CALIFORNIA ENERGY COMMISSION

CALIFORNIA NATURAL RESOURCES AGENCY

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

Ten Level II Fleet Electric Vehicle Charging Outlets at the University of California, San Diego

Prepared for: California Energy Commission

Prepared by: Alternative Energy Systems Consulting, Inc.

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California Energy Commission

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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-11-602 to provide funding opportunities under the ARFVT Program for alternative fuels infrastructure. In response to PON-11-602, the recipient submitted an application which was proposed for funding in the CEC's notice of proposed awards November 14, 2012 and the agreement was executed as ARV-12-013 on January 29, 2013.

ABSTRACT

In January 2013, the California Energy Commission awarded grant funding of $69,446 to Alternative Energy Systems Consulting, Inc. to install, commission, and assess the performance of five Level II eStation Smart systems (10 charging outlets or ports) for fleet operations at the University of California, San Diego campus. Alternative Energy Systems Consulting, Inc. sub-contracted with Rheinisch-Westfälische Elektrizitätswerke Effizienz, a subsidiary of the German-based utility Rheinisch-Westfälische Elektrizitätswerke Aktiengesellschaft and an expert on the global International Organization for Standardization/International Electrotechnical Commission 15118 electric vehicle charging standard, to install and assess the charging units in the University of California, San Diego's microgrid environment.

The goal of the project is to demonstrate the feasibility of electric charging at the fleet level in order to achieve substantial reductions in greenhouse gas emissions through electrification of the transportation sector.

The official collection of electric vehicles charging data began on March 31, 2014 with the commissioning of the first Level II charger. As of August 2014, all chargers are installed and operational. Installation and commissioning occurred later than originally scheduled, impacting the duration of the data collection period. In addition to data collection and performance assessment, this report also includes lessons learned.

Governor Brown's Executive Orders B-16-12 and B-18-12 accelerate the integration of battery electric vehicles in state government and promote battery electric vehicle adoption by state employees and the public by making charging stations readily accessible at state buildings. This project has been responsive to these policy directives and has met its goals and objectives through the installation of ten Level II electric vehicle charging ports in the University of California, San Diego campus. This project will accelerate the integration of electric vehicles in state fleets and make charging stations available at state buildings for fleet and workplace charging.

Keywords: California Energy Commission, Alternative and Renewable Fuel and Vehicle Technology Program, zero-emission vehicles, electric vehicle supply equipment, battery electric vehicles, plug-in electric vehicles, plug-in hybrid electric vehicles, Level II electric vehicle chargers, charging ports

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EXECUTIVE SUMMARY

Introduction

In January 2013, Alternative Energy Systems Consulting, Inc. was awarded $69,446 by the California Energy Commission to install, commission, and access the performance of five Level II eStation Smart Systems (10 charging outlets or ports) for fleet operations at the University of California, San Diego campus. Alternative Energy Systems Consulting, Inc. sub-contracted with Rheinisch-Westfälische Elektrizitätswerke Effizienz, an expert on the global International Organization for Standardization/International Electrotechnical Commission 15118 electric vehicle charging standard, to install and access the charging units in the University of California, San Diego microgrid.

Purpose

The goal of the project is to demonstrate the feasibility of electric charging at the fleet level in order to reduce greenhouse gas emissions through the electrification of the transportation sector.

Objectives

- Monitor and operate the electric vehicle supply equipment for a period of three (3) years (scope of the Daimler Smart Charging project) and provide relevant charge detail records to UCSD for its microgrid.
- Provide a unique back office system which allows three levels of communication and electric vehicle supply equipment-management, including:
    - **Customer Relations Management** (authentication via plug and charge, no radio frequency identification card needed), registration, billing, roaming;
    - **Asset management** such as infrastructure control, status control, real-time-status-availability, reservation; and,
    - **Demand Management** including tariff signal negotiation according to International Organization for Standardization/International Electrotechnical Commission 15118, peak limitation based on grid restrictions, renewable energy integration and prioritization. The unique technology would synchronize the University of California, San Diego's microgrid capability with the intelligent smart-device-management software solution provided by Rheinisch-Westfälische Elektrizitätswerke Effizienz.
- Deliver high-quality electric vehicle supply equipment hardware with a two-year warranty for operation at University of California, San Diego's campus.
- Allow access for research and evaluation of customer behavior, driver patterns, charging behavior, and tariff models by providing relevant data for analysis by the project partners.

Conclusion

The collection of electric vehicle charging data began on March 31, 2014 with the commissioning of the first Level II dual port chargers at Keck Center. The installation contractor completed installation of the four remaining chargers during the period July 3, 2014 – August 4, 2014. Ten electric vehicle chargers for the use of the University of California, San Diego fleet, its employees, faculty, and students have been installed. Additionally, the project's goal of creating new job opportunities in California has also been achieved. KnGrid, a California entity, will manage and operate the intelligent electric vehicle supply equipment

system on campus consisting of 10 Fleet-electric vehicle supply equipment outlets, 16 workplace outlets and three direct current fast charger outlets. Monrovia, California-based AeroVironment Inc. will provide the after-sales service for the term of the maintenance agreement. In early 2015, University of California, San Diego will kick-off an awareness and information campaign targeted towards faculty and staff that aims to increase the use of electric vehicles.

Alternative Energy Systems Consulting, Inc. and Rheinisch-Westfälische Elektrizitätswerke encountered unforeseen difficulties establishing a subcontract agreement due to legal and tariff issues. Although these were eventually resolved, this delayed the project by six months. The number of project partners also presented problems in coordination and performance monitoring. Installation planning and the permitting process also contributed to overall project delay. The entire process could have benefited from installation guidance from the expedited process contained in the Governor's *Plug-in Electric Vehicles: Universal Charging Access Guidelines and Best Practices* and the *Plug-in Electric Vehicles Charging Infrastructure Guidelines for Multi-unit Dwellings*.

CHAPTER 1:
Objectives and Planning Phase

1.1 Project Overview

The California Energy Commission awarded grant funding of $69,446 to Alternative Energy Systems Consulting Inc. to install, commission, collect data, and assess the performance of Underwriter Laboratories listed Level II eStation Smart systems electric vehicle supply equipment with ten ports, for fleet operations at the University of California, San Diego (UCSD) campus. Alternative Energy Systems Consulting, Inc. executed this project collaboratively with two other California Energy Commission projects at the same site involving eight workplace Level II chargers (ARV-12-020) and three direct current fast chargers (ARV-12-027). Alternative Energy Systems Consulting, Inc. subcontracted with Rheinisch-Westfälische Elektrizitätswerke Effizienz (RWE), a wholly owned subsidiary of the German-based utility RWE Aktiengesellschaft (AG),[1] to install and assess these charging units in UCSD's micro grid environment. RWE was responsible for the installation, construction oversight, commissioning, and International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) 15118 expertise. Additionally, Alternative Energy Systems Consulting, Inc. subcontracted with AeroVironment, Inc., a California- based electric vehicle supply equipment (EVSE) manufacturer, to purchase five dual port Level II AC chargers with J1772 connectors. Under a separate agreement, RWE and AeroVironment, Inc. formed a joint venture to develop an end-to-end solution for a smart electric vehicle (EV) charging device with full backend connectivity and smart-grid-functionalities according to ISO/IEC 15118. Authentication via Plug and Charge (ISO 15118) allows customers an easy and convenient way to activate a charging session just by plugging the connector into the charge pole.

The data collection phase was limited because of significant delays in subcontracting, installation, and vehicle leasing. The final report includes the data and metrics collected in addition to lessons learned.

1.2 Intelligent EV Charging

In 2009, RWE started to promote high EV penetration on existing grids and to deliver high-quality products and services for the electric vehicle industry on a global level. RWE committed to transfer experience, expertise and technology of smart charging technology to the San Diego region, one of the early adopters in the United States of clean technology research and deployment. As part of the company's strategy to grow internationally, RWE became part of a consortium of technology leaders and experts in the field of smart energy, which includes San Diego Gas and Electric, UCSD, Alternative Energy Systems Consulting, Inc., Daimler and CleanTech San Diego. RWE committed to develop and install the United States version of its own state-of-the-art intelligent EV charging post enabling intelligent EV charging based on the ISO and IEC standards. RWE planned to install and operate five dual-outlet Level II EVSEs

[1] RWE AG (until 1990: Rheinisch-Westfälisches Elektrizitätswerk AG), is a German electric utility company based in Essen, North Rhine-Westphalia. Through its various subsidiaries, the energy company supplies electricity and gas to more than 20 million electricity customers and 10 million gas customers, principally in Europe. RWE is the second largest electricity producer in Germany.

with functional above standard technology to support UCSD's goal to expand the network of electric vehicle charging infrastructure in the campus.

Alternative Energy Systems Consulting, Inc. and RWE planned to deliver and install five (5) dual port, ground-mounted, Underwriters Laboratories listed EVSE. The 10 outlets are rated at 7.3 kilowatt per port, with J1772 connector, smart technology and ISO/IEC Commission 15118 communication functionality. The objectives were to:

- Monitor and operate the EVSE for a period of three (3) years (scope of the Daimler Smart Charging project) and provide relevant charge detail records to UCSD for its microgrid.
- Provide a unique back office system which allows three levels of communication and EVSE-management, including:
    - **Customer Relations Management** (authentication via plug and charge, no radio frequency identification card needed), registration, billing, roaming;
    - **Asset management** such as infrastructure control, status control, real-time-status-availability, reservation; and,
    - **Demand Management** including tariff signal negotiation according to ISO/IEC 15118, peak limitation based on grid restrictions, renewable energy integration and prioritization. The unique technology would synchronize the UCSD micro grid capability with the intelligent smart-device-management software solution provided by RWE Effizienz.
- Deliver high-quality EVSE hardware with a two-year warranty for operation at UCSD's campus.
- Allow access for research and evaluation of customer behavior, driver patterns, charging behavior, and tariff models by providing relevant data for analysis by the project partners.

UCSD is an ideal host for electric vehicle charging infrastructure. As a leader in reducing reliance on conventional, gas-powered vehicles and capitalizing on new technology to build a more sustainable fleet, it was chosen as the host for this effort. More than 50 percent of its fleet of more than 800 vehicles consists of hybrid and alternative fuel vehicles. It has replaced diesel fuel with ultra-low sulfur biodiesel, and many of its buses, street sweepers, cars and trucks have been converted to run on compressed natural gas.

1.3 Project Planning and Technology Adoption

In early 2012, RWE and AeroVironment Inc., a California-based EVSE manufacturer, signed an agreement to jointly develop an intelligent EVSE and synchronize the new, global standard for EV charging with United States' legal and market requirements. Based on the AeroVironment dual port with standard Level II alternating current charger and J1772 connectors, both companies created an end-to-end solution for a smart EV charging device with full backend connectivity and smart-grid functionalities complying with ISO/IEC Commission 15118. In addition to RWE and AeroVironment Inc., the project's participants are the following:

- Alternative Energy Systems Consulting, Inc.
- University of California, San Diego
- RWE Effizienz GmbH
- San Diego Gas & Electric
- Daimler AG

As part of the project, Daimler offered affordable leases on Smart Cars to interested faculty staff. The staff will provide a test bed of consumer driving, testing and behavior. The cars are fully compatible ISO 15118. The purpose of the project is to implement the "vehicle to grid" communication interface, called vehicle to grid communication, which will help create one coherent system that better integrates electric vehicles with the power grid, into UCSD's fleet. To enable electric vehicles to become a significant part of the fleet on campus, the deployment of intelligent Level II EVSE was a prerequisite. Vehicle to grid communication is required to identify and authenticate a vehicle, coordinate the charging and discharging process, handle the billing and support any additional services such as remote diagnostics, navigation system updates, and entertainment.

The project team established four key competencies:

- **Smart charging**: Information technology solutions for smart charging and product development of an industrial production EVSE made in California.
- **Information Technology**: Scalable information technology backend system for electric vehicle infrastructure, leveraging RWE information technology resources.
- **Utility perspective**: High safety standards and business orientation based on the needs and requirements of a large grid operator.
- **Original Equipment Manufacturer perspective**: Deep understanding of original equipment manufacturers' needs through joint cooperation on technology development with other original equipment manufacturers.

The electric vehicle charging stations supplied by RWE are the only charging stations in the United States that are currently certified for the new ISO 15118 standards. Carlsbad-based Alternative Energy Systems Consulting, Inc. assumed the lead contracting role in the project.

The project aimed to demonstrate following use cases on campus:

1.3.1 Authentication via Plug & Charge

Authentication via Plug and Charge (ISO 15118) allows customers an easy and convenient way to activate a charging session just by plugging the connector into the charge pole. There is no additional user interaction needed. The charging session starts automatically. Customers use a radio frequency identification card-enabled credit or debit card.

1.3.2 Backend Services

A web-based user interface provided by the RWE's backend system, allowed for the following functionalities on campus:

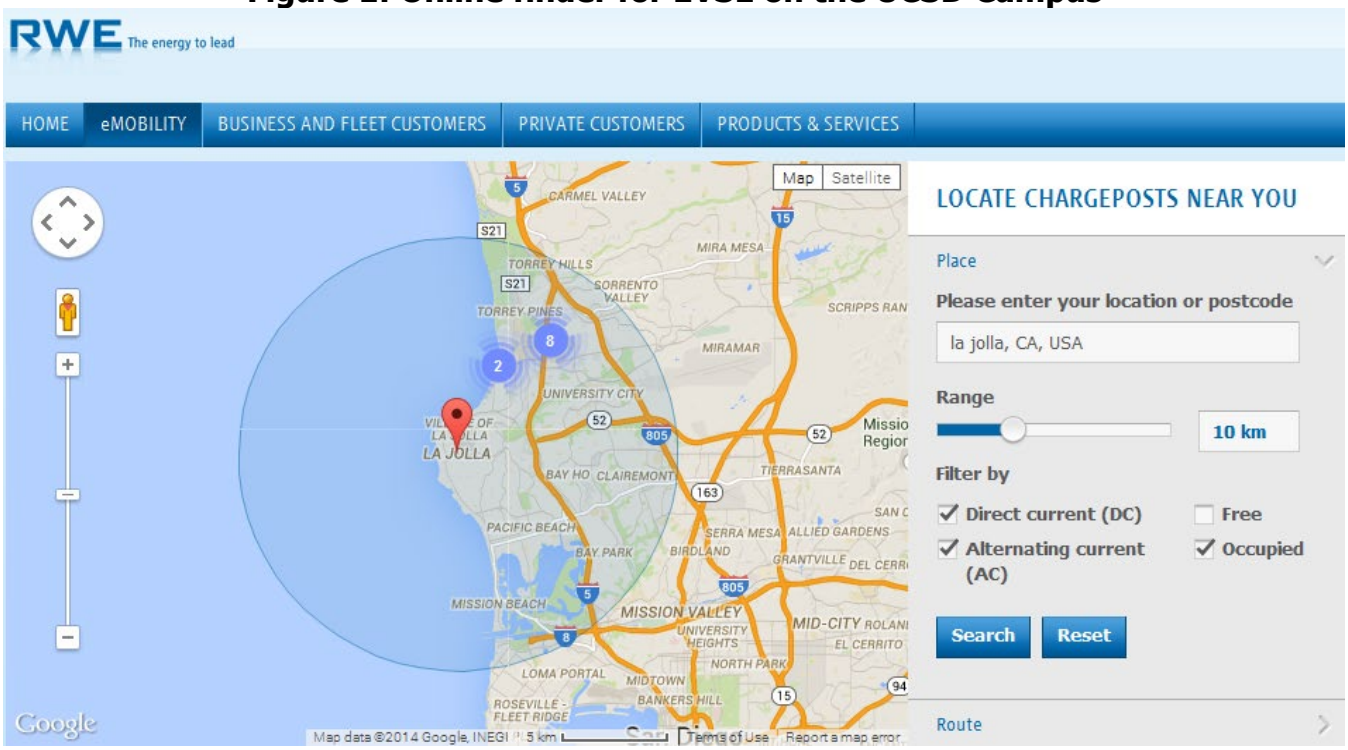
- Configuration Management
- Remote activation
- Activation by smartphone app
- Energy management
- Infrastructure monitoring
- Infrastructure dashboard

A standard internet browser using a common internet connection is the only requirement for program participation. Under this scenario, UCSD will be able to access and manage its own fleet and the pool of EVSE revenues within this project.

1.3.3 Energy Management

The RWE backend allows for independent load management of the ten intelligent outlets. The project team grouped the charge points into clusters to manage the data flow. The clusters represent a physical location such as UCSD Fleet Service complex. For each cluster, the project team has defined various load limits (per phase) and balancing strategies. The customer, using the graphic user interface, can adjust cluster grouping, balancing strategy and load limits (Figure 1).

Figure 1: Online finder for EVSE on the UCSD Campus



HYPERLINK "https://www.rwe-mobility.com/web/cms/en/1195202/emobility/rwe-charging-post-finder/" Source: RWE.

1.3.4 Charge Detail Records

The project team has provided charge detail records for the entire volume of 10 EVSE outlets on campus from the backend connection. Charge detail records indicate which Contract Identification charged at which charge point, at what time, using how many kilowatt hours, etc.

There are two kinds of charge detail records:

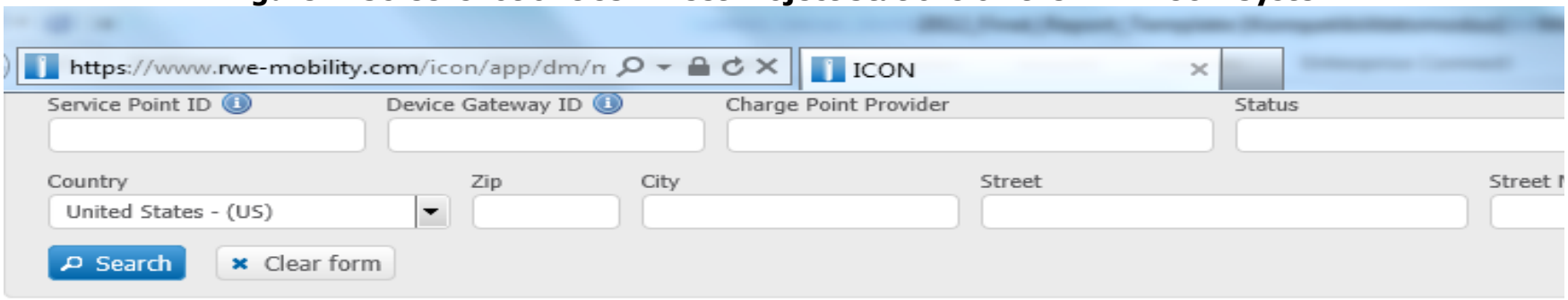
- Charge detail records per charge point: users may analyze charging behavior and energy consumption at their infrastructure.
- Charge detail records per contract identification: users may analyze their user's usage behavior and energy consumption.

At the end of the planning phase, RWE, UCSD, San Diego Gas and Electric, Sullivan Solar and Alternative Energy Systems Consulting, Inc. selected four locations in the UCSD campus for the fleet chargers:

1. Scripps Institute of Oceanography Keck Center with one dual port and a total of two outlets.
2. Gilman parking structure with two dual ports and a total of four outlets (each port is separated in this installation).
3. UCSD Fleet Services with one dual port and a total of two outlets.
4. East Campus Parking with one dual port and a total of two outlets.

Figure 2 below illustrates all five EVSE with 10 outlets as currently installed and connected to the RWE backend.

Figure 2. Screenshot of UCSD Fleet Project Stations on the RWE ICON System



Select page | Deselect page | Refresh Status (0)

	SID	Station ID	Countr	Zip	City	Street	Charge Point Provider
☐	AV-0018-9	US01910	US	92093	La Jolla - San Diego	Gilman Drive 3119	KN GRID LLC
☐	AV-0023-5	US01913	US	92093	La Jolla - San Diego	Gilman Drive 3119	KN GRID LLC
☐	AV-0024-1	US01917	US	92093	La Jolla - San Diego	Gilman Drive 3119	KN GRID LLC
☐	AV-0017-2	US01918	US	92093	La Jolla - San Diego	Gilman Drive 3119	KN GRID LLC
☐	AV-0010-8	US01907	US	92037	La Jolla - San Diego	Medical Center Drive	KN GRID LLC
☐	AV-0012-0	US01908	US	92037	La Jolla - San Diego	Medical Center Drive	KN GRID LLC
☐	AV-0028-7	US01908	US	92037	La Jolla - San Diego	Medical Center Drive	KN GRID LLC
☐	AV-0007-4	US01909	US	92037	La Jolla - San Diego	Medical Center Drive	KN GRID LLC
☐	AV-0016-6	US01909	US	92037	La Jolla - San Diego	Medical Center Drive	KN GRID LLC
☐	AV-0025-8	US01914	US	92037	La Jolla - San Diego	Medical Center Drive	KN GRID LLC
☐	AV-0011-4	US01906	US	92093	La Jolla - San Diego	Scholars Drive South	KN GRID LLC
☐	AV-0021-2	US01906	US	92093	La Jolla - San Diego	Scholars Drive South	KN GRID LLC
☐	AV-0020-6	US01904	US	92037	La Jolla - San Diego	Shellback Way 8831	KN GRID LLC
☐	AV-0027-0	US01904	US	92037	La Jolla - San Diego	Shellback Way 8831	KN GRID LLC
☐	US-2101-6	LB00236	US	92653	Laguna Hills	Dapple Grey Dr 26602	KN GRID LLC

Source: RWE.

CHAPTER 2:
Implementation Phase

2.1 Setup of Project Team

Phase 2 began in late 2012. The following contractual agreements were signed:

- Alternative Energy Systems Consulting, Inc. and RWE: flow down agreement for the installation and commissioning of five dual-ports (10 outlets) on UCSD campus.
- Alternative Energy Systems Consulting, Inc. and AeroVironment Inc.: pricing-model for five dual-port Level II EVSE including two-year warranty.
- RWE and Sullivan Solar: on-site pre-installation services and construction.
- RWE and KnGrid: operation of 10 simultaneous use Level II outlets.

There were a number of international legal issues that needed resolution before the agreement was signed between RWE and Alternative Energy Systems Consulting, Inc. Since RWE does not operate as a registered legal entity in the United States, equipment purchased directly from RWE would require RWE to take possession in Germany for equipment assembled in California, resulting in additional tariffs and taxes.

An external international business-consulting firm, Klynveld Peat Marwick Goerdeler, was engaged to recommend a solution. It was agreed that RWE would provide services and equipment through purchase order agreements. Under this scenario, RWE provided a turnkey solution for its state-of-the-art charging technology and AeroVironment delivered fully functional Level II and direct current fast chargers. The California Energy Commission's terms and conditions were incorporated in these agreements. RWE then proceeded with the procurement process, after a delay of six months.

2.2 Testing and Installation

RWE and AeroVironment continued to develop and test the prototypes of the new, state-of-the-art EVSE. The partners established a test laboratory at AeroVironment's site in Monrovia, California and installed two Daimler smart Electric Drive, four dual-ports and a local copy of the RWE information technologies backend system. The partners successfully completed testing in August 2013 in order to comply with the requirements for Underwriter Laboratories-listed charging equipment. Underwriter Laboratories certified the modified EVSE in September 2013 and after additional functional tests and use-case scenarios, AeroVironment delivered the entire lot of equipment to UCSD in December 2013. On January 14, 2014, the installation of the first dual-port system began at UCSD's Scripps Institute of Oceanography, Keck Center, where the installation contractor had already completed pre-installation work. Installation of the chargers was successfully completed within one day.

On February 14, 2014, installation began at UCSD's Gilman Garage. Due to a change in the parking lot setup, the installation had to be modified and split into four single-outlet wall mounted Level II EVSE. Concerns with drilling into the parking structure floor and disturbing the tensioning system necessitated that the units be wall mounted. These changes in plan caused significant delay but installation was completed on April 4, 2014.

2.3 Going Live

On April 9, 2014, UCSD hosted a press conference and demonstration with representatives of San Diego Gas and Electric, Daimler, KnGrid, RWE, Alternative Energy Systems Consulting, Inc., and Commissioner Janea Scott of the California Energy Commission in attendance. This event marked the first official demonstration of an ISO/IEC 15118 alternating current charger in Northern America.

The photo (Figure 3) shows RWE Project Manager, Joerg Lohr, with the first Daimler lease customer, Professor Veerabhadran Ramanathan of Scripps Institute of Oceanography, in front of the newly installed EVSE for UCSD's fleet vehicles.

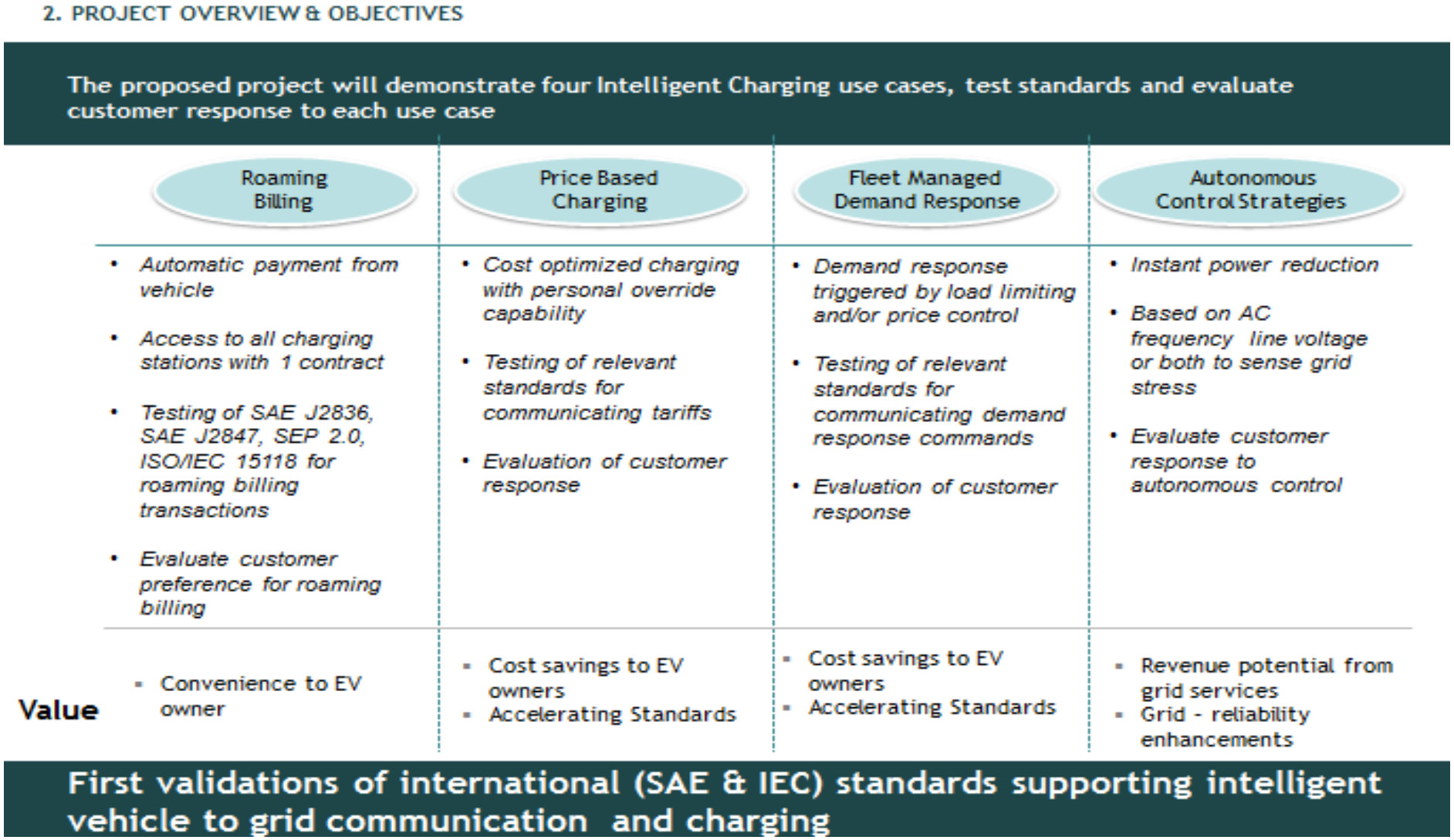
Figure 3. First EVSE Installation Media Event

Source: RWE

2.4 Follow Through and Additional Testing

RWE and UCSD will continue with additional demonstration and testing of the EV chargers over the next three years. Figure 4 below lists the Project objectives for each of the four planned use cases.

Figure 4. Planned Use Cases



Source: Alternative Energy Systems Consulting, Inc.

2.5 Photographs of Installations

The following photographs (Figures 5-11) show the installations of the chargers at the four locations:

1. **Scripps Institute of Oceanography Keck Center Site** – The first EVSE installed on campus, a pedestal mount dual charger.

Figure 5. Scripps Institute of Oceanography (Keck Building) Level II Ports 1 & 2

Source: Alternative Energy Systems Consulting, Inc.

2. **Gilman Parking Structure Site –** This was the second installation. Because drilling into the floor could potentially compromise the parking garage's tensioning system, the equipment was wall mounted. The individual outlets were also separated to comply with Americans with Disabilities Act requirements and UCSD's parking plan.

Figure 6. Gilman Parking Level II Charger 1 Port 1 (Americans with Disabilities Act compliant)

Source: Alternative Energy Systems Consulting, Inc.

Figure 7. Gilman Parking Level II Charger 1 Port 2

Source: Alternative Energy Systems Consulting, Inc.

Figure 8. Gilman Parking Level II Charger 2 Port 1

Source: Alternative Energy Systems Consulting, Inc.

Figure 9: Gilman Parking Level II Charger 2 Port 2

Source: Alternative Energy Systems Consulting, Inc.

3. **Fleet Services Site -** Below is the third installation, located in front of the Fleet Services Building.

Figure 10. Fleet Services Level II Ports 1 & 2

Source: Alternative Energy Systems Consulting, Inc.

4. **East Campus Parking** – This was the last fleet installation on campus. The dual port charger is installed in a wall-mounted configuration. As with the Gilman site, the chargers were not pedestal mounted based on parking structure tensioning issues. The chargers serve both the Thornton Hospital and the newly constructed Jacob's Hospital.

Figure 11. East Campus Parking Level II Ports 1 & 2

Source: Alternative Energy Systems Consulting, Inc.

CHAPTER 3:
Project Results

The collection of EV charging data (Charge Detail Records) began on March 31, 2014 with the commissioning of the first Level II dual port chargers at Keck Center. The installation contractor completed installation of the four remaining chargers during the period July 3, 2014 – August 4, 2014. Because of the delay in installation and commissioning, there are not many data points available at this time. At present, there are only two electric vehicles using the chargers on a regular basis. In early 2015, UCSD will kick-off an awareness and information campaign targeted towards faculty and staff that aims to increase the use of electric vehicles. In addition, there were several data integrity problems that resulted in the underreporting of overall usage. First, charge energy is not accumulated for charge records where the charger shuts off and then powers back on. According to data analysis, this phenomenon appears to be occurring sporadically. A software fix is currently being developed to address the problem. Second, charge energy data is being corrupted when connected to a specific vehicle (Smart Car Generation 2). This is also currently being addressed.

3.1 Number of Fleet and Employee Vehicles Fueled

Between April and November 2014, four vehicles had been configured to operate on the fleet-designated RWE chargers. Additionally, these chargers will be available for workplace vehicles. The initial retail rates will be $0.22/kilowatt hour or $4.95 per month membership plus $0.16/kilowatt hour. After the awareness campaign, Daimler will offer the same program to forty (40) students, faculty and staff to participate in a forthcoming research project.

UCSD has also exchanged term sheets for a public car-sharing program on campus that will involve the exclusive use of EVs. UCSD anticipates that about 25 EVs will participate in the program. UCSD is also negotiating with NRG Energy, Inc., a Fortune 300 company, which provides charging solutions, to bring an additional 50 Level II charging stations in the campus.

3.2 Number of Days Vehicles are Fueled

Between April and November 2014, four participating fleet vehicles and approximately 15 other student/facility vehicles have accessed the charging stations over a total of 66 days as shown in table 1.

Table 1. Number of Days Vehicles Fueled

Charging Station Days Location	Apr-14	May-14	June-14	July-14	Aug-14	Sep-14	Oct-14	Nov-14	Grand Total
East Campus (Hospitals)							10	7	17
Fleet Operations					1	2	2	2	7
Gilman Garage							8	9	17
Keeling Apartments							4	3	7
Scripps Inst. Ocean. Keck	3	1	1	7	4		2		18
Grand Total	**3**	**1**	**1**	**7**	**5**	**2**	**26**	**21**	**66**

Source: Alternative Energy Systems Consulting, Inc.

3.3 Number of Charging Events

Between April and November 2014, the fleet charging outlets only saw 200 charging events and 146 hours of charging as shown in table 2. Charging occurred across all five locations:

- (Scripps Institute of Oceanography [Keck Building]
- Fleet Operations Building
- Gillman Parking Garage
- East Campus Parking [Green and Jacobs Hospitals]
- Keeling Apartment complex.

Table 2. Charge Events by Location

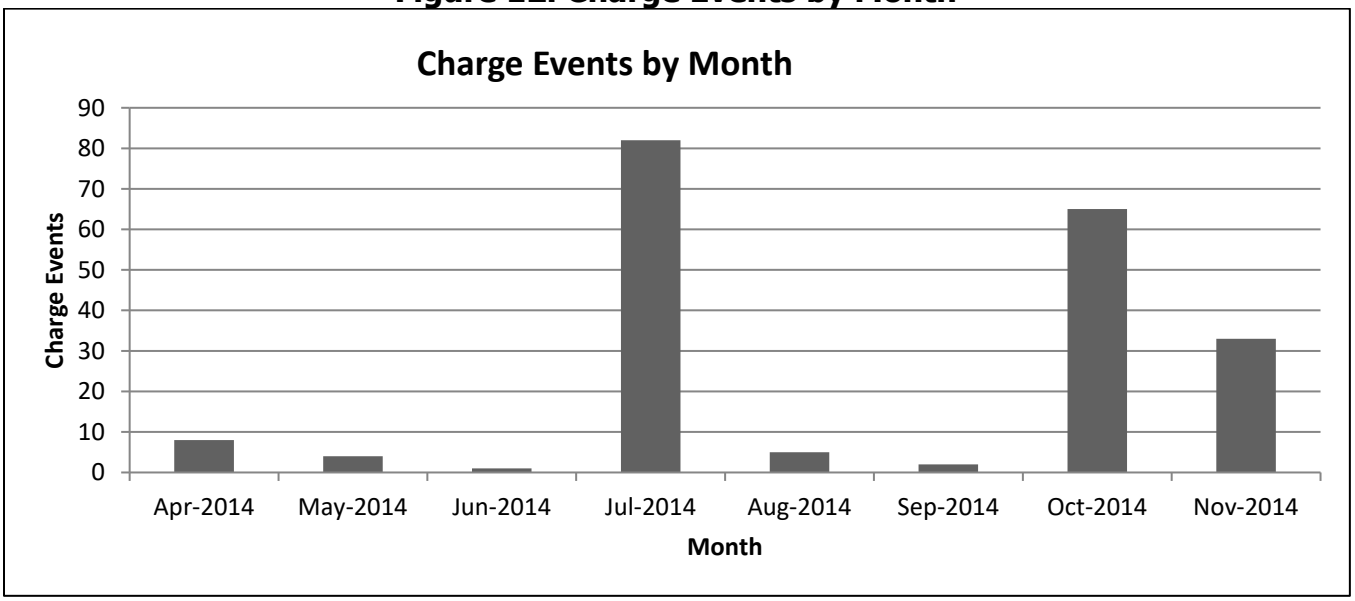
Charge Evenets by Location Month Location	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Grand Total
East Campus (Hospitals)							38	12	50
Fleet Operations					1	2	6	2	11
Gilman Garage							15	16	31
Keeling Apartments							4	3	7
Scripps Inst. Ocean. Keck	8	4	1	82	4		2		101
Grand Total	**8**	**4**	**1**	**82**	**5**	**2**	**65**	**33**	**200**

Source: Alternative Energy Systems Consulting, Inc.

The July charging jump occurred following the completion of testing/configuration and the initiation into service of the two Fleet Services Smart cars. August and September charging tapered off after some data problems had been discovered. The following charts summarize project charging events and durations.

Figure 12 summarizes monthly charging events for all locations.

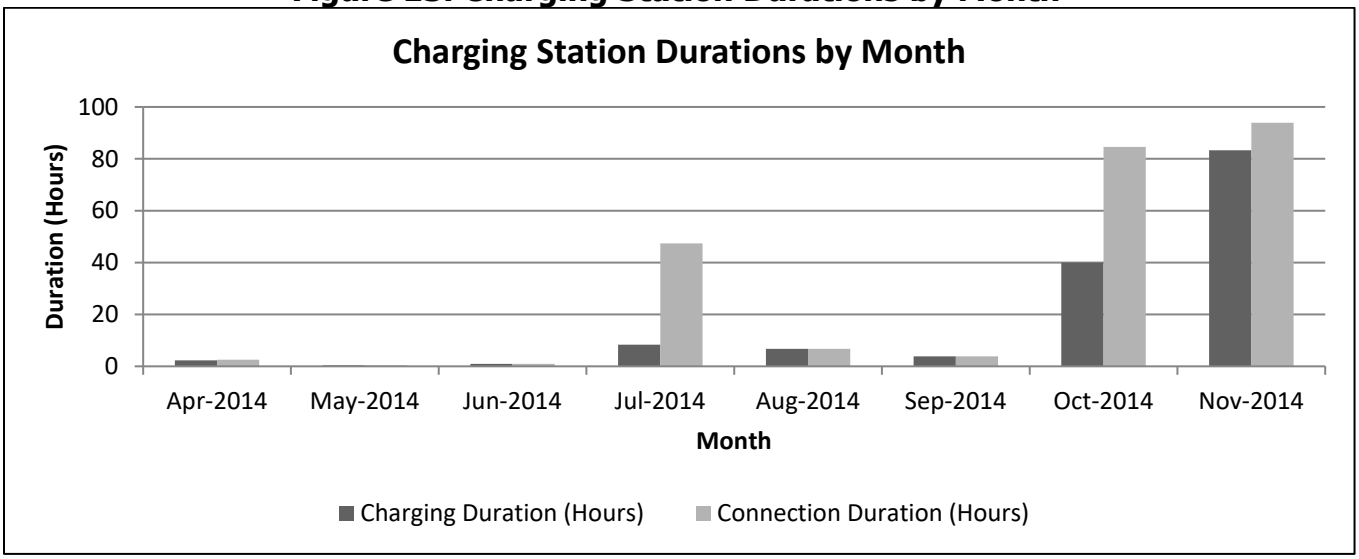
Figure 12. Charge Events by Month



Source: Alternative Energy Systems Consulting, Inc.

Figure 13 summarizes monthly charging durations by month.

Figure 13. Charging Station Durations by Month



Source: Alternative Energy Systems Consulting, Inc.

3.4 Maximum Capacity of the New Fueling System

In total, UCSD will have 26 RWE ISO Compliant Level II charging stations and 3 direct current fast chargers. In addition to 25 Ecotality/Blink systems installed during the American Recovery and Reinvestment Act program.

3.5 Gallons of Gasoline Displaced

Since UCSD began the leasing program in early April 2014, the vehicles have logged 1,361 miles. According to the fuelecnomy.gov website (www.fueleconomy.gov), this has resulted in displacing 12 gallons of regular gasoline, compared to a 2012 Chevrolet Impala using regular unleaded fuel.

3.6 Emissions Reductions

Displacing 12 gallons of regular gasoline equates to lowering greenhouse gas emissions by 0.58 metric tons of carbon dioxide. According to the fueleconomy.gov website, the only greenhouse gas emissions associated with electric vehicles are those from the production of electricity. Based on this project's location in La Jolla, California, the fueleconomy.gov website rates the Daimler Smart fortwo carbon dioxide emissions from electricity production at 130 grams per mile. However, because of the unique renewable substantial weighting, UCSD's microgrid has been rated 51 grams per mile.[2] This compares to 480 grams per mile for the average gasoline powered car of similar size. There are no tailpipe emissions associated with these electric vehicles.

3.7 Duty Cycle of the Fleet

The UCSD EV fleet is in transition from Nissan Leaf's expiring or expired leases to an affinity lease program with Daimler for their Smart Car Gen III models, which are ISO 15118 compliant. Thus, for the first time, there will be an EV to EVSE charging that is both ISO 15118 and 15188 compliant. UCSD has committed to adding at least eight new Daimlers for fleet operations and workplace charging. The Daimler affinity lease program consists of an $1,100 initial payment for license/fees/first/last month payment for a 3-year lease at $86/month. In addition, there is a $2,500 state rebate that effectively reduces the monthly payment to only $17/month.

3.8 Jobs and Economic Development

Electric vehicles are transformative technologies, which create a variety of benefits to the economy. EV and EVSE manufacturing creates jobs. Although it is difficult to estimate the impact of this project, the installations have at the minimum provided either temporary jobs or have contributed to increasing revenues for companies engaged in EVSE installations. Electrification of personal transportation can push job creation in a host of industries. More efficient cars require more sophisticated technology, which are designed and produced by adding workers to the auto industry. Many of these jobs would be in industrial sectors closely tied to auto manufacturing, advanced batteries, and research and development.

In the long run, electric vehicles are more cost efficient to operate than conventional vehicles. Drivers who switch to electric vehicles will eventually have more disposable income to spend for housing, entertainment, and other services. This increased spending in other sectors will stimulate the economy and enhance job creation.

Quality of life of employees, students, and users of the EV infrastructure are also enhanced with the availability of EV chargers. Workplaces that offer alternative fuel infrastructure are able to attract the early adopters of green technology as employees. This project and similar projects also reduce dependence on foreign oil and studies have shown that the use of EVs can reduce utility prices.

This project makes use of the Vehicle to Grid charge system, allowing vehicles to feed electricity back to the grid. Peak hours of electricity demand usually occur in the early to mid-afternoon, when most vehicles are sitting idle and can feed power back into the grid. On the other hand, electric vehicles are generally charging late in the evening, overnight, and in the

[2]Washom, Byron, Sept 2013 Presentation - *Replicability and Scalability of UC San Diego's 42 MW Microgrid for Pacific Islands*, p.30.

early morning, when there is excess generation capacity in the grid. Hence, large-scale deployment of EVs will allow utilities to forego the use of power plants that are only needed to satisfy peak demand. This could substantially decrease operating costs and therefore utility rates. Further, vehicle to grid makes possible the greater use of clean energy. Electric vehicles generally charge from late afternoon to early morning, a period during which a major portion of energy is generated from renewable energy sources such as wind.

3.9 Renewable Energy at the Facility

Since the late-2000's UCSD has been installing photovoltaic systems on its rooftops and parking structures and today it has produced 2.2 megawatt of electric generating capacity from the combined output of those systems.

Located at UCSD's East Campus Utility Plant is a 2.8-megawatt Fuel Cell Energy DFC3000 fuel cell system that is configured to run on directed biogas from the Point Loma Wastewater Treatment Plant. While the main output of the fuel cell is electricity for use on campus, it also generates water and high temperature heat. The byproduct heat is a valuable resource that can be utilized for process or district heating or it can be used to generate cooling capacity via an absorption chiller. UCSD recently commissioned a 350-ton absorption chiller that will utilize the fuel cells waste heat and provide baseload cooling capacity to the campus. In this new configuration (fuel cell plus absorption chiller) the project is considered a combined heat and power system and it will achieve total efficiencies in excess of 68 percent.

In January 2014 UCSD's Fleet Services changed its biodiesel feed stock source from soybeans to waste grease. It presently contracts with a local company (New Leaf Biodiesel) to pick up waste grease from numerous kitchens on campus. New Leaf refines the waste grease into biodiesel, which is sold back to the campus. This closes the loop with the use of B20 biodiesel making at least 20 percent of diesel fuel dispensed renewable.

UCSD has concluded contract negotiations to change its natural gas supplier to use 100 percent all renewable, frack free, domestic, landfill/digester methane gas to be dispensed at UC compressed natural gas fueling station.

UCSD has received the following Awards and Recognition:

- Recognized as a Model Pollution Prevention Shop (2005)
- Sustainable Transportation Best Practices Award (2006)
- San Diego Excellence in Energy Award for Special Achievement in Transportation (2006)
- United States Senate Certificate of Commendation for energy efficiency and conservation, renewable energy, and mass transportation (2007)
- Member of the Environmental Protection Agency's National Partnership for Environmental Priorities program (2009) and recognized for our successful compliance (2011)
- Green Fleet recognized UCSD Fleet Manager as a Sustainability All-Star for reducing emissions and fuel consumption (2011)
- Ranked 22nd Government Green Fleet (2010)
- Ranked 18th Government Green Fleet (2011)
- Ranked 14th Government Green Fleet (2012)
- Recognized as one of the 100 Best Fleets in the nation (2012)

3.10 Source of the Alternative Fuel

UCSD is firmly committed to provide a world class alternative fuel vehicle fleet. Approximately 60 percent of the current fleet vehicles at UCSD are alternatively fueled vehicles. In comparison, 10 years ago the campus had less than 10 percent of the fleet alternative fueled. The current UCSD fleet are as follows:

- 3 Bi-Fuel (Compressed Natural Gas-Underwriters Laboratory)
- 100 Hybrid
- 51 Dedicated Compressed Natural Gas
- 3 Plug-In Hybrids
- 17 E85 Flex Fuel
- 49 Biodiesel
- 396 Unleaded (excludes Hybrids)
- 336 Electric (non-Full Speed)
- 4 Full Speed EV (down from 7 before leases expired)

3.11 Energy Efficiency Measures

In 2013, San Diego Gas and Electric presented the UCSD with a $7.2 million check representing energy efficiency incentives earned through implementation of 30 energy efficiency projects from 2010 to 2012. UCSD has saved more than 21 million kilowatt hours, 2.1 million therms and reduced more than 2 megawatts of demand.

"UCSD was recently honored as the grand champion in San Diego Gas and Electric's Energy Champion awards for implementing energy-efficiency measures to optimize energy performance across the campus. Optimizing facilities is a high priority at UCSD, with all new construction targeting leadership in energy and environmental design silver certification or higher; the campus is already home to 14 buildings have met this certification. Renewable energy sources are also a critical component in the UCSD's campus infrastructure."

3.12 Lessons Learned

Alternative Energy Systems Consulting, Inc. and RWE encountered unforeseen difficulties establishing a subcontract agreement due to legal and tariff issues. Although these were eventually resolved, this delayed the project by six months. The number of project partners also presented problems in coordination and performance monitoring. Installation planning and the permitting process also contributed to overall project delay. The project team approached this project as a traditional construction effort and did not receive the benefit that could have been obtained from utilizing an EVSE specific planning and permitting process. The installation and the connection of the EVSE to the grid took only about six hours per outlet, but the permitting and planning process ranged from five days to six weeks. The entire process could have benefited from installation guidance from the expedited process contained in the Governor's *Plug-in Electric Vehicles: Universal Charging Access Guidelines and Best Practices* and the *Plug-in Electric Vehicles Charging Infrastructure Guidelines for Multi-unit Dwellings*.

3.13 Accomplishments

The project team has fully achieved one of the project's major goals of providing made in California, state-of-the-art technology to the state. Ten electric vehicle chargers for the use of

the UCSD fleet, its employees, faculty, and students have been installed. Additionally, the project's goal of creating new job opportunities in California has also been achieved. KnGrid, a California entity, will manage and operate the intelligent EVSE system on campus consisting of 10 Fleet-EVSE outlets, 16 workplace outlets and three direct current fast charger outlets. Monrovia, California-based AeroVironment Inc. will provide the after-sales service for the term of the maintenance agreement.

The goal to increase EV adoption on the UCSD campus is still a work in process at this time. The EV marketing campaign is planned for early 2015. The details of the vehicle lease program with Daimler are still being worked out. Substantial adoption of EVs and usage of the EVSE is anticipated by the first quarter of 2015.

The project has succeeded in increasing electric vehicle infrastructure on the UCSD campus, which will eventually lead to the more widespread adoption of electric vehicles, not only for its fleet, but also for the use of its employees, faculty, and students.

GLOSSARY

AKTIENGESELLSCHAFT (AG)—German word meaning stock company.[3]

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

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

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)— Founded in 1906, the International Electrotechnical Commission is the world's leading organization for the preparation and publication of International Standards for all electrical, electronic and related technologies.[4]

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)—An independent, non-governmental organization with members from standards organizations in 164 member countries. It is the world's largest developer of voluntary international standards and facilitates world trade by providing common standards between nations.[5]

RHEINISCH-WESTFÄLISCHE ELEKTRIZITÄTSWERKE (RWE)—With its four subsidiaries RWE Power, RWE Generation, RWE Supply & Generation, RWE Supply & Trading and RWE Renewables- RWE AG is a German electric utilities company based in Essen, North Rhine-Westphalia.[6]

UNIVERSITY OF CALIFORNIA, SAN DIEGO (UCSD)—The University of California, San Diego is one of the world's leading public research universities, located in La Jolla, California.

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[3] Firma.de (https://www.firma.de/en/company-formation/what-is-a-aktiengesellschaft-stock-company/)

[4] International Electrotechnical Commission (https://www.iec.ch/)

[5] International Organization for Standardization (https://www.iso.org/about-us.html)

[6] Rheinisch-Westfälische Elektrizitätswerke's website (www.group.rwe/en)