FEASIBILITY STUDY
Behind-the-Meter Services

Financial impact of installing solar carports and energy storage

Technology Campus
Long Beach, California, USA

12 June 2020

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

1. INTRODUCTION

UL Advisory Services was engaged to perform a feasibility study for installing solar carports and energy storage in a behind-the-meter application at a Technology Campus located in California, USA. The team used HOMER Grid modeling software to analyze various system options and find the least-cost solution.

The following provides an overview of the Project Criteria:

Table 1.1: Project Details

Project	Location	Technologies Considered	Savings Applications	Utility
Technology Campus	Long Beach, California, USA	Solar Carport + Storage	Energy Savings, Demand Charge Reduction and Demand Response	Southern California Edison

The Client is considering installing solar + storage at the facility to lower their annual electric consumption and demand charges. Power is currently supplied by entirely by Southern California Edison through their existing tariff rate structure**.** 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. 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.

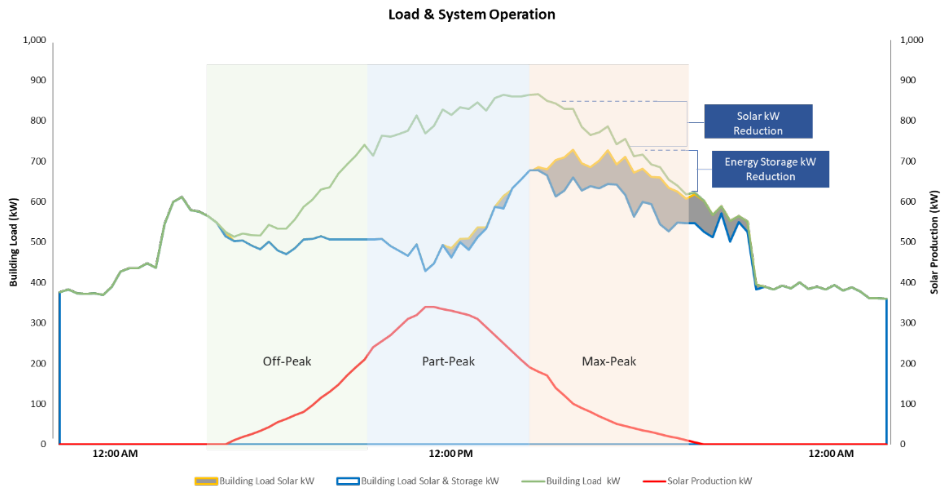

Figure 2.1: Reducing Demand with Solar + Storage

Figure 2.1 demonstrates a typical application of solar + storage in a behind-the-meter application, the mechanism for reducing peak demand and the resulting demand charges.

3. FACILITY SITE DATA AND MODEL ASSUMPTIONS

UL conducted a feasibility analysis using the facility's 15-minute load profiles and tariff rates to determine the optimal solar + storage configuration and the related financial savings of a Technology Campus located in California, USA. UL was provided with 15-minute load data from the facility from January 2018 through December 2018**,** which was used in the analysis. This facility's energy consumption and demand varies throughout the day and year and are substantially greater between March and October. The following figure provides an overview of the Client's current energy consumption and peak demand by month.

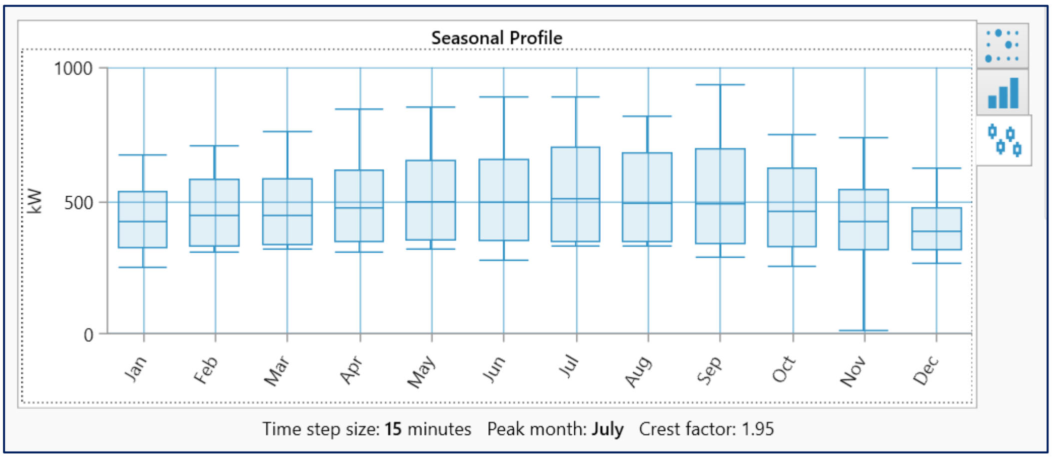

Figure 3.1: Facility's Energy Consumption and Demand

The facility currently procures energy from Southern California Edison under a tariff rate which has considerable demand charges, GS-2 The following table provides an overview of the tariff structure. UL notes that the electricity costs for this site are representative of many C&I buildings.

Table 3.1: Tariff Structure

Tariff	Rate
Energy Consumption	\$0.11/kWh (off-peak) \$0.13/kWh (on-peak)
Demand Charge	\$11.50/kW-month (off-peak) \$27.70/kW-month (on-peak)

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. 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 500 kW of carport PV on the campus**.** 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 789,000 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 $/MWh
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 3) enable the customer to change a more favorable tariff rate 4) contribute to the organization's sustainability goals by producing and consuming clean electricity.

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 which includes different annual escalation rates for peak demand charges and energy charges. 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 System Results vs. Current System

Facility Parameters	Current System	Proposed System
Facility (Year 1)		
Annual Grid Import	4,060,689 kWh	3,316,136 kWh
Solar PV Size (dc-coupled)	N/A	500 kW
Energy Storage Size	N/A	548 kWh
Solar Generation	N/A	788,753 kW
Solar Generation % of Load	N/A	18.3%
Electricity Tariff		
Electricity Tariff Plan	SCE, Large General - Time of Use - No PDP	SCE, Large General - Time of Use - No PDP
Cost of Electricity	$0.11/kWh (off-peak) $0.13/kWh (on-peak)	$0.11/kWh (off-peak) $0.13/kWh (on-peak)
Demand Charge	$11.50/kW-month (off-peak) $27.70/kW-month (on-peak)	$11.50/kW-month (off-peak) $27.70/kW-month (on-peak)
Energy Charges (Year 1)		
Energy Charges	$479,006	$361,881
Demand Charges	$165,118	$91,854
Demand Response	N/A	$20,432
Total Electricity Expense	$615,306	$453,736
Facility Savings		
First Year Electricity Savings	N/A	$161,571
20-Year Electricity Savings	N/A	$2,140,335

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: Current System – Electricity Costs

	January	February	March	April	May	June	July	August	September	October	November	December
Energy Charges	$35,132	$34,887	$37,533	$38,020	$41,237	$45,548	$48,720	$46,930	$45,782	$38,657	$34,080	$32,482
Consumption	313,257 kWh	311,076 kWh	335,026 kWh	339,017 kWh	367,687 kWh	354,869 kWh	379,596 kWh	365,626 kWh	356,704 kWh	344,666 kWh	303,539 kWh	289,627 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	$7,701	$8,125	$8,733	$9,661	$9,752	$24,616	$24,727	$22,650	$25,018	$8,572	$8,435	$7,128
Peak Demand	672 kW	709 kW	762 kW	843 kW	851 kW	889 kW	893 kW	818 kW	939 kW	748 kW	736 kW	622 kW
Fixed charges ($)	-$2,374	-$2,374	-$2,374	-$2,374	-$2,374	-$2,456	-$2,456	-$2,456	-$2,456	-$2,374	-$2,374	-$2,374
Monthly Total	$40,459	$40,638	$43,892	$45,307	$48,615	$67,707	$70,991	$67,124	$68,343	$44,855	$40,140	$37,236
Annual Total	**$615,306**											

Table 4.3: Proposes Solar + Storage System – Electricity Costs

	January	February	March	April	May	June	July	August	September	October	November	December
Energy Charges	$30,442	$29,386	$30,431	$30,079	$32,705	$36,074	$38,801	$37,192	$36,844	$31,920	$28,951	$27,876
Consumption	271,436 kWh	262,021 kWh	271,698 kWh	268,214 kWh	291,588 kWh	281,078 kWh	302,318 kWh	289,756 kWh	287,069 kWh	284,349 kWh	258,051 kWh	248,557 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	$5,736	$6,191	$6,004	$6,392	$6,583	$16,785	$14,935	$15,086	$16,974	$5,992	$6,185	$5,425
Peak Demand	501 kW	540 kW	524 kW	558 kW	574 kW	606 kW	539 kW	545 kW	637 kW	523 kW	540 kW	473 kW
Fixed charges ($)	-$2,374	-$2,374	-$2,374	-$2,374	-$2,374	-$2,456	-$2,456	-$2,456	-$2,456	-$2,374	-$2,374	-$2,374
Monthly Total	$33,803	$33,203	$29,334	$34,097	$36,913	$50,403	$51,280	$49,821	$45,991	$30,836	$29,768	$28,288
Annual Total	**$453,736**											

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	$1,631,186
O&M Year One Costs (2% escalator)	$8,332
Rebates and Incentives applied	ITC, MACRS, SGIP
Rebates and Incentives applied	$105,000
Simple Payback	6.3 years
Utility Escalation Rate Blended	7%
Federal Income Tax Rate	21%
State Income Tax Rate	8.3%
Return on Investment	11.8%
20-Year Internal Rate of Return	15.4%
20-Year LCOE PV	$0.03
20-Year Net Present Value (8%)	$1,001,893

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										($1,595,933)	($1,595,933)
1	($615,306)	$83,891	$69,601	$80,000	($8,332)	($390,146)	$225,160	$440,771	$757,329	$982,489	($613,444)
2	($633,348)	$82,495	$75,308	$32,400	($8,397)	($451,541)	$181,806	$0	($50,029)	$131,778	($481,666)
3	($652,544)	$81,123	$81,483	$32,808	($8,467)	($465,597)	$186,948	$0	($51,443)	$135,504	($346,162)
4	($672,988)	$79,774	$88,165	$33,224	($8,541)	($480,366)	$192,622	$0	($53,005)	$139,617	($206,544)
5	($694,777)	$78,447	$95,394	$33,649	($8,618)	($495,906)	$198,871	$0	($54,724)	$144,147	($62,397)
6	($718,019)	$77,142	$103,217	$34,082	($8,700)	($512,279)	$205,740	$0	($56,615)	$149,126	$86,728
7	($742,830)	$75,859	$111,681	$22,523	($8,786)	($541,554)	$201,276	$0	($55,386)	$145,890	$232,619
8	($769,334)	$74,597	$120,838	$22,974	($8,876)	($559,801)	$209,533	$0	($57,658)	$151,875	$384,493
9	($797,668)	$73,356	$130,747	$23,433	($8,969)	($579,101)	$218,567	$0	($60,144)	$158,423	$542,916
10	($827,978)	$72,136	$141,468	$23,902	($9,067)	($599,538)	$228,440	$0	($62,861)	$165,579	$708,495
11	($860,422)	$70,936	$153,069	$24,380	($160,849)	($772,886)	$87,535	$0	($24,088)	$63,448	$771,943
12	($895,172)	$69,756	$165,621	$24,867	($9,272)	($644,200)	$250,972	$0	($69,061)	$181,911	$953,854
13	($932,413)	$68,596	$179,201	$25,365	($9,381)	($668,632)	$263,781	$0	($72,586)	$191,195	$1,145,049
14	($972,346)	$67,455	$193,896	$25,872	($9,493)	($694,616)	$277,730	$0	($76,424)	$201,306	$1,346,354
15	($1,015,189)	$66,333	$209,795	$26,390	($9,609)	($722,280)	$292,909	$0	($80,601)	$212,308	$1,558,662
16	($1,061,176)	$65,229	$226,999	$26,917	($9,728)	($751,759)	$309,417	$0	($85,144)	$224,274	$1,782,936
17	($1,110,561)	$64,144	$245,612	$27,456	($9,851)	($783,200)	$327,362	$0	($90,082)	$237,280	$2,020,216
18	($1,163,620)	$63,077	$265,753	$28,005	($9,977)	($816,763)	$346,858	$0	($95,447)	$251,411	$2,271,627
19	($1,220,649)	$62,028	$287,544	$28,565	($10,108)	($852,620)	$368,030	$0	($101,273)	$266,757	$2,538,384
20	($1,281,971)	$60,996	$311,123	$29,136	($10,241)	($890,957)	$391,014	$0	($107,597)	$283,417	$2,821,801
21	($1,347,934)	$59,982	$336,635	$29,719	($10,379)	($931,977)	$415,957	$0	($114,461)	$301,496	$3,123,297
22	($1,418,914)	$58,984	$364,239	$30,313	($10,520)	($975,897)	$443,017	$0	($121,907)	$321,110	$3,444,407
23	($1,495,319)	$58,003	$394,107	$30,920	($10,665)	($1,022,954)	$472,365	$0	($129,983)	$342,382	$3,786,788
24	($1,577,589)	$57,038	$426,424	$31,538	($10,813)	($1,073,403)	$504,186	$0	($138,740)	$365,447	$4,152,235
25	($1,666,202)	$56,089	$461,390	$32,169	($10,966)	($1,127,519)	$538,683	$0	($148,232)	$390,451	$4,542,686
26	($1,761,674)	$55,157	$499,224	$32,812	($93,346)	($1,267,827)	$493,847	$0	($135,894)	$357,953	$4,900,639
27	($1,864,563)	$54,239	$540,161	$33,468	($11,281)	($1,247,976)	$616,587	$0	($169,669)	$446,918	$5,347,556
28	($1,975,474)	$53,337	$584,454	$34,138	($11,445)	($1,314,990)	$660,484	$0	($181,749)	$478,735	$5,826,291
29	($2,095,059)	$52,450	$632,379	$34,820	($11,612)	($1,387,022)	$708,037	$0	($194,834)	$513,203	$6,339,494
30	($2,224,026)	$51,577	$684,234	$35,517	($11,783)	($1,464,481)	$759,545	$0	($209,008)	$550,537	$6,890,032
Total	**($35,065,067)**	**$1,994,227**	**$8,179,764**	**$931,362**	**($528,073)**	**($24,487,787)**	**$10,577,280**	**$440,771**	**($2,091,316)**	**$6,890,032**	

6. OPERATIONAL BREAKDOWN

Yearly demand profile purchased entirely from the Grid (blue) and new grid purchases with PV solar generation (black).

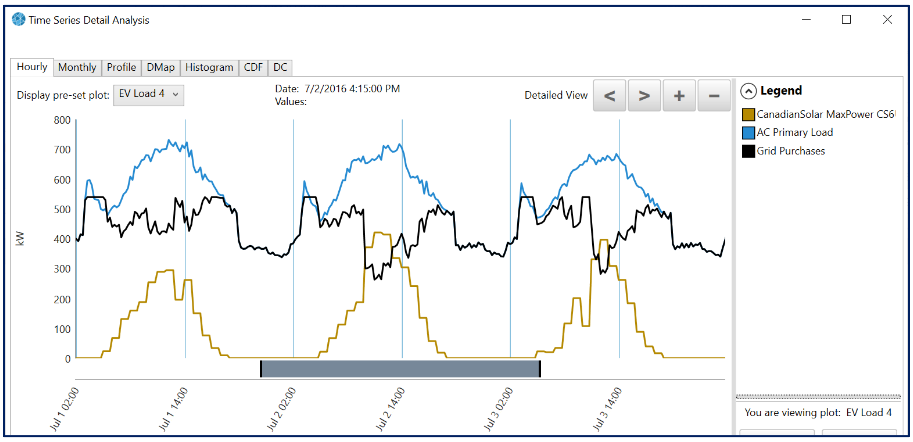

Figure 6.1: Detailed view – total electrical load, solar production, energy storage charging/discharging.

7. SUMMARY

UL Advisory Services conducted a feasibility study using HOMER Grid modeling software to analyze the financial impact of the deployment of carport based solar + energy storage for a Technology Campus located in California. The primary objectives were to configure and architect a renewable energy system to offset the increasing cost of electricity, particularly the peak demand charges. Peak demand charges are a considerable portion of the facility's expenses and the portion that is increasing the most. Additionally, this facility is seeking LEED certification and both solar and storage contribute to the sustainability mission - the production and consumption of clean, zero-carbon energy.

In this analysis, UL determined the cost of energy and demand charges based on analysis of historical utility bills, and current tariff rates. 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 $88,306 in energy in the first year (20% in kWh energy consumption), $73,264 in demand charges in the first year, with a 6.3 year payback and cash-on-cash return of 15.4% with a net upfront investment of $1,631,186.

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