CALIFORNIA ENERGY COMMISSION

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

DC Fast Charging Infrastructure Along Highway Interstate 5 Oceanside to San Clemente

Prepared for: California Energy Commission

Prepared by: EV Connect, Inc.

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- Staff of BTCPower, Inc.
- The staff and ownership of the Volare Hotel, San Clemente
- Staff of EV Connect and Rosendin Electric for their hard work and dedication

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 GFO-15-601 to provide funding opportunities for electric vehicle charging infrastructure. In response to GFO-15-061, the recipient submitted an application which was proposed for funding in the CEC's notice of proposed awards and the agreement was executed as ARV-15-064 on May 20, 2016.

ABSTRACT

This report entitled "DC Fast Charging Infrastructure Along Highway Interstate 5 Oceanside to San Clemente" is the final project report from EV Connect, Inc. for the CEC, under grant number ARV-15-064. The project was undertaken in cooperation with BTCPower, Inc.

The primary objectives of the project were:

- To design and install one direct current Fast Charging Station at one location along the Interstate 5 as described above
- To design and install two Level 2 Dual Port stations at this location
- To enable electric vehicles to travel from the Los Angeles area to the San Diego area with available electric power
- To accelerate plug-in electric vehicle adoption
- To promote green zero emission transportation

Key results: (extremely limited usage due to extended, COVID-19 related site closure)

- The project resulted in 16 charge sessions over the initial six-month period following completed commissioning at the location,
- This project reduced 188 kilograms of greenhouse gas emissions, and saved 21 gallons of gasoline, and
- This project provided insight of usage of fast charging stations along the Interstate 5 freeway.

Keywords: Electric vehicle, electric vehicle charge station, electric vehicle service equipment, high occupancy vehicle, Los Angeles County Metropolitan Transit Authority, greenhouse gas emissions, Open Charge Point Protocol, pollution, direct current (DC)

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EXECUTIVE SUMMARY

The State of California established the goal of having sufficient zero-emission vehicles infrastructure that is able to support up to 1.5 million vehicles by 2025. However, one of the major barriers for the acceptance and deployment of electric vehicles in California is a lack of charging infrastructure, especially infrastructure that connects major highway corridors.

Interstate 5 is the key north–south state highway in the U.S. state of California, stretching almost the entire length of the State. Corridor charging gives existing and prospective electric vehicle owners the assurance that they can recharge when driving long distances along a freeway or highway.

The objectives of the project are:

- To design and install one DC fast charging station at one location along the Interstate 5 freeway between Oceanside and San Clemente
- To enable electric vehicles to travel from the Bay Area to Southern California through the border with Mexico
- To accelerate plug-in electric vehicle adoption
- To promote green zero emission transportation

EV Connect installed one DC fast charging station manufactured by BTCPower, Inc. at this location, together with two Level 2 stations manufactured by EV Box. All network and software were provided by EV Connect, Inc., using Open Charge Point Protocol communication.

After six months of usage and data collection, EV Connect, Inc. and the team have achieved the following results (note: extremely limited usage due to extended, COVID-19 related site closure)

- The project resulted in more than 15 charge sessions over the initial six-month period following completed commissioning at the location,
- This project reduced 188 kilogram of greenhouse gas emissions, and saved 21 gallons of gasoline, and
- This project provided insight of usage of fast charging stations along the Interstate 5 freeway.

The data on utilization likely reflects the conditions of 2020 and more normalized use patterns will be prevalent in 2021 and beyond.

CHAPTER 1: Project Description

Overview

In October 2013, the governments of California, Washington, Oregon, and British Columbia signed an agreement called the "Pacific Coast Action Plan on Climate and Energy" which includes a commitment to transition the West Coast to clean modes of transportation. One action is to expand the use of zero-emission vehicles, aiming for ten percent of new vehicle purchases in public and private fleets to be zero-emission vehicles by 2016.

The State of California has the zero emission vehicle goals of having sufficient zero-emission vehicles infrastructure that is able to support up to 1.5 million vehicles by 2025. However, one of the major barriers for the acceptance and deployment of electric vehicles in California is a lack of charging infrastructure, especially that connects major highway corridors. It was a great challenge for electric vehicle drivers to travel from Northern California to the Central Valley or Southern California due to the lack of fast charging stations along State Route 99.

Interstate 5 is the key north–south state highway in the U.S. state of California, stretching almost the entire length of the State. The project under review here covers the short portion of the highway between Oceanside and San Clemente.

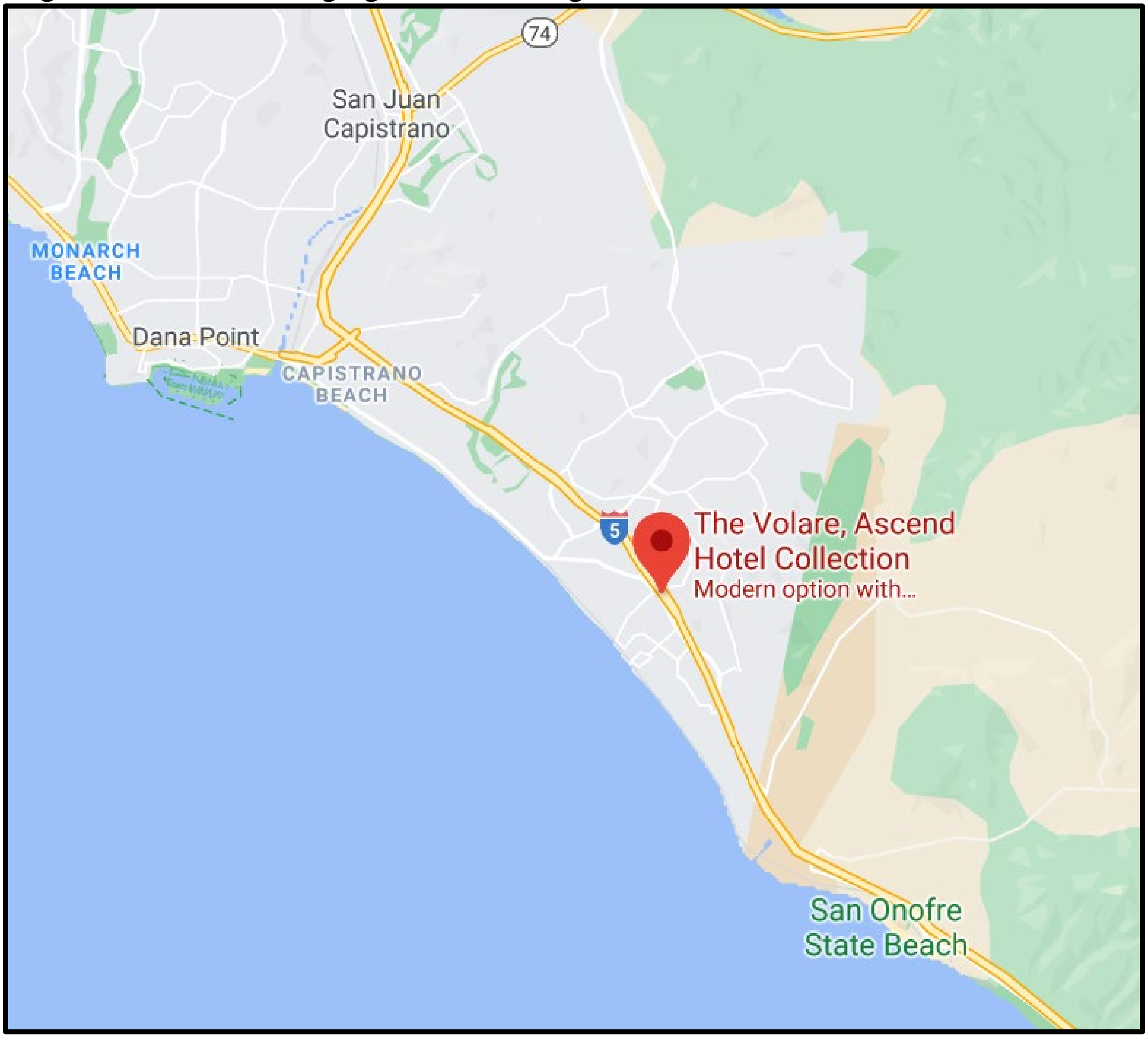
Corridor charging also gives existing and prospective electric vehicle owners the assurance that they can recharge when driving long distances along a freeway or highway.

Establishing an adequate charging infrastructure network will help to address range anxiety.

Project Sites

For this project, we have designed and installed a DC fast charging station at one site at the location indicated along the Interstate 5. The site is conveniently located within less than one mile to the Interstate 5 as shown on the map in Figure 1.

Figure 1: DC Fast Charging Stations along Interstate 5 Funded under ARV-15-064



Source: EV Connect, Inc.

CHAPTER 2: Project Execution

The project execution includes planning, equipment purchases and testing, installation and commissioning, and maintenance.

Planning

Project planning included the following:

- Review and approval of site plans
- Preparation of construction drawings and documents
- Permit application
- Electric vehicle supply equipment specification approval and ordering
- Electric vehicle supply equipment testing and approval
- Installation contractor's approval
- Project schedule review and approval
- Payment system set-up and field testing
- Signage Plan review and approval
- Maintenance & Inspection Plan review and approval
- Installation & Commissioning

Equipment Purchase and Testing

EV Connect evaluated a number of DC fast charging equipment options and chose the BTCPower, Inc. DC fast charging station 50-kilowatt unit (Figure 2).

In addition, EV Box Level 2 units were used, as their footprint is smaller than other models in the restricted space available.

Figure 2: BTCPower, Inc. DC Fast Charger

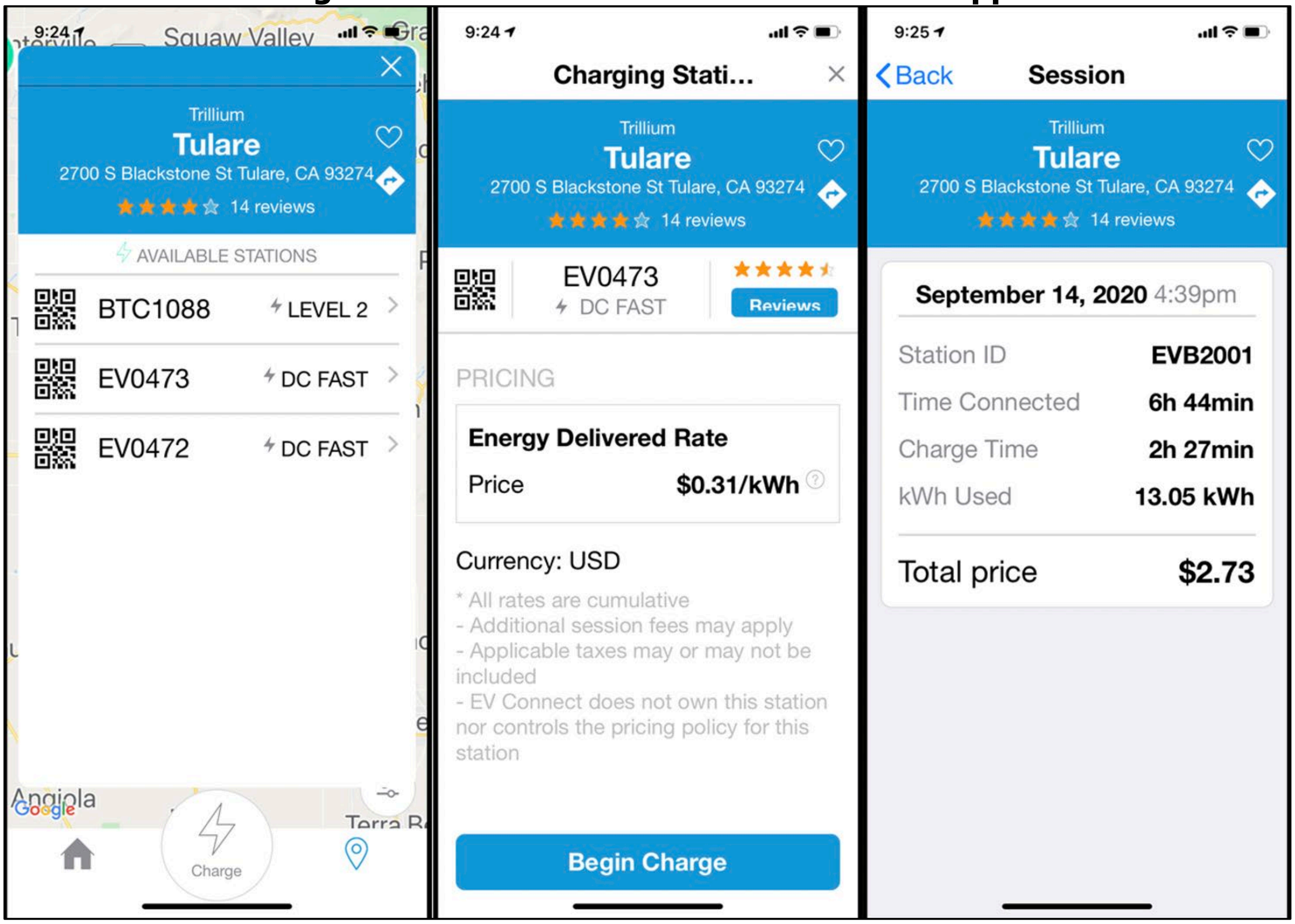
Source: BTCPower, Inc.

The charge stations can be started by a radio frequency identification cards card or an app. A new user can order a radio frequency identification cards card to ship to the home address.

In addition, the user can download an app for an iPhone, or an Android phone and payment can be made on the app using a major credit card or PayPal payment system. No membership or subscription is required, and the payment can be done at any time from any place on the app.

User can see the status of charging on the app that displays the real time price of the charge session and the energy dispensed (Figure 3). After the completion of the charging session, a receipt is immediately sent to the user’s cell phone (if the app is used).

Figure 3: Screen Shots of the EV Connect App



Source: EV Connect, Inc.

Installation and commissioning includes the following:

- Obtaining city permit
- Hiring installation subcontractors
- Site preparation including concrete cutting and trenching
- Running the electrical and communication conduit
- Concrete pouring
- Forming and pouring of reinforced concrete foundations for the sites
- Pre-installation inspection of cement
- Electric service upgrades including circuit breakers, panels, and safety disconnect and transformers
- Negotiation with San Diego Gas and Electric (utility) overpower provision
- Electric vehicle supply equipment installation
- Signage installation
- Final inspection and approval
- Network commissioning
- Final testing with an electric vehicle (EV)

Final commissioning meeting includes the following:

- Check and validate radio frequency identification cards
- Check the internet communication between a charging station and the central server
- Turn on and charge a test EV
- Check the app. Validate the sign-up and login as a new customer
- Test the automatic switch-off in response to a major fault
- Test the charging session in the case of a minor fault
- Test the remote system control and monitoring system
- Test the charging session and display of state of charge on a test EV

Operating Costs of Managing DC Fast Charging Stations

The ongoing operation costs of a DC fast charging station includes the costs of electricity, utility fees, city utility user taxes, demand charges from utility, insurance, internet communication network, customer services and technical support.

The hotel property decided to set the price of charging at $3.00/hour.

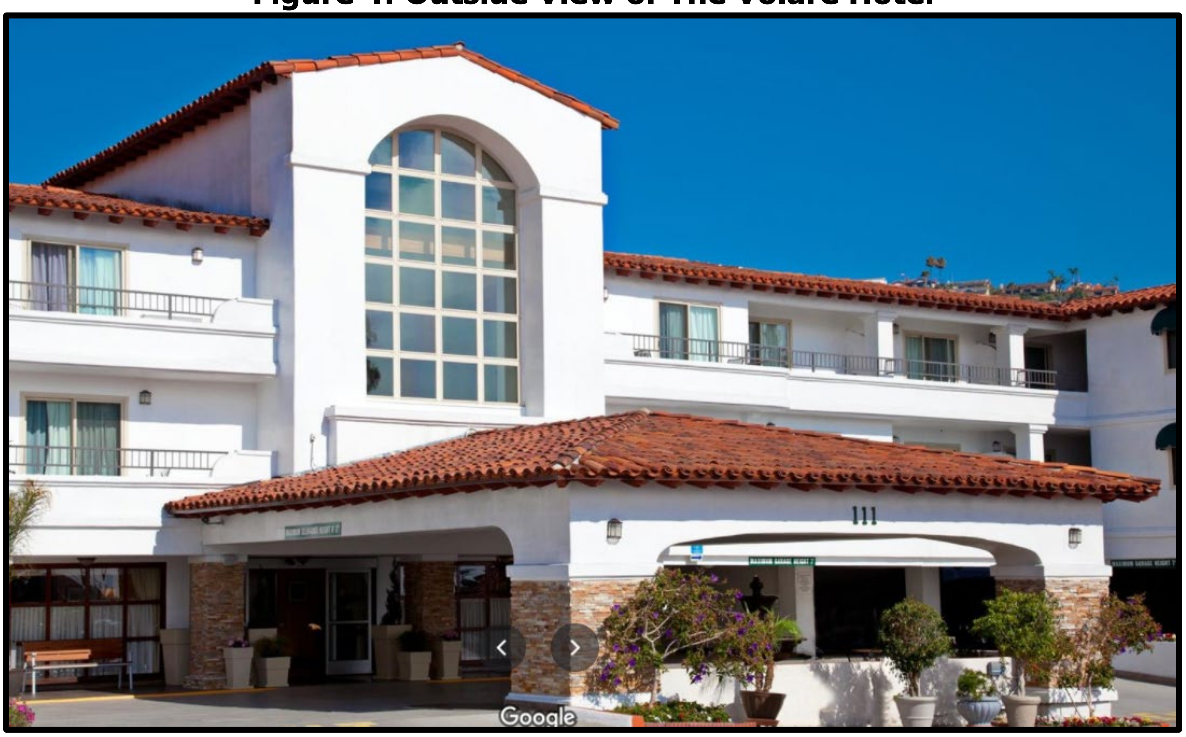
EV Connect are contributing match funds to cover the utility bill in support of the charging stations, and Utility Demand Charges which are onerous in San Diego Gas and Electric territory.

Installation Project

Site: Volare Hotel

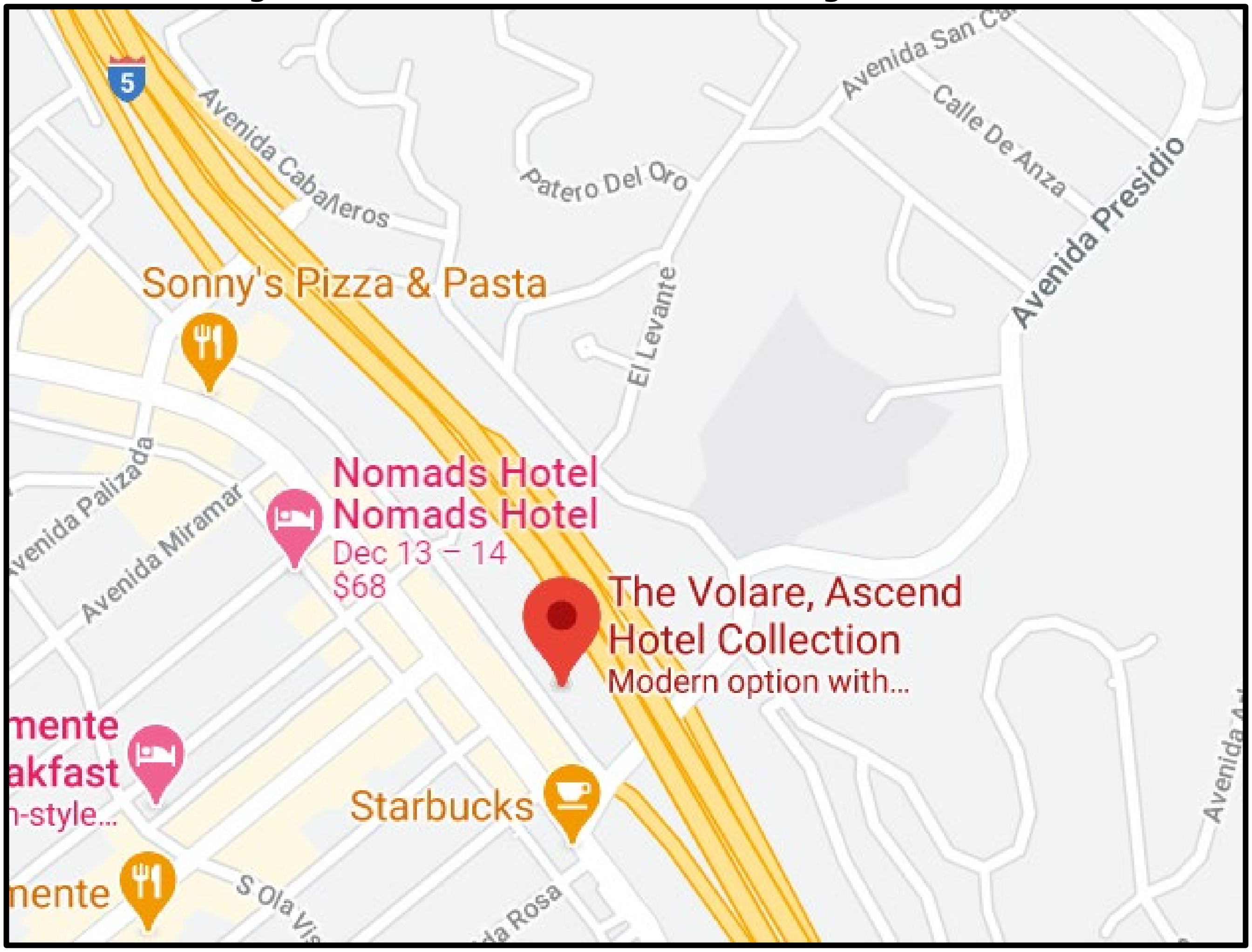
Figures 4 through 6 show different views of the installation site at The Volare Hotel at 111 S. Avenida De La Estrella, San Clemente, CA 92672.

Figure 4: Outside View of The Volare Hotel



Source: Google Maps

Figure 5: The Volare Hotel Location along Interstate 5



Source: Google Maps

Figure 6: Aerial View of The Volare Hotel

Source: Google Maps

The permit application process is one of the most time-consuming processes in designing and implementing a DC fast charging project. The process between the City and San Diego Gas and Electric was lengthy, and the design criteria seemed to change with each visit to the authority having jurisdiction. The housing site at The Volare Hotel applied for an electric vehicle supply equipment permit through the City of San Clemente.

The process of applying a permit for a DC fast charging station involves many steps that require due diligence preparation including the following key steps:

- Preparation of a site plan, engineering design
- Prepare Single Line Diagram for high voltage electrical equipment
- Contact utility company for new meter installation
- Obtaining Business Permit for local jurisdiction
- Submission an application for plan checks and paying fees
- Meeting with Plan Check Reviewers

- Make modifications if needed
- Meeting with Inspectors at site

Lack of guidelines and inconsistencies in permit requirement has been a major time-consuming process (although it has markedly improved over the last several years), and a barrier to deployment of EV charging stations in the local communities. We would like to highlight some key issues of the permitting process and suggestions to staff of the local Building Permit Departments.

- Guidelines should be developed and posted online to better inform contractors and building owners the permit process, requirement, and fees structure.
- The Guidelines should include a checklist to enable applicant to prepare document(s) in advance, such as site plan, panel upgrade, load calculation, wiring diagram, meter install, trenching, and electric vehicle supply equipment charger specification sheet.
- Streamlining and standardizing the permit process within the region would reduce costs.

CHAPTER 3: Data and Analysis

Overview of Data Analysis

One DC fast charging station and two Level 2 units were deployed at one site along the Interstate 5 corridor. After deployment and commissioning, the charge station was monitored continuously for a period of six months under operation from initial commissioning.

This section details the technical findings from the project. The results provided below include:

- Number of charging sessions per station per month
- The total time of usage at each station per month
- The total kilowatt-hour (kWh) of electrical energy usage at each station per month
- Greenhouse gas (GHG) savings
- Estimated gallons of gasoline displaced

Summary of EV Charging Data for the Volare

Table 1 shows a summary of the EV charging data for the site. Note that the site was closed to the public for an extended period of time due to state-mandated and county-mandated closures thus the usage of the stations was extremely low.

Table 1: EV Charging Usage Data

Station Type	Period	Charge Session Count	Charge Duration (min)	Connected Duration (min)	Power Provided (kWh)	GHG Savings (kg CO2)	Gasoline Saved (gal)	eMiles Provided (mi)
DCFC	All	0	-	-	-	-	-	-
Level 2	All	16	3,089	7,733	233	188	21	838
All	All	0	3,089	7,733	233	188	21	838
Level 2	Jun-20	2	358	1,008	21	17	2	77
Level 2	Jul-20	5	721	1,862	60	49	5	217
Level 2	Aug-20	2	255	1,256	12	10	1	44
Level 2	Sep-20	6	1,435	2,340	122	99	11	441
Level 2	Oct-20	1	320	1,267	17	13	2	59
Level 2	Nov-20	0	-	-	-	-	-	-
DCFC	Jun-20	0	-	-	-	-	-	-
DCFC	Jul-20	0	-	-	-	-	-	-
DCFC	Aug-20	0	-	-	-	-	-	-
DCFC	Sep-20	0	-	-	-	-	-	-
DCFC	Oct-20	0	-	-	-	-	-	-
DCFC	Nov-20	0	-	-	-	-	-	-

Source: EV Connect, Inc.

GHG Reduction

The GHG reductions are calculated using information given below. The calculation method is to convert the kWh consumed by the EV charging stations in the project to the equivalent number of gallons of gasoline saved and number of tons of carbon dioxide (CO_2) reduced.

- First, we calculate the miles/kWh for a representative electric vehicle. Based on various vehicle data, we have determined that this is 3.6 miles/kWh
- The average CO_2 emissions for an internal combustion engine vehicle is 450 gram/mile. Likewise, the average CO_2 emissions for a plug-in EV is 225 gram/mile assuming power is generated using an efficient mix of fossil and renewable power generation. (Reference EPRI; NRDC and Charles Clark Group: Nationwide Greenhouse Gas Emissions 2007)
- The difference in CO_2 (or CO_2 savings using an EV) between an internal combustion engine vehicle and an EV is (450–225) =225 gram/mile CO_2 reduced.
- Therefore, the GHG reduction calculation is as follows:

  (kwh consumed x miles/kwh) x 225 gram/mile = Grams of CO_2 reduced by using EVs
- For the entire project, the calculation shows:
  - (233 kWh x 3.6) x 225 gram/mile = 188 kilogram of CO_2 reduced by using EVs charged by the project.

Gallons of Gasoline Consumed

To obtain the number of grams of CO_2 emitted per gallon of gasoline combusted, the heat content of the fuel per gallon is multiplied by the kilogram CO_2 per heat content of the fuel. In the preamble to the joint United States Environmental Protection Agency/United States Department of Transportation rulemaking on May 7, 2010 that established the initial National Program fuel economy standards for model years 2012-2016, the agencies stated that they had agreed to use a common conversion factor of 8,887 grams of CO_2 emissions per gallon of gasoline consumed.[1] This value assumes at all the carbon in the gasoline is converted to CO_2.[2]

In our calculation, 8,887 grams of CO_2 is equivalent to one gallon of gasoline.

Therefore, the entire project over the initial six months of each site saved: 21 gallons of gasoline.

[1] Federal Register (2010). Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule https://www.govinfo.gov/content/pkg/FR-2010-05-07/pdf/2010-8159.pdf

[2] International Panel on Climate Change (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

CHAPTER 4: Summary and Conclusion

The project concluded with the following results:

- The project resulted in just 16 charge sessions over a six-month period due to extended site closure resulting from COVID-19 related restrictions
- The total charging time: 3,089 minutes or about 51 hours
- The total consumed energy: 233 kWh
- The estimated GHG reduction: 188 kilograms
- The estimated number of gallons of gasoline displaced: 21 gallons
- It delivered the expected results on budget and within schedules

It should be noted that the data presented here corresponds to the period in 2020 in which the COVID-19 pandemic affected the United States and has caused significant downward impact on road travel and use of the units. The site was closed to the public for most of this time.

The data herein on utilization likely reflects that environment and more normalized use patterns will be more prevalent in 2021 and beyond.

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.

CARBON DIOXIDE (CO_2)—A colorless, odorless, nonpoisonous gas that is a normal part of the air. Carbon dioxide is exhaled by humans and animals and is absorbed by green growing things and by the sea. CO_2 is the greenhouse gas whose concentration is being most affected directly by human activities. CO_2 also serves as the reference to compare all other greenhouse gases (see carbon dioxide equivalent).

DIRECT CURRENT (DC)—A charge of electricity that flows in one direction and is the type of power that comes from a battery.

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

GREENHOUSE GAS (GHG)—Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO_x), halogenated fluorocarbons (HCFCs), ozone (O_3), per fluorinated 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.