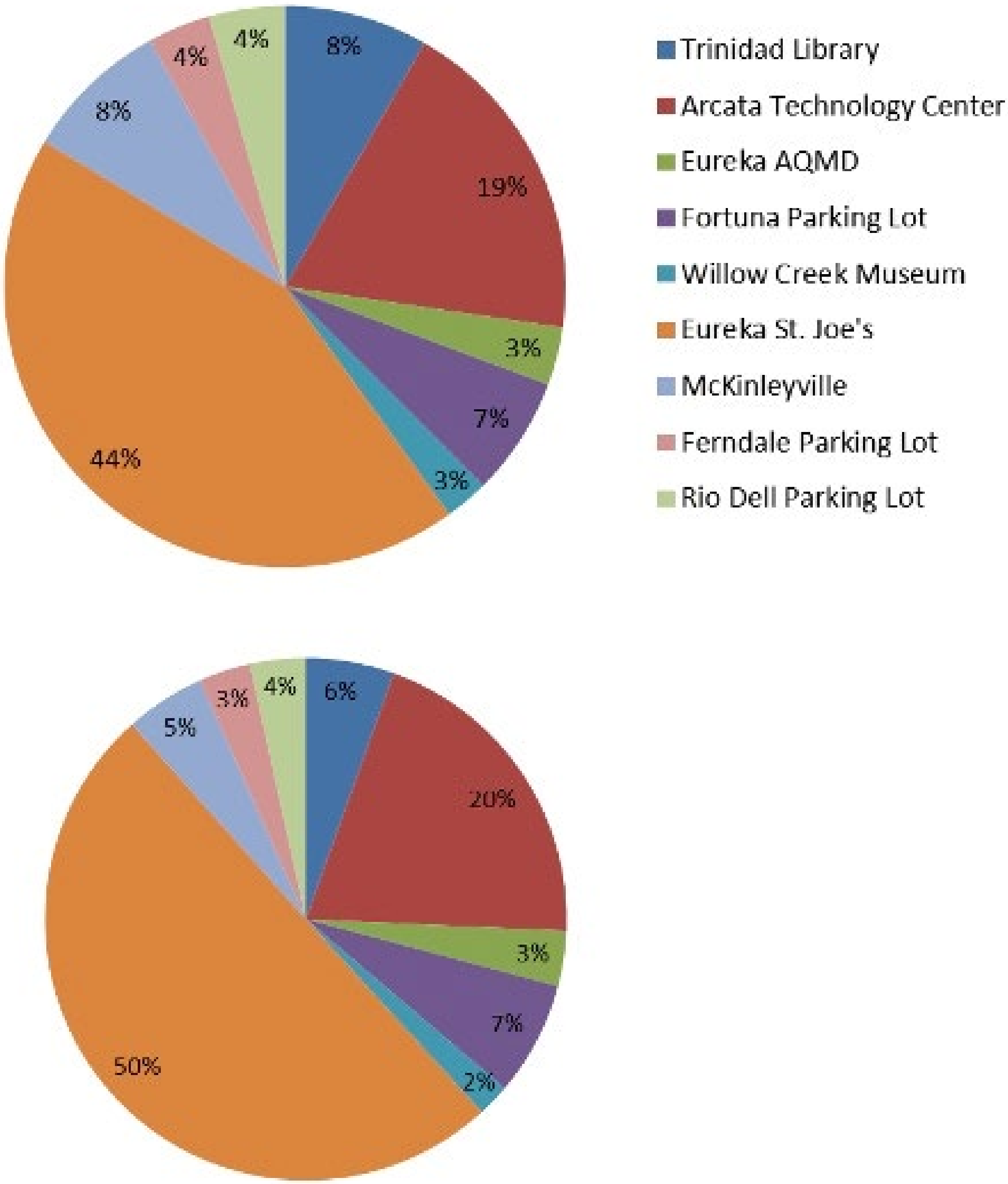
Table 24 and Figure 34 provide a bird's-eye view of the data. It is noted that the fraction of successful charge events increased for five of the eight station locations since the data analyzed through December 2016; the overall fraction of successful charge events between all the stations increased slightly from 91 percent to 92 percent. In additional, it is noted that stations at Eureka's St. Joseph Hospital and the Arcata Technology Center contribute an increased fraction of the stations' usage.

Table 24: Useful Metrics by EVCS Location, Updated Through May 2017

Location	Duration the station has been online (months)	Total number of successful charge events	Number of successful charge events per charging port	Fraction of successful events	Average duration per charge event (hour)	Average usage per charge event (kWh)	Fraction of overnight events
Trinidad Library	16	132	66	87%	1.7	6.0	3%
Arcata Technology Center	15	286	143	95%	4.0	9.6	6%
Eureka AQMD	15	50	25	71%	2.4	9.2	3%
Fortuna Public Lot	16	109	55	92%	2.9	9.3	10%
Willow Creek Museum	14	34	17	74%	1.4	7.2	4%
Eureka St. Joseph Hospital	16	660	165	97%	3.9	10.4	1%
McKinleyville Shopping Center	14	116	58	85%	1.5	5.3	2%
Rio Dell Public Lot	13	57	29	95%	2.2	7.1	3%
Ferndale Public Lot	5	18	9	100%	2.9	8.0	6%

Source: Schatz Energy Research Center

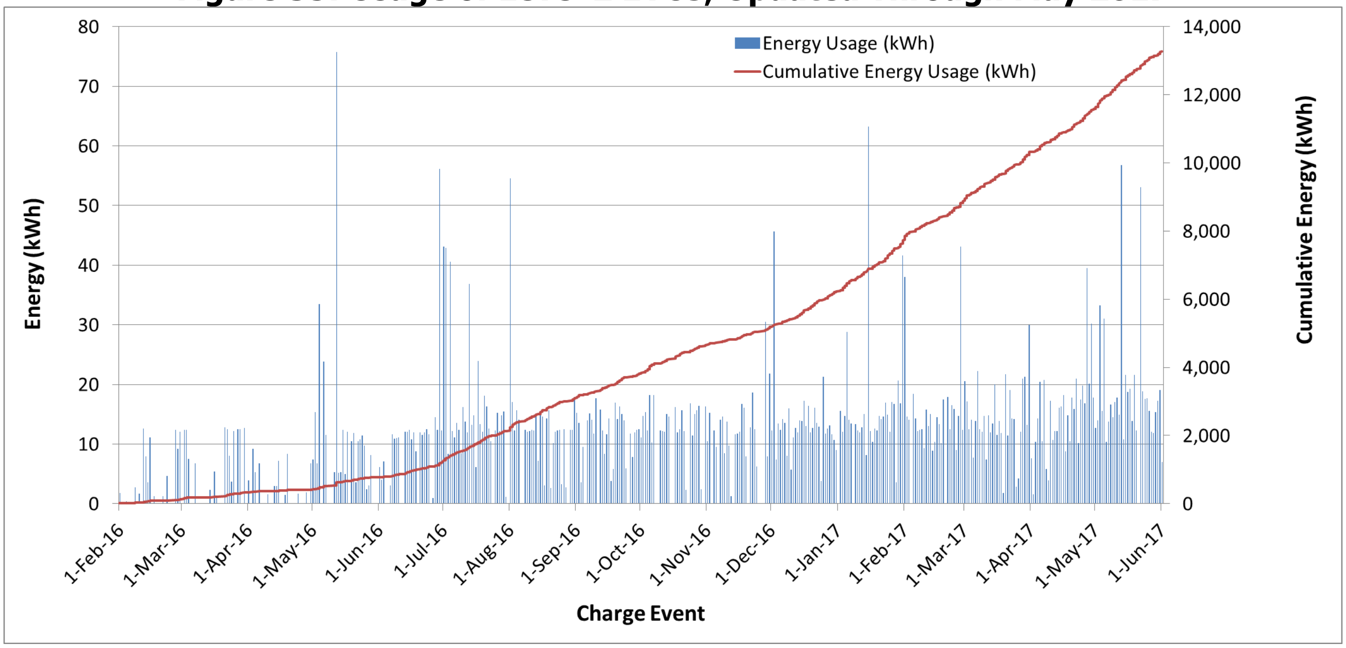
Figure 34: Percentage of Successful Level 2 EVCS Charge Events per Year by EVCS Location (top); Percentage of energy Usage per Year by EVCS Location (bottom), Updated Through May 2017



Source: Schatz Energy Research Center

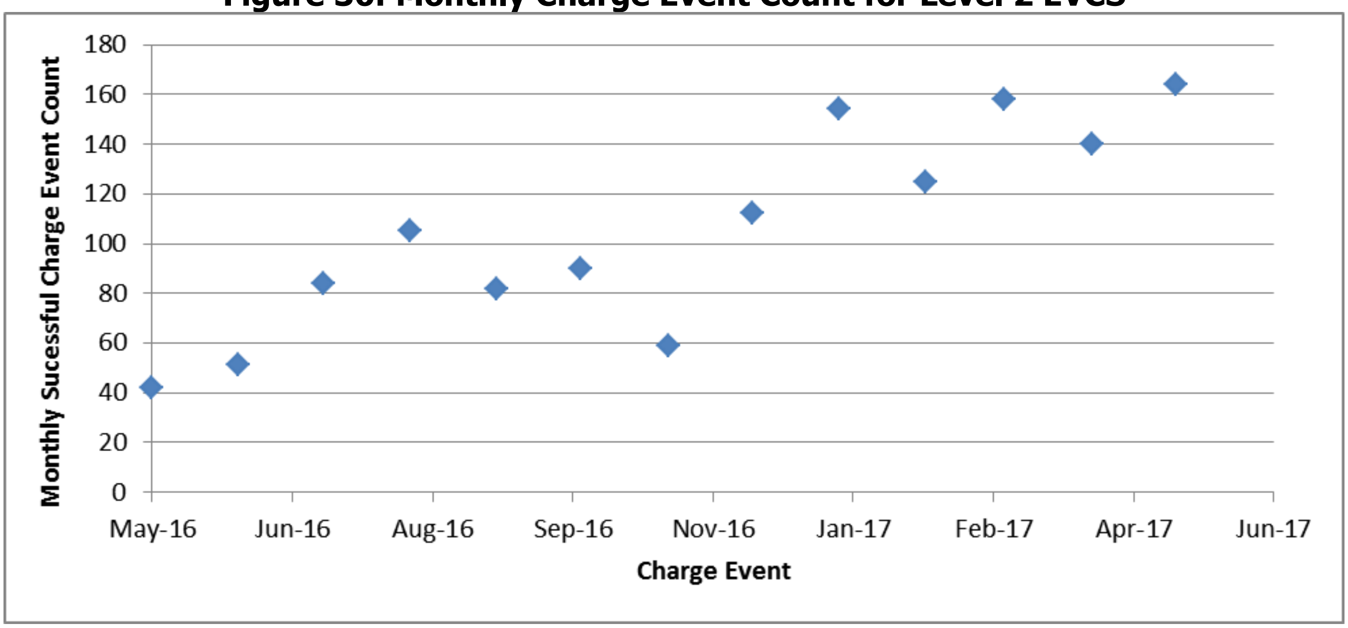
Figure 35 shows the 1462 successful charging events that have occurred through May 2017 on the Level 2 EVCS over time in terms of each event's energy usage; the figure also illustrates the accumulated energy usage over all the EVCS together. The number of successful charging events has doubled since the previous analysis on January 1, 2017. This is exciting since the previous analysis's 702 events are over approximately 10 months (based on each site's start date weighted by number of ports) and this analysis's 1462 events are over approximately 15 months. Figure 36 clearly shows the increase in number of charging events per month between all charging stations over time; the plot shows data beginning in May when the majority of stations were online, safe Ferndale.

Figure 35: Usage of Level 2 EVCS, Updated Through May 2017



Source: Schatz Energy Research Center

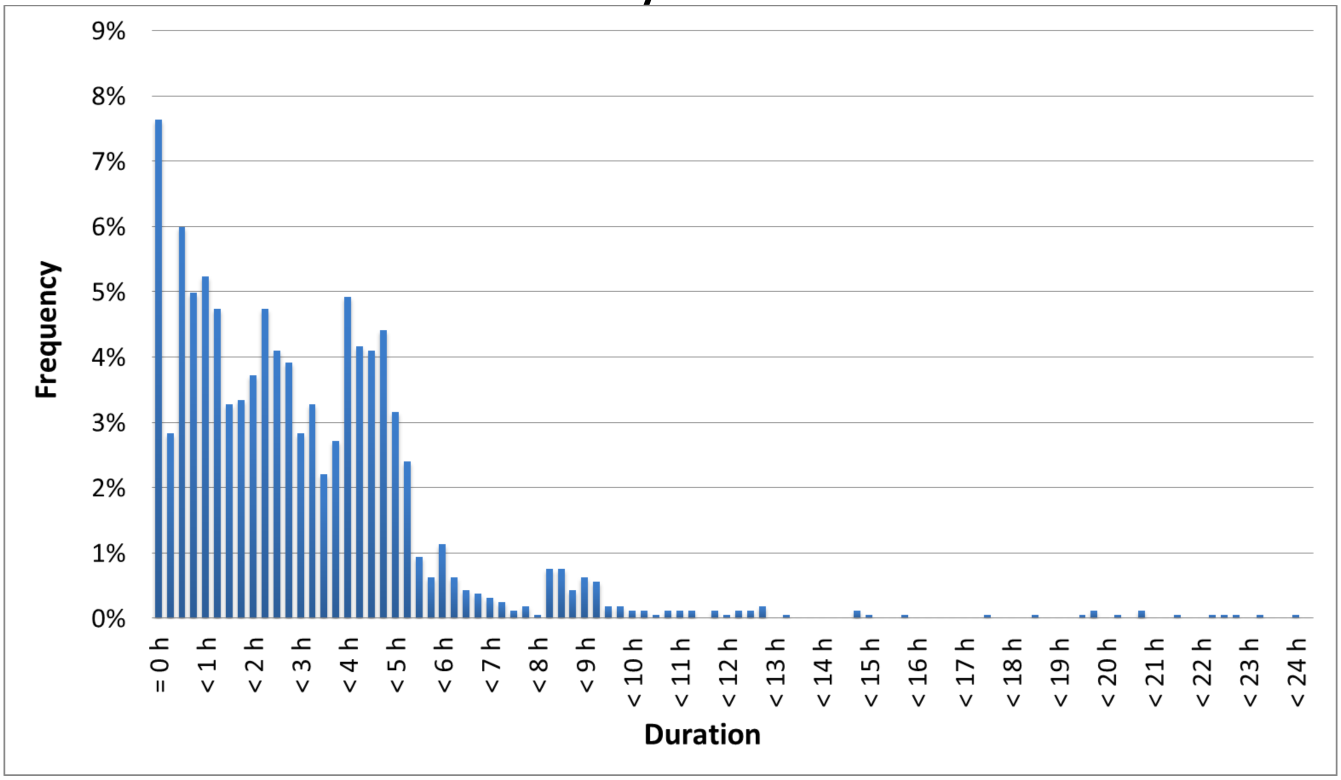
Figure 36: Monthly Charge Event Count for Level 2 EVCS



Source: Schatz Energy Research Center

Figure 37 shows an updated histogram of the Level 2 charge event durations in 15-minute intervals. The unsuccessful charges (duration of 0 seconds or energy draw of 0 kWh) were removed from the 0-15-minute duration interval and sit in their own category of "=0h." Of the successful charges, the average duration of the charge events is 3.3 hours and the median is 2.7 hours.

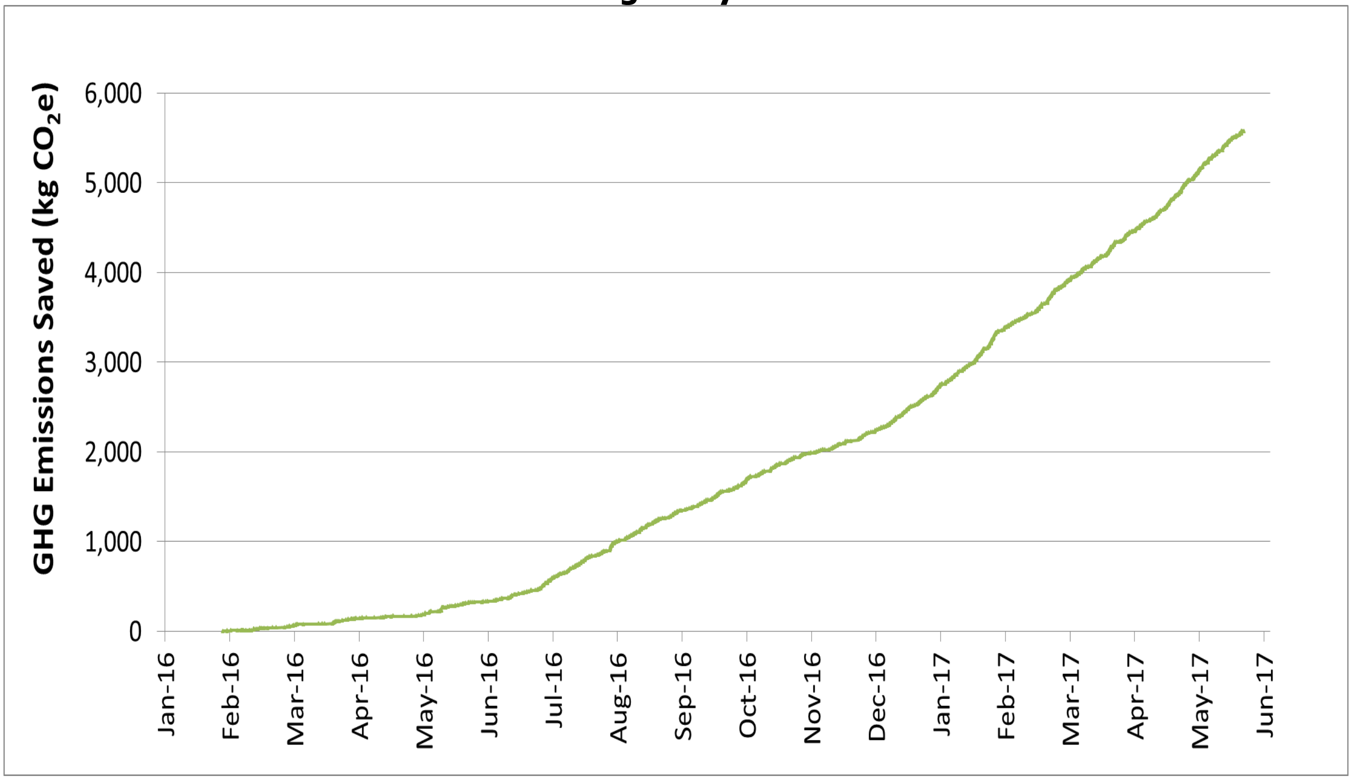
Figure 37: Charge Duration Frequency Distribution for New EVCS, Updated Through May 2017



Source: Schatz Energy Research Center

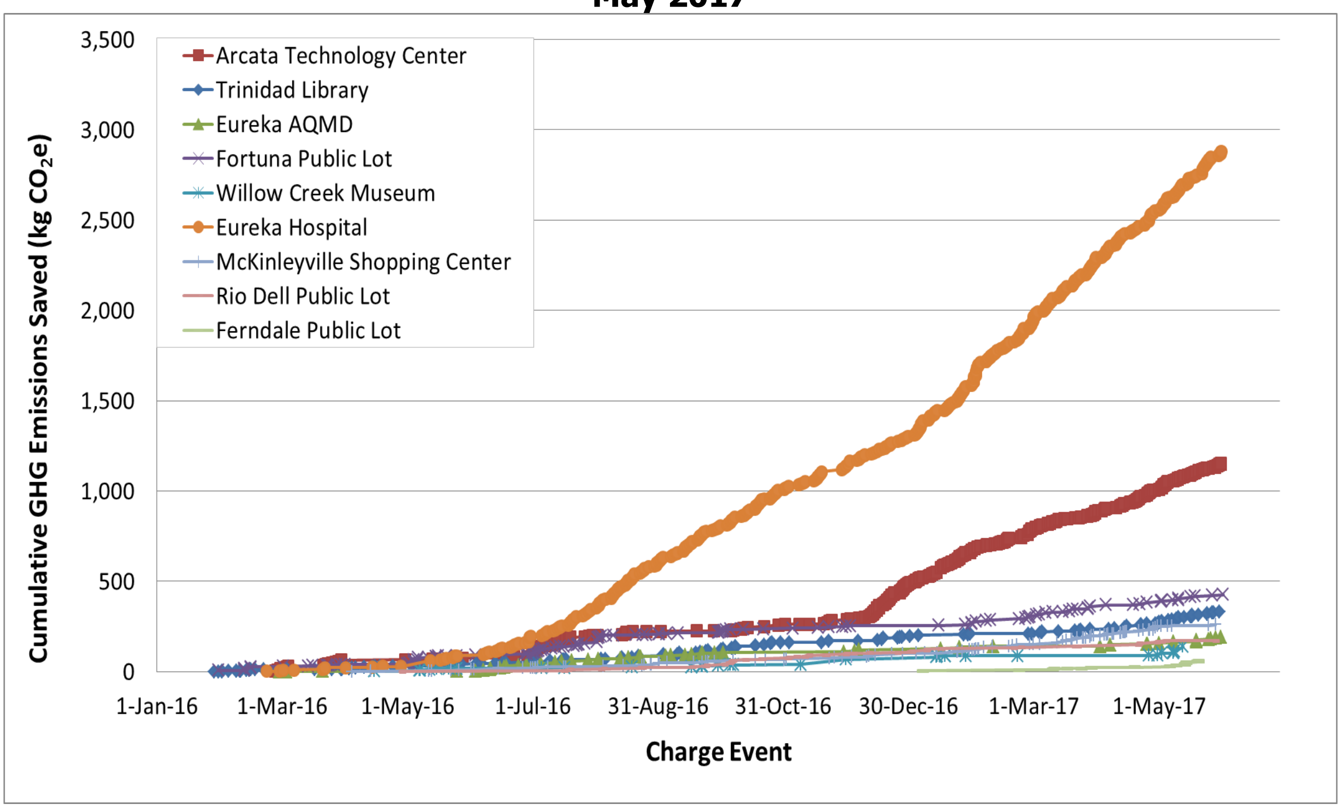
Figure 38 shows the cumulative GHG emissions reductions overall, and Figure 39 shows it by station location. It is evident that the slope continues to increase, which is a factor of increased station awareness and increased PEV usage through Humboldt County. It is important to reiterate that while sites like Eureka's St. Joseph Hospital and the Arcata Technology Center have the highest use, this project success lies with the spread of stations to remote locations to reduce potential EV driver's hesitation from range anxiety.

Figure 38: Cumulative GHG Emissions Reduction Over Time by New EVCS, Updated Through May 2017



Source: Schatz Energy Research Center

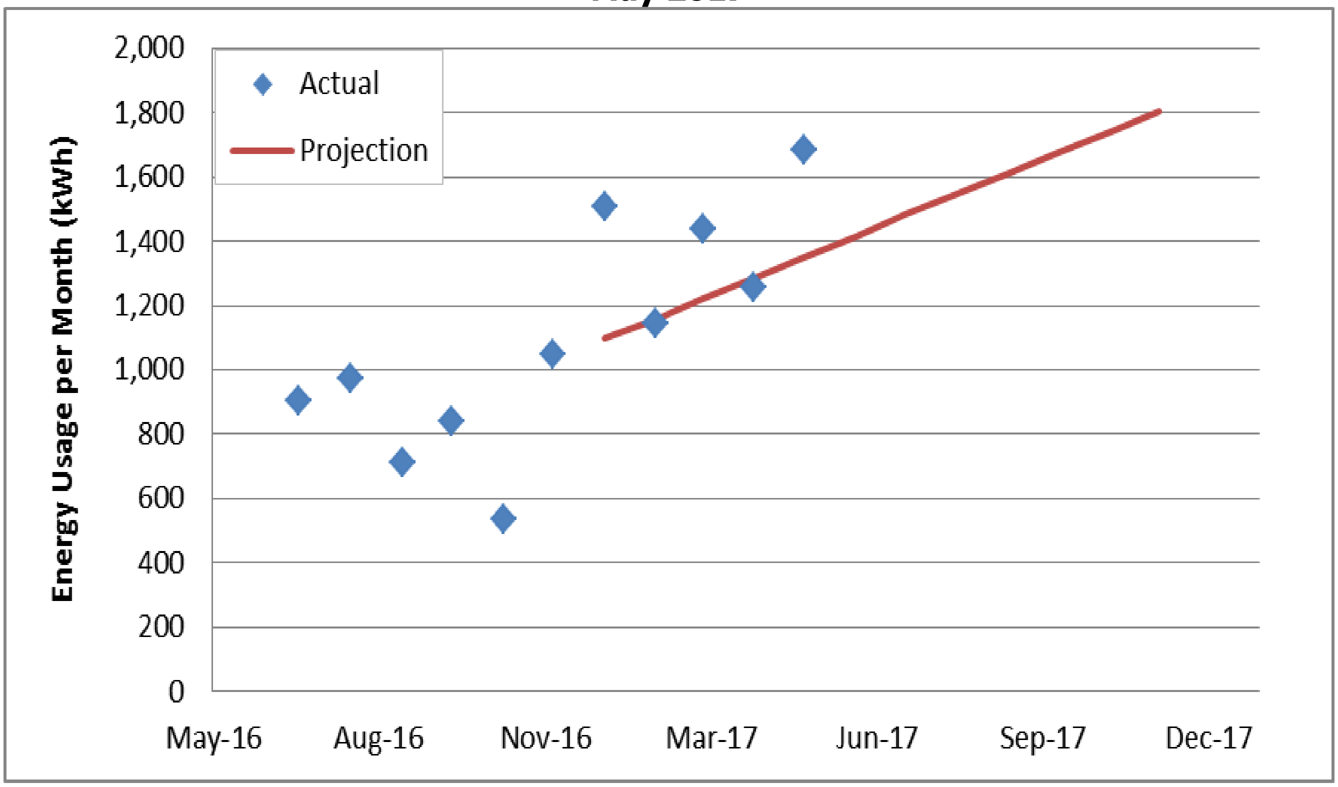
Figure 39: GHG Emissions Reduction Over Time by New EVCS, Updated Through May 2017



Source: Schatz Energy Research Center

We estimate the projected network usage through 2020 using data through December 2017. Now having part of 2017 data, Figure 40 adds the network's actual usage per month from May 2016 through May 2017 with a segment of the projection for January 2017 through December 2017. This five-month overlap supports the projection.

Figure 40: GHG Emissions Reduction Over Time by New EVCS, Updated Through May 2017



Source: Schatz Energy Research Center