CALIFORNIA ENERGY COMMISSION

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

Renewable Energy Workplace Charging with Vehicle to Grid and Peak Demand Reduction

Prepared for: California Energy Commission

Prepared by: US Hybrid Corporation

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US Hybrid Corporation also acknowledges the tremendous support from the City of Torrance planning division, Southern California Edison, the efforts of our Engineering, Administration, Procurement, and Construction Contractor with their tireless dedication to completing the project despite technical obstacles and difficulties, including the challenges that naturally emerge when trying to develop innovative new energy technologies projects.

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 installation across a range of categories. 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-14-016 on August 18, 2014.

ABSTRACT

In response to the electric vehicle charging infrastructure solicitation, US Hybrid Corporation proposed to design, develop and implement a renewable solar powered charger with multiple electric vehicle supply equipment to facilitate alternating and direct current electric vehicle charging, and battery storage capability, at the US Hybrid Corporation headquarters in Torrance, California.

Battery electric and plug-in vehicles are more commercially viable and available than ever before; however, the lack of charging infrastructure limits the mainstream utilization and deployment of this promising technology. There is a fundamental need to expedite the installation of electric vehicle supply equipment at commercial, workplace, and publicly accessible buildings or locations.

Government funding is needed to assist the end-user in the infrastructure upgrades due to the high cost. Also, there is a need to utilize off-peak charging to reduce stress on utility distribution and reduce the cost of charging energy. Lastly, there is a need to integrate this electric vehicle supply equipment with renewable resources to provide truly zero emission transportation. A small amount of renewable solar generation in concert with energy storage provides a significant reduction in average utility charges and demand during peak hours.

Keywords: Renewable Energy, Workplace Charging, Vehicle to Grid, Peak Demand Reduction, City of Torrance, US Hybrid Corporation, Electric Vehicle, Electric Vehicle, Direct Current Fast Charger

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EXECUTIVE SUMMARY

California has been a dynamic force for shifting to sustainable and renewable energy sources, including solar and wind, to reduce greenhouse gas emissions with a specific focus on on-road and off-road mobile sources. In the past several years, there has been explosive growth in support for zero-emission deployment and renewable charging, particularly in photovoltaic solar installations. Electricity, regardless of energy source, must be used the instant it is generated, which makes solar and wind resources challenging to manage on the power grid. Power from these renewable generation sources is generated at different times and does not always align with electricity demand. The next step in commercial building is to reduce peak demand charges to minimize the impact of high-power electric vehicle charging.

Integration of local battery energy storage can provide a facility with peak demand power, reducing the total cost and supporting the management of distribution grid overload and load demand. Renewable energy integrated with battery storage augment the grid, in contrast to the operation of power-generating microgrids that are independent of the grid.

The purpose of the project was initially to provide renewable electric vehicle charging, off-peak charging and vehicle to grid power transfer to allow potential utilization of electric vehicles' onboard batteries to support the utility during peak hours. This strategy would not only minimize the impact of electric vehicles on the grid, but also use the electric vehicles as a resource to stabilize the grid during peak hours and provide urgently needed power to meet the distribution load demand during peak load hours. However, due to restriction from the employee's authorization to allow the use of their vehicles, we concluded that installing an energy storage in the facility (repurposed batteries) would allow better optimization of energy and power and not restrict employee's vehicle utilization.

Typical renewable generation installations at community or utility facility levels do not include energy storage, relying instead on the utility grid to absorb and balance intermittent renewable generation. These installations cannot provide backup power in the event of a grid outage and do not increase energy security or reliability for the host community. In fact, larger levels of intermittent renewable generation at the distributed/community and utility scale is challenging grid stability statewide and is a critical barrier to installing more renewables in California.

To explore these challenges, a renewable photovoltaic energy system and battery energy storage were designed, installed and tested at the US Hybrid Corporation facility in Torrance California. The project team used commercially available photovoltaic renewable solutions and up to date alternating current J1772 and fast direct current charging ports with the innovative battery storage and fast dynamic DA04, bi-directional alternating current-direct current products to implement renewable energy utilization and peak demand management. The total photovoltaic installed is less than one percent of facility feeder size (1.2 megawatts) and the battery energy storage was less than three percent but was able to provide average energy use by more than 20 percent and actual monthly saving of over $1,200, while supporting more electric vehicles and plug-in hybrid electric vehicles for employees and offer public charging.

The project team successfully designed, constructed and provided two alternating current J1772 ports, and one fast direct current-charge port, for employee and public use, while reducing the average monthly energy use by 20 percent and over $1,200 saving per month. The system operation and control were optimized using the developed model.

Capital costs of the project were measured and documented as part of the project budgeting process. The project team successfully commissioned the system and ran it through a full range of operational scenarios and failure modes. The system has been operating with over 92 percent availability.

In addition to the charge ports, US Hybrid Corporation has added two 40 kilowatt chargers for trucks and buses and additional high-power test equipment (dynamometers and 380-kilowatt power converter products test cell) and peak demand charge count for 55 percent of the monthly utility bill, which is mostly due to testing the high-power alternating current/direct current, direct current/direct current and electric powertrain systems. The peak demand control algorithm utilizing the on-site battery storage has proven to be effective and we plan to expand the program and battery storage system capacity (200 kilowatt-hours, utilizing repurposed batteries from commercial battery electric vehicles) and power (200 kilowatt-hours) with an interface to facility feeder panel to remedy the peak demand charges

Meanwhile, we continue to provide free public alternating current J1772-Level II and direct current fast charging as well as a charger for our employees. US Hybrid Corporation employees operate two battery electric, three plug-in, and two fuel cell vehicles along with charging for trucks and buses (80 kilowatts, onboard charger) in support of our vehicle testing.

The project successfully demonstrated that a small renewable energy generation and energy storage can provide a substantial reduction in utility operation cost (less than 20 percent lower average daily kilowatt-hour and cumulative energy saving over 16 months).

The peak demand management is proven to be the most cost-effective product and US Hybrid Corporation is planning to extend this system to a commercial product offering for commercial building usage that has many cyclic loads. The project also significantly advanced commercial building peak demand management utilizing localized energy storage, whereas currently most of such efforts focused on load management and scheduling, which may not be effective for facilities with cyclic loads.

CHAPTER 1: Project Background and Objectives

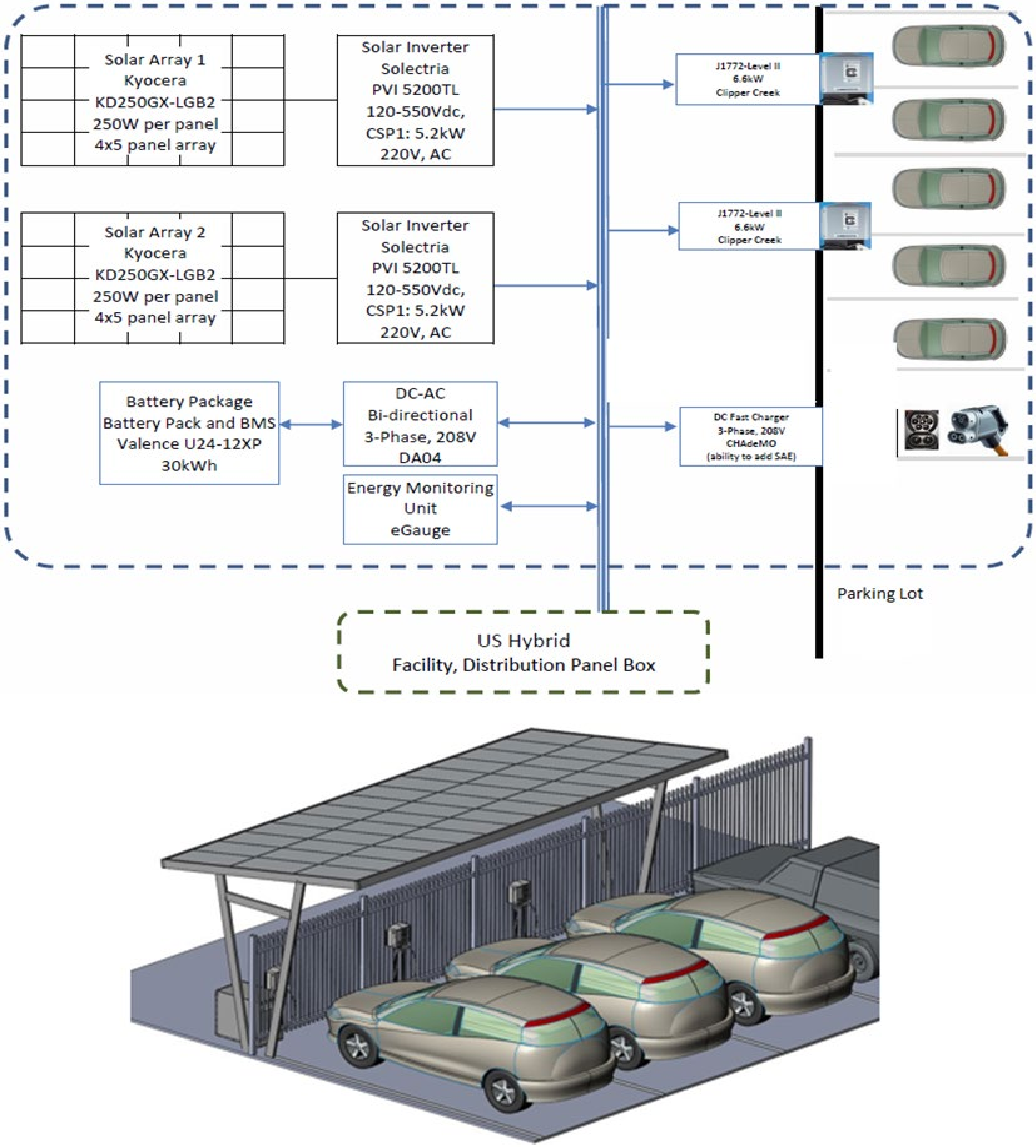
The goal of this agreement is to develop and deploy alternative fuel and renewable energy advanced transportation technologies to help attain California's climate change policies. This project will further the state's goals through the installation of renewable energy charging stations and will enable off-peak charging, reducing the cost and grid impact as the deployment of electric vehicles substantively increases.

The objectives of this agreement are to provide renewable electric vehicle charging, off-peak charging and vehicle to grid power transfer to allow potential utilization of electric vehicles onboard battery to support the utility during peak hours and not only to minimize the impact of electric vehicles on the grid, but also use the electric vehicles as a resource to stabilize the grid during peak hours and provide urgently needed power to meet the distribution load demand during peak load hours.

US Hybrid Corporation proposes the implementation of a renewable solar power charger with multiple electric vehicle charge points and vehicle to grid capability at the company's headquarters in Torrance, California. The proposed renewable energy smart grid charge ports will also utilize battery storage that can be charged via solar power or off-peak rates, reducing facility peak demand charges. US Hybrid Corporation will utilize their bi-directional direct current/alternating current converter to provide power generation to the grid either via solar generation, battery storage or the vehicle battery to assist the grid in peak demand with voltage stability and loading. The renewable energy charge ports will provide charging for company employees who drive electric vehicles (including Ford Transit Connect, Chevrolet Volt and S-10 EV). The company would provide free charge energy and preferred parking spots to these employees driving battery and plug-in electric vehicles.

Figure 1 shows the proposed renewable energy generation and charging stations.

Figure 1: Renewable Energy Charge Stations and Battery Storage Schematic and Visual



The technical description of the proposed renewable energy charge port system depicted in Figure 1 is as follows:

a) Two Level 2 electric vehicle supply equipment charging ports with Society of Automotive Engineers J1772 connectors with a rated output of 6.6 kilowatt alternating current

b) One direct current fast charger electric vehicle supply equipment charging port combined with a Society of Automotive Engineers J1772 Combined Charging System, 25-kilowatt direct current
c) A 10-kilowatt solar system with a bi-directional converter to provide power to meet the charger load or the battery charging with Maximum power point tracking.
d) The solar charging station will also function as carport for up to three vehicles.
e) A 30-kilowatt-hour lithium ion battery for local energy storage to allow charging energy during off-peak and powering the facility to reduce the peak demand load, while providing charging energy to the vehicles as needed.
f) A 30-kilowatt bi-directional direct current/alternating current converter with anti-islanding to enable off-peak charging and peak demand reduction and power-to-grid during peak demand.
g) The electric vehicle supply equipment will be utilizing an open source protocol as a basic framework for purposes of network interoperability.
h) The renewable energy charge and smart grid system has Controller Area Network with real time operation status reporting via local Wi-Fi and cellular system.

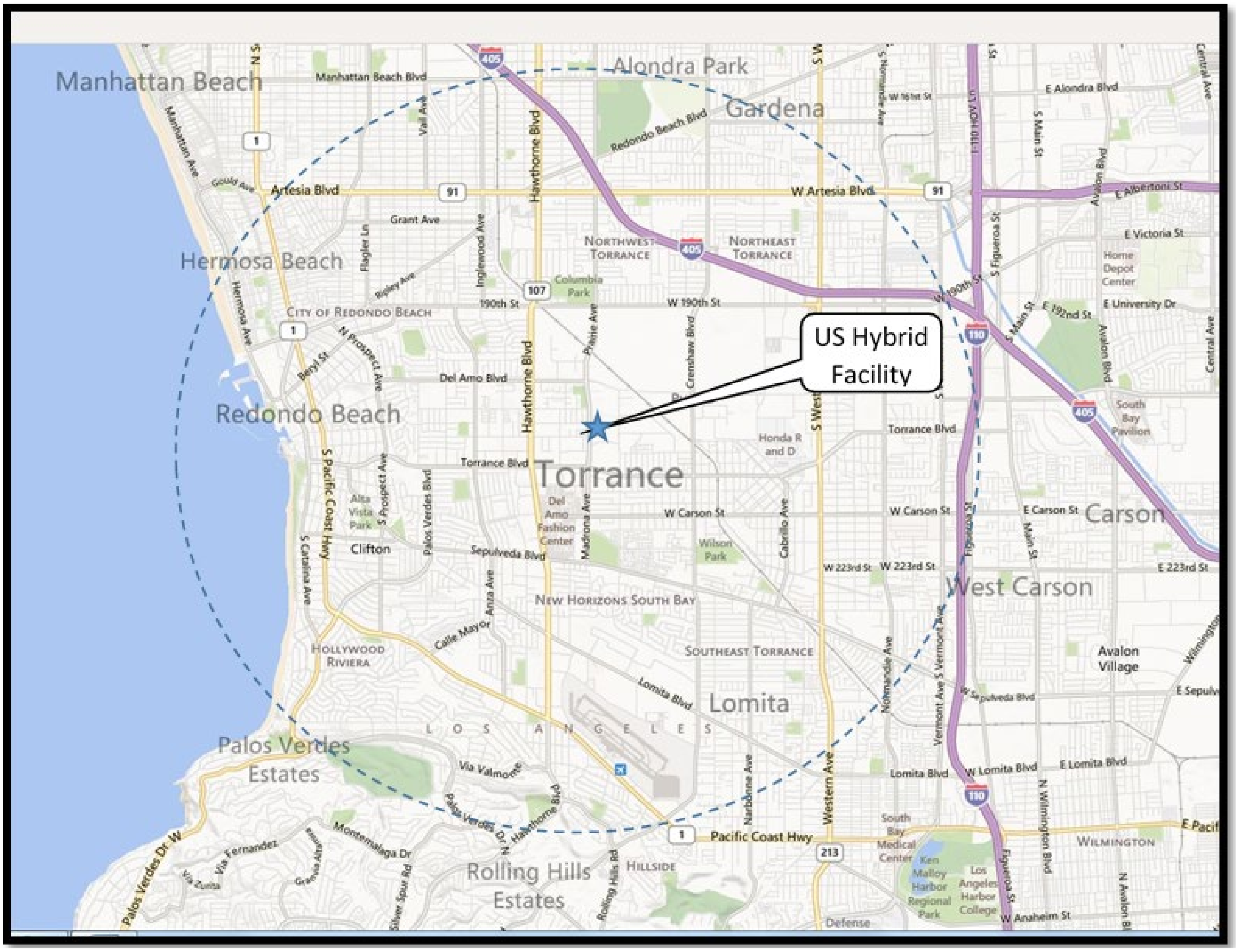
The proposed site is located at US Hybrid Corporation's headquarters at 445 Maple Avenue in Torrance California, 90503. The facility is within an eight-mile radius from major urban areas such as Torrance, Redondo Beach, Manhattan Beach, Gardena, and Hawthorne.

The site has been US Hybrid Corporation's corporate headquarters for the last 11 years and is in a non-residential place of business. US Hybrid Corporation is the owner and lease operator of the site and facilities, which is used as a workplace for design and development of powertrains for electric, fuel cell, and plug-in hybrid vehicle systems.

Figure 2 and Figure 3 show the renewable charge port smart grid facility and locations.

Figure 2: US Hybrid Corporation Location

Figure 3: US Hybrid Corporation Location and Surrounding Cities



US Hybrid Corporation's operational goals and objectives for the project are as follows:

- Provide renewable energy electric vehicle charging to provide zero emission transportation
- Reduce the facility's electric utility bill by eliminating/minimizing the peak demand charge
- Provide off-peak charging and energy storage to reduce the overall electric utility charges
- Provide energy to the grid during peak time to enhance grid stability and capacity from either the stored energy in the battery, the solar power or the vehicle battery via vehicle to grid
- Support and encourage US Hybrid Corporation employees to drive electric and plug-in vehicles.
- US Hybrid Corporation will provide an electric car to the employee of the month free of charge for the six months of operation, at which point the incentive program will be reevaluated for a potential twelve-month extension

CHAPTER 2: Solar Panels and Photovoltaic Converter

2.1 Activities Performed and Changes Made

The project involves the implementation of a renewable energy system with a photovoltaic system, battery charger, and battery storage with multiple electric vehicle supply equipment and vehicle to grid capability at US Hybrid Corporation's headquarters in Torrance, California. Appendix A includes the project data sheets for the components used in this project. The proposed renewable energy smart grid charge ports will also utilize battery storage that can be charged via solar power at off-peak rates, reducing facility peak demand charges.

This report includes a technical description of the system capabilities, system design of major components, and breakdown of each major components' operating specifications. Computer Aided Design drawings showing exact dimensions of canopy system and a site plan showing the placement of components will be released once ongoing structural revisions requested by the City of Torrance are complete.

The installation is a result of US Hybrid Corporation's electrical, mechanical, and project personnel design work. The design incorporates constraints, electrical and structural, posed by off-the-shelf components and in-house US Hybrid Corporation products.

2.1.1 Technical Description

The system features a canopy that will have two solar panel arrays (shown in Figure 4) capable of producing up to ten kilowatts in the combined array. The panels will supply power through a converter (shown in Figure 5) to three alternating currents charge ports (shown in Figure 6, Figure 7, and Figure 8) that are Level 2 Society of Automotive Engineers J1772, capable of outputting 6.6 kilowatts of power. The renewable energy charge ports will provide charging for company employees who drive electric vehicles, including a Ford Transit Connect, Chevrolet Volt, and S-10 electric vehicle. There is an additional three-phase, 208-volt direct current charge station rated at 20 kilowatts for fast charging. The fast charger will adhere to CHAdeMO standards, and depending on the direct current fast charger vendor, will have the ability to add a Society of Automotive Engineers Combined Charging Standard. Currently, no vendor selling direct current fast charging units supports a vehicle to grid interface. However, it is intended that this ability be added when/if possible. Physically, the canopy provides both a structure to house the panels and charge ports and shade for the electric cars. The canopy will span six car spots, with the charge ports staggered every other space. The fast charger will occupy one car spot due to its size and installation requirements.

Figure 4: Solar Panels Installed on Rooftop

Figure 5: Photovoltaic Converter and Battery/Charging Station Panels

Figure 6: US Hybrid Corporation Charging Station

Figure 7: US Hybrid Corporation High Speed Charging Station

Figure 8: US Hybrid Corporation Charging Stations

A total of 30 kilowatts of on-site lithium ion battery energy storage is available to allow charging when solar energy is too low, as well as to accept solar energy that is not being used. The battery also serves as an energy management tool. It can supply power to US Hybrid Corporation’s facility to reduce the peak demand load when not providing energy to charge vehicles. Because the battery is direct current and the charging system and grid is alternating current, an inverter is required for the battery system (the direct current fast charger also takes alternating current and then converts it to direct current). US Hybrid Corporation is providing its in-house DA04 inverter for this application. The DA04 has been purposely designed for bi-directional direct current/alternating current operation of fast and dynamic systems. Such inverters are hard to find on the market. Those that exist are mainly designed for smart grid and battery storage applications, sized at a higher power of 100 kilowatts-1 megawatt. In contrast, the DA04’s power requirement does not exceed 30 kilowatts.

Moreover, there is no such product rated for the 220-volt, three phase system that meets the system specifications we have. If any other inverter is used, it would require customization, resulting in substantial cost beyond the original scope of work. For reference, the DA04 has been a US Hybrid Corporation commercial product since 2007 and is very cost competitive with fast dynamic response (sub-cyclic response to support microgrid stability and reactive power control), high power density, and high reliability. Therefore, it is the best product of choice for our renewable energy system.

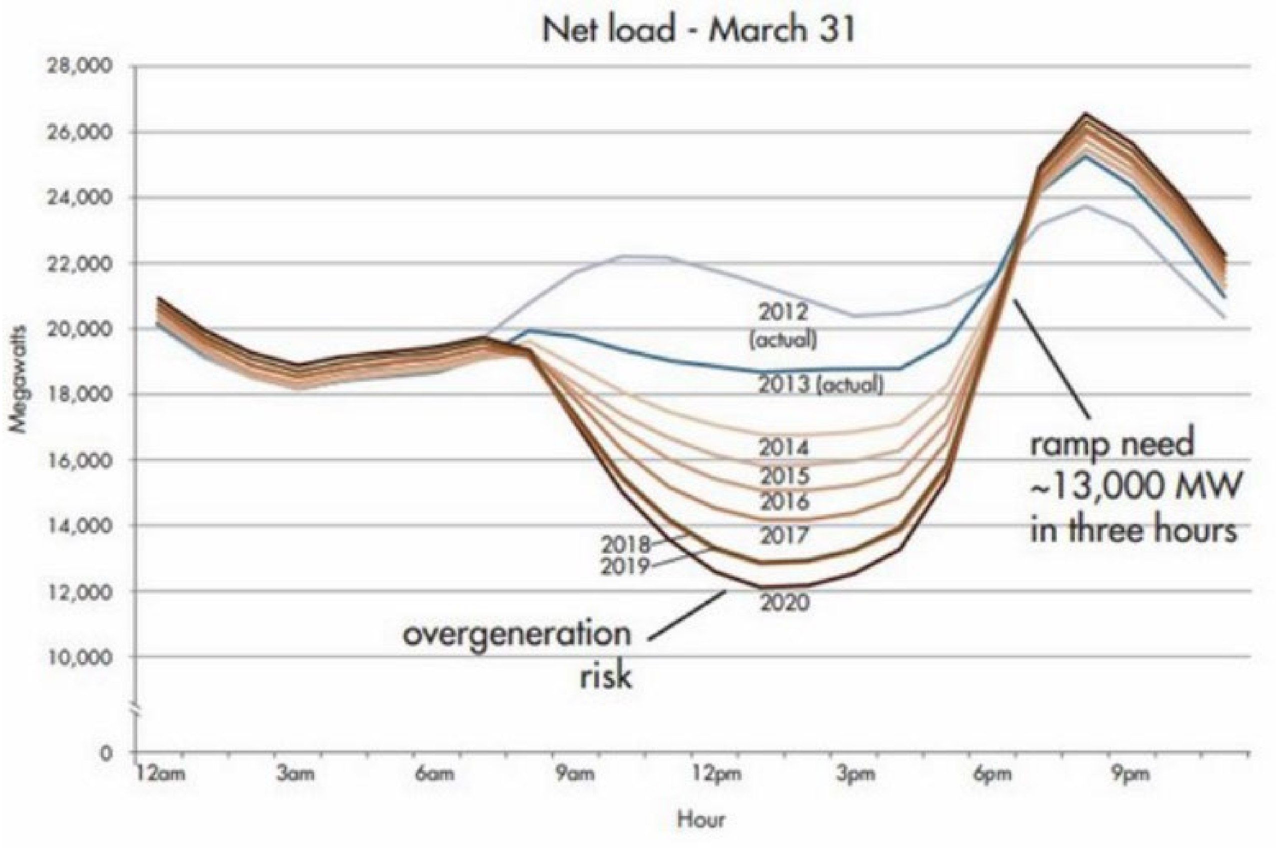
In terms of system control, the electric vehicle supply equipment will be utilizing an open source protocol as a basic framework for purposes of network interoperability. The renewable energy system has Controller Area Network control with real-time operation status reporting via Wi-Fi and cellular system.

US Hybrid Corporation has done extensive power flow, energy flow, and battery power flow modeling. From such analyses, the following are key performance metrics relative to our facility:

1. The renewable energy system will monitor the facility total current use (adding additional current sensors to the power panel post after the meter-please, see eGauge monitoring unit). The main objective is to reduce peak power demand and charges. Reducing peak power demand is the main objective of this renewable energy project that will result in utility bill reduction. The system will minimize the power flow into the grid and out of the grid, to maximize efficiency, by controlling generation and storage. Our facility energy need is much higher than the solar power, so we will always be net positive power demand from the grid, unless over the weekend or holidays, but the project is not about renewable energy resale.
2. The future product plan for our proposed renewable energy storage system, once proven viable through this project, is to provide Daytime Renewables Energy Curtailments.

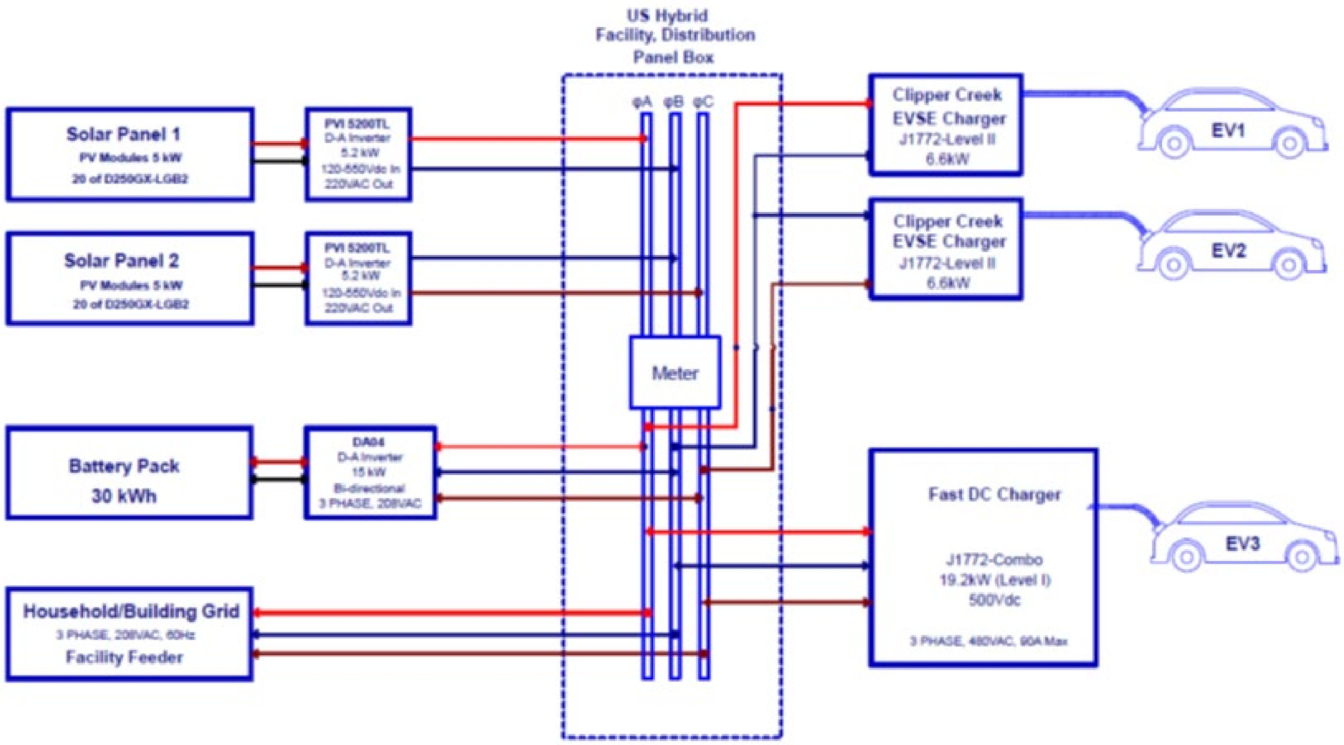
Current day power generation experiences a utility duck demand curve (illustrated in Figure 10), as developed by the California Independent System Operator. The duck demand curve describes how massive amounts of customer-sited photovoltaic and wind systems could cause problems to the state's supply-demand balance on its electricity grid due to over-generation.

Figure 9: Duck Curve Showing Deep Ramping Needs and Over-Generation Risk



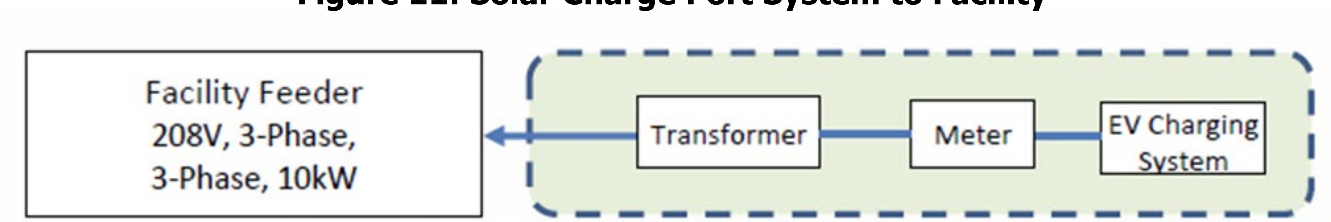
Over-generation happens when more electricity is available than is needed to satisfy real-time electricity demand requirements. The California Independent System Operator experiences over-generation in two main operating conditions. The first occurs as the Independent System Operator prepares to meet the upcoming upward ramps that occur in the morning and in the late afternoon. The existing fleet includes many long-start resources that need time to come online before they can support an upcoming ramp. Through placing an on-site battery storage system and vehicle charging on demand (Figure 11 and Figure 12), the renewable solar energy is not curtailed.

Figure 10: Renewable Energy Solar Charge Station System Configuration



Source: US Hybrid Corporation

Figure 11: Solar Charge Port System to Facility



Source: US Hybrid Corporation

2.2 Project Activities Timeline Summary

The project took about four years to complete. A timeline of the project activities is listed below in Table 1.

Table 1: Project Timeline

Date	Activity
September 2014	• Attended the Kick-off Meeting. • Released the schedule of products on September 12. • US Hybrid Corporation updated the list of permits on September 19 in coordination with city of Torrance Planning Division of the Community Development Department to obtain list of permits and Obtained Permit.
October 2014	• Drafted customized drawings of the canopy and sent then to Pacific Structures for civil engineering certification and input. • Contacted Southern California Edison and determined the necessary paperwork to request net energy metering.
November 2014	• Pacific Structures recommended we contract K&M Structural Engineering, LLC for the structural design and permitting work. We received the structural analysis results from the preliminary designs we sent to K&M Structural Engineering, LLC. • Internal review of necessary paperwork to request net energy metering. • Finalized the top-level system configuration.
December 2014	• Finalizing electrical drawings necessary to request net energy metering to submit with the K&M Structural Engineering, LLC drawings to the city and Southern California Edison.
January 2015	• Finalized electrical drawings. Requested City of Torrance for electrical permitting appointment.
February 2015	• Revised plans. Worked with electrical equipment vendor on procurement of chargers and monitoring units. • Worked on battery-pack drawing for engineering mounting.
March 2015	• Revised structural drawings. • Delivered specifications report.

Date	Activity
	• Met revision request of the CEC for design specifications report. Also designed around a direct current fast charger that is CHAdeMO.
April 2015	• Panels and solar inverters to arrive in May. • Discussions with the CEC on direct current fast charging. • US Hybrid Corporation is actively performing a search of direct current fast charge vendors.
May 2015	• Panels and solar inverters have arrived and are on-site. • Initiated DA04 design.
June 2015	• Selected direct current fast charger vendor. Has both the Society of Automotive Engineers and CHAdeMO.
July 2015	• Application form 14-957 filed with Southern California Edison on August 4. Obtained an extended purchase order for the direct current fast charger.
August 2015	• Fabricated DA04. • Installation and preliminary testing of DA04.
September 2015	• Continued pursuit of Southern California Edison for project approval
October 2015	• Critical Project Review meeting held with the CEC.
November 2015	• Due to delays in permitting, schedule has been pushed back by a few months.
December 2015	• Executed agreement amendment for no-cost time extension.
January 2017	• Finished installation of charge system. • Continued software development, Increased system energy load, Continued battery testing.
February 2017	• System commissioned.
March 2017	• Open for workplace and public access charging

Date	Activity
September 2018	• Continued operation. As of September 2018, there have been over 1,287 unique charge session events.

Source: US Hybrid Corporation

2.3 Energy Savings and Economic Analysis

The energy utilization statistics that were pulled from Southern California Edison billing periods of July 2016 to February 2017, before the implementation of the solar panels, is presented in Table 1. The data also consists of billing periods from July 2017 to February 2018, after the implementation of the solar panels. Using the data provided, there has been an overall 20 percent reduction in average kilowatt-hours/day and a 23 percent reduction in total cumulative kilowatt-hours (illustrated in Table 2, Table 3, Table 4, Figure 13, and Figure 14).

Table 2: Facility Energy Usage Statistics Before Photovoltaic Installations (2016-2017)

	July 2016	August 2016	September 2016	October 2016	November 2016	December 2016	January 2017	February 2017
Total Kilowatt-hours Used	12,516	13,447	13,254	14,446	6,158	9,460	10,891	9,452
Number of Days	30	29	32	30	19	31	31	32
Average Kilowatt-hours/Day	417	463	414	481	324	305	351	297
Cumulative Kilowatt-hours	12,516	25,963	39,217	53,663	59,821	69,281	80,172	89,624
Utility Bill ($/Kilowatt-hour)	$0.31	$0.33	$0.38	$0.28	$0.17	$0.19	$0.28	$0.21

Source: US Hybrid Corporation

Table 3: Facility Energy Usage Statistics After Photovoltaic Installations (2017-2018) and Cumulative Data

	July 2017	August 2017	September 2017	October 2017	November 2017	December 2017	January 2018	February 2018
Total Kilowatt-hours Used	8,900	10,508	9,388	9,687	9,019	8,227	8,928	8,301
Number of Days	30	31	30	29	30	31	32	31
Average Kilowatt-Hour/Day	296	338	312	334	300	265	279	267
Cumulative Kilowatt-hours	8,900	19,408	28,796	38,483	47,502	55,729	64,657	72,958
Utility Bill ($/Kilowatt-hour)	$0.69	$0.55	$0.54	$0.32	$0.27	$0.32	$0.25	$0.33
Average Kilowatt-hour/Day Savings	29%	27%	25%	31%	7%	13%	21%	10%
Cumulative Kilowatt-hour Savings	29%	25%	27%	28%	21%	20%	19%	19%

Note: US Hybrid Corporation has added an additional 550 kilowatt of load (High power direct current-direct current and dyno testing) to its facility, hence compression is not relevant.

Source: US Hybrid Corporation

Figure 12: Energy Saving Due to Renewable Energy Photovoltaic Installation

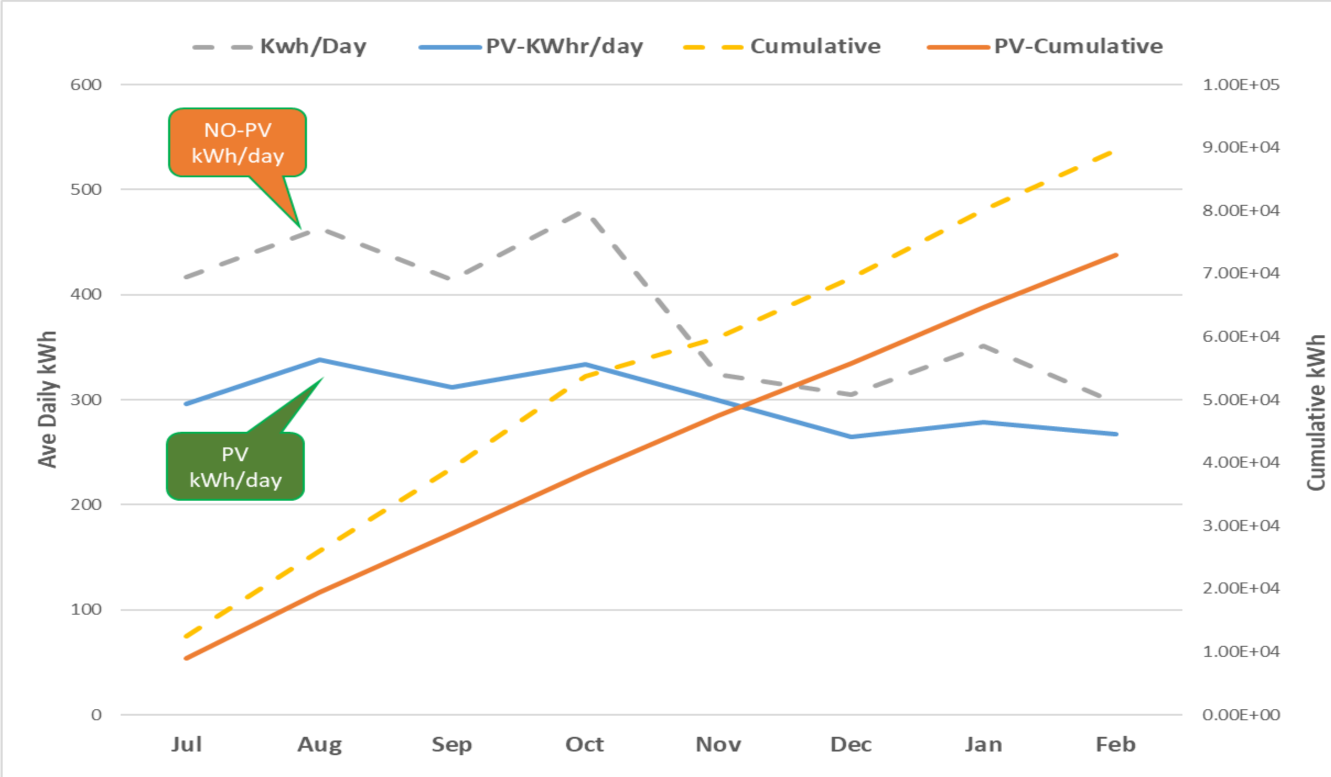
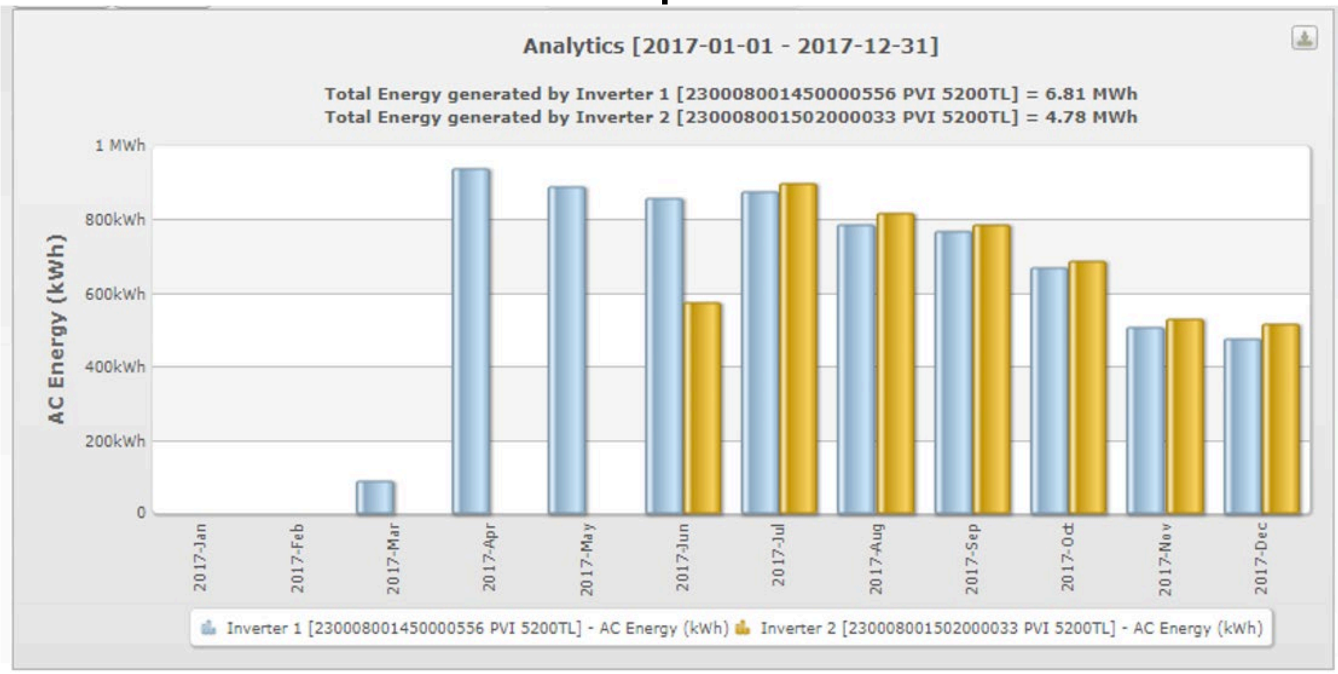


Table 4: Dual 5.2-Kilowatt Photovoltaic System Average Energy per Month

Month	Inverter 1 (Kilowatt-hours)	Inverter 2 (Kilowatt-hours)
March 2017	84.6	Inspection Issue
April 2017	934.1	
May 2017	887	
June 2017	853.1	568.9
July 2017	869.9	895.8
August 2017	783.1	814.1
September 2017	762.9	783
October 2017	666.2	683.6
November 2017	501.4	525.7
December 2017	471.8	511.9
January 2018	479.3	510.1

Source: US Hybrid Corporation

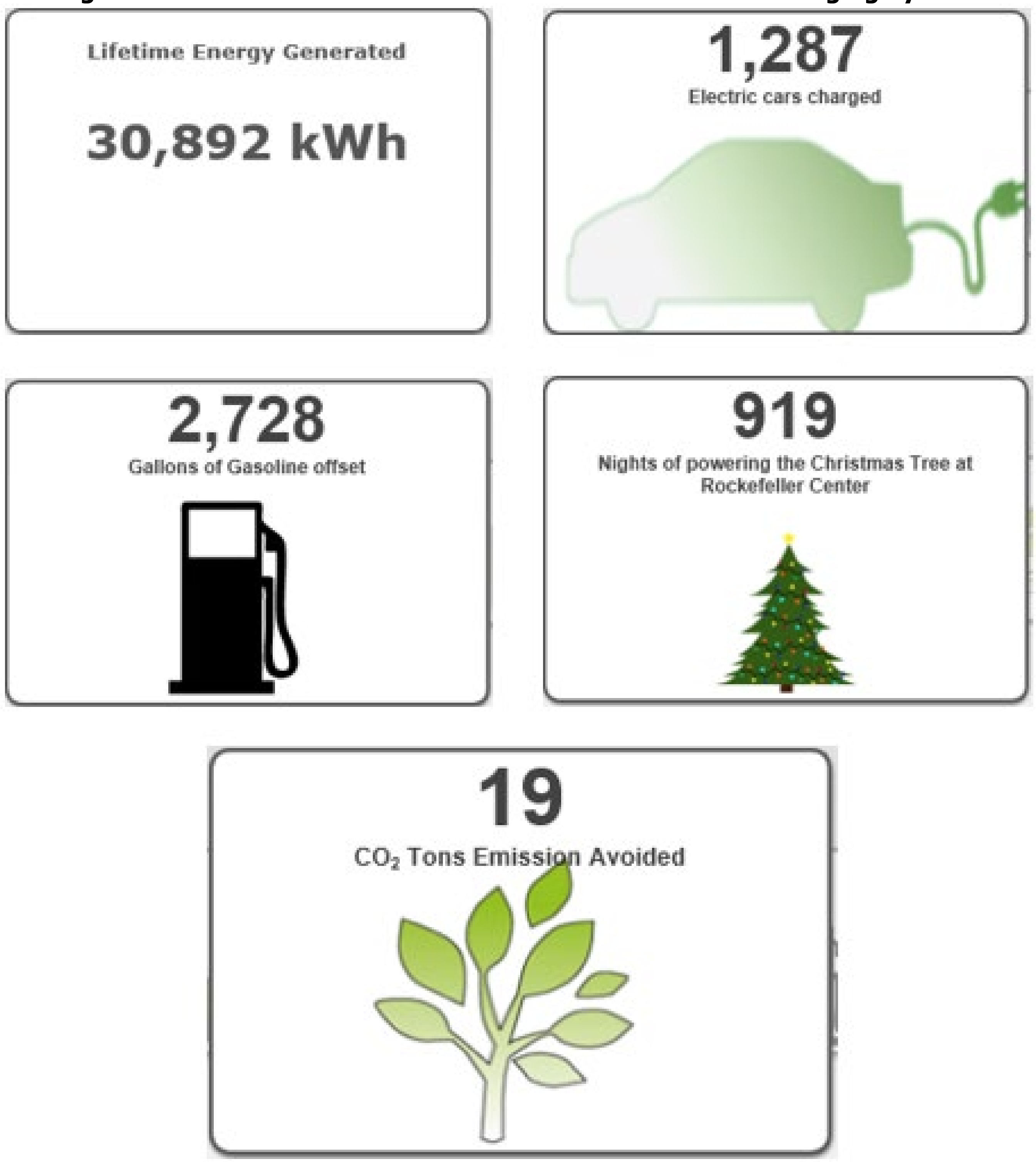
Figure 13: Photovoltaic System (Dual 5.2-Kilowatt Photovoltaic System) Energy Report



Source: US Hybrid Corporation

From March 2017 to February 2018 we have generated a total of 30,892 kilowatt-hours, which offset 2,728 gallons of gasoline and helped avoid 19 tons of carbon dioxide equivalent emissions. We have provided three electric vehicle charge ports for public use (heavy use due to proximity to Galaxy Soccer American Youth Soccer Organization fields in Torrance). During this period, there was a total of 1,287 public car charging sessions (Figure 15).

Figure 14: Overall Benefits of Renewable Electric Vehicle Charging System



Source: US Hybrid Corporation

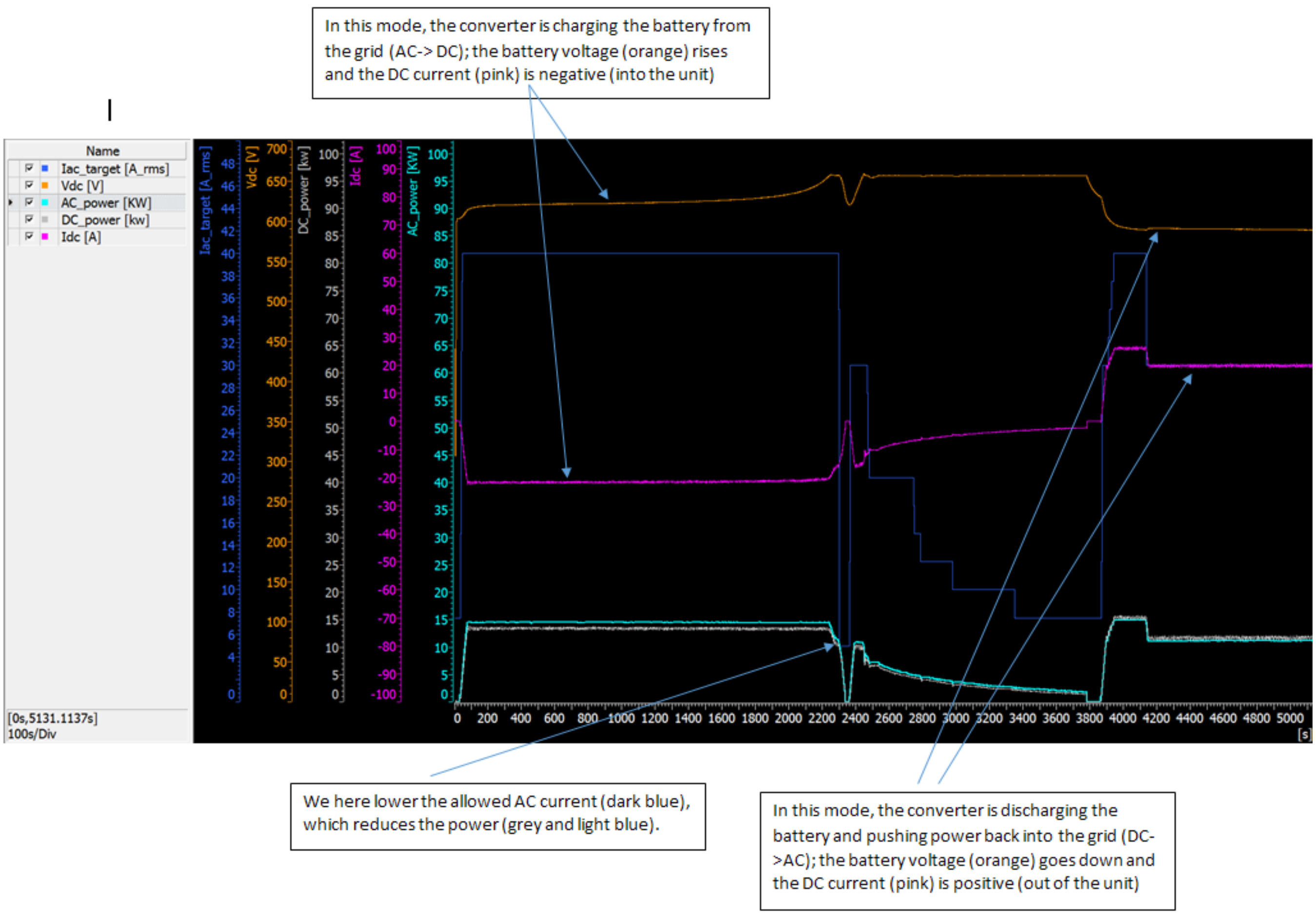
2.4 Battery Storage and Peak Demand Performance

Several test cycles in grid-connected mode demonstrated that the system controller was capable of peak-shaving and time-shifting of loads via battery system dispatch. Extensive modeling of system performance using measured loads and the applicable Southern California Edison tariff structure, conducted during the facility study phase of this project, indicated that substantial levels of utility savings would be achievable at the facility, given these capabilities at the tested levels. With optimal scaling of photovoltaic generation and battery storage capacities, the modeling indicates that grid-connected utility savings in the 30 percent or greater range would be achievable for facilities or communities under current Southern California Edison tariff structures.

Figure 16 depicts the battery storage system (DA04 performance data) demonstration's various operation modes;

- Mode 1: Charging the battery from renewable, photovoltaic energy and the grid.
- Mode 2: Grid charging power management (photovoltaic power reduction)
- Mode 3: Battery power is fed to the grid (peak demand reduction algorithms)

Figure 15: Power Flow from the Battery Storage System (DA04 Operation Data)



Source: US Hybrid Corporation

US Hybrid Corporation peak demand charges count for 55 percent of the monthly utility bill, which is mostly due to testing the high-power direct current to direct current and powertrain system. To remedy the peak demand charges, we scheduled our testing and planned to add additional battery storage.

The peak demand control algorithm has proven to be effective and we plan to expand the program and battery storage system capacity and power with the interface to the facility feeder panel. Meanwhile, we continue to provide public charging as well as a charger for our employees. US Hybrid Corporation employees operate two battery electric, three plug-in, and two fuel cell vehicles along with charging for trucks and buses capable with dual 40-kilowatt onboard chargers.

2.5 Problems and Resolutions

This project involves the implementation of a renewable solar power charger with multiple electric vehicle charge points and vehicle to grid capability at US Hybrid Corporation's headquarters in Torrance, California. The renewable energy smart grid charge ports utilize battery storage that can be charged via solar power or at off-peak rates, reducing facility peak demand charges.

A problem with the permitting issues between Southern California Edison and City of Torrance caused a delay in deployment. A minor problem with our server security and the Solectria/Yaskawa license for the data collection via Wi-Fi delayed data reporting for two months. After the renewal of the license, we were able to accurately collect the data.

Installation cost, insurance complication and equipment protection required us to install the panels and inverters inside the facility and the photovoltaic was installed on the roof.

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 Energy Commission'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.

APPENDIX A:
Product Data Sheets and Electrical Permit

The project data sheets and electrical permit used in the project located at US Hybrid Corporation's headquarters in Torrance, California are shown in Figure #16.

Figure 16: Product Data Sheets and Electrical Permit

CS Series EVSE

OUR FLAGSHIP PRODUCT

- UL listed. Outdoor Rated (NEMA 4) enclosure.
- Reclosure: Smart software that automatically self-checks unit and resumes charging after minor fault.
- Charge Circuit Interruption Device: Ground Fault protection with fully automatic self-check feature that eliminates the need for monthly testing by user.
- Service Ground Monitor: Constantly checking for presence of proper safety ground.
- External Control Input: Allows external control from smart meter (AMI), billing or load management device.
- Cold Load Pickup: Time-delayed and randomized to allow re-energizing of unit following power outages.

PRODUCT SPECS

- Service Entrance: 208V to 240V - 30 to 100 Amps, single phase, 2 wire w/ground
- 17" W x 14" H x 6" D (430mm W x 360mm H x 150mm D) NEMA 4 Construction
- Operating Temperatures: -22 F to 122 F (-30 C to 50 C)

AVAILABLE THIS FALL

- Innovative low cost BILLING SYSTEM
- SMART GRID Enabled EVSE - tie directly into your AMI Meter

CODES, STANDARDS AND RECOMMENDED PRACTICES

UL 2202 Charging Station Safety
UL 2231 Personal Protection Device (i.e., CCID hardware)
UL 1998 Standard for Safety Related Software
UL 991 Standard for Tests for Safety-Related Controls Employing Solid-State Devices
NEC 625 Electric Vehicle Charge System
SAE-J1772 Electric Vehicle Conductive Charge Coupler

The CS line offers multiple currents that enable you to charge at the highest rate possible, so that vehicles are always fully charged.

Model	CS-100	CS-90	CS-80	CS-70	CS-60	CS-50	CS-40	CS-30
Circuit Breaker Rating, Amps	100	90	80	70	60	50	40	30
Continuous Current, Amps	80	72	64	56	48	40	32	24

QUESTION?
Call 530-887-1674 or Information@ClipperCreek.net

ClipperCreek®
THE Electric Vehicle Charging Station
ClipperCreek.com

SAFETY. RELIABILITY. INNOVATION. ANTICIPATION. If you're looking for the safest, most reliable and affordable EVSE charge station, then ClipperCreek is the smart choice. In fact, we're the first company in the world to meet the rigid testing standards of Underwriter's Laboratories to earn their UL listing for not one, but six of our EVSE products. So what can we do for you?

- Originally founded in 1993 — currently on 12th generation of products
- Products in the field for over 10 years
- Over 3,000 units delivered since 2009
- Exclusive manufacturer for BMW Mini and Tesla Level 2 EVSE
- Long history of working closely with industry leading Utilities and Automakers
- Smart "reclosure" technology that self-tests, resets and ensures your car will be charged

CLIPPERCREEK®
THE Electric Vehicle Charging Station
ClipperCreek.com

SPECIFICATIONS		PVI 3800TL	PVI 5200TL	PVI 6600TL	PVI 7600TL
DC Input					
Absolute Maximum Open Circuit Voltage		600 VDC			
Operating Voltage Range		120-550 VDC			
MPPT Input Voltage Range		200-500 VDC			
MPP Trackers		1	2		
Maximum Operating Input Current		20 A	15 A per MPP tracker	18 A per MPP tracker	20 A per MPP tracker
Start Voltage		150 V			
AC Output					
Nominal Output Voltage		208 or 240 VAC, 1-Ph			
AC Voltage Range		-12%/+10%			
Continuous Output Power	208 VAC	3300 W	5200 W	6600 W	6600 W
	240 VAC	3800 W	5200 W	6600 W	7600 W
Continuous Output Current	208 VAC	15.8 A	25 A	31.7 A	31.7 A
	240 VAC	15.8 A	21.6 A	27.5 A	31.7 A
Maximum Backfeed Current		0 A			
Nominal Output Frequency		60 Hz			
Output Frequency Range		59.3-60.5 Hz			
Power Factor		Unity, > 0.99			
Total Harmonic Distortion (THD) @ Rated Load		< 3%			
Efficiency					
Peak Efficiency		98.3%			
CEC Efficiency		97.5%			
Tare Loss		< 1 W			
Temperature					
Ambient Temperature Range (full power)		-13°F to +122°F (-25°C to +50°C)			
Storage Temperature Range		-40°F to +185°F (-40°C to +85°C)			
Relative Humidity (non-condensing)		0-100%			
Operating Altitude		6562 ft/2000 m			
Data Monitoring					
Optional SolrenView Web-based Monitoring		External			
Optional Revenue Grade Monitoring		External			
External Communication Interface		RS-485			
Testing & Certifications					
Safety Listings & Certifications		UL 1741/IEEE 1547, UL 1699B, CSA C22.2#107.1, FCC part 15 A&B			
Testing Agency		ETL	CSA		
Warranty					
Standard		10 year			
Optional		–			
Enclosure					
dBA (Decibel) Rating		< 45 dBA @ 3 m			
DC Disconnect		Standard, fully-integrated			
Dimensions (H x W x D)		17.5 x 15.8 x 8.5 in. (445 x 401 x 216 mm)	26.8 x 15.8 x 8.5 in. (680 x 401 x 216 mm)		
Weight		43 lbs (19.5 kg)	65 lbs (29.5 kg)		
Enclosure Rating		Type 4 + Salt Mist Corrosion Protection			
Enclosure Finish		Aluminum			

		Date	10/01/2015
	TECHNICAL SPECIFICATION CHARGING STATION G2 24kW-DC	Author(s)	Sebastien LE FLOCH
		Contact	Friedemann STEINBACH

CHARGING STATION G2 24kW-DC

A Quick charging station for Electric Vehicle (EV)

Technical Specification

Photo only for example

	TECHNICAL SPECIFICATION CHARGING STATION G2 24kW-DC	Date	10/01/2015
		Author(s)	Sebastien LE FLOCH
		Contact	Friedemann STEINBACH

REVISIONS

Rev	Date	Description	Edited by	Verified by
Rev 1.1	04/07/2015	Creation	Sébastien LE FLOCH	Francois XARDEL
Rev 1.2	07/06/2015	add various car coupler	Sébastien LE FLOCH	Francois XARDEL
Rev 1.3	10/01/2015	Draft - under validation	Sébastien LE FLOCH	Francois XARDEL

Table 1 – Revisions

1. Reference documents

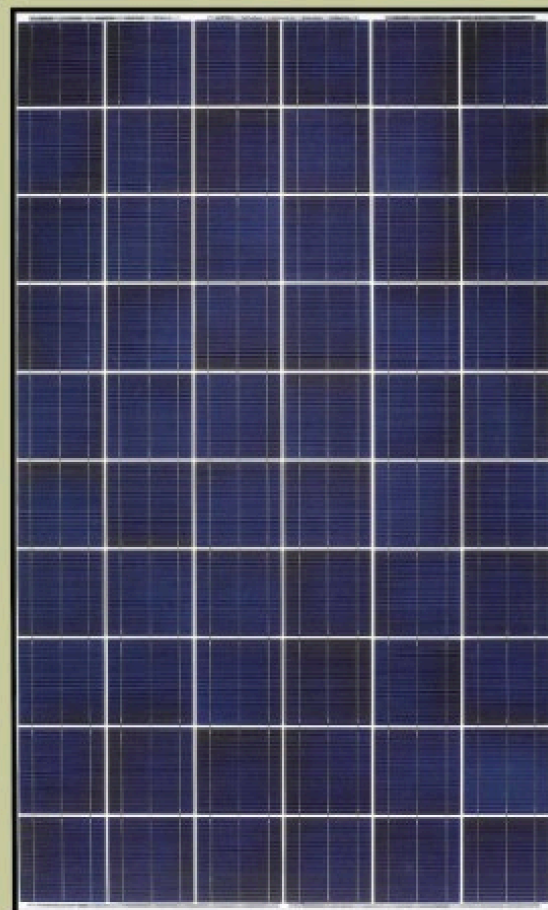
Reference document(s)	Date:	Title	Source/Author
2006/95/EC	Dec 2006	Low voltage EC directive (LVD)	EC Commission
2004/108/EC	Dec 2004	EC electromagnetic directive	EC Commission
EN61851-1	Apr 2012	Charging system for Electric Vehicle	European Standards
IEC 61851-23	Mar 2014	Charging system for Electric Vehicle – DC station	IEC
EN61851-21-2	Jun 2002	Part 21-2 EMC requirements for OFF board electric Vehicle charging system	European Standards
UL2202	Oct 2009	Electric Vehicle (EV) charging system Equipment	UL Standards
SAE J1772	Jan 2010	Electric Vehicle and Plug Hybrid Electric Vehicle Conductive charge Coupler	SAE international
UL2231-1	Sept 2012	Personal Protection Systems for Electric Vehicle (EV) Supply Circuit: General Requirement	UL Standards
UL2231-2	Sept 2012	Personal Protection Systems for Electric Vehicle (EV) Supply Circuit: Particular Requirements for Protection Devices for Use un Charging Systems	UL Standards
UL2251	Dec 2009	Plugs, Receptacles and Couplers for Electric Vehicles	UL Standards
UL2594	Feb 2013	Electric Vehicle Supply Equipment	UL Standards
FCC part 15	Aug 2002	Part 15 - Radio Frequency device	FCC
ISO/IEC15118	Apr 2013	Charge Communication systems Standards	ISO
UL746C	Aug 2009	Polymeric Materials – use in electrical equipment	UL Standards

Table 2 – References

KYOCERA

KD 200-60 F Series

KD255GX-LFB2 KD260GX-LFB2



CUTTING EDGE TECHNOLOGY

As a pioneer with four decades of experience in the development of photovoltaic systems, Kyocera drives the market as a leading provider of PV products. We demonstrate our *Kaizen* philosophy, or commitment to continuous improvement, by setting the industry standard in the innovation of best-in-class solar energy equipment.

QUALITY BUILT IN

- UV-stabilized, anodized aluminum frame in black
- Supported by major mounting structure manufacturers
- Easily accessible grounding points on all four corners for fast installation
- Proven junction box technology with 12 AWG PV wire works with transformerless inverters
- Locking plug-in connectors provide safe, quick connections

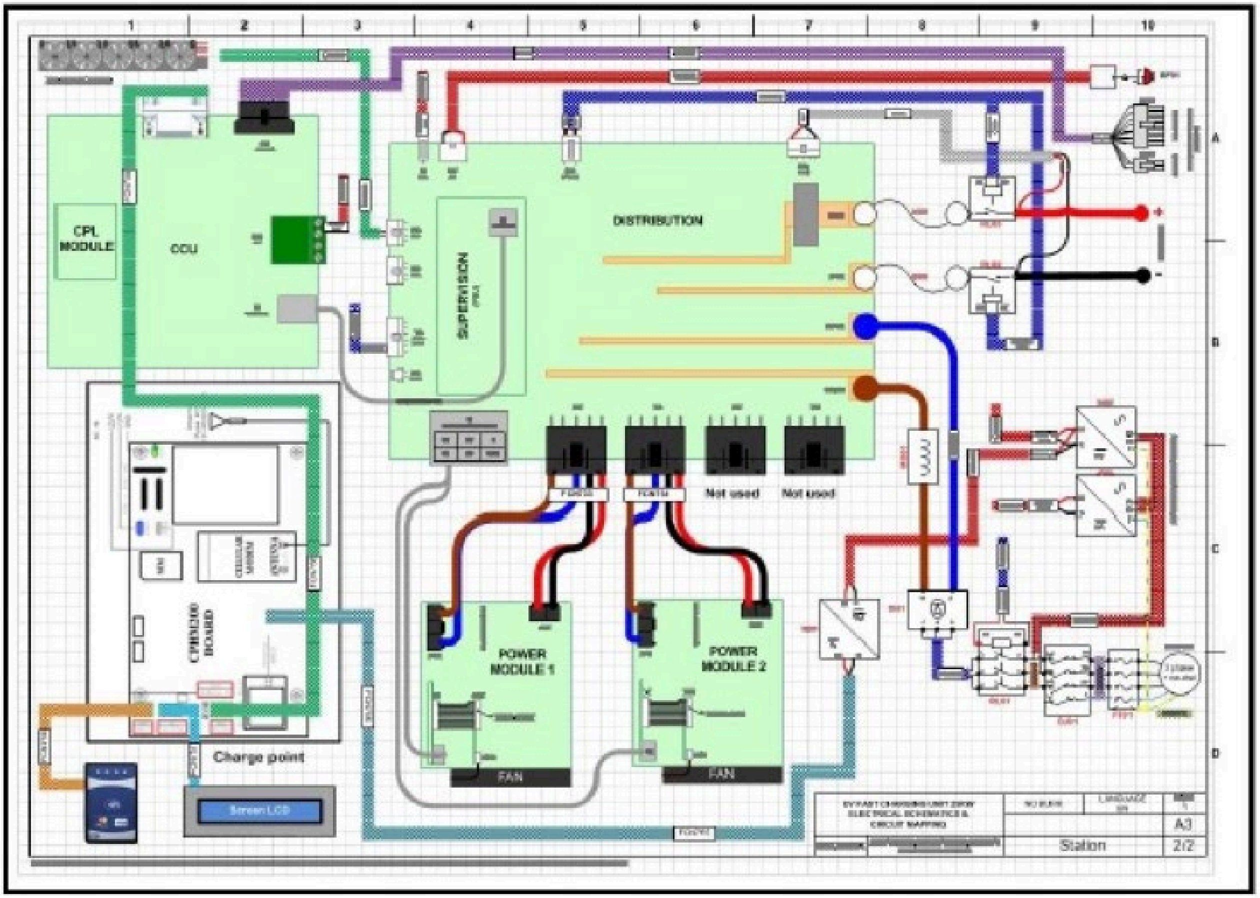
PROVEN RELIABILITY

- Kyocera modules confirmed by the Desert Knowledge Australia Solar Centre to have the highest average output of any crystalline module
- First module manufacturer in the world to pass long-term sequential testing performed by TÜV Rheinland
- This series construction also passed TÜV Rheinland's Salt Mist Corrosion Test at Severity Level 6, the most intense test conditions available
- Only module manufacturer to achieve the rank of "Performance Leader" in all six categories of GTM Research's 2014 PV Module Reliability Scorecard

CERTIFICATIONS

- UL1703 Certified and Registered, UL Module Fire Performance: Type 2, CEC
- NEC2008 Compliant, IEC 61215/61730, and ISO 14001
- IEC61701 Ed.2 Severity 6 (Salt Mist Corrosion Test)

e. Electric Architecture



5. ELECTRICAL DEFINITION

a. AC tri-phase input requirement

The power supply to the charging station 24kW DC must include the 3 phase wires "X Y Z", and the ground wire "G". The neutral wire "N" connection is not mandatory (the charging station can operate without neutral wire). The materials for wires, insulation and marking must comply with National Electrical Code NFPA 70 in case of installation in USA and must comply with any other standard regulation in effect locally. The presence of the grounding (earth wire) and the frame with proper ground-fault protection breaker is mandatory.
Wires must be correctly connected to the Charging Station as follows:

- Input side in accordance with applicable standards and regulations
- Output side in accordance with installation manual

Tri-phase power supply	V_{AC}	400 (480 Vac)	+/- 10%
Max Input current per phase	I_{AC}	40A (32A)	Max
input supply network, current rating per phase	I_{AC}	50A (40A) *(3)*	min
frequency	f	50 (60Hz)	+/- 5Hz
Power Factor	pf	93 %	nom
Efficiency	η	94 %	nom

(3) The Supply network with associated external breakers must be dimensioned at least for 50A per phase + ground wire in EU & 40A per phase in USA.

Table 3 – AC input requirement

b. Internal AC input protection

Inrush current limitation	$I_{INRUSH\ LIMIT}$	90A per phase	Max
Rated Current Breaker	$I_{BREAK\ Rating}$	50A (40A in USA)	typ
Breaking capacity of circuit breaker	$I_{BREAK\ Capacity}$	6 kA	Max
Circuit breaker curve	-	C	-
Max earth leakage current	$I_{LEAKAGE}$	< 3,5 mA	Max
AC Emergency button	-	Yes	-
Switch off AC mains when door open		Yes	
Overvoltage (IEC60664-1)	Class III		
Insulation protection Class (IEC62103)	Class I	1500Vac	min

(4) Only in EU version.

c. *DC Output performance*

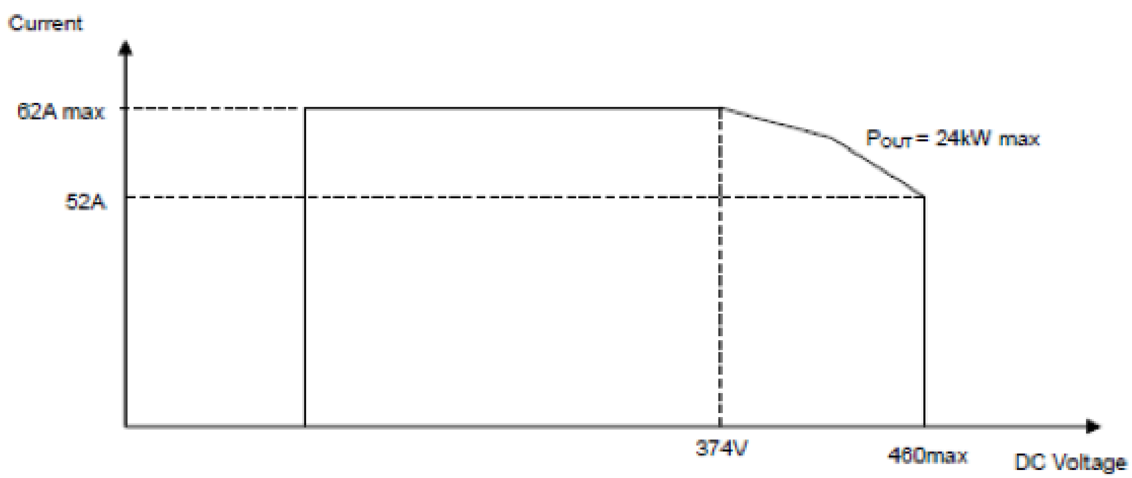
The charger is working as a true current generator. The charger operates in slave mode. The Vehicle battery managing system (BMS) unit communicates with the charger to manage the battery charge, stop & safety condition in accordance with Standards Combo 1/ combo 2 / Chademo / Cartac/ and Regulations.

Output voltage	V_{DC_max}	460 VDC	Max
Max Output current	I_{DC_max}	62A *(5)(6)*	Max
Max Output Power	P_{OUT}	24kW	Max
Current Ripple (20Hz to 100Khz)	I_{RIPPLE_MAX}	± 1Arms	Max
DC Voltage Accuracy	V_{MES}	+/- 2 %	Max
DC Current Accuracy	I_{MES}	+/- 2,5 %	Max
Output connector (charging station side)	-	Permanent mounting	-
Car Plug coupler (single output)	-	COMBO 1 plug (7), COMBO 2, CHADEMO or CARTAC	
Output cable length	-	20' (6m) other on demand	Max

Table 5 – DC Output requirement

(5) The SAE J1772 Combo1 EV coupler with cable 8AWG with from REMA is specified 65A up to 50°C ambient
(6) Output current can be even reduced with the limitation of AC input current or internal temperature limitation.
(7) Available with either Combo 1, Combo 2, Chademo or CATARC Output cable. Single output only.

Typical charging profile (management by BMS) :



ELECTRICAL SPECIFICATIONS

Standard Test Conditions (STC) *STC=1000 W/M² irradiance, 25°C module temperature, AM 1.5 spectrum**			
	KD255GX-LFB2	KD260GX-LFB2	
P_{max}	255	260	W
V_{mp}	30.4	31.0	V
I_{mp}	8.39	8.39	A
V_{oc}	37.6	38.3	V
I_{sc}	9.09	9.09	A
$P_{tolerance}$	+5/-0	+5/-0	%
Nominal Operating Cell Temperature Conditions (NOCT) *NOCT=800 W/M² irradiance, 20°C ambient temperature, AM 1.5 spectrum**			
T_{NOCT}	45	45	°C
P_{max}	184	187	W
V_{mp}	27.4	27.9	V
I_{mp}	6.72	6.71	A
V_{oc}	34.4	35.1	V
I_{sc}	7.36	7.36	A
PTC	228.3	232.9	W
Temperature Coefficients			
P_{max}	-0.46	-0.45	%/°C
V_{mp}	-0.52	-0.48	%/°C
I_{mp}	0.0065	0.02	%/°C
V_{oc}	-0.36	-0.36	%/°C
I_{sc}	0.06	0.06	%/°C
Operating Temp	-40 to +90	-40 to +90	°C
System Design			
Series Fuse Rating			15 A
Maximum DC System Voltage (UL)			600 V
Hailstone Impact			in (25mm) @ 51mp (23m/s)

*Subject to simulator measurement uncertainty of +/- 3%.
KYOCERA reserves the right to modify these specifications without notice.

NEC 2008 COMPLIANT
UL 1703 LISTED
070914

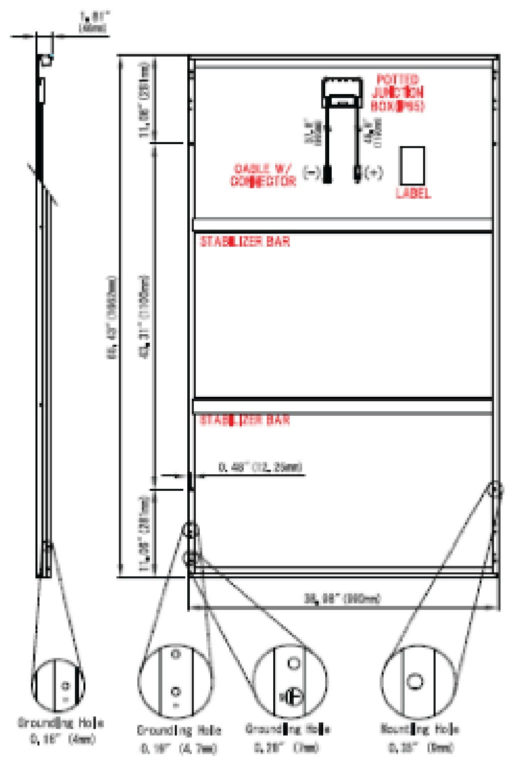
WARNING: Read the instruction manual in its entirety prior to handling, installing & operating Kyocera Solar modules.

MODULE CHARACTERISTICS

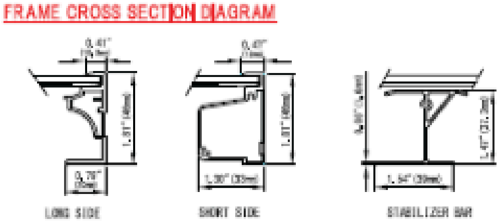
Cells per module:	60 (6 x 10)
Dimensions: *length/width/height*	65.43in/38.98in/1.81in (1662mm/990mm/46mm)
Weight:	44.1lbs (20.0kg)

PACKAGING SPECIFICATIONS

Modules per pallet:	20
Pallets per 53' container:	36
Pallet box dimensions: *length/width/height*	66in/40in/47in (1675mm/1005mm/1175mm)
Pallet box weight:	990lbs (450kg)



FRAME CROSS SECTION DIAGRAM



OUR VALUED PARTNER

KYOCERA Solar, Inc. 800-223-9580 800-523-2329 fax www.kyocerasolar.com

Three-Phase DC-AC Converter DA04

PRODUCT OVERVIEW:

DC-AC converters utilizes advanced Digital Power Processing with high frequency magnetic design to provide efficient and high bandwidth dynamic response for voltage and current regulations with input and output voltage and current and power limits protections. The cost effective high frequency proven magnetic design with robust redundant control provides fast response, flexibility, reliability, light weight and volume product for Fuel Cell and alternative energy industry. Extensive diagnostics via CAN-J1939 and RS232.

FEATURES:

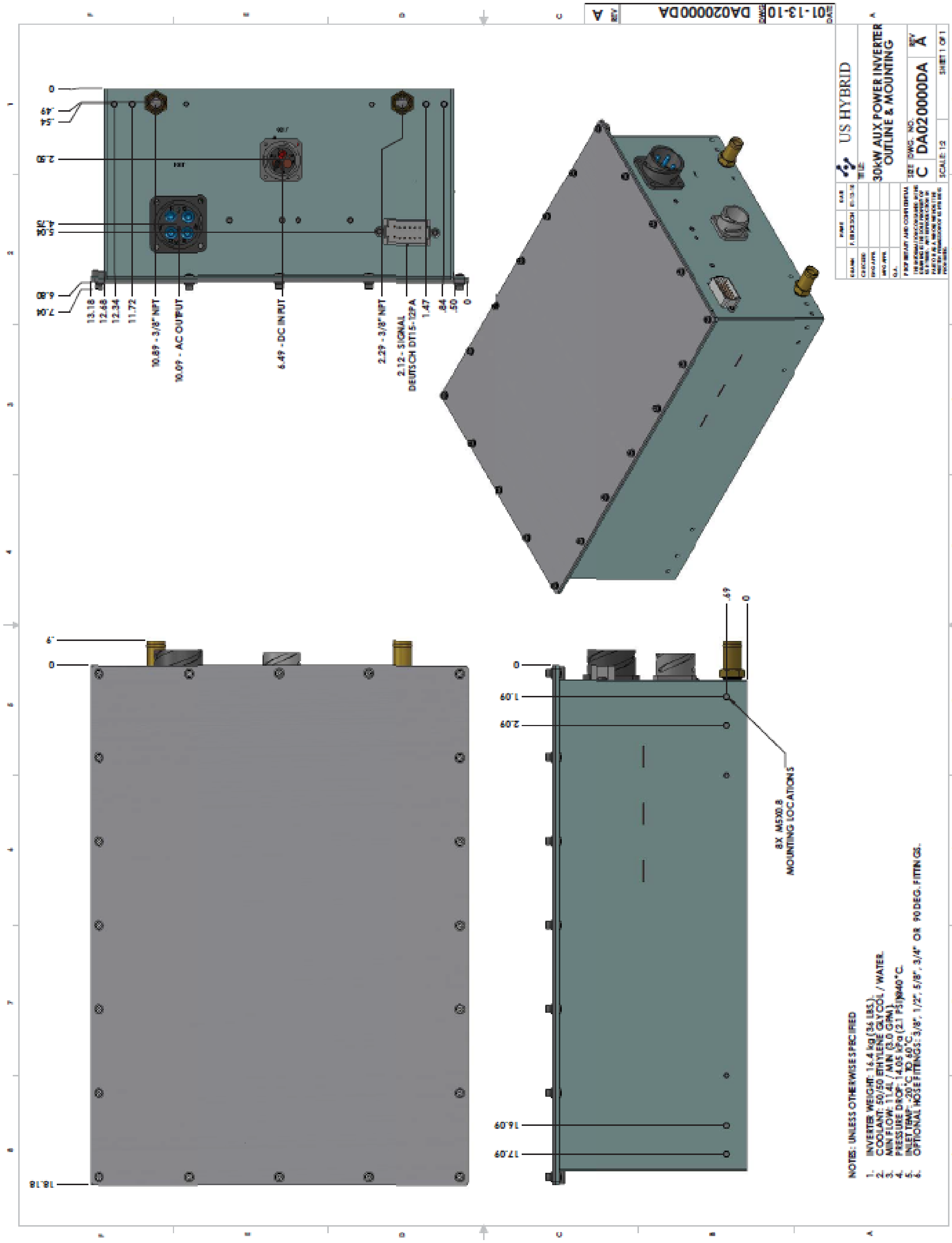
- DC Input Voltage Range: 450-700V_{DC}
- AC output, 110/220 V_{AC} or 208V_{AC}, 3Φ, 52A, 15KW
- Efficiency: 92% rated,
- Short Circuit, OC, O/U V and OT protection.
- Stand alone operation.
- CAN command, control and diagnostics. Output voltage, Input and output current/power can be regulated or limited via CAN command.
- Output voltages, currents, power, temperature and STATUS reporting.
- CAN communication parameters reconfigurable by user through RS232 interface.

APPLICATIONS:

Hybrid Electric and Fuel Cell Vehicles and Renewable Energy Systems.

Signal Connector: DEUTSCH DT15-12PA	
1	GND
2	PWR_ON (Opto, 10-30V)
3	12V_POS
4	12V_NEG
5	VOUT_ANALOG_CMD
6	ANALOG_RTN
7	#FAULT (active low OC)
8	CAN_H
9	CAN_L
10	RS232_RX
11	RS232_TX
12	#PROGRAM
DC Input Power Connector: ITT	
AC Output Power Connector: ITT	

Line regulation (±10%)	±2 %
Load regulation	±2%
Ripple	< ±1% + 300 mVp-p
Load transient (10-90%)	< 5% typical
Response time	250 ms typical
Turn-on rise time	Soft-start, 450 ms typical
Output protection	Overload and short circuit
Cooling	Liquid cooled < 60°C, 12 Lpm
Operating temperature	-20°C to +70 °C
Load de-rating	2.5% /°C from 60°C liquid
Storage temperature	-40°C to +105°C
Efficiency	> 92%
Isolation resistance	> 1 MΩ at 500Vdc
Weight	42 kg.
Dimensions (mm)	L=475, W=345, H=180


NOTES: UNLESS OTHERWISE SPECIFIED
1. INVERTER WEIGHT: 16.4 kg (36 LBS.).
2. COOLANT: 50/50 ETHYLENE GLYCOL / WATER.
3. MIN FLOW: 11.4L / MIN (3.0 GPM).
4. PRESSURE DROP: 14.05 kPa (2.1 PSI)@40°C.
5. INLET TEMP: -20°C TO 60°C.
6. OPTIONAL HOSE FITTINGS: 3/8", 1/2", 5/8", 3/4" OR 90 DEG. FITTINGS.
8X M5X0.8
MOUNTING LOCATIONS
10.89 - 3/8" NPT
10.09 - AC OUTPUT
6.49 - DC INPUT
2.29 - 3/8" NPT
2.12 - SIGNAL
DEUTSCH DT15-12PA
US HYBRID
30kW AUX POWER INVERTER
OUTLINE & MOUNTING
C
DA020000DA
A
01-13-10

16-9037

CITY OF TORRANCE
COMMUNITY DEVELOPMENT DEPARTMENT
3031 Torrance Blvd. Torrance, CA 90503 (310) 618-5910
For inspections call (310) 618-5901
Inspectors Office Phone: (310) 618-5951 M-Th 7:00-8:00am; 4:00-5:00 pm
Alternating Fridays 7:00-8 :00am; 3:30 -4:00 pm

ELECTRICAL PERMIT

Permit #: ELE16-01832
Issued Date: 11/14/2016
Issued By: JGO
Expire Date: 5/13/2017
Inspector: RGO

E L E 445 MAPLE AVE

Zone: M2
Group: B
Valuation: $0.00
Fees Paid: $68.20

ADDRESS: 445 MAPLE AVE

APN: 7352-012-007 **LOT:** **BLOCK:** **TRACT:**

Owner:
GROUP 55 PARTNERSHIP
14943 ALTATA DR
PACIFIC PLSDS CA 90272

Architect/Engineer:

? RGO

PROJECT DESCRIPTION: INSTALL 40A EV CHARGING STATION @ NORTH SIDE OF BUILDING (ADA REQUIREMENTS - 15" MIN - 48" MAX)

ELECTRICAL INFORMATION

TYPE OF WORK: Alteration	TRANSFORMERS kva	MOTORS (hp)	RANGES:
TYPE OF USE: Commercial	0-1:	0-1:	CLO DRYERS:
METERS:	1-3:	1-3:	WATER HEATERS:
SUBPANEL/MISC: 1	3-8:	3-8:	GARB DISP:
MRC VP FIXT:	8-15:	8-15:	DISHWASHERS:
OUTLETS:	15-50:	15-50:	SPACE HTRS:
TEMP POLES:	50-100:	50-100:	STA APPLI:
TIMERS:	100-500:	100-500:	STA COOK:
SIGN TRNS/BLST:	Over 500:	Over 500:	OVENS:
ADDL TRNS/BLST:	SERVC <= 200A:		AUTO WASHRS:
FIXTURES:	SERVC > 200A:		PLAN SHEETS:
LAMPS:	SERVC > 600V:		

LICENSED CONTRACTOR'S DECLARATION
I hereby affirm under penalty of perjury that I am licensed under the provisions of Chapter 9 (commencing at Sec. 3700) of Division 3 of the Business and Professions Code, and my license is in full force and effect.

BARDEN ELECTRIC INC
PMB 380
PO BOX 7000
REDONDO BEACH, CA 90277-8710
3103251155
LIC#: 767487 EXP: 08/31/2017
CLASSIFICATION CODES: B, C10, ,

Signature__________ **Date:** ______

WORKER'S COMPENSATION DECLARATION
I hereby affirm under penalty of perjury one of the following per Sec. 3700 of the Labor Code:
( ) I have and will maintain workers' compo ins., or a certificate of consent to self insure for workers' compo for the performance of the work for which the permit is issued. **WC#: ZAWCI25149 EXP: 01/01/2017**
( ) I certify that in the performance of work for which the permit is issued, I shall not employ any person in any manner so as to become subject to the workers' comp laws of CA, and agree that if I should become subject to the workers' comp provisions of Section 3700 of the Labor Code, I shall forthwith comply with those provisions.

Signature: __________ **Date:**______

CONSTRUCTION LENDING AGENCY
I hereby affirm that there IS a constructionLending agency for the performance of this work for which this permit is issued (Section 3097 California Civil code).
Lender's name: __________ **Address:** __________

RIGHT OF ENTRY: I certify that I have read this application and state that the above information is correct. I agree to comply with all City and applicable County ordinances, and State laws relating to building construction and hereby authorize representatives of the City to enter upon the above mentioned property for the purposes of inspections.

Signature:__________ **Date:**______

ANY PERMIT ISSUED AS A RESULT OF THIS APPLICATION BECOMES NULL AND VOID IF WORK IS NOT COMMENCED WITHIN 180 DAYS FROM DATE OF ISSUANCE OF SUCH PERMIT OR FROM THE DATE WORK IS SUSPENDED OR ABANDONED. CLAIMS FOR REFUNDS OF ANY FEES MUST BE FILED WITHIN 180 CALENDAR DAYS FROM THE DATE COLLECTED BY THE CITY.

INSPECTIONS	DATE	SIGNATURE	INSPECTIONS	DATE	SIGNATURE
TEMP POWER POLE (080)			ROUGH CEILING ONLY (226)		
GROUND - UFER (205)			FIXTURES (227)		
GROUNDWORK (210)			ELECTRICAL SERVICE (230)		
ROUGH (220)			UTILITY CO. NOTIFIED		
ROUGH WALLS ONLY (225)			FINAL (290)	11-22-16	

Electrical Permit 1)Inspector 2)File 3)Applicant

Source: US Hybrid Corporation