FEASIBILITY STUDY
EV Charging

Financial impact: installing DC fast charging with solar carports and energy storage

Hospital Campus
Oakland, California, USA

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Prepared by:
UL Advisory Services using HOMER Grid modeling software
ul.com/renewables & homerenergy.com/products/grid

HOMER Grid

1. INTRODUCTION

UL Advisory Services was engaged to perform a feasibility study for installing solar carports and energy storage to charge a fleet of ambulances at a hospital and medical center located in California, USA. The team used the recently released, HOMER® Grid v1.8 modeling software with its new EV Charging module to analyze various system options and find the least-cost solution.

When an electric vehicle (ambulance) plugs in, the hospital must pay for both the energy consumed during the charge and a demand charge for the EV's high-charge power load, where applicable. The demand charge is difficult to predict because it is based on several factors, including the number of chargers on the site, the time energy is consumed, the maximum power used by the vehicle when it plugs in, and the number of vehicles charging at the same time in any 15- to 30-minute segment. The specific demand load-profile of a facility with EV charging stations is an essential part of designing a Renewable Energy system and its techno-economic analysis.

On-site Energy Storage Systems (ESS) and PV Solar arrays can defray these charges. When one or more vehicles recharge, the ESS provides some or all charge power. This reduces or even eliminates the station's power draw from the grid. The ESS may be recharged from the grid at a lower power during down-time between vehicle charges. Using the ESS to supply charge power throughout the billing cycle lowers the station's peak power and the corresponding demand charge. In addition, an on-site photovoltaic (PV) array may be used to recharge the ESS, offering further financial benefit of reduced grid energy consumption. In either case, the ESS dramatically improves the economics of the station.

Charging stations are typically space-constrained with limited space available for a roof-top PV array. For this reason, it is critical to optimize sizing of the ESS and PV array to minimize footprint while maximizing savings generated for the station. In addition to reducing electricity costs, the ESS and PV contribute to the sustainability mission of the station: the production and consumption of clean, zero-carbon energy.

The economy of electrified transportation is growing at an accelerated rate, but it is still a relatively new institution. Because each site has specific load profiles, a data base of electricity load profiles related to charging EV is still being formed. HOMER Grid v1.8 addresses these challenges by including two EV charging design tools that allow users to simulate the necessary load profiles particular to the charger, and the EV and charging behavior: '*On-Demand'* charging and '*Smart*' charging design tools.

On-Demand charging is analogous to being able to model an extra electrical load in HOMER. An EV or fleet of connected EVs charge the EV as quickly as possible until the battery is full. The Smart charger models an EV or fleet of EVs that can be charged in a more controlled fashion over a longer period (i.e. overnight). The Smart charger would better control the facility's demand charges. It would also allow facilities that have a Solar PV array to better use any PV production instead of shedding excess mid-day energy production because of functional or economic restrictions in selling this energy to the utility. The Smart charger has deferrable charging capabilities and may be an ideal applicable for a fleet of vehicles or for an office application.

In this analysis, 1-, 2- and 4-hour batteries were considered for integration with a 1,000 kW PV array and modeled using HOMER Grid. The costs and benefits to the station operator were then calculated.

The following provides an overview of the Project Criteria:

Table 1.1: Project Details

Project	Location	Technologies Considered	Savings Applications	Utility
Hospital/Medical Center	Oakland, California, USA	DC Fast Chargers Solar Carport + Storage	Energy Savings, Demand Charge Reduction and Demand Response	Pacific Gas & Electric

The hospital is considering installing solar + storage at the facility to lower their annual electric consumption and expenses while charging the ambulances. Power is currently supplied entirely by Pacific Gas & Electric through their BEV-2 tariff rate structure, a commercial rate specifically designed for EV Charging**.** The analysis below provides an overview of the economic and technical considerations of installing solar + storage at the facility.

2. BACKGROUND AND CONSIDERATIONS

Determining how much solar and storage to install is highly specific to each facility, as is quantifying how much the system can save.

While commercial solar can provide significant savings by generating on-site clean energy, adding an energy storage system can produce deeper financial benefits by also reducing demand charges and shifting consumption from the grid to off-peak periods. As illustrated in the graph below, combining the two platforms increases the value of each: solar reduces reliance on utility electricity energy and storage decreases demand charges by controlling spikes in consumption. By storing and shifting power to times when the native load and prices are at their peak, the impact of high-cost energy from the utility is reduced. Including grid services opportunities, incentives, and backup power can also bolster economic returns.

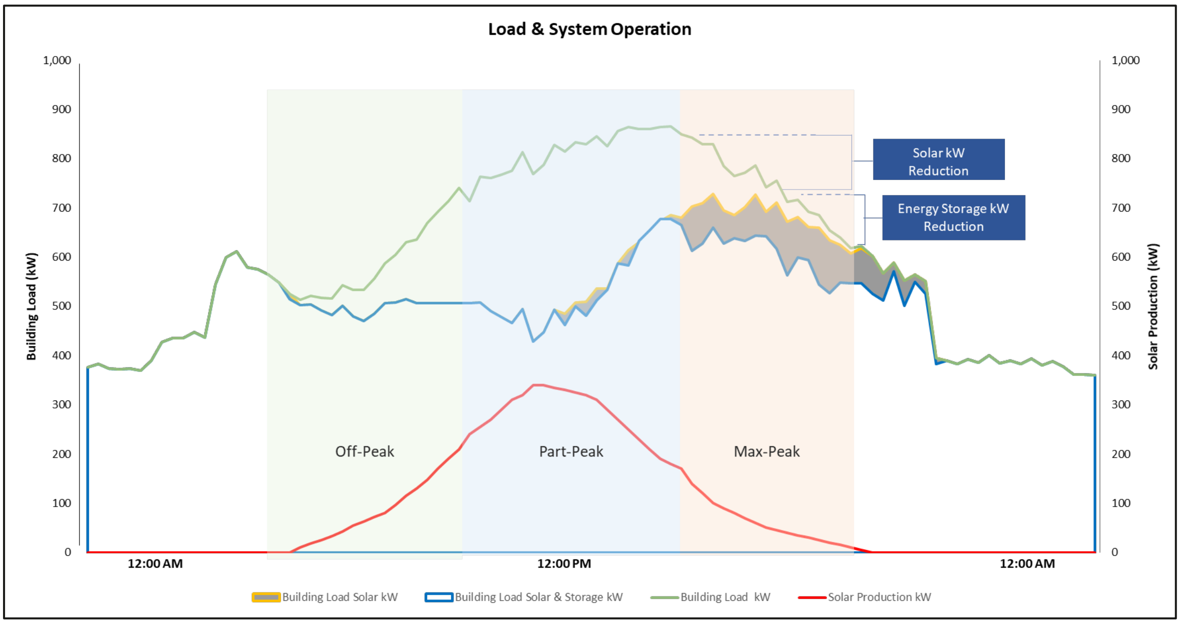

Figure 2.1: Reducing Demand with Solar + Storage

Figure 2.1 illustrates the mechanism for reducing peak demand for a typical application of solar + storage in a behind-the-meter application.

3. FACILITY SITE DATA AND MODEL ASSUMPTIONS

UL conducted a feasibility analysis by using 15-minute load profiles and applying the tariff rates to determine the optimal solar + storage configuration and the related financial savings of a hospital and medical center located in California, USA.

Using HOMER's recently released EV Charging Module, a 15-minute load profile for charging the ambulances overnight and three times during day was created and used in the analysis. The following figure provides an overview of the Client's current energy consumption and peak demand by month.

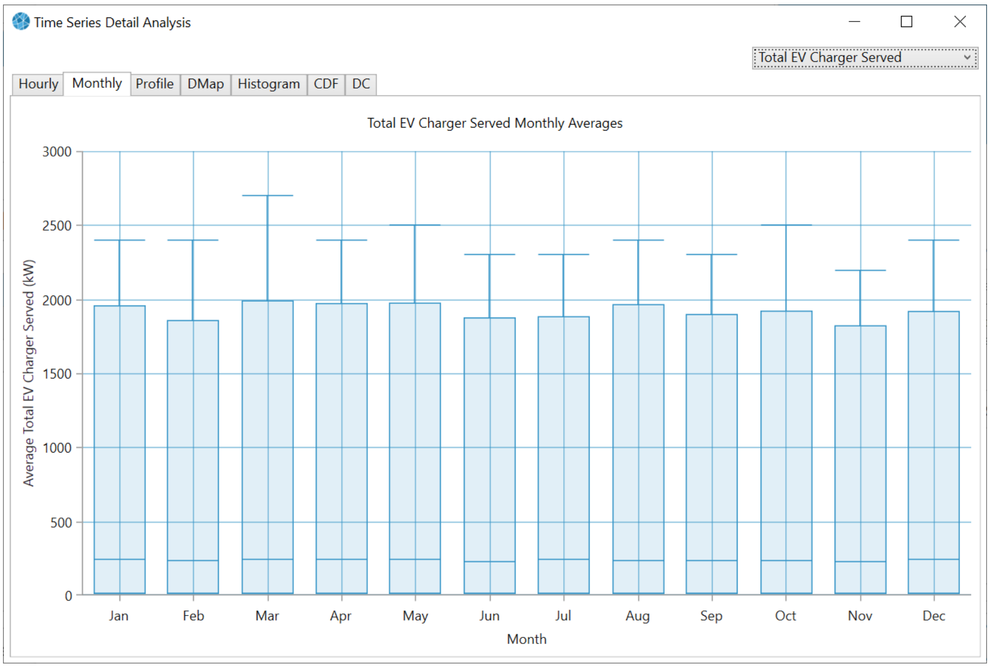

Figure 3.1: Facility's Energy Consumption and Demand

The hospital will procure energy from Pacific Gas & Electric under a tariff rate (BEV-2), which does not have demand charges but does have block charges. The BEV rate replaces the customer charge and traditional maximum kW demand charge with a subscription-based model for monthly kW allocation. Customers taking service on this rate schedule can use any amount of kW and kWh but will incur an "overage" fee if the kW usage exceeds a customer's self-designated subscription level. The following table provides an overview of the tariff structure.

Table 3.1: Tariff Structure

Tariff	Rate
Energy Consumption	$0.11 (super-off peak) $0.14/kWh (off-peak) $0.35/kWh (on-peak)
Demand Charge	Postponed until 2025
Block Size	50 kW
Subscription Charge	$95.56/block/month
Subscription Charge	$1.91/kW/month
Overage Fee	$3.82/kW/month

This site is supported by a robust Demand Response Program which has been considered in this feasibility study. Demand Response is an incentive offered by utilities in exchange for lowering consumption at certain times during the year. If the facility can successfully reduce its demand during a demand event, then the utility will pay a pre-approved amount for every kW reduced. For this analysis, we assumed a conservative incentive of $12.00 for every kW reduced. This amount is considered conservative because incentive values in the 2018 and 2019 period have been as high as $19.00. The BEV-2 tariff rate as well as other commercial EV rates have a holiday on Peak Demand Charges until 2025. We assumed different annual escalation rates for peak demand charges and energy charges.

UL notes that space is limited for a PV array and for this reason, it is critical to optimize the sizing of the solar + storage to minimize the footprint while maximizing their savings. For this facility, UL and the Client identified the potential for 1,000 kW of carport PV on the campus**.** Although HOMER can optimize the tilt and azimuth of the PV array, for the analysis, UL considered a range of commercially available 72 cell poly-silicone panels with a fixed tilt facing the South West horizon producing 1,454,636 kWh.

For the storage application, we identified a lithium-ion battery using a dc-coupled power conversion system (inverter). In dc-coupled systems, the harvested solar energy first flows to a battery bank via a charge controller and then to ac loads via a battery-based inverter. In ac-coupled systems, harvested solar energy first flows to ac loads via a grid-tied inverter and then to a battery bank via a battery-based inverter.

For installation and operation costs, our assumed costs are outlined in the following table, which are based on our experience of current market costs for such systems and feedback from the Client.

Table 3.2: System Costs

Component	**Cost**
CAPEX	
PV	2.55 $/$W_{DC}$
Storage	703 $/kWh
OPEX	
PV	4.2 $/$kW_{DC}$/yr
Storage	11 $/kWh/yr

UL notes that operation and maintenance of the facility will be conducted by the construction company under a long-term service agreement with ready access to a virtual network operating center to measure and monitor system performance.

4. FEASIBILITY STUDY RESULTS

Due to space constraints and limits of roof top PV Solar, UL collaborated with the Client to optimize a solar + storage platform to 1) reduce electricity expenses 2) hedge against future utility rate increases and 3) contribute to the organization’s sustainability goals by producing and consuming clean electricity. A solar + storage system can also protect the facility from outages in its electric supply from the utility company.

HOMER Grid was used to determine the best mix of resources for the least-cost solution by calculating the value of demand charge reduction, energy arbitrage, and self-consumption, using the input assumptions described above.

The project is anticipated to have a payback of approximately 6 years. The table below provides an overview of economic results of the proposed system compared to the current arrangement for the facility.

Table 4.1: Proposed Grid Tied Only Results vs. Proposed Solar + Storage System

Facility Parameters	Grid Tied Only	Proposed System
Facility (Year 1)		
Annual Grid Import	2,189,764 kWh	1,518,672 kWh
Solar PV Size (dc-coupled)	N/A	1,000 kW
Energy Storage Size	N/A	511 kWh
Solar Generation	N/A	1,454,636 kWh
Solar Generation % of Load	N/A	48.9%
Electricity Tariff		
Electricity Tariff Plan	BEV-2-S, Secondary, Business Electric Vehicles	
Energy charge	$0.11 (super-off peak) $0.14/kWh (off-peak) $0.35/kWh (on-peak)	
Blended cost of energy	$0.264/kWh (blended	$0.157/kWh (blended)
Demand Charge	Postponed until 2025	
Block Size	50 kW	
Subscription Charge	$95.56/block/month	
Subscription Charge	$1.91/kW/month	
Overage Fee	$3.82/kW/month	
Energy Charges (Year 1)		
Energy Charges	$431,291	$157,641
Block and Fixed Charges	$107,724	
Demand Response Income	N/A	$20,623
Total Electricity Expense	$539,015	$312,318
Facility Savings		
First Year Electricity Savings	N/A	$244,733
20-Year Electricity Savings	N/A	$3,540,000

The following two figures show the monthly breakdown of the Total Electricity Expense for the Current System compared to the Proposed System. The saving strategies include energy shifting arbitrage for peak demand charge reduction and participation in a demand response program.

Table 4.2: Proposed Grid Tied Only – Electricity Costs

	January	February	March	April	May	June	July	August	September	October	November	December
Energy Charges	$37,243	$32,653	$36,957	$35,982	$37,013	$34,587	$36,882	$36,519	$35,251	$35,954	$34,572	$36,534
Consumption	178,025 kWh	155,200 kWh	176,650 kWh	171,150 kWh	176,000 kWh	162,825 kWh	175,125 kWh	172,625 kWh	166,225 kWh	170,350 kWh	162,850 kWh	174,000 kWh
Sales	0 kWh	0 kWh	0 kWh	0 kWh	0 kWh	0 kWh	0 kWh	0 kWh	0 kWh	0 kWh	0 kWh	0 kWh
Demand Charges	$8,977	$8,977	$10,123	$8,977	$9,359	$8,595	$8,595	$8,977	$8,595	$9,359	$8,213	$8,977
Peak Demand	2,400 kW	2,400 kW	2,700 kW	2,400 kW	2,500 kW	2,300 kW	2,300 kW	2,400	2,300 kW	2,500	2,200 kW	2,400 kW
Fixed charges ($)	$96	$96	$96	$96	$96	$96	$96	$96	$96	$96	$96	$96
Monthly Total	$46,315	$41,725	$47,175	$45,054	$46,468	$43,277	$45,573	$45,591	$43,941	$45,409	$42,880	$45,606
Annual Total	**$539,015**											

Table 4.3: Proposed Solar + Storage System – Electricity Costs

	January	February	March	April	May	June	July	August	September	October	November	December
Energy Charges	$19,803	$14,852	$12,881	$10,957	$10,302	$7,860	$8,564	$9,428	$9,536	$13,277	$18,013	$21,021
Consumption	143,460 kWh	119,516 kWh	131,059 kWh	124,070 kWh	125,082 kWh	112,181 kWh	122,172 kWh	122,666 kWh	119,889 kWh	126,544 kWh	129,545 kWh	142,488 kWh
Sales	63,888	60,426	80,545	76,128	78,854	78,957	84,679	81,673	83,742	72,787	57,637	56,245 kWh
Demand Charges	$8,977	$8,977	$10,123	$8,977	$9,359	$8,595	$8,595	$8,977	$8,595	$9,359	$8,213	$8,977
Peak Demand	2,400 kW	2,400 kW	2,700 kW	2,400 kW	2,500 kW	2,300 kW	2,300 kW	2,400	2,300 kW	2,500	2,200 kW	2,400 kW
Fixed charges ($)	$96	$96	$96	$96	$96	$96	$96	$96	$96	$96	$96	$96
Monthly Total	$28,875	$23,925	$23,100	$20,030	$19,757	$16,550	$17,255	$18,500	$18,227	$22,732	$26,322	$30,094
Annual Total	**$265,365**											

5. PROJECT FINANCIAL SUMMARY

The following table provides an overview of the key financial parameters and financial metrics for the proposed solar + storage project, including the capital investment, operational costs, and associated rebates, incentives and assumed tax rates that were applied in the analysis. Figure 5.1 shows the resulting cash flow of the proposed system.

Table 5.1: Key Financial Metrics for Proposed System

Item	Value
Capital Investment	$2,471,158
O&M Year One Costs (2% escalator)	$9,805
Rebates and Incentives applied	ITC, MACRS, SGIP
Rebates and Incentives applied	$105,000
Simple Payback	6.2 years
Utility Escalation Rate Blended	2%
Federal Income Tax Rate	21%
State Income Tax Rate	8.3%
20-Year Internal Rate of Return	15.7%
20-Year Net Present Value (8%)	$914,380

Table 5.2: Cash Flow Results of Proposed Solar + Storage System

Project Year	Current Electricity Cost	Energy Savings	Demand Savings	Demand Response & Incentives	Operating Expenses & Reserves	New Cost	Savings Total	Cash Benefit of Federal ITC	Tax Benefit/(Liability)	Cash Flow	Cumulative Cash Flow
0										($2,471,158)	($2,471,158)
1	($539,015)	$264,462	$0	$73,123	($9,805)	($211,236)	$327,780	$699,308	$1,192,896	$1,520,675	($950,482)
2	($553,031)	$269,672	$0	$31,329	($9,899)	($261,930)	$291,101	$0	($80,104)	$210,998	($739,485)
3	($567,446)	$274,984	$0	$31,329	($9,998)	($271,130)	$296,316	$0	($81,539)	$214,777	($524,708)
4	($582,272)	$280,401	$0	$31,329	($10,099)	($280,640)	$301,631	$0	($83,001)	$218,630	($306,078)
5	($597,520)	$285,925	$0	$31,329	($10,205)	($290,471)	$307,050	$0	($84,492)	$222,557	($83,520)
6	($613,204)	$291,558	$0	$31,329	($10,314)	($300,631)	$312,573	$0	($86,012)	$226,561	$143,040
7	($629,335)	$297,302	$0	$20,829	($10,427)	($321,632)	$307,704	$0	($84,672)	$223,031	$366,071
8	($645,928)	$303,159	$0	$20,829	($10,544)	($332,485)	$313,444	$0	($86,252)	$227,192	$593,263
9	($662,996)	$309,131	$0	$20,829	($10,665)	($343,701)	$319,295	$0	($87,862)	$231,433	$824,697
10	($680,553)	$315,221	$0	$20,829	($10,789)	($355,292)	$325,261	$0	($89,504)	$235,758	$1,060,454
11	($698,614)	$321,431	$0	$20,829	($183,812)	($540,166)	$158,448	$0	($43,601)	$114,847	$1,175,301
12	($717,192)	$327,763	$0	$20,829	($11,048)	($379,648)	$337,544	$0	($92,884)	$244,660	$1,419,961
13	($736,304)	$334,220	$0	$20,829	($11,183)	($392,438)	$343,866	$0	($94,623)	$249,243	$1,669,204
14	($755,966)	$340,804	$0	$20,829	($11,322)	($405,654)	$350,311	$0	($96,397)	$253,914	$1,923,118
15	($776,193)	$347,518	$0	$20,829	($11,464)	($419,310)	$356,883	$0	($98,205)	$258,678	$2,181,796
16	($797,002)	$354,364	$0	$20,829	($11,610)	($433,419)	$363,583	$0	($100,049)	$263,534	$2,445,330
17	($818,411)	$361,345	$0	$20,829	($11,760)	($447,997)	$370,414	$0	($101,929)	$268,485	$2,713,815
18	($840,437)	$368,463	$0	$20,829	($11,914)	($463,058)	$377,379	$0	($103,845)	$273,533	$2,987,348
19	($863,098)	$375,722	$0	$20,829	($12,071)	($478,618)	$384,480	$0	($105,799)	$278,681	$3,266,029
20	($886,414)	$383,124	$0	$20,829	($12,233)	($494,694)	$391,720	$0	($107,792)	$283,929	$3,549,958
21	($910,404)	$390,671	$0	$20,829	($12,398)	($511,301)	$399,103	$0	($109,823)	$289,280	$3,839,237
22	($935,087)	$398,367	$0	$20,829	($12,567)	($528,457)	$406,630	$0	($111,894)	$294,736	$4,133,973
23	($960,484)	$406,215	$0	$20,829	($12,740)	($546,180)	$414,305	$0	($114,006)	$300,298	$4,434,271
24	($986,617)	$414,218	$0	$20,829	($12,917)	($564,487)	$422,130	$0	($116,160)	$305,971	$4,740,242
25	($1,013,507)	$422,378	$0	$20,829	($13,098)	($583,398)	$430,109	$0	($118,355)	$311,754	$5,051,996
26	($1,041,177)	$430,699	$0	$20,829	($107,007)	($696,656)	$344,521	$0	($94,804)	$249,717	$5,301,713
27	($1,069,649)	$439,183	$0	$20,829	($13,472)	($623,108)	$446,541	$0	($122,877)	$323,664	$5,625,377
28	($1,098,948)	$447,835	$0	$20,829	($13,665)	($643,948)	$455,000	$0	($125,205)	$329,795	$5,955,172
29	($1,129,098)	$456,658	$0	$20,829	($13,862)	($665,473)	$463,624	$0	($127,578)	$336,047	$6,291,219
30	($1,160,124)	$465,654	$0	$20,829	($14,064)	($687,705)	$472,419	$0	($129,998)	$342,421	$6,633,640
Total	**($24,266,026)**	**$10,678,443**	**$0**	**$729,671**	**($616,951)**	**($13,474,863)**	**$10,791,163**	**$699,308**	**($1,686,366)**	**$6,633,640**	

6. OPERATIONAL BREAKDOWN

Yearly new grid purchases with PV solar generation (black), PV solar production (brown) and energy storage state of charge (red).

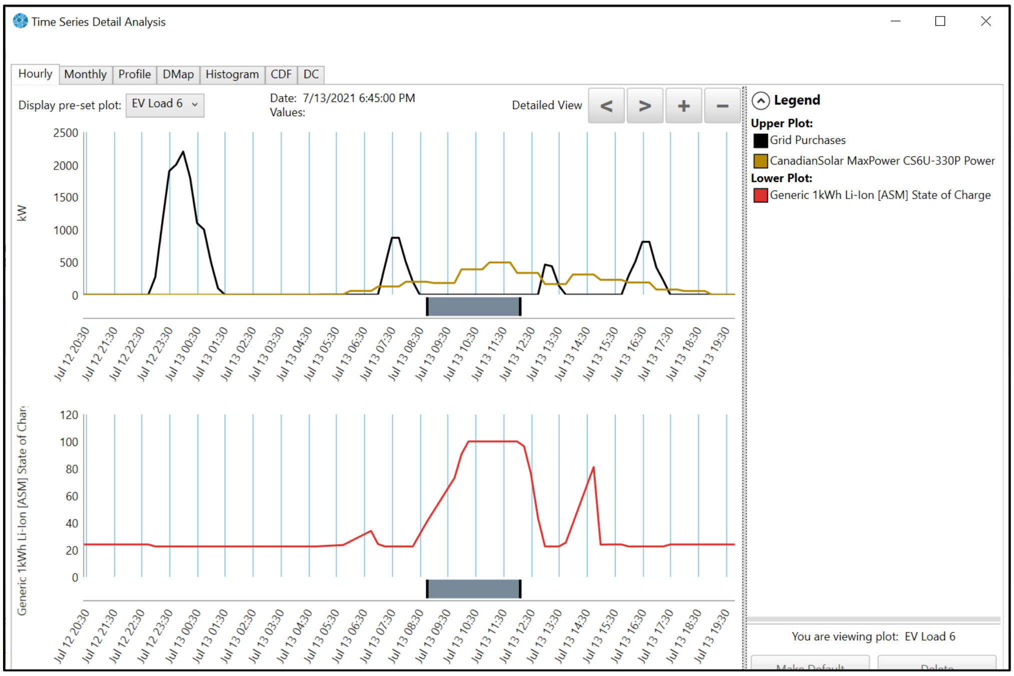

Figure 6.1: Detailed view – Grid purchases solar production, energy storage charging/discharging.

7. SUMMARY

UL Advisory Services conducted a feasibility study using HOMER Grid modeling software to analyze the techno-economic impact of deploying carport based solar + energy storage for a Medical/Hospital Center located in California. The primary objectives were to gain clarity on the impacts of EV charging, design the most economic renewable energy system to meet the energy requirements and to supplement the utility, and to offset the increasing cost of electricity.

In this analysis, UL determined the cost of energy by creating new load profiles using HOMER's 'On-Demand' charging and the 'Smart' charging design tools to simulate the loads as a result of charging the ambulances and to use HOMER Grid to model how different tariff rates impact the economics.

In collaborating with the client, UL performed system simulations of several configurations and technology platforms based on the client's current and future plans. The team then optimized the configurations and architecture to maximize incentives and tariff rate analysis before finalizing the financial analytics to show the potential reduction in utility expenses and increase in cash-on-cash return on investment.

With solar PV and energy storage, the campus can expect to save $321,431 in energy in the first year 26% in kWh energy consumption), with a 6.3-year payback and cash-on-cash return of 15.7% with a net upfront investment of $2,471,158.

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