Settlement Year 7 – Q4 Report
Progress Report to California Public Utilities Commission
Electric Vehicle Charging Station Project

For the period September 6, 2019 through Dec 5, 2019(the Reporting Period)
Submitted January 6, 2020 by NRG Energy, Inc. on behalf of the Dynegy Parties[1]

EXECUTIVE SUMMARY

NRG Energy, Inc. (NRG) and EVgo continue to implement the 2012 settlement agreement (Settlement) between the California Public Utilities Commission (CPUC) and certain NRG-affiliated entities to deploy electric vehicle (EV) charging infrastructure across the state. While NRG remains the obligated party, EVgo is executing the implementation of the Settlement as a service provider to NRG. The program has spurred a growing EV ecosystem that would not have been possible without this partnership. Through the reporting period, NRG and EVgo have delivered on virtually all the compliance obligations under the Settlement, overdelivering in most categories and continuing to execute on a small tail of final projects to deliver a robust network enabling Californians to electrify transportation.

As a fierce proponent for electric for all, EVgo can report that, today, more than 80% of California residents live within a 15-minute drive of an EVgo fast charger, thanks to both Settlement activities and other EVgo deployments. Additionally, of the 250 direct current fast chargers (DCFC) locations built under the Settlement, more than 40% of sites are in low-income communities and more than 20% of sites are in disadvantaged communities.

As of January 6, 2020, the submission date of this quarterly report, 241 fast charging sites built under the Settlement are open to the public, offering more than 500 DCFCs ranging from 50 kW to 350kW. This month EVgo will have delivered more than double the number of DCFCs anticipated under the amended Settlement budget. In proportion to the Settlement's achievements, EVgo experienced a small number of project delays in delivering the largest public fast charging network in California. All but one of these delays reflects over-delivery to Program objectives beyond compliance thresholds.[2] There are only five locations out of the 1,044 locations constructed under the Settlement that have any work remaining; four sites only have utility side construction remaining, and one site has EVSE and utility construction remaining. Of these, there is only one outlier which likely will extend beyond Q1 2020. Notwithstanding the conclusion of the term under the Settlement in 2019, NRG and EVgo continue to expend the resources necessary to complete these sites.

The Settlement has fostered and supported the growth of the country's strongest electric vehicle market through the deployment of the public charging infrastructure across the state of California. Despite a handful of project delays, NRG and EVgo have led the way in making

[1] Capitalized terms not otherwise defined herein shall have the meaning ascribed to such terms in the Long-Term Contract Settlement and Release of Claims Agreement by and among the California Public Utilities Commission and the Dynegy Parties dated April 27, 2012 (the "Settlement").
[2] The last Freedom Station compliance site's building inspection and commissioning is anticipated in January 2020.

California a transportation leader with first of its kind public charging infrastructure in an industry quickly moving from infancy to rapid growth. Fast charging infrastructure is critical to reach California's increasing population of EV drivers and is especially crucial to enable electrification for drivers without reliable access to charging at home or in the workplace, such as residents of multi-unit dwellings (MUDs) who rely on public charging for the majority of their charging needs[3], drivers who seek the convenience of charging while they shop, go to the park, library or community center, drivers who travel along key transit corridors, and light duty vehicle (LDV) fleets, including car sharing and ride sharing applications.

The network of chargers deployed through the Settlement has translated into 50.6 million electrified miles and 11,500 metric tons of GHG emissions reductions across California.

Year	MT CO2e	EV Miles	% Change YoY
2019	11,500	50.6 MM miles	3%

Table 1. GHG Emissions Reductions & EV Miles powered from Settlement DC Fast Chargers

NRG and EVgo thank the Commission and Staff for their partnership and continued dedication to enabling access to EVs for Californians across geographies and demographics. This report will summarize the fulfillment of Settlement objectives as of the Reporting Date, December 5, 2019 (the Reporting Date), and EVgo looks forward to continuing to build on the progress to date.

[3]International Council on Clean Transportation, Quantifying the Electric Vehicle Charging Infrastructure Gap Across U.S. Markets (January 2019), p. 9, https://www.theicct.org/sites/default/files/publications/US_charging_Gap_20190124.pdf

INSTALLATION OF PUBLIC EV CHARGING STATIONS (FREEDOM STATIONS)

As of the Reporting Date, 218 Freedom Station sites are constructed delivering 419 DCFCs; one site is scheduled to receive its final building inspection in early January 2020. This marks the fulfillment of all regional targets, low-income PUMA targets of 20% by region, and an incremental 18 Freedom Stations beyond the original compliance target set forth in the Settlement.

While not a requirement of the Settlement, at the request of the CPUC, NRG and EVgo have tracked Freedom Station installations against the CalEnviroScreen (CES) tool and AB 1550, two leading California designations benchmarking equity in access. That tracking shows as follows:

- 20% of Freedom Stations (43 of 218) in disadvantaged communities per CES 2.0
- 22% of Freedom Stations (47 of 218) in disadvantaged communities per CES 3.0
- 40% of Freedom Stations (88 of 218) in low-income communities per AB 1550

Fulfillment of geographic distribution and low-income PUMA is reflected in the Tables below. Completed Freedom Stations as of the Reporting Date are listed in Appendix A.

Geography	**Required**	**Final**	**%**
LA Basin	110	110	100%
SF Bay Area	55	69	125%
San Joaquin Valley	15	15	100%
San Diego County	20	21	105%
Other PG&E Counties	-	3	-
Total:	**200**	**218**	**109%**

Table 2. Freedom Station Distribution by Region

Geography	**Final**	**Low Income PUMA Sites**	**%**
LA Basin	110	22	20%
SF Bay Area	69	15	22%
San Joaquin Valley	15	4	27%
San Diego County	21	5	24%
Other Counties	3	-	-
Total	218	46	21%

Table 3. Freedom Station Low Income PUMA Distribution

INSTALLATION OF HIGH-POWER CHARGING PLAZAS (HPC PLAZAS)

On behalf of NRG, EVgo has exceeded the compliance requirement of 10 HPC Plazas with at least 30 DC fast chargers. As of January 5, 2020, a total of 65 DCFCs at 16 HPC Plazas are complete. Of these, all but one location (accounting for 6 DCFCs) is fully operational and is set to be commissioned in January 2020. HPC Plazas are located in the top 50% of California PUMAs ranked by percentage of residents in multi-family housing, of which, 20% of completed sites are in low-income PUMAs.

Geography	**Requirement**	**Complete**	**Low-Income PUMA**
LA Basin	-	5	-
SF Bay Area	-	9	4
San Joaquin Valley	-	-	-
San Diego County	-	1	-
Other PG&E Counties	-	1	-
Total:	10	16	4 or 25%

Table 4. High Power Charging Plaza Low Income PUMA Distribution

Taking into account completed HPC Plazas and the ones finishing final permitting, inspection, and interconnection in the next several months, EVgo will have delivered 102 DCFCs at 22 HPC Plazas, which is more than double the number of sites and more than three times the number of DCFCs originally contemplated under the Settlement's requirements for HPC Plazas. There are only five locations with construction work remaining. The remaining work on HPC Plaza Savings Event is detailed in Confidential Appendix B.

The final distribution of HPC Plazas and total low-income PUMAs are summarized in the table below.

Geography	**Requirement**	**Final Distribution**	**Low-Income PUMA**
LA Basin	-	7	
SF Bay Area	-	10	5
San Joaquin Valley	-	-	
San Diego County	-	4	
Other PG&E Counties	-	1	
Total:	10	22	5 or 23%

Table 5. HPC Plaza Low Income PUMA Distribution

Completed HPC Plazas as of the Reporting Date are listed in Appendix A.

INSTALLATION OF MAKE-READY STUBS AND MAKE-READY ARRAYS[4]

As of the Reporting Date, a total of 6,901 Make-Ready Stubs have been installed at 794 sites,[5] exceeding the minimum requirement of 6,875 Make-Ready Stubs required by the Settlement and satisfying the public interest, workplace, and regional distribution targets set forth in the Settlement.

Geography	**% of Make-Ready Stubs**	**Build Obligation**	**Completed**
LA Basin	55%	2,269	2,580
San Diego County	10%	413	1,417
SF Bay Area	27.5%	1,134	2,535
San Joaquin Valley	7.5%	309	369
Total	60% of 6,875 OR 4,125	6,875	6,901

Table 6. Make-Ready Installation by Region

Make Readies	**% of Make-Ready Stubs**	**Build Obligation**	**Completed**
Workplace	15%	1031	3156
Public Interest	10%	688	797

Table 7. Make-Ready Installation by Property Type

For information purposes, CPUC staff requested an analysis of distribution based on the CES standard, which did not exist at the time the Settlement was executed. The distribution is reported in the table below.

	CES Qualified Sites			Percent of total sites			CES Qualified Make-Ready Stubs			Percent of total Make-Ready Stubs		
Region	MDU	WP	All	MUD	WP	All	MUD	WP	All	MUD	WP	All
LA	48	40	89	33.1%	22.9%	26.6%	266	308	578	26.2%	21.1%	22.4%
SD	14	12	27	19.2%	18.5%	17.1%	133	111	252	20.5%	19.4%	17.8%
SF	7	21	38	5.7%	22.1%	13.9%	73	218	366	5.8%	26.3%	14.4%
SJV	0	15	16	0.0%	46.9%	41.0%	0	142	152	0.0%	48.5%	41.2%
Total	**69**	**88**	**170**	**20.1%**	**24.0%**	**21.1%**	**472**	**779**	**1348**	**16.0%**	**24.7%**	**19.5%**

Table 8. Make-Ready Distribution per CalEnviroScreen

Another way to consider the distribution of Make-Ready Stubs to disadvantaged communities or residents is to analyze the percentage of MUD properties (and stubs) that have deed-restricted housing units. By this standard, 31% of total MUD Make-Ready Stubs benefit disadvantage

[4] A "Make-Ready Array" is a group of connected Make-Ready Stubs at the same site.

[5] Pursuant to Section 4(b)(vi)(B) of the Settlement, EVgo has established a website which identifies each installed Make-Readies Array's location and Start-Up Period expiration date. See http://www.evgo.com/california-rev-progress/.

communities. This is due in part to inclusionary housing requirements in many California communities, where mixed-income housing in single properties is a norm.

	Deed Restricted Sites	Percent of Total Operational MUD Sites	Deed Restricted Make-Ready Stubs	Percent of Total Operational MUD Make-Ready Stubs
LA	78	53.8%	523	51.6%
SD	17	23.3%	117	18.0%
SF	21	17.1%	270	21.6%
SJV	0	0.0%	0	0.0%
CA - All	**116**	**33.7%**	**910**	**30.9%**

Table 9. Make-Ready Stubs Distribution per Deed-Restricted Housing

Completed Make-Ready Stubs as of the Reporting Date are listed in Appendix C.

EV OPPORTUNITY PROJECTS

EACH

The Equal Access Charging Hub (EACH) project aims to enable EV access and to spur the adoption of electric vehicles in neighborhoods disproportionately impacted by pollution by providing publicly available fast charging, supporting EV carsharing and ridesharing, and through community outreach.

As of the Reporting Date, all seven hubs are fully operational.

Region	Required	Operational
LA	-	3
SD	-	1
SF	-	3
Total	**7**	**7**

Completed EACH hubs as of the Reporting Date are listed in Appendix A.

EVgo has held four public EACH events to date, including in Anaheim, Richmond and San Diego in the summer of 2019. The most recent event, in San Leandro, was led by Green For All in partnership with the Lucky grocery store, the site host partner for that particular EACH hub. The Sunday before Thanksgiving, EVgo and Green For All representatives held an in-store pop-up paired with demonstration EVs and charging tutorials at the newly opened station. EVgo and Green For All shared the economic and environmental benefits of electric vehicles as well as the accessibility of these vehicles through rebates and other state/local incentives.

Building on EVgo's geographically dispersed network, deployments like EACH ensure that the Californians most impacted by pollution burden stand to benefit from electrified transport. Furthermore, the introduction of CARB's $17 million award to fund Clean Mobility Options for Disadvantaged Communities (Clean Mobility Options) will further support communities seeking to diversify and expand electric carshare options in California. Communities with EACH hubs—Inglewood, Compton, Anaheim, Richmond (2 locations), San Diego, and San Leandro— stand to further benefit from the Clean Mobility Options now that the foundational piece of public fast charging is open.

TECHNOLOGY DEMONSTRATION PROGRAMS

EV Storage Accelerator (EVSA)

Final Project Report to the CPUC available in Appendix D.

Appendix A

Freedom Station Table

See attached.

APPENDIX A - Freedom Station Detail
Dated as of: December 5, 2019

	Name	Street Address	City	Region	Operational Date	PUMA	Both SAE & CC	CES 2.0 SB 535 DAC
	SF Bay Area							
1	Westlake Shopping Center	75 Southgate Ave.	Daly City	SF Bay Area	6/24/2013		x	
2	Whole Foods Fremont	3111 Mowry Ave.	Fremont	SF Bay Area	9/25/2013		x	
3	Whole Foods SF	2001 Market Street	San Francisco	SF Bay Area	11/7/2013		x	
4	Vacaville Premium Outlets	321 Nut Tree Road	Vacaville	SF Bay Area	11/20/2013		x	
5	Livermore Premium Outlets	2774 Paragon Outlets Drive	Livermore	SF Bay Area	1/6/2014		x	
6	Walgreens SF	1175 Columbus	San Francisco	SF Bay Area	2/26/2014		x	
7	Public Market	5959 Shellmound St.	Emeryville	SF Bay Area	12/23/2013	x	x	
8	The Mall at Northgate	2150 Northgate Dr.	San Rafael	SF Bay Area	12/18/2013		x	
9	The Village at Corte Madera	1618 Redwood Hwy	Corte Madera	SF Bay Area	3/25/2014	x	x	
10	Whole Foods Cupertino	20955 Stevens Creek Blvd	Cupertino	SF Bay Area	4/29/2014		x	
11	Whole Foods Novato	790 De Long Ave	Novato	SF Bay Area	3/3/2014		x	
12	Whole Foods Telegraph Ave	3000 Telegraph Ave	Berkeley	SF Bay Area	4/2/2014		x	
13	Whole Foods Berkeley	1025 Gilman	Berkeley	SF Bay Area	11/12/2014		x	
14	Linda Mar	1227 Linda Mar Shopping Center	Pacifica	SF Bay Area	8/29/2014		x	
15	Whole Foods Lafayette	3502 Mt. Diablo Blvd	Lafayette	SF Bay Area	12/5/2014		x	
16	Whole Foods Los Altos	4800 El Camino Real	Los Altos	SF Bay Area	6/5/2014		x	
17	Rose Pavilion	3903 Santa Rita Rd.	Pleasanton	SF Bay Area	11/11/2014		x	
18	Great Mall	447 Great Mall Dr	Milpitas	SF Bay Area	6/24/2014		x	
19	Whole Foods Santa Rosa	733 Coddingtown Center	Santa Rosa	SF Bay Area	12/1/2014	x	x	
20	Petaluma Outlets	2200 Petaluma Blvd North	Petaluma	SF Bay Area	2/11/2014	x	x	
21	Nob Hill Foods Mountain View	1250 Grant Rd	Mountain View	SF Bay Area	7/15/2014		x	
22	Crossroads	2316 Monument Blvd	Pleasant Hill	SF Bay Area	5/28/2014		x	
23	Santa Rosa Plaza	1071 Santa Rosa Plaza	Santa Rosa	SF Bay Area	12/1/2014	x	x	
24	Napa Outlets	629 Factory Stores Drive	Napa	SF Bay Area	1/30/2015		x	
25	Whole Foods Redwood City	1250 Jefferson Ave	Redwood City	SF Bay Area	3/13/2015		x	
26	Gateway Plaza-Vallejo	173 Plaza Drive	Vallejo	SF Bay Area	4/24/2015	x	x	
27	F&E Hayward	19691 Hesperian Blvd	Hayward	SF Bay Area	4/24/2015	x	x	x
28	Stoneridge Mall	1700 Stoneridge Mall Rd	Pleasanton	SF Bay Area	4/30/2015		x	
29	Whole Foods Dublin	5200 Dublin Boulevard	Dublin	SF Bay Area	5/21/2015		x	
30	City of San Mateo	385 1st Ave	San Mateo	SF Bay Area	7/13/2015		x	
31	Fresh & Easy Sunnyvale	1180 N Fair Oaks Ave	Sunnyvale	SF Bay Area	8/4/2015		x	
32	Nob Hill Watsonville	1912 Main Street	Watsonville	SF Bay Area	8/27/2015		x	
33	Whole Foods Santa Cruz	911 Soquel Avenue	Santa Cruz	SF Bay Area	8/28/2015		x	
34	Whole Foods San Francisco (Potrero Hill)	50 Rhode Island St	San Francisco	SF Bay Area	10/9/2015	x	x	
35	Gilroy Premium Outlets	681 Leavesley Rd	Gilroy	SF Bay Area	11/16/2015		x	x
36	San Francisco Premium Outlets	2774 Livermore Outlets Drive	Livermore	SF Bay Area	11/17/2015		x	
37	Lucky Fremont	5000 Mowry Ave.	Fremont	SF Bay Area	12/2/2015		x	
38	Lucky Daly City #707	6843 Mission Blvd.	Daly City	SF Bay Area	12/31/2015		x	
39	Legacy - Nineteen800	19800 Vallco Parkway	Cupertino	SF Bay Area	1/21/2016		x	
40	Whole Foods Oakland	230 Bay Place	Oakland	SF Bay Area	3/1/2016	x	x	
41	University of California - UC Hastings	333 Larkin Street	San Francisco	SF Bay Area	3/4/2016	x	x	
42	San Carlos Library	610 Elm St	San Carlos	SF Bay Area	7/21/2016		x	
43	Lucky Los Altos	2175 Grant Rd	Los Altos	SF Bay Area	8/18/2016		x	
44	Whole Foods San Francisco (Ocean Ave)	1150 Ocean Ave	San Francisco	SF Bay Area	9/21/2016		x	
45	Lucky Capitola #702	1475 41st Ave	Capitola	SF Bay Area	10/6/2016		x	
46	Fairfield - Verdant Freedom Station	3700 Casa Verde St	San Jose	SF Bay Area	10/18/2016		x	
47	Lucky Napa (Trancas St) #731	1312 Trancas St	Napa	SF Bay Area	10/18/2016		x	
48	Whole Foods San Francisco (Franklin)	1765 California St	San Francisco	SF Bay Area	10/24/2016	x	x	
49	Whole Foods San Francisco (SOMA)	399 4th St	San Francisco	SF Bay Area	10/24/2016	x	x	x
50	Whole Foods Walnut Creek (Ygnacio Rd)	2941 Ygnacio Valley Rd	Walnut Creek	SF Bay Area	10/31/2016		x	
51	Walmart 5139 Dixon	235 E Dorset Dr	Dixon	SF Bay Area	11/1/2016		x	
52	Walmart 2553 Windsor	6650 Hembree Ln	Windsor	SF Bay Area	11/2/2016	x	x	
53	Walmart 5884 San Jose	5095 Almaden Expy	San Jose	SF Bay Area	11/4/2016		x	
54	Raley's Brentwood #336	2400 Sand Creek Rd	Brentwood	SF Bay Area	11/16/2016		x	
55	Lucky Sebastopol #777	776 Gravenstein Hwy N	Sebastopol	SF Bay Area	12/1/2016	x	x	
56	Lucky Martinez #725	1145 Arnold Dr	Martinez	SF Bay Area	12/1/2016		x	
57	Nob Hill Alameda #632	2531 Blanding Ave	Alameda	SF Bay Area	12/2/2016		x	
58	Marsh Manor Shopping Center	3640 Florence St	Redwood City	SF Bay Area	12/2/2016		x	
59	New Leaf Half Moon Bay	150 San Mateo Rd	Half Moon Bay	SF Bay Area	1/9/2017		x	
60	Cupertino Village	10869 N Wolfe Rd	Cupertino	SF Bay Area	12/19/2016		x	
61	Walmart 5435 San Jose (Story Rd)	777 Story Rd	San Jose	SF Bay Area	6/14/2017		x	x
62	City of Union City - Smith St. Lot	3960 SMITH ST	Union City	SF Bay Area	11/30/2017		x	
63	Lucky San Jose #758	565 W Capitol Expy	San Jose	SF Bay Area	11/28/2017		x	
64	ABB San Jose Headquarters	3055 Orchard Dr.	San Jose	SF Bay Area	11/22/2017		x	
65	New Seasons Sunnyvale	760 E El Camino Real	Sunnyvale	SF Bay Area	11/7/2017		x	
66	Walmart #2697 Antioch	4893 Lone Tree Way	Antioch	SF Bay Area	10/30/2017	x	x	
67	Walmart #1651 American Canyon	7011 Main St	American Canyon	SF Bay Area	10/26/2017		x	
68	City of St. Helena	1304 Oak Ave	Saint Helena	SF Bay Area	12/21/2017		x	
69	Town of Colma	1198 El Camino Real	Colma	SF Bay Area	12/12/2018		x	
					69	**15**	**69**	**4**
	San Diego							
1	Fashion Valley	7007 Friars Road	San Diego	San Diego	9/18/2013		x	
2	Las Americas Premium Outlets	4211 Camino De La Plaza	San Diego	San Diego	10/29/2013	x	x	
3	Flower Hill Promenade	2600 Via De La Valle	Del Mar	San Diego	12/20/2014		x	
4	Carlsbad Premium Outlets	5620 Paseo Del Norte	Carlsbad	San Diego	12/6/2013		x	
5	Broadway Plaza	1166 Broadway	Chula Vista	San Diego	1/6/2014	x	x	
6	SDG&E Innovation Center	4750 EV Clairemont Mesa Blvd	San Diego	San Diego	3/9/2014		x	
7	Rancho Penasquitos	13255 Black Mountain Rd	San Diego	San Diego	3/31/2014		x	
8	Del Norte Plaza	330 West El Norte Plaza	Escondido	San Diego	3/9/2014	x	x	
9	Fenton Marketplace	2482 Friars Rd	San Diego	San Diego	2/5/2015		x	
10	San Diego Tech Center	9605 Scranton Rd	San Diego	San Diego	2/27/2015		x	
11	Mira Mesa Mall	8110 - 8340 Mira Mesa Blvd	San Diego	San Diego	3/31/2015		x	
12	Melrose Village	1601 South Melrose Drive	Vista	San Diego	5/21/2015		x	
13	Walmart - San Diego # 2479	3412 College Ave	San Diego	San Diego	11/3/2016	x	x	
14	Walmart - Chula Vista #3516	1360 Eastlake Pkwy	Chula Vista	San Diego	11/10/2016		x	
15	Lazy Acres - Encinitas	150 Encinitas Blvd	Encinitas	San Diego	12/9/2016		x	
16	Santee Trolley	9846 Mission Gorge Rd	Santee	San Diego	6/8/2017		x	

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Dated as of: December 5, 2019

	Name	Street Address	City	Region	Operational Date	PUMA	Both SAE & CC	CES 2.0 SB 535 DAC
17	Walmart - Oceanside #2245	705 College Blvd	Oceanside	San Diego	12/5/2017		x	
18	Lazy Acres - Hillcrest	422 W Washington St	San Diego	San Diego	9/27/2017		x	
19	Camino Town and Country	2227 S El Camino Real	Oceanside	San Diego	8/28/2018		x	
20	SD Educational Cultural Complex	4343 Ocean View Blvd	San Diego	San Diego	6/27/2019	x	x	**x**
21	Sheraton Mission Valley San Diego Hotel	1433 Camino Del Rio S	San Diego	San Diego	7/17/2019		x	
				Subtotal	**21**	**5**	**21**	**1**
	LA Basin							
1	Camarillo Premium Outlets	900 1/2 Camarillo Center Dr.	Camarillo	LA Basin	11/11/2013		x	
2	Walgreens Tarzana	5353 Mecca Ave.	Tarzana	LA Basin	3/24/2014		x	
3	Outlets at Orange	20 City Blvd W	Orange	LA Basin	4/21/2014		x	
4	Westminster Mall	1025 Westminster Mall	Westminster	LA Basin	5/30/2014		x	x
5	Brea Mall	200 Brea Mall	Brea	LA Basin	5/2/2014		x	
6	Los Cerritos Center	200 Los Cerritos Mall	Cerritos	LA Basin	6/4/2014		x	x
7	Stonewood Center	306 Stonewood Street	Downey	LA Basin	3/28/2014		x	x
8	Larwin Square	654 East 1st Street	Tustin	LA Basin	3/31/2014		x	
9	Walgreens Huntington Beach	19501 Beach Boulevard	Huntington Beach	LA Basin	8/14/2014		x	
10	Corona Hills Plaza	360 McKinley Street	Corona	LA Basin	9/2/2014		x	
11	Hines Warner Center	5700 Canoga Ave	Woodland Hills	LA Basin	3/28/2014		x	
12	Cabazon Outlets	48400 Seminole Drive	Cabazon	LA Basin	4/23/2014	x	x	
13	Country Fair SC	12013 Central Avenue	Chino	LA Basin	5/20/2014		x	x
14	Inland Center	500 Inland Center Drive	San Bernardino	LA Basin	6/2/2014	x	x	x
15	Oaks Mall	350 W Hillcrest Drive	Thousand Oaks	LA Basin	4/30/2014		x	
16	Pacific View Mall	3301 East Main Street	Ventura	LA Basin	4/23/2014		x	
17	Pavilions Place	1600 Beach Blvd	Westminster	LA Basin	9/19/2014		x	
18	Bristol Plaza	3361 South Bristol St	Santa Ana	LA Basin	12/2/2014		x	
19	Shops at Mission Viejo	555 Shops At Mission Viejo	Mission Viejo	LA Basin	6/2/2014		x	
20	City of Hermosa Beach Parking	1334 Hermosa Avenue	Hermosa Beach	LA Basin	7/30/2014		x	
21	Dunlap - Huntington Harbor	16821 Algonquin St	Huntington Beach	LA Basin	9/15/2014		x	
22	8000 Sunset Strip	8000 Sunset Strip	Los Angeles	LA Basin	2/19/2015		x	
23	Tarragona	1000 N. Western Avenue	San Pedro	LA Basin	8/13/2014		x	
24	Morongo Casino	49500 Seminole Drive	Cabazon	LA Basin	3/4/2015	x	x	
25	Plaza Rio Vista	67800 Vista Chino	Cathedral City	LA Basin	3/5/2015	x	x	
26	Savi Ranch- Yorba Linda	23030 1/2 Eastpark Dr	Yorba Linda	LA Basin	1/30/2015		x	
27	F&E Manhattan Beach	1700-C Rosecrans Ave	Manhattan Beach	LA Basin	2/5/2015		x	
28	Ontario Mills	1 Mills Circle	Ontario	LA Basin	3/4/2015		x	
29	F&E Long Beach	3300 Atlantic Avenue	Long Beach	LA Basin	1/28/2015		x	x
30	F&E Norwalk	10930 Rosecrans Ave	Norwalk	LA Basin	2/25/2015		x	
31	F&E Signal Hill	2475 Cherry Ave	Signal Hill	LA Basin	2/5/2015	x	x	
32	Gelson's Calabasas	22277 Mulholland Hwy	Calabasas	LA Basin	3/20/2015		x	
33	Playa Vista Community Center	5510 Lincoln Blvd	Los Angeles	LA Basin	3/30/2015		x	
34	F&E Calimesa #1238	1126 Calimesa	Calimesa	LA Basin	4/7/2015	x	x	
35	Mall of Victor Valley	14370 Bear Valley Rd	Victorville	LA Basin	4/7/2015	x	x	
36	Gelsons Sherman Oaks	4520 Van Nuys Blvd	Sherman Oaks	LA Basin	4/22/2015		x	
37	Anaheim Plaza	510 N Euclid St.	Anaheim	LA Basin	5/6/2015		x	x
38	F&E Rosemead #1445	9026 E. Valley Blvd	Rosemead	LA Basin	5/13/2015	x	x	x
39	Sassounian Huntington Beach	21190 Beach Blvd	Huntington Beach	LA Basin	5/21/2015		x	
40	Lincoln Place Apartments	1050 Frederick Street	Venice	LA Basin	9/1/2014		x	
41	Whole Foods Redondo Beach	405 N. PCH	Redondo	LA Basin	7/10/2015		x	
42	Canyon Country Plaza	19242 Soledad Canyon	Santa Clarita	LA Basin	7/20/2015		x	
43	Esplanade Shopping Center	195 W. Esplanade Dr	Oxnard	LA Basin	9/29/2015		x	
44	Ince Garage	9290 Culver Blvd	Culver City	LA Basin	10/13/2015		x	
45	F&E Ontario #1164	2275 S. Euclid Ave	Ontario	LA Basin	11/23/2015		x	x
46	Gateway Plaza - Santa Fe Springs	10629 Carmenita Road	Santa Fe Springs	LA Basin	12/4/2015		x	x
47	Lakewood Center	500 Lakewood Center Mall	Lakewood	LA Basin	1/8/2016		x	
48	Del Amo Fashion Center	3525 West Carson Street	Torrance	LA Basin	1/19/2016		x	
49	2Rodeo - CBRE	2 Rodeo	Beverly Hills	LA Basin	3/3/2016		x	
50	Ocean View Plaza	638 Camino De Los Mares	San Clemente	LA Basin	4/4/2016		x	
51	The Current	707 E. Ocean Blvd.	Long Beach	LA Basin	4/26/2016	x	x	
52	Promenade at Downey	8830 Apollo Way	Downey	LA Basin	4/26/2016		x	x
53	Santa Fe Trail Plaza	10601 Valley Blvd	El Monte	LA Basin	6/2/2016	x	x	x
54	Puente Hills Town Center	17342 Colima Road	Rowland Heights	LA Basin	6/3/2016		x	
55	Serfas Service Station, LLC	800 Serfas Club Dr.	Corona	LA Basin	6/14/2016		x	x
56	Las Palmas Shopping Center - Paragon	42370 Bob Hope Dr	Rancho Mirage	LA Basin	7/28/2016	x	x	
57	Lake Elsinore Outlet Mall	17600 Collier Ave	Lake Elsinore	LA Basin	8/11/2016		x	x
58	Town Center Gateway - Menifee	30340 Haun Rd	Menifee	LA Basin	9/16/2016		x	
59	Walmart Murrieta #2952	41200 Murrieta Hot Springs Rd	Murrieta	LA Basin	10/14/2016		x	
60	Walmart Garden Grove #4171	11822 Gilbert St	Garden Grove	LA Basin	10/24/2016		x	
61	Walmart Glendora #1941	1950 Auto Centre Dr	Glendora	LA Basin	11/1/2016		x	
62	Walmart Duarte store #2401	1600 Mountain Ave	Duarte	LA Basin	11/2/2016		x	x
63	Walmart Baldwin Park # 3522	3250 Big Dalton Ave	Baldwin Park	LA Basin	11/2/2016		x	x
64	Walmart Corona #2842	1290 E Ontario Ave	Corona	LA Basin	11/9/2016		x	
65	Walmart Ontario #3796	1333 N Mountain Ave	Ontario	LA Basin	11/17/2016		x	x
66	Walmart Upland #1992	1540 W Foothill Blvd	Upland	LA Basin	11/17/2016		x	
67	Walmart City of Industry #2251	17150 Gale Ave	City of Industry	LA Basin	11/17/2016		x	x
68	Bridgeport Marketplace	23841 Newhall Ranch Rd	Valencia	LA Basin	11/18/2016		x	
69	The Americana at Brand	889 Americana Way	Glendale	LA Basin	11/23/2016		x	x
70	Temecula Brixmor - Vail Ranch Center	31685 Highway 79 South	Temecula	LA Basin	12/2/2016		x	
71	Walmart Simi Valley # 5685	2801 Cochran St	Simi Valley	LA Basin	12/2/2016		x	
72	Walmart Highland #1914	4210 East Highland Ave	Highland	LA Basin	12/4/2016	x	x	
73	Promenade on the Peninsula	550 Deep Valley Drive	Rolling Hills Estates	LA Basin	12/4/2016		x	
74	Oceanwest Deli	2600 Michelson Dr	Irvine	LA Basin	1/12/2017		x	
75	Walmart #1693 Redlands	2050 W Redlands Blvd	Redlands	LA Basin	1/6/2017		x	
76	Walmart La Habra #3248	1340 S Beach Blvd	La Habra	LA Basin	4/6/2017		x	
77	San Dimas Plaza	877 W Arrow Hwy	San Dimas	LA Basin	4/12/2017		x	
78	Walmart Huntington Beach #2636	8230 Talbert Ave	Huntington Beach	LA Basin	5/17/2017		x	
79	WinCo - Moreno Valley	12882 Day St	Moreno Valley	LA Basin	6/1/2017		x	**x**
80	IQ Air - La Mirada	14351 Firestone Blvd	La Mirada	LA Basin	8/14/2017		x	**x**
81	Walmart #5072 Torrance	19503 Normandie Ave	Torrance	LA Basin	12/5/2017		x	x
82	Newport Beach City Hall	100 Civic Center Dr	Newport Beach	LA Basin	11/22/2017		x	

APPENDIX A - Freedom Station Detail
Dated as of: December 5, 2019

	Name	Street Address	City	Region	Operational Date	PUMA	Both SAE & CC	CES 2.0 SB 535 DAC
83	Walmart #2495 Westminster	13331 Beach Blvd	Westminster	LA Basin	11/15/2017		x	x
84	Walmart #2288 Pomona	80 Rio Rancho Rd	Pomona	LA Basin	11/15/2017	x	x	x
85	Walmart #3276 San Bernardino	4001 Hallmark Pkwy	San Bernardino	LA Basin	11/9/2017	x	x	x
86	Walmart # 1756 Fontana	17251 Foothill Blvd	Fontana	LA Basin	10/30/2017	x	x	x
87	Walmart #1747 Perris	1800 N Perris Blvd	Perris	LA Basin	10/30/2017	x	x	
88	Walmart #2028 Riverside	5200 Van Buren Blvd	Riverside	LA Basin	10/30/2017		x	x
89	Walmart #3464 Chino	3943 Grand Ave	Chino	LA Basin	10/4/2017		x	
90	Walmart #1853 Hemet	1231 S Sanderson Ave	Hemet	LA Basin	9/9/2017	x	x	
91	Walmart #5425 San Jacinto	1861 S San Jacinto Ave	San Jacinto	LA Basin	9/9/2017	x	x	
92	Rialto Marketplace	1310 S Riverside Ave	Rialto	LA Basin	1/9/2018		x	x
93	Bristol Farms West Hollywood	9039 Beverly Blvd	West Hollywood	LA Basin	1/17/2018		x	
94	Newport Coast Community Center	6401 San Joaquin Hills Rd	Newport Beach	LA Basin	1/10/2018		x	
95	6060 Wilshire Blvd	6060 Wilshire Blvd	Los Angeles	LA Basin	8/28/2018		x	
96	Lazy Acres - Hermosa Beach	2510 Pacific Coast Highway	Hermosa Beach	LA Basin	10/5/2018		x	
97	Hollywest Promenade	5455 Hollywood Blvd	Los Angeles	LA Basin	2/13/2019	x	x	
98	820 Mound Ave	820 Mound Ave.	South Pasadena	LA Basin	8/26/2019		x	
99	Venice Crossroads	8985 Venice Blvd.	Los Angeles	LA Basin	4/22/2019		x	
100	Costa Mesa South Coast Metro	3002 S. Harbor Blvd.	Santa Ana	LA Basin	4/16/2019		x	
101	Chevron #200913 - Aliso Creek	23022 Aliso Creek Rd.	Aliso Viejo	LA Basin	7/19/2019		x	
102	Chevron #95243 - Lincoln Blvd	2400 Lincoln Blvd.	Venice	LA Basin	6/7/2019		x	
103	Chevron #99778 - Aviation Blvd	2301 N. Aviation Blvd.	Manhattan Beach	LA Basin	8/8/2019		x	
104	Hampton Inn Lancaster	2300 Double Play Way	Lancaster	LA Basin	11/26/2019	x	x	
105	Hyatt House El Segundo	810 South Douglas Street	El Segundo	LA Basin	11/21/2019		x	
106	Pacoima Center	9727 Laurel Canyon Blvd.	Arleta	LA Basin	6/7/2019		x	x
107	Residence Inn Ontario	2025 Convention Center Drive	Ontario	LA Basin	6/13/2019	x	x	x
108	Sierra Way Plaza	3993 Sierra Way	San Bernardino	LA Basin	7/17/2019	x	x	
109	Yorba Linda Town Center	18421 Yorba Linda Blvd.	Yorba Linda	LA Basin	awaiting building final		x - no CC	
110	UCLA Lot 36 Kinross	11100 Kinross Ave	Los Angeles	LA Basin	11/19/2019		x	
				Subtotal	**110**	**22**	**110**	**30**
	San Joaquin Valley							
1	Applegate Ranch	1000 Commerce Avenue	Atwater	SJV	10/28/2014		x	
2	West Valley Mall	3200 N Naglee Road	Tracy	SJV	2/6/2015		x	
3	Fashion Fair Mall	563 E. Shaw Ave.	Fresno	SJV	4/1/2015	x	x	x
4	Vine Fuels Salida	4530 Kiernan Avenue	Salida	SJV	8/5/2015		x	x
5	Clovis Commons	695 W Herndon Avenue	Clovis	SJV	9/16/2015		x	x
6	Whole Foods Fresno	650 W Shaw Ave	Fresno	SJV	9/17/2015		x	
7	Vine Fuels - Ceres	1240 E Whitmore Ave.	Ceres	SJV	10/26/2015		x	x
8	Vintage Faire Mall	3401 Dale Road	Modesto	SJV	11/9/2015	x	x	
9	City of Clovis	748 5th St.	Clovis	SJV	11/20/2015		x	
10	Swan Court Hotel	2950 Pea Soup Anderson Blvd.	Selma	SJV	2/2/2016	x	x	x
11	City of Visalia	320 E Acequia Ave.	Visalia	SJV	7/22/2016		x	x
12	Save Mart Chowchilla #103	1225 E Robertson Blvd	Chowchilla	SJV	8/12/2016		x	
13	Walmart Bakersfield #1574 (Colony St.)	6225 Colony St	Bakersfield	SJV	11/2/2016	x	x	x
14	Save Mart Madera (Howard Rd) #77	1504 Howard Rd	Madera	SJV	11/7/2016		x	
15	Walmart 5215 Delano	530 Woollomes Ave	Delano	SJV	11/9/2016		x	x
				Subtotal	**15**	**4**	**15**	**8**
	Other (PG&E)							
1	Raley's Rancho Cordova #440	4030 Sunrise Blvd	Rancho Cordova	Sacramento	5/10/2017		x	
2	Lucky Hollister #719	291 Mccray St	Hollister	San Benito	8/8/2017		x	
3	Lucky Sand City #772	2000 California Ave	Sand City	Monterey	11/17/2017		x	
				Subtotal	**3**	**0**	**3**	**0**
			Totals		**218**	**46**	**218**	**43**
						PUMA		**CES**
						21%		20%

High Power Charging Plazas
Dated as of: December 5, 2019

	Name	Street Address	City	Region	Operational Date	PUMA	Both SAE & CC	CES
1	Whole Foods San Jose	777 The Alameda	San Jose	SF Bay Area	1/18/2019	x	x	
2	Chevron #207718 - Willow Road	1399 Willow Rd	Menlo Park	SF Bay Area	4/4/2019		x	
3	City of Sacramento - Southside Park HPCP	2201 6th street Southside Park	Sacramento	Sacramento	5/2/2019		x	x
4	Union 76 - Valley Village	4654 Laurel Canyon Blvd	Valley Village	LA Basin	6/11/2019		x	
5	City of Foster City Police Station - HPCP	1000 E. Hillsdale Blvd.	Foster City	SF Bay Area	6/17/2019		x	
6	Oakland - Lafayette Square	610 E 10th St	Oakland	SF Bay Area	6/14/2019	x	x	
7	Whole Foods Mill Valley (Blithedale)	731 E Blithedale Ave.	Mill Valley	SF Bay Area	6/21/2019	x	x	
8	City of Millbrae - Broadway	446 Broadway	Millbrae	SF Bay Area	7/19/2019		x	
9	South San Francisco - Miller Garage	329 Miller Ave.	South San Francisco	SF Bay Area	8/16/2019		x	
10	Burlingame - Chula Vista Lot HPCP	1133 Chula Vista Ave.	Burlingame	SF Bay Area	9/3/2019		x	
11	Veterans Memorial Park	4117 Overland Ave	Culver City	LA Basin	10/3/2019		x	
12	Culver City Senior Center	4095 Overland Ave	Culver City	LA Basin	10/11/2019		x	
13	CIM - La Brea HPCP	1302 South La Brea Ave.	Los Angeles	LA Basin	11/16/2019		x	x
14	Chevron #91965 - Santa Monica Blvd	10867 Santa Monica Blvd.	Los Angeles	LA Basin	11/26/2019		x	
15	Rosecrans Plaza	3156 Sports Arena Blvd	San Diego	San Diego	12/12/2019		x	
16	Lucky Hayward (Santa Clara St) #716	25151 Santa Clara St	Hayward	SF Bay Area	Building Final received, Scheduling Commissioning	x	x	
17	UCLA - Lot 4	Lot 4 Westwood Plaza	Los Angeles	LA Basin	awaiting building final		x	
18	Apollo Center	10335 1/2 Lakewood Blvd #1041	Downey	LA Basin	utility construction		x	

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	Name	Street Address	City	Region	Operational Date	PUMA	Both SAE & CC	CES 2.0 SB 535 DAC
19	SD CalTrans Dist. 11 HQ	4050 Taylor St. Stop 250	San Diego	San Diego	utility construction		x	
20	SP Plus - 2548 Kettner Blvd	2548 Kettner Blvd	San Diego	San Diego	utility construction		x	
21	561 Vulcan Street	561 S Vulcan Ave	Encinitas	San Diego	under construction		x - no CC	
22	Oakland - Lake Park	519 Lake Park Ave.	Oakland	SF Bay Area	utility construction	x	x	
			Totals		**22**	**5**	**22**	**2**
						22.73%		

EV Opportunity Program

Equal Access Charging Hubs
Dated as of: December 5, 2019

	Name	Street Address	City	Region	Operational Date	PUMA	Both SAE & CC	CES
1	Brookhurst Community Center	2271 Crescent Ave	Anaheim	LA Basin	2/11/2019		x	x
2	City of Richmond - Civic Center	325 Civic Center Plaza	Richmond	SF Bay Area	6/17/2019	x	x	x*
3	City of Richmond - 41st Street EACH	201 41st Street	Richmond	SF Bay Area	7/31/2019	x	x	x
4	Northgate Gonzalez Market #21	1410 S 43rd St	San Diego	California	7/30/2019	x	x	x
5	Inglewood City Hall - EACH Hub	113 South La Brea Ave.	Inglewood	San Diego	8/20/2019	x	x	x
6	Soledad Center	909 S. Central Ave	Compton	LA Basin	10/2/2019	x	x	x
7	Lucky San Leandro #767	1300 Fairmont Dr.	San Leandro	SF Bay Area	11/6/2019		x	x*
				Subtotal	**7**	**5**	**7**	**7**

Green Raiteros
Dated as of: December 5, 2019

	Name	Street Address	City	Region	Operational Date	PUMA	Both SAE & CC	CES
1	FoodMaxx Fresno #456	1177 Fresno St	Fresno	SJV	9/12/2019	x	x	x
				Subtotal	**1**	**1**	**1**	**1**

Totals		**8**	**6**	**8**	**8**	

Appendix B

Description of Remaining Project Work

See attached.
[CONFIDENTIAL]

The following information is confidential and protected material and may only be provided to those parties and their Eligible Reviewers that have executed a protective order in the FERC proceeding approving the Agreement and the settlement of the EL02-60/62 Proceeding. NRG retains an exclusive, non-public, proprietary right to such information for eighteen (18) months after the date of submittal to the CPUC, and during such time such information shall not to the extent permitted by law be subject to disclosure under FOIA or CAPRA.

Material Redacted in Public, Non-Confidential Version

Appendix C

Make-Readies Detail

See attached.

Dated as of: December 5, 2019 **Completed installations**

#	Name	Street Address	City	IOU	Market	Type	Host	Contract Date	Stubs	Completion Date	Start-up Period End Date	Deed Restricted Housing	CES
1	The Terraces at Emery Station	5855 Horton Street	Emeryville	PGE	SF	Workplace	Wareham Development	3/26/2013	10	8/29/2013	2/28/2015	N/A	No
2a	Solterra EcoLuxury Apartments (Array 1)	9865 Erma Road	San Diego	SDGE	SD	Multi-Family	HG Fenton	5/24/2013	10	5/23/2013	11/23/2014	No	No
2b	Solterra EcoLuxury Apartments (Array 2)	9865 Erma Road	San Diego	SDGE	SD	Multi-Family	HG Fenton	5/24/2013	10	5/23/2013	11/23/2014	No	No
2c	Solterra EcoLuxury Apartments (Array 3)	9865 Erma Road	San Diego	SDGE	SD	Multi-Family	HG Fenton	5/24/2013	10	5/23/2013	11/23/2014	No	No
2d	Solterra EcoLuxury Apartments (Array 4)	9865 Erma Road	San Diego	SDGE	SD	Multi-Family	HG Fenton	5/24/2013	10	5/23/2013	11/23/2014	No	No
3	Energy Solutions	449 15th St.	Oakland	PGE	SF	Workplace	Energy Solutions	9/19/2013	6	12/4/2013	6/4/2015	N/A	Yes
4	Santa Monica Media Center	2100 Colorado Ave.	Santa Monica	SCE	LA	Workplace	Kilroy Realty	9/12/2013	4	1/10/2014	7/10/2015	N/A	No
5	NRG Marsh Landing	3201-C Wilbur Ave	Antioch	PGE	SF	Workplace	NRG	9/5/2013	10	12/11/2013	6/11/2015	N/A	Yes
6	Towers at Costa Verde	8775 Costa Verde	San Diego	SDGE	SD	Multi-Family	Garden Communities, Inc.	9/11/2013	10	1/10/2014	7/10/2015	No	No
7	NRG Mandalay	393 N Harbor Blvd	Oxnard	SCE	LA	Workplace	NRG	10/17/2014	10	2/18/2015	8/18/2016	N/A	No
8	NRG Pittsburg	696 W. 10th St.	Pittsburg	PGE	SF	Workplace	NRG	11/21/2013	6	1/20/2014	7/20/2015	N/A	No
9	Linear Technology	790 Sycamore Dr.	Milpitas	PGE	SF	Workplace	Linear Technology Corp.	11/18/2013	8	5/9/2014	11/9/2015	N/A	No
10	Pacific Ridge Corporate Centre	5790 Fleet St.	Carlsbad	SDGE	SD	Workplace	Fleet Pacific Ridge, LLC	1/15/2014	10	5/7/2014	11/7/2015	N/A	No
11	Diablo View Apartments	4265 Clayton Rd.	Concord	PGE	SF	Multi-Family	Diablo View, LLC	2/2/2014	8	5/14/2014	11/14/2015	No	No
12	Apex Apartments	1102 S. Abel St.	Milpitas	PGE	SF	Multi-Family	Lyon Communities	10/31/2013	6	4/17/2014	10/17/2015	No	No
13	Cross Pointe Apartments	5100 Vista Grande Drive	Antioch	PGE	SF	Multi-Family	Sequoia Equities	11/20/2013	6	5/30/2014	11/30/2015	No	No
14	Flora Apartments	140 Flora Avenue	Walnut Creek	PGE	SF	Multi-Family	Sequoia Equities	11/20/2013	2	5/15/2014	11/15/2015	No	No
15	Mill Springs Park	1809 Railroad Avenue	Livermore	PGE	SF	Multi-Family	Sequoia Equities	11/20/2013	4	5/21/2014	11/21/2015	No	No
16	Plum Tree Apartments	1097 Maywood Lane	Martinez	PGE	SF	Multi-Family	Sequoia Equities	11/20/2013	4	6/3/2014	12/3/2015	No	No
17	River Oaks Apartments	1000 Allison Drive	Vacaville	PGE	SF	Multi-Family	Sequoia Equities	11/20/2013	10	6/4/2014	12/4/2015	No	No
18	Sterling Heights Apartments	150 Rankin Way	Benecia	PGE	SF	Multi-Family	Sequoia Equities	11/20/2013	4	5/27/2014	11/27/2015	No	No
19	Tanglewood Apartments	1880 Cowell Blvd	Davis	PGE	SF	Multi-Family	Sequoia Equities	11/20/2013	6	6/3/2014	12/3/2015	No	No
20	University Village Davis	625 Cantrill Drive	Davis	PGE	SF	Multi-Family	Sequoia Equities	11/20/2013	4	6/3/2014	12/3/2015	No	No
21	Valley Ridge Apartments	900 Roanoke Drive	Martinez	PGE	SF	Multi-Family	Sequoia Equities	11/20/2013	4	6/2/2014	12/2/2015	No	No
22	Villa Palms Apartments	51 Murdell Lane	Livermore	PGE	SF	Multi-Family	Sequoia Equities	11/20/2013	4	5/22/2014	11/22/2015	No	No
23	NRG Ivanpah	100302 Yates Well Rd.	Nipton	SCE	LA	Workplace	NRG	2/26/2014	4	7/8/2014	1/8/2016	N/A	No
24	Autry Garage	10202 W. Washington Blvd	Culver City	SCE	LA	Workplace	Sony Pictures Entertainment	3/27/2014	10	7/23/2014	1/23/2016	N/A	No
25	Culver Parking Structure	10202 W. Washington Blvd	Culver City	SCE	LA	Workplace	Sony Pictures Entertainment	3/27/2014	10	7/23/2014	1/23/2016	N/A	No
26	Culver Studios (TCSOB)	9050 W. Washington Blvd	Culver City	SCE	LA	Workplace	Sony Pictures Entertainment	3/27/2014	10	7/23/2014	1/23/2016	N/A	No
27	Overland Parking Structure	10202 W. Washington Blvd	Culver City	SCE	LA	Workplace	Sony Pictures Entertainment	3/27/2014	10	7/23/2014	1/23/2016	N/A	No
28	SPP Garage	10000 W. Washington Blvd	Culver City	SCE	LA	Workplace	Sony Pictures Entertainment	3/27/2014	10	7/23/2014	1/23/2016	N/A	No
29	Thalberg North Garage	10202 W. Washington Blvd	Culver City	SCE	LA	Workplace	Sony Pictures Entertainment	3/27/2014	10	7/23/2014	1/23/2016	N/A	No
30	Casa Mira View I	11195 Westview Pkwy	San Diego	SDGE	SD	Multi-Family	Garden Communities, Inc.	5/14/2014	10	8/20/2014	2/20/2016	Yes	No
31	Torrey Hills Luxury Apartments	10880 West Ocean Air Dr.	San Diego	SDGE	SD	Multi-Family	Garden Communities, Inc.	2/27/2014	8	7/30/2014	1/30/2016	Yes	No
32	Circa 37	7800 Westside Drive	San Diego	SDGE	SD	Multi-Family	Sudberry Properties	5/1/2014	5	7/7/2014	1/7/2016	N/A	No
33	Terraces at Copley Point	5887 Copley Drive	San Diego	SDGE	SD	Workplace	Sudberry Properties	5/5/2014	10	7/7/2014	1/7/2016	N/A	Yes
34	2175 Market	2175 Market St.	San Francisco	PGE	SF	Multi-Family	Forest City	5/21/2014	6	7/25/2014	1/25/2016	Yes	No
35a	Stoneridge Apartments (Array 1)	6250 Stoneridge Mall Rd.	Pleasanton	PGE	SF	Multi-Family	Lyon Communities	11/22/2013	4	8/15/2014	2/15/2016	No	No
35b	Stoneridge Apartments (Array 2)	6250 Stoneridge Mall Rd.	Pleasanton	PGE	SF	Multi-Family	Lyon Communities	11/22/2013	4	8/15/2014	2/15/2016	No	No
35c	Stoneridge Apartments (Array 3)	6250 Stoneridge Mall Rd.	Pleasanton	PGE	SF	Multi-Family	Lyon Communities	11/22/2013	4	8/15/2014	2/15/2016	No	No
36	17 Mile Drive Village	1012 Pacific Grove Lane	Pacific Grove	PGE	SF	Multi-Family	Sequoia Equities	11/20/2013	3	7/3/2014	1/3/2016	No	No
37	Park Central Apartments	1400 Technology Lane	Petaluma	PGE	SF	Multi-Family	Sequoia Equities	11/20/2013	6	8/12/2014	2/12/2016	No	No
38	Park Ridge Apartments	4949 Snyder Lane	Rohnert Park	PGE	SF	Multi-Family	Sequoia Equities	11/20/2013	8	6/6/2014	12/6/2015	No	No
39	Rosewalk Apartments	3601 Copperfield Drive	San Jose	PGE	SF	Multi-Family	Sequoia Equities	11/20/2013	10	6/6/2014	12/6/2015	No	No
40	Sandpiper Village Apartments	999 Marshall Road	Vacaville	PGE	SF	Multi-Family	Sequoia Equities	11/20/2013	4	5/26/2014	11/26/2015	No	No
41	Shadow Oaks Apartments	202 Calvert Drive	Cupertino	PGE	SF	Multi-Family	Sequoia Equities	11/20/2013	4	6/24/2014	12/24/2015	No	No
42	Sharps & Flats Apartments	1660 Drew Circle	Davis	PGE	SF	Multi-Family	Sequoia Equities	11/20/2013	4	8/22/2014	2/22/2016	No	No
43	Tower 737 Apartments	737 Post Street	San Francisco	PGE	SF	Multi-Family	Sequoia Equities	11/20/2013	4	6/24/2014	12/24/2015	Yes	No
44	Trinity House Apartments	1812 Trinity Avenue	Walnut Creek	PGE	SF	Multi-Family	Sequoia Equities	11/20/2013	2	5/15/2014	11/15/2015	No	No
45	Silicon Image	1140 Arques Ave.	Sunyvale	PGE	SF	Workplace	Silicon Image, Inc.	4/2/2014	10	6/24/2014	12/24/2015	N/A	No
46	Emery Station Joint Venture	5858 Horton	Emeryville	PGE	SF	Workplace	Wareham Development	4/10/2014	10	8/29/2014	2/29/2016	N/A	No
47	Emery Station Office II	5980 Horton	Emeryville	PGE	SF	Workplace	Wareham Development	4/10/2014	6	7/25/2014	1/25/2016	N/A	No
48	Butte College - Chico Campus	2320 Forest Ave	Chico	PGE	SF	Publ Int	Butte College	6/24/2014	10	9/10/2014	3/10/2016	N/A	No
49a	Uptown District (Array 1)	1250-1270 Cleveland Ave.	San Diego	SDGE	SD	Multi-Family	Uptown District Owner's Association	1/14/2014	10	10/10/2014	4/10/2016	Condo	No
49b	Uptown District (Array 2)	1250-1270 Cleveland Ave.	San Diego	SDGE	SD	Multi-Family	Uptown District Owner's Association	1/14/2014	10	10/10/2014	4/10/2016	Condo	No
49c	Uptown District (Array 3)	1250-1270 Cleveland Ave.	San Diego	SDGE	SD	Multi-Family	Uptown District Owner's Association	1/14/2014	8	10/10/2014	4/10/2016	Condo	No
50	Qualcomm - Pac Center Garage AQ	5865 Pacific Center Blvd	San Diego	SDGE	SD	Workplace	Qualcomm	6/23/2014	1	10/28/2014	4/28/2016	N/A	No
51	Lake Merced Hills	1100 Lake Merced Blvd.	San Francisco	PGE	SF	Multi-Family	Lake Merced Hills HOA	10/6/2014	16	12/4/2014	6/4/2016	Condo	No
52	The Marke	100 E. MacArthur Blvd	Santa Ana	SCE	LA	Multi-Family	Lyon Communities	6/9/2014	10	9/26/2014	3/26/2016	No	Yes
53	Crossroads Phase I	9120 Judicial Drive	San Diego	SDGE	SD	Multi-Family	Garden Communities, Inc.	7/15/2014	2	10/6/2014	4/6/2016	Yes	No
54	360 Residences	360 S. Market St.	San Jose	PGE	SF	Multi-Family	Pinnacle Family	8/29/2014	10	11/6/2014	5/6/2016	No	Yes
55	Mason O'Farrell Garage	325 Mason	San Francisco	PGE	SF	Workplace	Harsch Investment Properties	5/2/2014	10	10/1/2014	4/1/2016	N/A	Yes
56	District Administrative Complex	333 East 8th Street	Oakland	PGE	SF	Publ Int	Peralta Community College District	5/24/2014	10	10/28/2014	4/28/2016	N/A	Yes
57	The Highlands Apt Homes	11750 Mt. Vernon Ave	Grand Terrace	SCE	LA	Multi-Family	Sequoia Equities	1/22/2014	10	10/16/2014	4/16/2016	Yes	No
58	Portofino	2500 Northside drive	San Diego	SDGE	SD	Multi-Family	H.G. Fenton	4/30/2014	9	11/10/2014	5/10/2016	No	No
59	National Academy of Recording Arts and Sciences	3030 Olympic Blvd.	Santa Monica	SCE	LA	Workplace	Jamestown Company	9/29/2014	8	11/19/2014	5/19/2016	N/A	No
60	Lantana South	3301 Exposition Blvd.	Santa Monica	SCE	LA	Workplace	Jamestown Company	9/29/2014	8	11/12/2014	5/12/2016	N/A	No
61	Lantana West	2900 Olympic Blvd.	Santa Monica	SCE	LA	Workplace	Jamestown Company	9/29/2014	8	11/26/2014	5/26/2016	N/A	No
62	Riverfront	750 Camino de la Reina	San Diego	SDGE	SD	Multi-Family	H.G. Fenton	4/30/2014	8	9/11/2014	3/11/2016	No	No
63	El Dorado Hills - East	3828 Pendiente Ct.	San Diego	SDGE	SD	Multi-Family	H.G. Fenton	4/30/2014	6	10/1/2014	4/1/2016	No	No
64	Alize Apartments	2 Enterprise	Aliso Viejo	SCE	LA	Multi-Family	Sequoia Equities	11/20/2013	8	10/10/2014	4/10/2016	No	No
65	Tierrasanta Ridge	5410 Repecho Drive	San Diego	SDGE	SD	Multi-Family	H.G. Fenton	4/30/2014	8	10/31/2014	4/30/2016	No	No
66	Emery Station East	5885 Hollis St.	Emeryville	PGE	SF	Workplace	Wareham Development	4/10/2014	8	11/14/2014	5/14/2016	N/A	No
67	Wareham - 503 Canal	503 Canal St.	Richmond	PGE	SF	Workplace	Wareham Development	11/4/2014	6	11/14/2014	5/14/2016	N/A	Yes
68	Samsung	18600 S. Broadwick St.	Rancho Domingu	SCE	LA	Workplace	Samsung Electronics America	10/27/2014	6	12/15/2014	6/15/2016	N/A	Yes
69	Levecke Corporation	10810 Inland Ave.	Mira Loma	SCE	LA	Workplace	Levecke Corporation	9/22/2014	6	11/5/2014	5/5/2016	N/A	Yes
70	Coca-Cola, Downey	8729 Cleta St.	Downey	SCE	LA	Workplace	The Coca-Cola Company	10/3/2014	6	11/29/2014	5/29/2016	N/A	Yes

71	Aquaterra	5777 Mission Center Rd.	San Diego	SDGE	SD	Multi-Family	H.G. Fenton	4/30/2014	6	9/17/2014	3/17/2016	No	No
72	Paloma Summit Apartments	26371 Paloma	Foothill Ranch	SDGE	SD	Multi-Family	Sequoia Equities	11/20/2013	4	10/16/2014	4/16/2016	No	No
73	Club River Run Apartments	10041 Rio San Diego Dr.	San Diego	SDGE	SD	Multi-Family	H.G. Fenton	4/30/2014	4	10/30/2014	4/30/2016	No	No
74	Columbia Lofts	1941 Columbia St.	San Diego	SDGE	SD	Multi-Family	WestVentures LP	8/20/2013	3	9/26/2014	3/26/2016	No	No
75	FedEx Building	5391 Rickenbacker Rd.	Bell	SCE	LA	Workplace	Pacific Industrial	7/14/2014	4	9/9/2014	3/9/2016	N/A	Yes
76	Parcel G	5391 Rickenbacker Rd.	Bell	SCE	LA	Workplace	Pacific Industrial	7/14/2014	2	9/9/2014	3/9/2016	N/A	Yes
77	Parcel H	5630 Rickenbacker Rd.	Bell	SCE	LA	Workplace	Pacific Industrial	7/14/2014	2	9/9/2014	3/9/2016	N/A	Yes
78a	Sea Gate - West (Array 1)	6556 Seagate Road	Carlsbad	SDGE	SD	Multi-Family	H.G. Fenton	4/30/2014	10	2/25/2015	8/25/2016	No	No
78b	Sea Gate - West (Array 2)	6557 Seagate Road	Carlsbad	SDGE	SD	Multi-Family	H.G. Fenton	5/1/2014	10	2/26/2015	8/26/2016	No	No
78c	Sea Gate - West (Array 3)	6558 Seagate Road	Carlsbad	SDGE	SD	Multi-Family	H.G. Fenton	5/2/2014	10	2/27/2015	8/27/2016	No	No
78d	Sea Gate - West (Array 4)	6559 Seagate Road	Carlsbad	SDGE	SD	Multi-Family	H.G. Fenton	5/3/2014	6	2/28/2015	8/28/2016	No	No
79	The Uptown Apartments	600 William St.	Oakland	PGE	SF	Multi-Family	Uptown Housing Partners, LP	2/12/2014	16	3/4/2015	9/4/2016	Yes	Yes
80	2311 Rosecrans Ave.	2311 Rosecrans Ave.	El Segundo	SCE	LA	Workplace	Continental Development Corporation	1/16/2014	10	1/15/2015	7/15/2016	N/A	No
81	870 S. Nash St.	870 S. Nash St.	El Segundo	SCE	LA	Workplace	Continental Development Corporation	1/16/2014	8	1/5/2015	7/5/2016	N/A	No
82	871 S. Nash St.	872 S. Nash St.	El Segundo	SCE	LA	Workplace	Continental Development Corporation	1/16/2014	6	1/15/2015	7/15/2016	N/A	No
83	2371 Rosecrans Ave.	2371 Rosecrans Ave.	El Segundo	SCE	LA	Workplace	Continental Development Corporation	1/16/2014	10	1/15/2015	7/15/2016	N/A	No
84	860 Apollo St.	860 Apollo St.	El Segundo	SCE	LA	Workplace	Continental Development Corporation	1/16/2014	10	1/15/2015	7/15/2016	N/A	No
85	Ormond Beach Generating Station	6635 Edison Dr.	Oxnard	SCE	LA	Workplace	NRG	7/15/2014	4	2/18/2015	8/18/2016	N/A	Yes
86	Sony Electronics	16535 Villa Esprillo	San Diego	SDGE	SD	Workplace	Sony Electronics	9/29/2014	10	2/19/2015	8/19/2016	N/A	No
87	Enso	175 Baypointe Parkway	San Jose	PGE	SF	Multi-Family	Fairfield Residential	7/9/2014	10	1/19/2015	7/19/2016	No	No
88	The Presidio Landmark	1801 Wedemeyer St.	San Francisco	PGE	SF	Multi-Family	Forest City	1/15/2014	10	1/12/2015	7/12/2016	No	No
89	Ariba	310 Hermosa Ct	Sunyvale	PGE	SF	Workplace	Ariba	6/17/2014	10	1/23/2015	7/23/2016	N/A	No
90	Hartnell Community College 1	411 Central Ave	Salinas	PGE	SF	Publ Int	Hartnell Community College	12/5/2014	10	2/18/2015	8/18/2016	N/A	No
91	Hartnell Community College - Alisal Campus	1752 E Alisal	Salinas	PGE	SF	Publ Int	Hartnell Community College	12/5/2014	4	11/30/2015	5/30/2017	N/A	No
92	Napa Valley Community College: Napa Campus	2277 Napa-Vallejo Highway	Napa	PGE	SF	Publ Int	Napa Valley Community College	12/1/2014	4	3/4/2015	9/4/2016	N/A	No
93	Napa Valley Community College: Helena Campus	1088 College Avenue	Saint Helena	PGE	SF	Publ Int	Napa Valley Community College	12/1/2014	4	3/4/2015	9/4/2016	N/A	No
94	Verdant	3700 Casa Verde Street	San Jose	PGE	SF	Multi-Family	Fairfield Residential	7/9/2014	8	1/19/2015	7/19/2016	No	No
95	Coca-Cola, San Leandro	14655 Wicks Blvd.	San Leandro	PGE	SF	Workplace	Coca-Cola	10/3/2014	8	1/12/2015	7/12/2016	N/A	No
96	Shadow Ridge Apartments	1987 Ridgegate Lane	Simi Valley	SCE	LA	Multi-Family	Sequoia Equities	11/20/2013	8	12/15/2014	6/15/2016	Yes	No
97	The Villas at Wood Ranch	241 Country Club Drive	Simi Valley	SCE	LA	Multi-Family	Sequoia Equities	11/21/2013	6	12/15/2014	6/15/2016	No	No
98	Overlook at Wood Ranch	241 Country Club Drive	Simi Valley	SCE	LA	Multi-Family	Sequoia Equities	11/22/2013	2	12/15/2014	6/15/2016	No	No
99	Hidden Hills Apartments	30041 Tessier Street	Laguna Nigel	SCE	LA	Multi-Family	Sequoia Equities	11/23/2013	4	3/2/2015	9/2/2016	No	No
100	Niguel Summit Apartments	30252 Pacific Island Dr	Laguna Nigel	SCE	LA	Multi-Family	Sequoia Equities	11/24/2013	6	3/2/2015	9/2/2016	No	No
101	Coronado Shores	1820 Avenida del Mundo	Coronado	SDGE	SD	Multi-Family	Coronado Shores # 9 El Mirador HOA	12/22/2014	5	2/6/2015	8/6/2016	condo	No
102	Scripps Corporate Plaza	10680 Treena Street	San Diego	SDGE	SD	Workplace	Cushman and Wakefield	1/29/2015	5	1/30/2015	7/30/2016	N/A	No
103	El Segundo Generating Station	301 Vista del Mar	El Segundo	SCE	LA	Workplace	NRG	8/22/2014	4	2/18/2015	8/18/2016	N/A	No
104	Long Beach Generating Station	2665 Pier S Lane Terminal Island	Long Beach	SCE	LA	Workplace	NRG	7/1/2014	4	2/18/2015	8/18/2016	N/A	No
105	Encina Generating Station	4600 Carlsbad Blvd.	Carlsbad	SDGE	SD	Workplace	NRG	7/25/2014	4	2/18/2015	8/18/2016	N/A	No
106	Solana Highlands	701 South Nardo	Solana Beach	SDGE	SD	Multi-Family	H.G. Fenton	4/30/2014	4	12/6/2014	6/6/2016	Yes	No
107	Scripps Landing	9970 Erma Road	San Diego	SDGE	SD	Multi-Family	H.G. Fenton	4/30/2014	4	2/11/2015	8/11/2016	No	No
108	NRG Potrero	1201 Illinois St.	San Francisco	PGE	SF	Workplace	NRG	11/21/2013	2	1/31/2014	7/31/2015	N/A	No
109	Field House at Bay Meadows	380 East 28th Ave.	San Mateo	PGE	SF	Multi-Family	Wilson Meany	10/17/2013	4	1/14/2015	7/14/2016	Yes	No
110	Odwalla	2996 Alvarado St.	San Leandro	PGE	SF	Workplace	Coca-Cola	10/3/2014	4	1/12/2015	7/12/2016	N/A	Yes
111	Walnut Creek Energy Park	911 Bixby Drive	City of Industry	SCE	LA	Workplace	NRG	9/18/2014	2	2/18/2015	8/18/2016	N/A	No
112	BBI Construction	1155 3rd st	Oakland	PGE	SF	Workplace	BBI Construction	1/14/2015	2	2/18/2015	8/18/2016	N/A	No
113	Avana San Clemente	1100 Calle Del Cerro	San Clemente	SCE	LA	Multi-Family	Greystar	9/29/2014	10	5/8/2015	11/8/2016	No	No
114	Parcel 2	3059 Townsgate Rd	Thousand Oaks	SCE	LA	Workplace	Westlake Plaza Center East	11/11/2016	8	5/18/2015	11/18/2016	N/A	No
115	Parcel 3	3059 Townsgate Rd	Thousand Oaks	SCE	LA	Workplace	Westlake Plaza Center East	11/11/2016	8	5/18/2015	11/18/2016	N/A	No
116	Heritage Springs	12257 Heritage Springs Dr.	Santa Fe Springs	SCE	LA	Multi-Family	Fairfield Residential	2/19/2015	11	6/2/2015	12/2/2016	No	Yes
117	1500 Rosecrans	1500 Rosecrans	El Segundo	SCE	LA	Workplace	Continental Development Corporation	5/13/2015	10	6/17/2018	12/17/2019	N/A	No
118	1888 Rosecrans Blvd.	1888 Rosecrans Blvd.	El Segundo	SCE	LA	Workplace	Continental Development Corporation	4/10/2015	10	6/2/2015	12/2/2016	N/A	No
119	Urbana	450 Tenth Ave.	San Diego	SDGE	SD	Multi-Family	HG Fenton	12/16/2014	10	3/13/2015	9/13/2016	No	Yes
120	Avana La Jolla	7039 Charmant Dr.	La Jolla	SDGE	SD	Multi-Family	Greystar	9/29/2014	10	5/6/2015	11/6/2016	No	No
121	SummerHouse	2303 Ocean Street	Carlsbad	SDGE	SD	Multi-Family	Zephyr Partners	1/20/2015	10	6/4/2015	12/4/2016	Condo	No
122	199 New Montgomery HOA	199 New Montgomery St.	San Francisco	PGE	SF	Multi-Family	199 New Montgomery HOA	2/23/2015	10	5/8/2015	11/8/2016	Condo	No
123	Laney College	900 Fallon Street	Oakland	PGE	SF	Workplace	Peralta Community College District	3/11/2014	10	5/19/2015	11/19/2016	N/A	Yes
124	Abbott Medical Optics	510 Cottonwood Drive	Milpitas	PGE	SF	Workplace	Abbott Medical Optics	9/16/2014	10	3/31/2015	9/30/2016	N/A	No
125	Sunrise Power Company	12857 Sunrise Power Rd.	Fellows	SCE	SJV	Workplace	Sunrise Power Company	11/19/2014	8	5/21/2015	11/21/2016	N/A	Yes
126	Villagio	16301 Butterfield Ranch Rd.	Chino Hills	SDGE	SD	Multi-Family	Fairfield Residential	2/19/2015	8	6/1/2015	12/1/2016	No	No
127	500 Orange	500 N. State College Blvd.	Orange	SCE	LA	Workplace	Lincoln Properties	2/25/2015	7	5/21/2015	11/21/2016	N/A	No
128	Aquatic Park Center	725 Potter St.	Berkeley	PGE	SF	Workplace	Wareham Development	8/15/2014	6	5/28/2015	11/28/2016	N/A	Yes
129	999 Anthony	999 Anthony St.	Berkeley	PGE	SF	Workplace	Wareham Development	8/28/2014	6	5/5/2015	11/5/2016	N/A	Yes
130	Sherman Woods HOA	1500 Sherman Ave	Burlingame	PGE	SF	Multi-Family	Sherman Woods HOA	2/4/2015	5	4/1/2015	10/1/2016	Condo	No
131	9000 Clifton Way	9000 Clifton Way	Beverly Hills	SCE	LA	Multi-Family	David Finkelstein	2/5/2015	4	4/20/2015	10/20/2016	No	No
132	KPI Ultrasound Inc.	23865 Via Del Rio	Yorba Linda	SCE	LA	Workplace	KPI Medical	2/11/2015	4	3/31/2015	9/30/2016	N/A	No
133	Bella Del Mar	14031 Mango Dr.	Del Mar	SDGE	SD	Multi-Family	H.G. Fenton	4/30/2014	4	3/13/2015	9/13/2016	No	No
134	Etiwanda	8996 Etiwanda Ave.	Rancho Cucamon	SCE	LA	Workplace	NRG	11/4/2014	2	5/18/2015	11/18/2016	N/A	Yes
135	Centra Freight Services	5140 W. 104th St.	Inglewood	SCE	LA	Workplace	Centra Freight Services	4/23/2015	2	5/29/2015	11/29/2016	N/A	Yes
136	PAX Water	860 Harbour Way South	Richmond	PGE	SF	Workplace	PAX Water	2/20/2015	2	3/27/2015	9/27/2016	N/A	No
137	Bayside Commons HOA	535 Pierce Street	Albany	PGE	SF	Multi-Family	Bayside Commons HOA	4/28/2015	15	7/29/2015	1/29/2017	Condo	No
138	Ocean Club	300 Village Center Dr.	Redondo Beach	SCE	LA	Multi-Family	Lyon Communities	5/28/2015	14	7/31/2015	1/31/2017	No	No
139	Breakwater	13900 Fiji Way	Marina Del Rey	SCE	LA	Multi-Family	Equity Residential	4/29/2015	10	7/29/2015	1/29/2017	No	No
140	Casa Mira View II	11195 Westview Pkwy	San Diego	SDGE	SD	Multi-Family	Garden Communities, Inc.	5/14/2014	10	6/19/2015	12/19/2016	Yes	No
141	Legacy - Nineteen800	19800 Vallco Parkway	Cupertino	PGE	SF	Multi-Family	Legacy Partners	5/8/2015	10	7/24/2015	1/24/2017	No	No
142	Bayside Village - 500 Beale	500 Beale	San Francisco	PGE	SF	Multi-Family	Forest City	5/29/2015	10	8/28/2015	2/28/2017	Yes	No
143	Bayside Village - 160 Brannan	160 Brannan St.	San Francisco	PGE	SF	Multi-Family	Forest City	5/29/2015	10	8/28/2015	2/28/2017	Yes	No
144	Bayside Village - 2 Bayside Village	2 Bayside Village Place	San Francisco	PGE	SF	Multi-Family	Forest City	5/29/2015	10	8/28/2015	2/28/2017	Yes	No
145	555 YVR HOA	555 Ygnacio Valley Road	Walnut Creek	PGE	SF	Multi-Family	555 YVR Owners Association	5/5/2015	10	7/31/2015	1/31/2017	Yes	No
146	Monarch Coast	32400 Crown Valley Pkwy	Dana Point	SDGE	SD	Multi-Family	Lyon Communities	5/28/2015	10	8/21/2015	2/21/2017	No	No
147	1200 Lakeshore Apartments	1200 Lakeshore Ave.	Oakland	PGE	SF	Multi-Family	Diamond Properties	7/8/2015	10	9/3/2015	3/3/2017	No	Yes
148	Via Del Campo	16761 Via Del Campo Court	Rancho Bernardo	SDGE	SD	Workplace	General Atomics	6/9/2015	10	8/17/2015	2/17/2017	N/A	No

149	The Culver Studios	9336 W Washington Blvd	Culver City	SCE	LA	Workplace	The Culver Studios	5/28/2015	10	7/15/2015	1/15/2017	N/A	No
150	City Hall	9770 Culver Blvd.	Culver City	SCE	LA	Publ Int	City of Culver City	7/17/2015	8	9/4/2015	3/4/2017	N/A	No
151	Knollbrook Falls	5711 Ravenspur Dr.	Rancho Palos Ver	SCE	LA	Multi-Family	Gardner Company	6/16/2015	5	8/21/2015	2/21/2017	No	No
152	1 South Park	1 South Park St.	San Francisco	PGE	SF	Multi-Family	Titan Management	6/2/2015	6	9/4/2015	3/4/2017	Condo	No
153	Palos Verdes Terraces	5762 Ravenspur Dr.	Rancho Palos Ver	SCE	LA	Multi-Family	Gardner Company	6/16/2015	4	8/10/2015	2/10/2017	No	No
154	Adagio on the Green	26170 Country Club Dr.	Mision Viejo	SDGE	SD	Multi-Family	Greystar	6/24/2015	2	7/13/2015	1/13/2017	Yes	No
155	Peninsula Apartments - 5757 Ravenspur	5757 Ravenspur Dr.	Rancho Palos Ver	SCE	LA	Multi-Family	Gardner Company	6/16/2015	2	8/11/2015	2/11/2017	No	No
156	Peninsula Apartments - 5727 Ravenspur	5727 Ravenspur Dr.	Rancho Palos Ver	SCE	LA	Multi-Family	Gardner Company	6/16/2015	2	8/11/2015	2/11/2017	No	No
157	Century 21 San Moritz Realty	24118 Lake Drive	Crestline	SCE	LA	Workplace	Century 21 San Moritz Realty	5/20/2015	2	8/25/2015	2/25/2017	N/A	No
158	Ocean House	24065 Ocean Ave.	Torrance	SCE	LA	Multi-Family	Gardner Company	6/16/2015	1	7/27/2015	1/27/2017	No	No
159	Park Terrace- 206 Park Blvd	206 Park Blvd	San Diego	SDGE	SD	Multi-Family	Park Terrace East Village HOA	6/2/2015	10	10/9/2015	4/9/2017	Condo	Yes
160	Park Terrace- 253 10th Ave.	253 10th Ave.	San Diego	SDGE	SD	Multi-Family	Park Terrace East Village HOA	6/2/2015	10	10/9/2015	4/9/2017	Condo	Yes
161	Sudberry - West Park I Building A	7777 Westside Drive	San Diego	SDGE	SD	Multi-Family	Sudberry	6/8/2015	20	10/9/2015	4/9/2017	No	No
162	Los Positas Community College - Lot H	3000 Campus Hill Dr.	Livermore	PGE	SF	Publ Int	Chabot - Los Positas Community College District	10/1/2015	10	10/30/2015	4/30/2017	N/A	N/A
163	Los Positas Community College - Lot AA	3000 Campus Hill Dr.	Livermore	PGE	SF	Publ Int	Chabot - Los Positas Community College District	10/1/2015	10	10/30/2015	4/30/2017	N/A	N/A
164	Butte College - Amphitheater	3536 Butte Campus Dr	Oroville	PGE	SF	Publ Int	Butte College	6/24/2014	10	10/12/2015	4/12/2017	N/A	N/A
165	Butte College - Sky Way Center	2480 Notre Dame Blvd.	Oroville	PGE	SF	Publ Int	Butte College	6/24/2014	10	10/16/2015	4/16/2017	N/A	N/A
166	Lyon Amalfi	500 Amalfi Loop	Milpitas	PGE	SF	Multi-Family	Lyon Communities	2/5/2015	10	11/20/2015	5/20/2017	No	No
167	Avalon Bay- Cortez Hill	1399 9th Ave.	San Diego	SDGE	SD	Multi-Family	Avalon Bay	3/30/2015	10	10/14/2015	4/14/2017	No	Yes
168	Lyon- Gallery 421	421 W. Broadway	Long Beach	SCE	LA	Multi-Family	Lyon Communities	6/2/2015	10	9/23/2015	3/23/2017	Yes	No
169	Lyon- 1900 Ocean	1900 E. Ocean Blvd.	Long Beach	SCE	LA	Multi-Family	Lyon Communities	4/29/2015	10	10/15/2015	4/15/2017	No	No
170	Albertsons Fullerton	1421 Manhattan Avenue	Fullerton	SCE	LA	Workplace	Albertsons	6/8/2015	10	10/15/2015	4/15/2017	N/A	Yes
171	Equity - Marina 41	4157 Via Marina	Marina Del Rey	SCE	LA	Multi-Family	Equity Residential	4/9/2015	10	9/29/2015	3/29/2017	No	No
172	Neighborhood Partnership Housing Services, Inc.	9551 Pittsburgh Ave	Rancho Cucamon	SCE	LA	Publ Int	Neighborhood Partnership Housing Services, Inc.	5/11/2015	6	8/4/2015	2/4/2017	N/A	N/A
173	Equity - SOMA Square	333 3rd St.	San Francisco	PGE	SF	Multi-Family	Equity Residential	8/7/2015	10	11/3/2015	5/3/2017	No	No
174	Wilson Meany - Pacific Terrace	1595 Pacific Ave #100	San Francisco	PGE	SF	Multi-Family	Wilson Meany	6/27/2013	2	6/8/2014	12/8/2015	Yes	No
175	Qualcomm-Q	6455 Luck Blvd	San Diego	SDGE	SD	Workplace	Qualcomm	6/24/2016	3	10/28/2014	4/28/2016	N/A	No
176	Dole Foods	3059 Townsgate Rd	Thousand Oaks	SCE	LA	Workplace	Westlake Plaza Center East	11/19/2014	14	5/18/2015	11/18/2016	N/A	No
177	Butte College- Parking Lot 1	3536 Butte Campus Dr	Oroville	PGE	SF	Publ Int	Butte College	7/1/2015	10	10/2/2015	4/2/2017	N/A	No
178	BlackRock	114 Pacifica	Irvine	SCE	LA	Workplace	BlackRock	8/13/2015	8	12/11/2015	6/11/2017	N/A	No
179	Beach Villas	1830 E. Ocean Blvd	Long Beach	SCE	LA	Multi-Family	Gardner Company	6/22/2015	7	12/11/2015	6/11/2017	No	No
180	iHerb-North	22780 Harley Knox Blvd	Perris	SCE	LA	Workplace	iHerb	7/17/2015	10	12/11/2015	6/11/2017	N/A	Yes
181	iHerb-South	22780 Harley Knox Blvd	Perris	SCE	LA	Workplace	iHerb	7/17/2015	10	12/11/2015	6/11/2017	N/A	Yes
182	Doheny Plaza	818 N Doheny Dr	West Hollywood	SCE	LA	Multi-Family	Doheny Plaza	8/19/2015	8	12/16/2015	6/16/2017	Condo	No
183	Chabot Campus - 1800	2555 Hesperian Blvd	Hayward	PGE	SF	Publ Int	Chabot-Las Positas Community College District	10/1/2015	10	12/22/2015	6/22/2017	N/A	Yes
184	Chabot Campus - Lot G	2555 Hesperian Blvd	Hayward	PGE	SF	Publ Int	Chabot-Las Positas Community College District	10/1/2015	10	12/22/2015	6/22/2017	N/A	Yes
185	Ocean Palisades	802 2nd St	Santa Monica	SCE	LA	Multi-Family	Alliance Residential	10/19/2015	6	12/22/2015	6/22/2017	No	No
186	Ocean Palms	950 4th St	Santa Monica	SCE	LA	Multi-Family	Alliance Residential	10/19/2015	6	12/22/2015	6/22/2017	No	No
187	APHS South	3536 Butte Campus Dr	Oroville	PGE	SF	Publ Int	Butte College	7/1/2015	10	12/28/2015	6/28/2017	N/A	No
188	Kaiser - San Diego Medical Center/ Kaiser Foundation Hospital	4647 Zion Ave	San Diego	SDGE	SD	Publ Int	Kaiser Permanente	8/7/2015	8	12/28/2015	6/28/2017	N/A	Yes
189	LocalAdvisors - Torrey Reserve West	3394 Carmel Mountain Road	San Diego	SDGE	SD	Workplace	Locale Advisors	8/31/2015	10	12/31/2015	6/30/2017	N/A	No
190	Sunnytech - 710 Lakeway Dr.	710 Lakeway Dr	Sunnyvale	PGE	SF	Workplace	Sunnytech	7/2/2015	10	1/7/2016	7/7/2017	N/A	No
191	Fairfield - Coleman / Seta	7380 Parkway Drive	La Mesa	SDGE	SD	Multi-Family	Fairfield Residential	2/19/2015	10	1/8/2016	7/8/2017	No	No
192	Marshall B Ketchum University	2575 Yorba Linda Blvd.	Fullerton	SCE	LA	Publ Int	Marshall B Ketchum University	8/13/2015	10	1/8/2016	7/8/2017	N/A	No
193	Avalon Center - 5405	5405 Garden Grove Blvd	Westminister	SCE	LA	Workplace	CBRE	7/24/2015	6	1/8/2016	7/8/2017	N/A	No
194	Avalon Center - 5455	5455 Garden Grove Blvd	Westminister	SCE	LA	Workplace	CBRE	7/24/2015	6	1/8/2016	7/8/2017	No	No
195	Avalon Center - 5555	5555 Garden Grove Blvd	Westminister	SCE	LA	Workplace	CBRE	7/24/2015	4	1/8/2016	7/8/2017	No	No
196	Kelvin Court	2552 Kelvin Ave	Irvine	SCE	LA	Multi-Family	Equity Residential	7/3/2015	10	1/8/2016	7/8/2017	Yes	No
197	Fairfield - Pravada	8625 Fletcher Parkway	La Mesa	SDGE	SD	Multi-Family	Fairfield Residential	2/20/2015	8	1/26/2016	7/26/2017	Yes	No
198	Fairfield - Alterra	8727 Fletcher Parkway	La Mesa	SDGE	SD	Multi-Family	Fairfield Residential	2/20/2015	8	1/26/2016	7/26/2017	Yes	No
199	AX Visitor Lot	10105 Pacific Heights Blvd.	San Diego	SDGE	SD	Workplace	Qualcomm	6/24/2014	4	2/8/2016	8/8/2017	N/A	No
200	LocaleAdvisor - Oberlin Drive	5825 Oberlin Drive	San Diego	SDGE	SD	Workplace	Locale Advisors	10/12/2015	10	2/12/2016	8/12/2017	N/A	No
201	Park Bellevue Tower Community HOA-	565 Bellevue Avenue	Oakland	PGE	SF	Multi-Family	Park Bellevue Tower Community HOA	11/14/2016	10	2/16/2016	8/16/2017	Condo	No
202	220 E. 12th street	202 E. 12th street	Long Beach	SCE	LA	Multi-Family	Great Homes LLC	10/28/2015	1	2/19/2016	8/19/2017	No	No
203	908 Saint louis ave	908 Saint louis ave	Long Beach	SCE	LA	Multi-Family	Great Homes LLC	10/28/2015	2	2/19/2016	8/19/2017	No	No
204	124 E. 12th street	124 E. 12th street	Long Beach	SCE	LA	Multi-Family	Great Homes LLC	10/28/2015	1	2/19/2016	8/19/2017	No	No
205	902 St Louis Ave	902 St Louis Ave	Long Beach	SCE	LA	Multi-Family	Great Homes LLC	10/28/2015	2	2/19/2016	8/19/2017	No	No
206	2185 E. 21st St	2185 E. 21st. St	Signal Hill	SCE	LA	Multi-Family	Great Homes LLC	10/28/2015	2	2/19/2016	8/19/2017	No	Yes
207	JDA - Cottle Station	5700 Village Oaks Drive.	San Jose	PGE	SF	Multi-Family	JDA West	10/23/2014	20	2/23/2016	8/23/2017	Yes	No
208	Wiseman - One Harbor Center	1 Harbor Center	Suisun city	PGE	SF	Workplace	The Wiseman Company	8/27/2015	6	3/1/2016	9/1/2017	N/A	No
209	Wiseman - Westside Professional Center I & II	2470 Hilborn Road	Fairfield	PGE	SF	Workplace	The Wiseman Company	8/4/2015	2	3/1/2016	9/1/2017	N/A	No
210	Wiseman - Green Valley Executive Business Center	5030 Business Center Drive	Fairfield	PGE	SF	Workplace	The Wiseman Company	8/27/2015	1	3/1/2016	9/1/2017	N/A	No
211	Arterra HOA- 300 Berry st	300 Berry St.	San Francisco	PGE	SF	Multi-Family	Arterra HOA	7/30/2015	10	3/1/2016	9/1/2017	Yes	No
212	Fairfield - Venue	3801 Zanker Rd	San Jose	PGE	SF	Multi-Family	Fairfield Residential	7/8/2014	18	3/1/2016	9/1/2017	No	No
213	Sudberry - West Park II Building B	7845 Westside Drive	San Diego	SDGE	SD	Multi-Family	Sudberry	6/9/2015	20	2/25/2016	8/25/2017	No	No
214	15253 Avenue of Science	15253Avenue of Science	San Diego	SDGE	SD	Workplace	Starwood	6/30/2015	10	3/8/2016	9/8/2017	N/A	No
215	15231 Avenue of Science	15231Avenue of Science	San Diego	SDGE	SD	Workplace	Starwood	6/30/2015	10	3/8/2016	9/8/2017	N/A	No
216	330 Distel Circle	330 Distel Circle	Los Altos	PGE	SF	Workplace	Midpeninsula Regional Open Space District	8/5/2015	10	3/8/2016	9/8/2017	N/A	No
217	KIngswood Court HOA-	1221 N. Kings Rd	West Hollywood	SCE	LA	Multi-Family	Kingswood Court HOA	1/12/2016	3	3/10/2016	9/10/2017	Condo	No
218	Federal Realty - Santana Row	Santana Row	San Jose	PGE	SF	Multi-Family	Federal Realty Investment Trust	8/31/2015	30	3/18/2016	9/18/2017	No	No
219	El Camino Real Los Altos HOA	4388 El Camino Real	Los Altos	PGE	SF	Workplace	El Camino Real Los Altos HOA	11/5/2015	10	3/22/2016	9/22/2017	N/A	No
220	Los Patos	17172 Bolsa Chica St	Huntington Beacl	SCE	LA	Multi-Family	Altic Properties	10/5/2015	3	3/22/2016	9/22/2017	No	No
221	Kaiser - Vallejo	975 Sereno Drive	Vallejo	PGE	SF	Publ Int	Kaiser Permanente	12/16/2015	5	3/25/2016	9/25/2017	N/A	N/A
222	BAE Systems Technology Place	10920 Technology Place	San Diego	SDGE	SD	Workplace	BAE Systems	8/6/2015	10	4/5/2016	10/5/2017	N/A	No
223	JCVI	4120 Capricorn Lane	San Diego	SDGE	SD	Workplace	J Craig Venter Institute	8/28/2016	10	4/6/2016	10/6/2017	N/A	No
224	JDA - Maria Drive Apartments	35 - 51 Maria Drive	Petaluma	PGE	SF	Multi-Family	JDA West	10/23/2014	14	4/7/2016	10/7/2017	No	No
225	Lot P	6500 Soquel Dr	Aptos	PGE	SF	Publ Int	Cabrillo Community College District	12/2/2015	2	4/7/2016	10/7/2017	N/A	N/A
226	K Lot	6500 Soquel Drive	Aptos	PGE	SF	Publ Int	Cabrillo Community College District	12/2/2015	4	4/7/2016	10/7/2017	N/A	N/A
227	A/B Building	6500 Soquel Drive	Aptos	PGE	SF	Publ Int	Cabrillo Community College District	12/2/2015	4	4/7/2016	10/7/2017	N/A	N/A
228	R Lot	6500 Soquel Drive	Aptos	PGE	SF	Publ Int	Cabrillo Community College District	12/2/2015	8	4/7/2016	10/7/2017	N/A	N/A
229	SAC Building	6500 Soquel Drive	Aptos	PGE	SF	Publ Int	Cabrillo Community College District	12/2/2015	2	4/7/2016	10/7/2017	N/A	N/A

230	N Lot	6500 Soquel Drive	Aptos	PGE	SF	Publ Int	Cabrillo Community College District	12/2/2015	10	4/7/2016	10/7/2017	N/A	N/A
231	Orange Grove	12681 Lewis Street	Garden Grove	SCE	LA	Multi-Family	Lyon Communities	3/15/2016	1	4/13/2016	10/13/2017	No	No
232	Sandpointe	2810 17th Street	Huntington Beac	SCE	LA	Multi-Family	Lyon Communities	3/15/2016	2	4/15/2016	10/15/2017	No	No
233	Huntington Continental	17101 Springdale	Huntington Beac	SCE	LA	Multi-Family	Lyon Communities	3/15/2016	6	4/18/2016	10/18/2017	No	No
234	Fairfield - Pulse Millenia	2043 Artisan Way	Chula Vista	SDGE	SD	Multi-Family	Fairfield Residential	2/19/2015	10	4/19/2016	10/19/2017	No	No
235	Kaiser - Oakland 3751 Broadway	3751 Broadway	Oakland	PGE	SF	Publ Int	Kaiser Permanente	10/30/2016	10	4/21/2016	10/21/2017	N/A	N/A
236	Callaway Golf	2180 Rutherford Road	Carlsbad	SDGE	SD	Workplace	Callaway Golf	1/13/2016	10	4/21/2016	10/21/2017	N/A	No
237	The Current	707 E Ocean Blvd	Long Beach	SCE	LA	Multi-Family	Ledcor	3/17/2016	8	4/26/2016	10/26/2017	No	No
238	Kaiser - Oakland 3510 Broadway	3510 Broadway	Oakland	PGE	SF	Publ Int	Kaiser Permanente	10/30/2016	10	4/27/2016	10/27/2017	N/A	N/A
239	Fenton - Sea Gate East	6555 Seagate Road	Carlsbad	SDGE	SD	Multi-Family	H.G. Fenton Company	4/30/2014	4	4/29/2016	10/29/2017	No	No
240	Equity - Azure	690 Long Bridge Street	San Francisco	PGE	SF	Multi-Family	Equity Residential	2/25/2016	10	4/29/2016	10/29/2017	No	No
241	Lyon - Levanto	5295 Kona Springs Lane	San Diego	SDGE	SD	Multi-Family	Lyon Communities	3/15/2016	2	5/4/2016	11/4/2017	No	No
242	Casa Madrid	6191 Orange Ave	Cypress	SCE	LA	Multi-Family	Lyon Communities	3/15/2016	3	5/6/2016	11/6/2017	No	No
243	Cushman - Oyster Point 395	395 Oyster Point Boulevard, Suite #117	South San Francis	PGE	SF	Workplace	Cushman & Wakefield of California	3/18/2015	10	5/9/2016	11/9/2017	N/A	Yes
244	Villa De Wright	1725 Wright Ave	Mountain View	PGE	SF	Multi-Family	Villa De Wright	8/5/2015	9	5/9/2016	11/9/2017	No	No
245	Cushman - Oyster Point 400	400 Oyster Point Boulevard, Suite #117	South San Francis	PGE	SF	Workplace	Cushman & Wakefield of California	3/18/2015	10	5/9/2016	11/9/2017	N/A	Yes
246	Equity - Park Place San Mateo	1101 Park Place	San Mateo	PGE	SF	Multi-Family	Equity Residential	8/7/2015	46	5/12/2016	11/12/2017	Yes	No
247	Equity - Potrero 1010	1010 16th street	San Francisco	PGE	SF	Multi-Family	Equity Residential	5/2/2016	10	5/23/2016	11/23/2017	No	No
248	Diamond Terrace H&S	427 9th Ave	San Diego	SDGE	SD	Multi-Family	Diamond Terrace Owners Association	11/20/2015	10	5/24/2016	11/24/2017	Condo	Yes
249	MG - Waterstone	1951 West MiddleField Drive	Tracy	PGE	SJV	Multi-Family	MG Properties	1/26/2016	10	5/30/2016	11/30/2017	No	No
250	MG-Waterfield Square	8035 Mariners Drive	Stockton	PGE	SJV	Multi-Family	MG Properties	1/26/2016	12	5/30/2016	11/30/2017	No	No
251	MG-Bella Vista	713 Trancas Ave	Napa	PGE	SF	Multi-Family	MG Properties	1/26/2016	4	5/31/2016	11/30/2017	No	No
252	Strom - Macara Gardens	1055 Escalon Ave	Sunnyvale	PGE	SF	Multi-Family	Strom Properties	10/26/2015	26	6/3/2016	12/3/2017	No	No
253	Olympus America- San Jose	2400 Ringwood ave.	San Jose	PGE	SF	Workplace	Olympus America	1/27/2016	9	6/3/2016	12/3/2017	N/A	No
254	Strom - Windemere Apts	395 Ano Nuevo Avenue	Sunnyvale	PGE	SF	Multi-Family	Strom Properties	10/26/2015	18	6/3/2016	12/3/2017	No	No
255	Garden - La Jolla Crossroads P1 Building 9115	9115 Judicial Drive	San Diego	SDGE	SD	Multi-Family	Garden Communities CA	7/31/2014	4	10/6/2014	4/6/2016	Yes	No
256	100 Bayview Circle	100 Bayview Circle, Suite 1200	Newport Beach	SCE	LA	Workplace	AEW Capital Management, L.P	3/16/2016	10	6/6/2016	12/6/2017	N/A	No
257	Kaiser - San Jose	250 Hospital Parkway	San Jose	PGE	SF	Publ Int	Kaiser Permanente	8/25/2015	10	5/31/2016	11/30/2017	N/A	N/A
258	Bay Scene	3940 Gresham Street	San Diego	SDGE	SD	Multi-Family	Bay Scene Condos	12/15/2015	10	6/13/2016	12/13/2017	Condo	No
259	15333 Avenue of Science	15333 Avenue of Science	San Diego	SDGE	SD	Workplace	Starwood	6/30/2015	9	6/20/2016	12/20/2017	N/A	No
260	15445 Avenue of Innovation	15445 Avenue of Innovation	San Diego	SDGE	SD	Workplace	Starwood	6/30/2015	10	6/21/2016	12/21/2017	N/A	No
261	15435 Avenue of Innovation	15435 Avenue of Innovation	San Diego	SDGE	SD	Workplace	Starwood	6/30/2015	10	6/21/2016	12/21/2017	N/A	No
262	MG - Pacific Place	2665 Geneva Avenue	Daly City	PGE	SF	Multi-Family	MG Properties	1/26/2016	8	6/21/2016	12/21/2017	Yes	Yes
263	MG-Granada Villas	43230 Gadsden Avenue	Lancaster	SCE	LA	Multi-Family	MG Properties	1/26/2016	16	6/23/2016	12/23/2017	No	No
264	MG - Barham Villas	570 East Barham Drive	San Marcos	SDGE	SD	Multi-Family	MG Properties	1/26/2016	10	6/24/2016	12/24/2017	No	Yes
265	Capistrano Pointe	26451 Camino de Vista	San Juan Capistra	SDGE	SD	Multi-Family	Lyon Communities	3/15/2016	6	6/29/2016	12/29/2017	No	No
266	Manzanita Apartments	457 Acalanes Drive 27301-9228	Sunnyvale	PGE	SF	Multi-Family	Manzanita Apartments	8/5/2015	6	6/30/2016	12/30/2017	No	No
267	MG-Cordova Park	43530 Gadsden Avenue	Lancaster	SCE	LA	Multi-Family	MG Properties	1/26/2016	10	6/30/2016	12/30/2017	No	No
268	MG-Woodlands West	44004 Engle Way, Unit 2	Lancaster	SCE	LA	Multi-Family	MG Properties	1/26/2016	10	6/30/2016	12/30/2017	No	No
269	Sysco - 20701 East Currier Road	20701 East Currier Road	Walnut	City of Indus	LA	Workplace	SYSCO	5/8/2016	10	7/14/2016	1/14/2018	N/A	No
270	Kaiser - Garfield Innovation Center San Leandro	590 Whitney Street	San Leandro	PGE	SF	Publ Int	Kaiser Permanente	1/20/2016	5	7/6/2016	1/6/2018	N/A	N/A
271	Promenade at Creekside- low income	3 Creekside Pl	San Marcos	SDGE	SD	Multi-Family	Promenade at Creekside Housing Partners, L.P.	2/5/2016	4	7/13/2016	1/13/2018	Yes	Yes
272	Garden - LJX 805, LLC - 360 North Building	9035 Judicial Drive	San Diego	SDGE	SD	Multi-Family	Garden Communities CA	10/28/2015	8	7/14/2016	1/14/2018	Yes	No
273	Garden - Metropolis Gardens 123 North	17872 Cartwright	Irvine	SCE	LA	Multi-Family	Garden Communities CA	10/28/2015	10	7/14/2016	1/14/2018	Yes	No
274	1901 E 1st St(New Construction)	1901 E 1st St	Santa Ana	SCE	LA	Multi-Family	Lyon Communities	3/9/2016	10	7/20/2016	1/20/2018	No	No
275	Endeavor Corp- Ramblewood Apartments	38800 Hastings St	Fremont	PGE	SF	Multi-Family	Endeavor Corp	8/7/2015	24	7/28/2016	1/28/2018	No	No
276	Presidio View | Alliance Residential-	1440 Hotel Circle North	San Diego	SDGE	SD	Multi-Family	AEW Capital Management, L.P	3/16/2016	10	7/28/2016	1/28/2018	No	No
277	West Los Angeles	6300 Bristol Pkwy	Culver City	SCE	LA	Workplace	California Highway Patrol	4/12/2016	10	7/28/2016	1/28/2018	N/A	No
278	Academy	3500 Reed Avenue	Sacramento	PGE	SF	Workplace	California Highway Patrol	4/12/2016	40	7/29/2016	1/29/2018	N/A	Yes
279	MG-Del Norte Place	11720 San Pablo Avenue	El Cerrito	PGE	SF	Multi-Family	MG Properties	1/26/2016	8	7/29/2016	1/29/2018	No	No
280	Maintenance Yard Parking-	1050 Hensely Creek Rd	Ukiah	PGE	SF	Publ Int	Mendocino-Lake Community College District	6/16/2016	8	7/29/2016	1/29/2018	N/A	N/A
281	Lake Center	2565 Parallel Dr.	Lakeport	PGE	SF	Publ Int	Mendocino-Lake Community College District	6/16/2016	10	7/29/2016	1/29/2018	N/A	N/A
282	Faculty Parking	1000 Hensely Creek Rd.	Ukiah	PGE	SF	Publ Int	Mendocino-Lake Community College District	6/16/2016	10	7/29/2016	1/29/2018	N/A	N/A
283	Main Parking Tennis Courts	1000 Hensely Creek Rd.	Ukiah	PGE	SF	Publ Int	Mendocino-Lake Community College District	6/16/2016	6	7/29/2016	1/29/2018	N/A	N/A
284	Mendocino Coast Center	1000 Hensley Creek Rd.	Ukiah	PGE	SF	Publ Int	Mendocino-Lake Community College District	6/16/2016	8	7/29/2016	1/29/2018	N/A	N/A
285	Altadena	2130 Windsor Ave	Altadena	SCE	LA	Workplace	California Highway Patrol	4/12/2016	10	7/29/2016	1/29/2018	N/A	Yes
286	North County Center	372 E Commercial St.	Willits	SDGE	SD	Publ Int	Mendocino-Lake Community College District	6/16/2016	8	7/29/2016	1/29/2018	N/A	N/A
287	600 Corporate Pointe Dr - Lincoln Property	600 Corporate Pointe Dr.	Culver City	SCE	LA	Workplace	Lincoln Property Company Commercial Inc.	2/25/2015	10	8/1/2016	2/1/2018	N/A	No
288	San Francisco	455 8th St.	San Francisco	PGE	SF	Workplace	California Highway Patrol	4/12/2016	4	8/1/2016	2/1/2018	N/A	No
289	Newhall	28648 the Old Rd	Valencia	SCE	LA	Workplace	California Highway Patrol	4/12/2016	10	8/1/2016	2/1/2018	N/A	No
290	East LA	1601 Corporate Center Dr	Monterey Park	SCE	LA	Workplace	California Highway Patrol	4/12/2016	10	8/1/2016	2/1/2018	N/A	Yes
291	Vista (Oceanside)	1888 Oceanside Blvd	Oceanside	SDGE	SD	Workplace	California Highway Patrol	4/12/2016	6	8/5/2016	2/5/2018	N/A	Yes
292	Capistrano	32951 Camino Capistrano	San Juan Capistra	SDGE	SD	Workplace	California Highway Patrol	4/12/2016	6	8/5/2016	2/5/2018	N/A	Yes
293	Rancho Cucamonga	9530 Pittsburgh Ave.	Rancho Cucamon	SCE	LA	Workplace	California Highway Patrol	4/12/2016	10	8/5/2016	2/5/2018	N/A	Yes
294	Baldwin Park	14039 Francisquito Ave.	Baldwin Park	SCE	LA	Workplace	California Highway Patrol	4/12/2016	2	8/5/2016	2/5/2018	N/A	Yes
295	400 Corporate Pointe Dr. - Lincoln Property	400 Corporate Pointe Dr.	Culver City	SCE	LA	Workplace	Lincoln Property Company Commercial Inc.	2/25/2015	10	8/12/2016	2/12/2018	N/A	Yes
296	AIMCO - Preserve at Marin	754 Robin Dr	Corte Madera	PGE	SJV	Multi-Family	AIMCO	12/22/2015	14	8/12/2016	2/12/2018	No	No
297	Kaiser - Union City	3555 Whipple Rd	Union City	PGE	SF	Publ Int	Kaiser Permanente	12/29/2015	10	8/18/2016	2/18/2018	N/A	N/A
298	San Gorgonio Pass	195 Highland Springs Ave	Beaumont	SCE	LA	Workplace	California Highway Patrol	4/12/2016	10	8/12/2016	2/12/2018	N/A	No
299	Inland Division Office (San Bernardino-Brier)	847 E. Brier Dr.	San Bernardino	SCE	LA	Workplace	California Highway Patrol	4/12/2016	10	8/12/2016	2/12/2018	N/A	Yes
300	Trabuco Highlands	31872 Joshua Drive	Ranch Santa Mar	SCE	LA	Multi-Family	Lyon Communities	3/15/2016	10	8/12/2016	2/12/2018	No	No
301	Simeon Commercial Properties-	6410 Overland Avenue	Emeryville	PGE	SF	Workplace	Simeon Commercial Properties	6/13/2016	10	8/12/2016	2/12/2018	N/A	No
302	Antelope Valley	2041 W Ave I	Lancaster	SCE	LA	Workplace	California Highway Patrol	4/12/2016	4	8/16/2016	2/16/2018	N/A	No
303	4900 California Ave (Tower B)	4900 California Ave	Bakersfield	PGE	SJV	Workplace	Adler Realty Investments	4/14/2016	10	8/18/2016	2/18/2018	N/A	No
304	AIRPORT PROFESSIONAL CENTER	17838 Fitch Ave	Irvine	SCE	LA	Workplace	AEW Capital Management, L.P	3/16/2016	10	8/23/2016	2/23/2018	N/A	No
305	2500 Atlas	2500 Atlas	Richmond	PGE	SF	Workplace	Bio-Rad Laboratories	11/31/15	8	8/26/2016	2/26/2018	N/A	Yes
306	6000 Alfred Nobel	6000 Alfred Nobel	Hercules	PGE	SF	Workplace	Bio-Rad Laboratories	11/31/15	8	8/26/2016	2/26/2018	N/A	No
307	5400 E 2nd Street	5400 E 2nd Street	Benecia	SCE	LA	Workplace	Bio-Rad Laboratories	11/31/15	10	8/26/2016	2/26/2018	N/A	No
308	825 Alfred Nobel	825 Alfred Nobel	Hercules	PGE	SF	Workplace	Bio-Rad Laboratories	11/31/15	10	8/26/2016	2/26/2018	N/A	No
309	225 Linus Pauling Dr	225 Linus Pauling Dr	Hercules	PGE	SF	Workplace	Bio-Rad Laboratories	11/31/15	10	8/26/2016	2/26/2018	N/A	No
310	15378 Avenue of Innovation	15378 Avenue of Innovation	San Diego	SDGE	SD	Workplace	Starwood	6/30/2015	10	8/26/2016	2/26/2018	N/A	No

311	San Bernardino	2211 Western Ave.	San Bernardino	SCE	LA	Workplace	California Highway Patrol	4/12/2016	10	8/26/2016	2/26/2018	N/A	Yes
312	Hanford	1565 Glendale Ave.	Hanford	SCE	SJV	Workplace	California Highway Patrol	4/12/2016	10	8/26/2016	2/26/2018	N/A	Yes
313	International Technological University- ITU	2711 North First Street	San Jose	PGE	SF	Publ Int	International Technological University	6/29/2015	10	8/26/2016	2/26/2018	N/A	N/A
314	9500 Jeronimo	9500 Jeronimo	Irvine	Irvine	LA	Workplace	Bio-Rad Laboratories	11/31/15	3	5/27/2017	11/27/2018	N/A	No
315	South LA	19700 Hamilton Ave	Torrance	SCE	LA	Workplace	California Highway Patrol	4/12/2016	10	8/26/2016	2/26/2018	N/A	No
316	SDIHAC-Iowa Street Senior Housing Partners	3939 Iowa Street	San Diego	SDGE	SD	Multi-Family	SD Interfaith Housing Assistance Corporation	2/29/2016	2	8/26/2016	2/26/2018	Yes	Yes
317	Merced Area Office	1500 Bell Drive	Atwater	PGE	SJV	Workplace	California Highway Patrol	4/12/2016	10	8/26/2016	2/26/2018	N/A	No
318	101 N Sepulveda	101 N Sepulveda	El Segundo	SDGE	SD	Workplace	Lincoln Property Company Commercial Inc.	2/25/2015	10	8/30/2016	2/28/2018	N/A	No
319	Modesto Area Office	4030 Kiernan Avenue	Modesto	PGE	SJV	Workplace	California Highway Patrol	4/12/2016	10	8/26/2016	2/26/2018	N/A	No
320	Kaiser - Fremont Medical Center	39400 Paseo Padre Pkwy	Fremont	SDGE	SD	Publ Int	Kaiser Permanente	12/29/2015	10	9/1/2016	3/1/2018	N/A	N/A
321	Visalia Area Office	5025 West Noble Avenue	Visalia	SCE	SJV	Workplace	California Highway Patrol	4/12/2016	10	9/2/2016	3/2/2018	N/A	Yes
322	Border Division	9330 Farnham St.	San Diego	SDGE	SD	Workplace	California Highway Patrol	4/12/2016	10	9/2/2016	3/2/2018	N/A	No
323	Fort Tejon (Lebec)	1033 Lebec Rd	Lebec	SCE	SJV	Workplace	California Highway Patrol	4/12/2016	10	9/9/2016	3/9/2018	N/A	No
324	Monterey	960 E Blanco Rd	Salinas	PGE	SF	Workplace	California Highway Patrol	4/12/2016	4	9/9/2016	3/9/2018	N/A	Yes
325	Santa Cruz (Aptos)	10395 Soquel Dr	Aptos	PGE	SF	Workplace	California Highway Patrol	4/12/2016	6	9/9/2016	3/9/2018	N/A	No
326	King City	2 Broadway Cir	King City	PGE	SF	Workplace	California Highway Patrol	4/12/2016	5	9/9/2016	3/9/2018	N/A	No
327	San Luis Obispo	675 California Blvd	San Luis Obispo	PGE	SF	Workplace	California Highway Patrol	4/12/2016	6	9/9/2016	3/9/2018	N/A	No
328	Golden Gate Division	1551 Benicia Rd	Vallejo	PGE	SF	Workplace	California Highway Patrol	4/12/2016	10	9/9/2016	3/9/2018	N/A	No
329	Hayward	2434 Whipple Rd	Hayward	PGE	SF	Workplace	California Highway Patrol	4/12/2016	4	9/9/2016	3/9/2018	N/A	No
330	Genentech - Bay Area	1 Dna Way	South San Francis	PGE	SF	Workplace	Genentech	7/15/2016	20	9/15/2016	3/15/2018	N/A	Yes
331	520 Broadway	520 Broadway	Santa Monica	SCE	LA	Workplace	Tishman Speyer	8/26/2016	10	9/19/2016	3/19/2018	N/A	No
332	Victorville	14210 Amargosa Rd	Victorville	SCE	LA	Workplace	California Highway Patrol	4/12/2016	6	9/19/2016	3/19/2018	N/A	No
333	MG - Creekside Village	495 E 3rd St	San Bernardino	SCE	LA	Multi-Family	MG Properties	1/26/2016	9	9/19/2016	3/19/2018	Yes	Yes
334	MG-Terramonte at Foothill	150 W Foothill Blvd	Pomona	SCE	LA	Multi-Family	MG Properties	1/26/2016	10	9/23/2016	3/23/2018	N/A	No
335	Morongo Basin (29 Palms)	63683 29 Palms Hwy	Joshua Tree	SCE	LA	Workplace	California Highway Patrol	4/12/2016	4	9/30/2016	3/30/2018	N/A	No
336	Arrowhead (Running Springs)	31230 Highway 18	Running Springs	SCE	LA	Workplace	California Highway Patrol	4/12/2016	2	9/30/2016	3/30/2018	N/A	No
337	The Metro at Corona Bldg 1	151 West Harrison Street	Corona	SCE	LA	Multi-Family	Watermarke - Wermer Properties	6/16/2016	10	9/30/2016	3/30/2018	N/A	Yes
338	Bishop	469 S Main St	Bishop	PGE	SJV	Workplace	California Highway Patrol	4/12/2016	6	9/30/2016	3/30/2018	N/A	No
339	Barstow	300 E Mountain View St	Barstow	SCE	LA	Workplace	California Highway Patrol	4/12/2016	10	10/7/2016	4/7/2018	N/A	No
340	Sedona	1630 Orchard Dr	Placentia	SCE	LA	Multi-Family	Lyon Communities	5/28/2015	14	10/7/2016	4/7/2018	No	No
341	Manhattan Towers	1230 Rosecrans Ave Ste 150	Manhattan Beach	SCE	LA	Workplace	Manhattan Towers	7/8/2016	10	10/7/2016	4/7/2018	N/A	No
342	Williams - 100 E St	100 E St	Williams	PGE	SF	Workplace	California Highway Patrol	4/12/2016	10	10/7/2016	4/7/2018	N/A	No
343	Garberville	30 West Coast Rd	Redway	PGE	SF	Workplace	California Highway Patrol	4/12/2016	10	10/7/2016	4/7/2018	N/A	No
344	Red Bluff	2550 Main St	Red Bluff	PGE	SF	Workplace	California Highway Patrol	4/12/2016	8	10/7/2016	4/7/2018	N/A	No
345	490 Oak St.	490 N Oak St	Inglewood	SCE	LA	Workplace	Marvin Group	6/29/2016	12	10/10/2016	4/10/2018	N/A	No
346	Northern Division Office	2485 Sonoma St	Redding	PGE	SF	Workplace	California Highway Patrol	4/12/2016	10	10/10/2016	4/10/2018	N/A	No
347	Waves MDR-	13700 Tahiti Way	Marina Del Rey	SCE	LA	Multi-Family	Waves MDR	6/9/2016	24	10/14/2016	4/14/2018	No	No
348	Yuba City	1619 Poole Blvd	Yuba City	PGE	SF	Workplace	California Highway Patrol	4/12/2016	10	10/14/2016	4/14/2018	N/A	No
349	Juniper Properties	16015,16062,16188,16240 Juniper Street	Hesperia	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	8	10/14/2016	4/14/2018	Yes	No
350	16th Street	1600 16th St	Firebaugh	PGE	SJV	Workplace	Firebaugh-Las Deltas Unified School District	8/17/2016	10	10/14/2016	4/14/2018	N/A	Yes
351	Sunset Gardens	12296 4th St # 1-39	Yucaipa	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	39	10/20/2016	4/20/2018	Yes	Yes
352	Brockton Property	725 E Brockton Ave # 1-8	Redlands	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	10/21/2016	4/21/2018	Yes	No
353	Las Palmas	2598 Associated Rd	Fullerton	SCE	LA	Multi-Family	Lyon Communities	5/28/2015	9	10/21/2016	4/21/2018	Yes	No
354	261 W Beach Ave.	261 W Beach Ave	Inglewood	SCE	LA	Workplace	Marvin Group	6/29/2016	8	10/21/2016	4/21/2018	N/A	No
355	MG-Morning View Terrace	439 W El Norte Pkwy	Escondido	SDGE	SD	Multi-Family	MG Properties	1/26/2016	10	10/21/2016	4/21/2018	No	Yes
356	MG-Sage Canyon	42200 Moraga Rd	Temecula	SCE	LA	Multi-Family	MG Properties	1/26/2016	7	10/21/2016	4/21/2018	No	No
357	Ventura	4656 Valentine Rd	Ventura	SCE	LA	Workplace	California Highway Patrol	4/12/2016	10	10/21/2016	4/21/2018	N/A	No
358	Lombard Property	1027 Lombard Dr # A-d	Redlands	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	10/28/2016	4/28/2018	Yes	Yes
359	Muni Property	16260 Muni Rd # 1-7	Apple Valley	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	10/28/2016	4/28/2018	Yes	No
360	Stillman Property	1324 Stillman Ave # 101-109	Redlands	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	10/28/2016	4/28/2018	Yes	No
361	Mountain View	15876 Chehalis Rd # 1-30	Apple Valley	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	10/28/2016	4/28/2018	Yes	No
362	Yakima	13652 Yakima Rd # 1-6	Apple Valley	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	10/28/2016	4/28/2018	Yes	No
363	San Mateo	48 N San Mateo St # 1-8	Redlands	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	10/28/2016	4/28/2018	Yes	No
364	Sun	220 E Sun Ave # 310	Redlands	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	10/28/2016	4/28/2018	Yes	Yes
365	Catalina Landing	320 Golden Shore	Long Beach	SCE	LA	Workplace	Rising Realty Partners	5/24/2016	10	10/28/2016	4/28/2018	N/A	No
366	Mojave	1313 State Highway 58	Mojave	SCE	SJV	Workplace	California Highway Patrol	4/12/2016	10	10/31/2016	4/30/2018	N/A	No
367	Welch Court	14457, 14463, 14469 Welsh Court	Hesperia	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	3	11/4/2016	5/4/2018	Yes	No
368	Santa Maria	1710 Carlotti Dr	Santa Maria	PGE	SF	Workplace	California Highway Patrol	4/12/2016	10	11/4/2016	5/4/2018	N/A	No
369	Oceanside Block 18 MAIN ST	260 Mission Ave	Oceanside	SDGE	SD	Multi-Family	Ryan Companies	9/15/2016	10	11/11/2016	5/11/2018	Yes	No
370	Shea - Ascent	5805 Charlotte Dr	San Jose	PGE	SF	Multi-Family	Shea Properties	9/28/2016	20	11/11/2016	5/11/2018	Yes	No
371	Building #16, 14200 Kirkham Way	14200 Kirkham Way	Poway	SDGE	SD	Workplace	General Atomics	7/21/2016	10	11/11/2016	5/11/2018	N/A	No
372	CBC Advisors - 303 Almaden	303 Almaden Blvd Ste 100	San Jose	PGE	SF	Workplace	CBC Advisors	7/7/2016	8	12/21/2016	6/21/2018	N/A	Yes
373	Equity - City Gate	5608 Stevens Creek Blvd	Cupertino	PGE	SF	Multi-Family	Equity Residential	4/29/2015	80	11/15/2016	5/15/2018	No	No
374	MG-Stonewood Gardens	3889 Midway Dr	San Diego	SDGE	SD	Multi-Family	MG Properties	1/26/2016	10	11/18/2016	5/18/2018	Yes	No
375	Building #15, 14115 Stowe Dr	14115 Stowe Dr	Poway	SDGE	SD	Workplace	General Atomics	7/21/2016	10	11/18/2016	5/18/2018	N/A	No
376	1644 N. Broadway	1644 N Broadway	Walnut Creek	PGE	SF	Workplace	City of Walnut Creek Public Works	9/22/2016	10	12/21/2016	6/21/2018	N/A	No
377	Equity -Fremont Center	39410 Civic Center Dr	Fremont	PGE	SF	Multi-Family	Equity Residential	10/19/2016	30	11/23/2016	5/23/2018	N/A	No
378	Eureka	35152 Eureka Ave # A-d	Yucaipa	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	4	11/23/2016	5/23/2018	Yes	No
379	15073 Avenue of Science	15073 Avenue of Science	San Diego	SDGE	SD	Workplace	Starwood	6/30/2015	10	11/30/2016	5/30/2018	N/A	No
380	Blythe	430 S Broadway	Blythe	SCE	LA	Workplace	California Highway Patrol	4/12/2016	8	11/30/2016	5/30/2018	N/A	No
381	Porterville	861 W Morton Ave	Porterville	SCE	SJV	Workplace	California Highway Patrol	4/12/2016	2	12/9/2016	6/9/2018	N/A	No
382	Casaba	18185 Casaba Rd # 1-7	Adelanto	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	12/9/2016	6/9/2018	Yes	No
383	Larkspur	18172 Larkspur Rd # 1-7	Adelanto	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	12/9/2016	6/9/2018	Yes	No
384	Santa Rosa	6100 Labath Ave	Rohnert Park	PGE	SF	Workplace	California Highway Patrol	4/12/2016	6	12/9/2016	6/9/2018	N/A	No
385	Solano	3050 Travis Blvd	Fairfield	PGE	SF	Workplace	California Highway Patrol	4/12/2016	4	12/9/2016	6/9/2018	N/A	No
386	Marin	53 San Clemente Dr	Corte Madera	PGE	SJV	Workplace	California Highway Patrol	4/12/2016	10	12/9/2016	6/9/2018	N/A	No
387	Building #18, 14250 Kirkham Way,	14250 Kirkham Way	Poway	SDGE	SD	Workplace	General Atomics	6/9/2015	10	12/9/2016	6/9/2018	N/A	No
388	Building #20, 14303 General Atomics Way	14303 General Atomics Way	Poway	SDGE	SD	Workplace	General Atomics	6/9/2015	10	12/9/2016	6/9/2018	N/A	No
389	CBRE Walnut Tech Business Center - 20277 Valley Blvd	20277 Valley Blvd	Walnut	SCE	LA	Workplace	AEW Capital Management, L.P	9/21/2016	2	12/16/2016	6/16/2018	N/A	No
390	CBRE Walnut Tech Business Center - 20265 Valley Blvd	20265 Valley Blvd	Walnut	SCE	LA	Workplace	AEW Capital Management, L.P	9/21/2016	2	12/16/2016	6/16/2018	N/A	No
391	Canada	24528 Canada St	Loma Linda	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	4	12/16/2016	6/16/2018	Yes	No

392	Building #17, 14170 Kirkham Way	14170 Kirkham Way	Poway	SDGE	SD	Workplace	General Atomics	6/9/2015	10	12/16/2016	6/16/2018	N/A	No
393	AVA Newport	1765 Santa Ana Ave	Costa Mesa	SCE	LA	Multi-Family	AvalonBay Communities, Inc.	11/3/2016	4	12/16/2016	6/16/2018	No	No
394	Sago	15780 Sago Rd # A-e	Apple Valley	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	5	12/19/2016	6/19/2018	Yes	No
395	Oakhurst	40500 Redbud Dr	Oakhurst	PGE	SJV	Workplace	California Highway Patrol	4/12/2016	10	12/21/2016	6/21/2018	N/A	No
396	Mariposa	5264 Highway 49 N	Mariposa	PGE	SJV	Workplace	California Highway Patrol	4/12/2016	10	12/21/2016	6/21/2018	N/A	No
397	Coalinga	125 S 6th St	Coalinga	PGE	SJV	Workplace	California Highway Patrol	4/12/2016	10	12/21/2016	6/21/2018	N/A	No
398	Napa	975 Golden Gate Dr	Napa	PGE	SF	Workplace	California Highway Patrol	4/12/2016	6	12/21/2016	6/21/2018	N/A	No
399	Central Division Office	5179 N Gates Ave	Fresno	PGE	SJV	Workplace	California Highway Patrol	4/12/2016	10	12/21/2016	6/21/2018	N/A	Yes
400	200 Rose	200 Rose St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	1/6/2017	7/6/2018	No	No
401	361 14th St.	361 14th St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	1/6/2017	7/6/2018	No	No
402	Yucca Property	1358 Yucca Dr # A-n	San Bernardino	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	1/6/2017	7/6/2018	Yes	No
403	Lugo	1405 N Lugo Ave	San Bernardino	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	1/6/2017	7/6/2018	Yes	Yes
404	Leichtag Main	441 Saxony Rd	Encinitas	SDGE	SD	Workplace	Leichtag Foundation	9/13/2016	8	1/6/2017	7/6/2018	N/A	No
405	Crafton Property	1248 Crafton Ave # A-e	Mentone	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	1/13/2017	7/13/2018	Yes	No
406	Merrill Property	224 W Merrill Ave # A1-c8	Rialto	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	8	1/13/2017	7/13/2018	Yes	Yes
407	Avalon Irvine Phase III Millikan	16952 Millikan Ave	Irvine	SCE	LA	Multi-Family	AvalonBay Communities, Inc.	12/13/2016	4	1/13/2017	7/13/2018	Yes	No
408	Avalon Irvine Phase I Alton	2777 Alton Pkwy Phase I	Irvine	SCE	LA	Multi-Family	AvalonBay Communities, Inc.	12/13/2016	6	1/13/2017	7/13/2018	Yes	No
409	Sonora	18437 5th Ave	Jamestown	PGE	SJV	Workplace	California Highway Patrol	4/12/2016	10	1/19/2017	7/19/2018	N/A	No
410	LocaleAdvisor - 5015 Shoreham Place	5015 Shoreham Pl	San Diego	SDGE	SD	Workplace	Locale Advisors	10/20/2016	2	1/23/2017	7/23/2018	N/A	No
411	Express Business Systems, Inc. Headquarters	9155 Trade Pl	San Diego	SDGE	SD	Workplace	Express Business Systems, Inc.	11/30/2016	10	1/26/2017	7/26/2018	N/A	No
412	Avalon Thousand Oaks Plaza	235 N Conejo School Rd	Thousand Oaks	SCE	LA	Multi-Family	AvalonBay Communities, Inc.	11/13/2016	28	1/27/2017	7/27/2018	No	No
413	Yucca Loma	21463 Yucca Loma Rd	Apple Valley	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	1/30/2017	7/30/2018	Yes	No
414	REV/V2G-Police Station	P307 Pd Greenhouse Lane	La Jolla	SDGE	SD	Workplace	UCSD	6/1/2015	10	1/30/2017	7/30/2018	N/A	No
415	REV/V2G Trade Street	7835 Trade St	San Diego	SDGE	SD	Workplace	UCSD	6/1/2015	10	1/30/2017	7/30/2018	N/A	No
416	Kaiser - Fontana Medical Center	9961 Sierra Ave	Fontana	SCE	LA	Publ Int	Kaiser Permanente	10/19/2016	20	1/31/2017	7/31/2018	N/A	N/A
417	Mindrum Precision Headquarters	10000 4th Street Rancho	Cucamonga	SCE	LA	Workplace	Mindrum Precision Inc.	10/7/2016	10	2/7/2017	8/7/2018	N/A	Yes
418	Helio Power Offices	25747 Jefferson Ave	Murrieta	SCE	LA	Workplace	Helio Power Inc.	6/14/2016	10	2/7/2017	8/7/2018	N/A	No
419	1111 Broadway	1111 Broadway	Oakland	PGE	SF	Workplace	CBRE-SemaConnect	8/30/2016	10	2/10/2017	8/10/2018	N/A	Yes
420	Summit Walk	1206 W 4th St	Ontario	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	3	2/16/2017	8/16/2018	Yes	Yes
421	Francis	319 W Francis St # 1-6	Ontario	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	2/16/2017	8/16/2018	Yes	Yes
422	Avalon Glendora	121 E Route 66	Glendora	SCE	LA	Multi-Family	AvalonBay Communities, Inc.	11/13/2016	10	2/16/2017	8/16/2018	Yes	No
423	Ralston	753 W Ralston St # 1-8	Ontario	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	2/16/2017	8/16/2018	Yes	Yes
424	Redwood City	355 Convention Way	Redwood City	PGE	SF	Workplace	California Highway Patrol	4/12/2016	8	2/16/2017	8/16/2018	N/A	No
425	9350 Flair Drive	9350 Flair Dr	El Monte	SCE	LA	Workplace	Multi Investment	11/9/2016	6	2/17/2017	8/17/2018	N/A	Yes
426	9300 Flair Drive	9300 Flair Dr	El Monte	SCE	LA	Workplace	Multi Investment	11/9/2016	10	2/17/2017	8/17/2018	N/A	Yes
427	Amador CHP	301 Clinton Rd	Jackson	PGE	SJV	Workplace	California Highway Patrol	4/12/2016	10	2/17/2017	8/17/2018	N/A	No
428	San Diego	4902 Pacific Hwy	San Diego	SDGE	SD	Workplace	California Highway Patrol	4/12/2016	2	2/17/2017	8/17/2018	N/A	No
429	Santa Barbara	6465 Calle Real	Santa Barbara	PGE	SF	Workplace	California Highway Patrol	4/12/2016	10	2/17/2017	8/17/2018	N/A	No
430	Madera Area Office	3051 Airport Dr	Madera	PGE	SJV	Workplace	California Highway Patrol	4/12/2016	10	2/20/2017	8/20/2018	N/A	Yes
431	Westminister	13200 Goldenwest St	Westminster	SCE	LA	Workplace	California Highway Patrol	4/12/2016	6	2/20/2017	8/20/2018	N/A	Yes
432	Auburn CHP	9440 Indian Hill Rd	Newcastle	PGE	SF	Workplace	California Highway Patrol	4/12/2016	10	2/20/2017	8/20/2018	N/A	No
433	Tracy	385 W Grant Line Rd	Tracy	PGE	SJV	Workplace	California Highway Patrol	4/12/2016	10	2/20/2017	8/20/2018	N/A	Yes
434	Avalon Oak Creek Phase II	29061 Oak Creek Lane	Agoura Hills	SCE	LA	Multi-Family	AvalonBay Communities, Inc.	12/6/2016	18	2/20/2017	8/20/2018	No	No
435	4180 La Jolla Village Drive	4180 La Jolla Village Dr	La Jolla	SDGE	SD	Workplace	Bollert LeBeau (BBL Inc).	6/19/2013	10	2/20/2017	8/20/2018	N/A	No
436	Buellton	166 Industrial Way	Buellton	PGE	SF	Workplace	California Highway Patrol	4/12/2016	2	2/20/2017	8/20/2018	N/A	No
437	Oakland	3601 Telegraph Ave	Oakland	PGE	SF	Workplace	California Highway Patrol	4/12/2016	4	2/20/2017	8/20/2018	N/A	No
438	Avalon Oak Creek Phase I	29128 Oak Creek Ln	Agoura Hills	SCE	LA	Multi-Family	AvalonBay Communities, Inc.	12/6/2016	30	2/20/2017	8/20/2018	No	No
439	Avalon Walnut Creek	1001 Harvey Dr Apt 156	Walnut Creek	PGE	SF	Multi-Family	AvalonBay Communities, Inc.	12/6/2016	29	2/22/2017	8/22/2018	No	No
440	Los Banos	706 W Pacheco Blvd	Los Banos	PGE	SJV	Workplace	California Highway Patrol	4/12/2016	4	2/23/2017	8/23/2018	N/A	Yes
441	Garden - LJX 805, LLC - 360 South Building 12- 9025	9025 Sydney Ct	San Diego	SDGE	SD	Multi-Family	Garden Communities CA	10/28/2015	6	2/28/2017	8/28/2018	No	No
442	Shea - 88 At Alhambra Place	88 South Garfield	Alhambra	SCE	LA	Multi-Family	Shea Properties	11/9/2016	10	2/28/2017	8/28/2018	No	No
443	Woodland	13739 Andrew Stevens Dr	Woodland	PGE	SF	Workplace	California Highway Patrol	4/12/2016	10	2/28/2017	8/28/2018	N/A	No
444	PCT	200 N Sepulveda Blvd	El Segundo	SCE	LA	Workplace	BlackRock	8/4/2015	9	2/28/2017	8/28/2018	N/A	No
445	5684 Bay Street	5684 Bay St	Emeryville	PGE	SF	Multi-Family	BlackRock	8/4/2015	10	2/28/2017	8/28/2018	Yes	No
446	Stockton	2720 N Wilcox Rd	Stockton	PGE	SJV	Workplace	California Highway Patrol	4/12/2016	10	2/28/2017	8/28/2018	N/A	Yes
447	Hollister-Gilroy	740 Renz Ln	Gilroy	PGE	SF	Workplace	California Highway Patrol	4/12/2016	10	2/28/2017	8/28/2018	N/A	Yes
448	San Jose	2020 Junction Ave	San Jose	PGE	SF	Workplace	California Highway Patrol	4/12/2016	10	2/28/2017	8/28/2018	N/A	No
449	Shea - Reata	24391 Avenida De La Carlota	Laguna Hills	SCE	LA	Multi-Family	Shea Properties	9/28/2016	5	2/28/2017	8/28/2018	No	Yes
450	Euclid	1409 E. Euclid Ave.#1	Ontario	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	3/1/2017	9/1/2018	Yes	Yes
451	Build Inc.- 680 Indiana HOA	315 Linden St	San Francisco	PGE	SF	Multi-Family	Build Inc.	6/19/2015	16	3/6/2017	9/6/2018	Yes	No
452	Buttonwillow	29449 Stockdale Hwy	Bakersfield	PGE	SJV	Workplace	California Highway Patrol	4/12/2016	10	3/8/2017	9/8/2018	N/A	Yes
453	Building #31, 14100 Danielson St,	14100 Danielson St	Poway	SDGE	SD	Workplace	General Atomics	6/9/2015	10	3/9/2017	9/9/2018	N/A	No
454	Building #26, 12385 First American Way	12385 First American Way	Poway	SDGE	SD	Workplace	General Atomics	6/9/2015	10	3/9/2017	9/9/2018	N/A	No
455	EVSA_REV/V2G-SVERDRUP HALL	8615 Discovery Way	La Jolla	SDGE	SD	Publ Int	UCSD	11/18/2016	10	3/10/2017	9/10/2018	N/A	N/A
456	1870 Pacific	1870 Pacific Ave	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2017	9/13/2018	No	No
457	325 9th Ave	325 9th Ave	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2017	9/13/2018	No	No
458	3449 22nd St.	3449 22nd St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2017	9/13/2018	No	No
459	600 Oak	600 Oak St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2017	9/13/2018	No	No
460	Wonderful Company Property-	3901 Via Oro Ave	Long Beach	SCE	LA	Workplace	Wonderful Company Property	7/7/2016	6	3/14/2017	9/14/2018	N/A	No
461	Avalon Simi Valley	1579 E Jefferson Way	Simi Valley	SCE	LA	Multi-Family	AvalonBay Communities, Inc.	3/30/2015	40	3/14/2017	9/14/2018	Yes	No
462	Sorrento Mesa Business Center	9883 Pacific Heights Blvd Ste E	San Diego	SCE	LA	Workplace	AEW Capital Management, L.P	10/24/2016	9	3/16/2017	9/16/2018	N/A	No
463	1660 Bay	1660 Bay St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/17/2017	9/17/2018	No	No
464	1690 North	1690 N Point St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/17/2017	9/17/2018	No	No
465	30401 Agoura Road	30401 Agoura Rd	Agoura Hills	SCE	LA	Workplace	Equity Office Properties Trust	10/4/2016	3	3/20/2017	9/20/2018	N/A	No
466	Valencia Grove	121 E Lugonia Ave	Redlands	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	26	3/22/2017	9/22/2018	Yes	Yes
467	Cushman & Wakefield - 2000 Powell	2000 Powell St	Emeryville	PGE	SF	Workplace	Cushman & Wakefield of California	10/28/2016	20	3/24/2017	9/24/2018	N/A	No
468	Contra Costa	5001 Blum Rd	Martinez	PGE	SF	Workplace	California Highway Patrol	4/12/2016	10	3/24/2017	9/24/2018	N/A	No
469	Kaiser - San Leandro	2500 Merced St	San Leandro	PGE	SF	Publ Int	Kaiser Permanente	12/6/2016	10	3/24/2017	9/24/2018	N/A	N/A
470	Santa Ana	2031 E Santa Clara Ave	Santa Ana	SCE	LA	Workplace	California Highway Patrol	4/12/2016	4	3/30/2017	9/30/2018	N/A	No
471	APEX Laguna Niguel	27960 Cabot Rd	Laguna Niguel	SCE	LA	Multi-Family	CALI CROWN VALLEY LLC	11/14/2016	10	3/30/2017	9/30/2018	Yes	No
472	Temecula	27685 Commerce Center Dr	Temecula	SCE	LA	Workplace	California Highway Patrol	4/12/2016	2	3/31/2017	9/30/2018	N/A	No

473	PS 1 Garage	2310 E El Segundo Blvd	El Segundo	SCE	LA	Workplace	Aerospace Corporation	9/26/2016	10	4/3/2017	10/3/2018	N/A	No
474	A8 Parking Lot	2310 E El Segundo Blvd	El Segundo	SCE	LA	Workplace	Aerospace Corporation	9/26/2016	10	4/3/2017	10/3/2018	N/A	No
475	A3 Parking Lot	2310 E El Segundo Blvd	El Segundo	SCE	LA	Workplace	Aerospace Corporation	9/26/2016	10	4/3/2017	10/3/2018	N/A	No
476	A2 Parking Lot	2310 E El Segundo Blvd	El Segundo	SCE	LA	Workplace	Aerospace Corporation	9/26/2016	10	4/3/2017	10/3/2018	N/A	No
477	D8 Parking Lot	200 N Aviation Blvd	El Segundo	SCE	LA	Workplace	Aerospace Corporation	9/26/2016	10	4/3/2017	10/3/2018	N/A	No
478	2250 5th Ave	2250 5th Ave Ste 900	San Diego	SDGE	SD	Workplace	Manchester Financial Group	3/31/2017	10	4/3/2017	10/3/2018	N/A	No
479	UCSB_6510 El Colegio_Parking lot 50	6510 El Colegio Rd	Santa Barbara	PGE	SF	Multi-Family	UC SANTA BARBARA	12/5/2016	10	4/4/2017	10/4/2018	No	No
480	UCSB_Engineering Science Isla Vista _Parking lot 10 Area 1	520 Mesa Rd	Santa Barbara	PGE	SF	Publ Int	UC SANTA BARBARA	12/5/2016	10	4/4/2017	10/4/2018	N/A	N/A
481	UCSB_Recreation Center Field _Parking lot 18	Ocean Rd Garage Lot 18	Santa Barbara	PGE	SF	Publ Int	UC SANTA BARBARA	12/5/2016	10	4/4/2017	10/4/2018	N/A	N/A
482	UCSB_Engineering II_Parking lot 10 Area 2	519 Mesa Rd	Santa Barbara	PGE	SF	Publ Int	UC SANTA BARBARA	12/5/2016	10	4/4/2017	10/4/2018	N/A	N/A
483	UCSB_Kohn Hall_Parking lot 10 Area 4	510 Mesa Rd	Santa Barbara	PGE	SF	Publ Int	UC SANTA BARBARA	12/5/2016	10	4/4/2017	10/4/2018	N/A	N/A
484	UCSB_Elings Hall_Parking lot 10 Area 3	512 Mesa Rd	Santa Barbara	PGE	SF	Publ Int	UC SANTA BARBARA	12/5/2016	10	4/4/2017	10/4/2018	N/A	N/A
485	UCSB_Student Resource Building_Parking lot 22 Area 1	Ocean Rd Garage 22	Santa Barbara	PGE	SF	Publ Int	UC SANTA BARBARA	12/5/2016	6	4/4/2017	10/4/2018	N/A	N/A
486	UCSB_Multi-Cultural Center _Parking lot 8	Rm 1504 Ucen Rd	Santa Barbara	PGE	SF	Publ Int	UC SANTA BARBARA	12/5/2016	10	4/4/2017	10/4/2018	N/A	N/A
487	UCSB_Events Center Building_Parking lot 22 Area 2	Ocean Rd Garage 22 B	Santa Barbara	PGE	SF	Publ Int	UC SANTA BARBARA	12/5/2016	10	4/4/2017	10/4/2018	N/A	N/A
488	UCSB_Department of Theater and Dance_Parking lot 22 Area 3	Design & Construction Services Lot 22 Garage	Santa Barbara	PGE	SF	Publ Int	UC SANTA BARBARA	12/5/2016	10	4/4/2017	10/4/2018	N/A	N/A
489	Cypress	8148 Cypress Ave # 1-5	Fontana	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	4/4/2017	10/4/2018	Yes	Yes
490	Reed	16988 Reed St # 1-9	Fontana	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	4/7/2017	10/7/2018	Yes	Yes
491	MG-MG Properties Group Corporate Office	10505 Sorrento Valley Road Sui	San Diego	SDGE	SD	Workplace	MG Properties	1/26/2016	11	4/12/2017	10/12/2018	N/A	No
492	Dublin	4999 Gleason Dr	Dublin	PGE	SF	Workplace	California Highway Patrol	4/12/2016	10	4/13/2017	10/13/2018	N/A	No
493	Condor	15230 Condor Rd # 1-4	Victorville	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	4/13/2017	10/13/2018	Yes	Yes
494	249 E. Ocean Blvd.	249 E Ocean Blvd	Long Beach	SCE	LA	Workplace	Adler Realty Investments	4/14/2016	10	4/18/2017	10/18/2018	N/A	No
495	Marygold	17668 Marygold Ave # A-d	Bloomington	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	4/18/2017	10/18/2018	Yes	Yes
496	Pepper	9034 Pepper Ave # 1-5	Fontana	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	4/18/2017	10/18/2018	Yes	Yes
497	Casa Feliz Studios	525 S 9th St	San Jose	PGE	SF	Multi-Family	First Community Housing	12/2/2016	8	4/21/2017	10/21/2018	Yes	Yes
498	Alder	9878 Alder Ave	Bloomington	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	4/21/2017	10/21/2018	Yes	Yes
499	eaves Mountain View at Middlefield	555 W Middlefield Rd	Mountain View	PGE	SF	Multi-Family	AvalonBay Communities, Inc.	3/30/2015	10	4/24/2017	10/24/2018	No	No
500	10241 Wateridge	10241 Wateridge Cir	San Diego	SDGE	SD	Workplace	Parallel Capital Partners	11/16/2016	7	4/25/2017	10/25/2018	N/A	No
501	El Paseo Studios	4980 Hamilton Ave	San Jose	PGE	SF	Multi-Family	First Community Housing	12/2/2016	8	4/26/2017	10/26/2018	Yes	No
502	El Cajon	1722 E Main St	El Cajon	SDGE	SD	Workplace	California Highway Patrol	4/12/2016	6	4/26/2017	10/26/2018	N/A	No
503	Acacia Property	9590 Acacia Ave # 1-28	Fontana	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	4	4/27/2017	10/27/2018	Yes	Yes
504	Plaza Towers HOA	838 N Doheny Dr	West Hollywood	SCE	LA	Multi-Family	Plaza Towers HOA	12/14/2016	10	4/27/2017	10/27/2018	No	No
505	Avalon Walnut Ridge II	2992 Santos Ln	Walnut Creek	PGE	SF	Multi-Family	AvalonBay Communities, Inc.	3/30/2015	40	4/28/2017	10/28/2018	No	No
506	Avalon Walnut Ridge I	121 Roble Rd	Walnut Creek	PGE	SF	Multi-Family	AvalonBay Communities, Inc.	3/30/2015	12	4/28/2017	10/28/2018	No	No
507	5731 W. Las Positas Ave	5731 W Las Positas	Pleasanton	PGE	SF	Workplace	Bio-Rad Laboratories	1/13/2015	3	5/2/2017	11/2/2018	N/A	No
508	Maple Plaza	407 N Maple Dr	Beverly Hills	SCE	LA	Workplace	Tishman Speyer	8/26/2016	9	5/2/2017	11/2/2018	N/A	No
509	Kaiser - Richmond	901 Nevin Ave	Richmond	PGE	SF	Publ Int	Kaiser Permanente	10/19/2016	8	5/5/2017	11/5/2018	N/A	N/A
510	Third Street	13629 3rd St # 1364	Yucaipa	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	18	5/5/2017	11/5/2018	Yes	No
511	Kaiser - San Diego MC - Clairemont Mesa	9455 Clairemont Mesa Blvd	San Diego	SDGE	SD	Publ Int	Kaiser Permanente	7/1/2016	10	5/8/2017	11/8/2018	N/A	N/A
512	Kaiser - Viewridge MOB	5251 Viewridge Court	San Diego	SDGE	SD	Publ Int	Kaiser Permanente	7/1/2016	3	5/8/2017	11/8/2018	N/A	N/A
513	Equity - Vista 99 Apartments	99 Vista Montana	San Jose	PGE	SF	Multi-Family	Equity Residential	3/6/2017	10	5/11/2017	11/11/2018	No	No
514	Tern	15722 Tern Rd # 1-5	Victorville	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	5/12/2017	11/12/2018	Yes	No
515	eaves South Coast	555 Paularino Ave	Costa Mesa	SCE	LA	Multi-Family	AvalonBay Communities, Inc.	3/30/2015	2	5/12/2017	11/12/2018	No	No
516	eaves Huntington Beach	6700 Warner Ave	Huntington Beacl	SCE	LA	Multi-Family	AvalonBay Communities, Inc.	3/30/2015	9	5/12/2017	11/12/2018	No	No
517	eaves Cerritos	11421 & 11454 East 186th Street	Artesia	SCE	LA	Multi-Family	AvalonBay Communities, Inc.	3/30/2015	2	5/12/2017	11/12/2018	No	No
518	Avalon Fashion Valley	7084 Friars Rd	San Diego	SDGE	SD	Multi-Family	AvalonBay Communities, Inc.	3/30/2015	6	5/12/2017	11/12/2018	No	No
519	Bandera	5161 Bandera St	Montclair	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	2	5/19/2017	11/19/2018	Yes	Yes
520	Brookwood Villas Apartment Homes - 1940 Nice Drive	1940 Nice Dr	Corona	SCE	LA	Multi-Family	AEW Capital Management, L.P	6/2/2016	2	5/23/2017	11/23/2018	No	No
521	Brookwood Villas Apartment Homes - 1830 Via Pacifica	1830 Via Pacifica	Corona	SCE	LA	Multi-Family	AEW Capital Management, L.P	6/2/2016	2	5/23/2017	11/23/2018	No	No
522	Brookwood Villas Apartment Homes - 1885 San Remo	1885 San Remo Dr	Corona	SCE	LA	Multi-Family	AEW Capital Management, L.P	6/2/2016	2	5/23/2017	11/23/2018	No	No
523	Brookwood Villas Apartment Homes - 1310 Genova Drive	1310 Genova Dr	Corona	SCE	LA	Multi-Family	AEW Capital Management, L.P	6/2/2016	2	5/23/2017	11/23/2018	No	No
524	5700 Warland Dr.	5700 Warland Dr	Cypress	SCE	LA	Workplace	Warland Investments Company	2/22/2017	10	5/23/2017	11/23/2018	N/A	No
525	Brookwood Villas Apartment Homes - 1975 Cannes Drive	1975 Cannes Dr	Corona	SCE	LA	Multi-Family	AEW Capital Management, L.P	6/2/2016	2	5/24/2017	11/24/2018	No	No
526	15231 Alton Plaza	15231 Alton Pkwy	Irvine	SCE	LA	Workplace	AEW Capital Management, L.P	6/1/2016	5	5/26/2017	11/26/2018	N/A	No
527	15251 Alton Plaza	15251 Alton Pkwy	Irvine	SCE	LA	Workplace	AEW Capital Management, L.P	6/1/2016	5	5/26/2017	11/26/2018	N/A	No
528	9920 Pacific Heights Blvd	9920 Pacific Heights Blvd	San Diego	SDGE	SD	Workplace	Bollert LeBeau (BLB Inc).	7/27/2016	4	5/26/2017	11/26/2018	N/A	No
529	5760 Fleet Street	5760 Fleet St	Carlsbad	SDGE	SD	Workplace	Bollert LeBeau (BLB Inc).	7/27/2016	10	5/26/2017	11/26/2018	N/A	No
530	Building #23, 14040 Danielson St	14040 Danielson St	Poway	SDGE	SD	Workplace	General Atomics	6/9/2015	10	5/26/2017	11/26/2018	N/A	No
531	CITYMARK - Celsius	100 Citronica Ln	Lemon Grove	SDGE	SD	Multi-Family	CITYMARK DEV	5/31/2016	10	5/26/2017	11/26/2018	No	Yes
532	eaves Mission Viejo	24950 Via Florecor	Mission Viejo	SCE	LA	Multi-Family	AvalonBay Communities, Inc.	3/30/2015	2	5/26/2017	11/26/2018	Yes	No
533	South Coast Villas HOA	1101 West MacArthur Blvd.	Santa Ana	SCE	LA	Multi-Family	South Coast Villas HOA	6/14/2016	12	6/1/2017	12/1/2018	No	No
534	500 Howard	500 Howard St	San Francisco	PGE	SF	Workplace	CBRE-SemaConnect	10/17/206	8	6/5/2017	12/5/2018	N/A	No
535	201 California St	201 California St	San Francisco	PGE	SF	Workplace	CBRE-SemaConnect	9/1/2016	4	6/5/2017	12/5/2018	N/A	No
536	Pacific Pointe	2459 Corte Merlango	San Clemente	SDGE	SD	Multi-Family	Lyon Communities	3/15/2016	12	6/5/2017	12/5/2018	No	No
537	Department of Justice	9425 Chesapeake Dr	San Diego	SDGE	SD	Workplace	Chesapeake Whiteside LLP	10/3/2016	4	6/5/2017	12/5/2018	N/A	Yes
538	Coca-Cola Coachella	86375 Industrial Way	Coachella	SCE	LA	Workplace	Coca-Cola Company	3/31/2015	4	1/1/2015	7/1/2016	N/A	No
539	Kaiser Oakland Admin - 2000 Broadway	2000 Broadway	Oakland	PGE	SF	Publ Int	Kaiser Permanente	6/26/2015	4	12/9/2015	6/9/2017	N/A	Yes
540	Kaiser Oakland Admin - 1800 Harrison	1800 Harrison St	Oakland	PGE	SF	Publ Int	Kaiser Permanente	6/26/2015	6	12/9/2015	6/9/2017	N/A	Yes
541	Kaiser Oakland Admin - 410 19th St	410 E 19th St	Oakland	PGE	SF	Publ Int	Kaiser Permanente	6/26/2015	6	12/9/2015	6/9/2017	N/A	Yes
542	Willows	464 N Humboldt Ave	Willows	PGE	SF	Workplace	California Highway Patrol	4/1/2016	10	10/14/2016	4/14/2018	N/A	No
543	Clear Lake	5700 Live Oak Dr	Kelseyville	PGE	SF	Workplace	California Highway Patrol	4/1/2016	16	10/14/2016	4/14/2018	N/A	Yes
544	Ukiah	540 S Orchard Ave	Ukiah	PGE	SF	Workplace	California Highway Patrol	4/1/2016	6	10/14/2016	4/14/2018	N/A	No
545	Quincy Area Office	86 Main St	Quincy	PGE	SF	Workplace	California Highway Patrol	4/1/2016	4	4/10/2017	10/10/2018	N/A	No
546	Oroville	2072 3rd St	Oroville	PGE	SF	Workplace	California Highway Patrol	4/1/2016	4	4/19/2017	10/19/2018	N/A	Yes
547	Gold Run	50 Canyon Creek Rd	Gold Run	PGE	SF	Workplace	California Highway Patrol	4/1/2016	4	4/19/2017	10/19/2018	N/A	No
548	450 B Street	450 B St	San Diego	SDGE	SD	Workplace	Bollert LeBeau (BLB Inc).	7/27/2016	6	6/6/2017	12/6/2018	N/A	Yes
549	Edison Lofts	100 Long Beach Blvd	Long Beach	SCE	LA	Workplace	The Kor Group	1/6/2016	10	6/6/2017	12/6/2018	N/A	No
550	Rincon de Los Esteros	1780 Oakland Rd	San Jose	PGE	SF	Multi-Family	First Community Housing	12/2/2016	24	6/6/2017	12/6/2018	Yes	No
551	eaves Santa Margarita	111 Via Serena	Rancho Santa Ma	SCE	LA	Multi-Family	AvalonBay Communities, Inc.	3/13/2017	10	6/6/2017	12/6/2018	No	No
552	eaves Lake Forest	22700 Lake Forest Dr	Lake Forest	SCE	LA	Multi-Family	AvalonBay Communities, Inc.	3/31/2017	14	6/6/2017	12/6/2018	No	No
553	HPO SB	672 S Waterman Ave	San Bernardino	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/5/2017	10	6/8/2017	12/8/2018	Yes	Yes

554	5930 Cornerstone Court West	5930 Cornerstone Ct W	San Diego	SDGE	SD	Workplace	Bollert LeBeau (BLB Inc).	7/27/2016	9	6/15/2017	12/15/2018	N/A	No
555	REV-Pangea	P375 Pangea	La Jolla	SDGE	SD	Publ Int	UCSD	12/19/2016	10	6/15/2017	12/15/2018	N/A	No
556	15 Enterprise	15 Enterprise	Aliso Viejo	SCE	LA	Workplace	Lincoln Properties	8/11/2016	10	6/16/2017	12/16/2018	N/A	No
557	UCSB_ 4401 Marine Science building_Parking lot 1 Area 1	518 Ucen Road	Santa Barbara	PGE	SF	Publ Int	UC SANTA BARBARA	10/31/2016	10	6/19/2017	12/19/2018	N/A	No
558	UCSB_2400 Brenhall Isla Vista_Parking lot 1 Area 2	520 Ucen Rd	Santa Barbara	PGE	SF	Publ Int	UC SANTA BARBARA	10/31/2016	10	6/19/2017	12/19/2018	N/A	No
559	Yucaipa Horizons	12279 3rd St	Yucaipa	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/5/2017	5	6/20/2017	12/20/2018	Yes	No
560	Yucaipa Crest	12385 6th St # 101-923	Yucaipa	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/5/2017	6	6/23/2017	12/23/2018	Yes	No
561	The Metro at Corona Bldg 2	418 N Main St	Corona	SCE	LA	Multi-Family	Watermarke - Wermer Properties	6/10/2016	10	6/26/2017	12/26/2018	No	No
562	15285 Alton Plaza	15285 Alton Pkwy	Irvine	SCE	LA	Workplace	AEW Capital Management, L.P	5/25/2016	5	6/26/2017	12/26/2018	N/A	No
563	CA State Prison, Corcoran (COR)	4001 King Ave	Corcoran	PGE	SF	Workplace	California Department of Corrections and Rehabilitation	7/23/2018	30	2/5/2019	8/5/2020	No	No
564	REV-Gilman	252 Russell Ln	La Jolla	SDGE	SD	Publ Int	UCSD	12/19/2016	10	6/27/2017	12/27/2018	N/A	No
565	301 E.Ocean Blvd	301 E Ocean Blvd	Long Beach	SCE	LA	Workplace	Parallel Capital Partners	3/15/2017	10	6/27/2017	12/27/2018	N/A	No
566	Kaiser - La Habra MOB	601 E Imperial Hwy	La Habra	SCE	LA	Publ Int	Kaiser Permanente	6/12/2017	4	7/5/2017	1/5/2019	N/A	Yes
567	SYSCO	15750 Meridian Pkwy	Riverside	SCE	LA	Workplace	SYSCO	5/18/2016	9	7/7/2017	1/7/2019	N/A	Yes
568	3885 State St.	3885 State St	Santa Barbara	PGE	SF	Workplace	REthink Development	10/7/2016	10	7/7/2017	1/7/2019	N/A	No
569	4th Street	217 E 4th St	San Bernardino	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/5/2017	3	7/7/2017	1/7/2019	Yes	Yes
570	Berkeley	754 N Berkeley Ave	San Bernardino	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/5/2017	3	7/7/2017	1/7/2019	Yes	Yes
571	MG-Sterling Village	88 Valle Vista Ave	Vallejo	PGE	SF	Multi-Family	MG Properties	6/15/2015	5	7/13/2017	1/13/2019	No	Yes
572	26940 Theatre Dr.	26940 Theater Dr	Valencia	SCE	LA	Workplace	CBRE-SemaConnect	12/21/2016	10	11/18/2018	5/18/2020	N/A	No
573	Kaiser - Davis Medical Center	1955 Cowell Blvd	Davis	PGE	SF	Publ Int	Kaiser Permanente	2/22/2016	7	7/14/2017	1/14/2019	N/A	Yes
574	CA Institution for Women (CIW)	16756 Chino Corona Rd	Corona	SCE	LA	Workplace	California Department of Corrections and Rehabilitation	1/11/2019	10	5/24/2019	11/24/2020	No	No
575	Ventura Youth Correctional Facility (VYCF)	3100 Wright Road	Ventura	SCE	LA	Workplace	California Department of Corrections and Rehabilitation	7/18/2018	8	5/28/2019	11/28/2020	No	No
576	Chuckawalla Valley State Prison (CVSP)	19025 Wiley's Well Rd.	Blythe	SCE	LA	Workplace	California Department of Corrections and Rehabilitation	7/11/2018	10	5/8/2019	11/8/2020	No	No
577	eaves Rancho Penasquitos	10024 Paseo Montril	San Diego	SDGE	SD	Multi-Family	AvalonBay Communities, Inc.	3/31/2017	19	7/19/2017	1/19/2019	No	No
578	Ironwood State Prison (ISP)	19005 Wiley's Well Road	Blythe	SCE	LA	Workplace	California Department of Corrections and Rehabilitation	1/11/2019	10	5/8/2019	11/8/2020	No	No
579	Lassen/Yosemite	1929 Yosemite Ct	Barstow	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/5/2017	18	7/20/2017	1/20/2019	Yes	Yes
580	Lugo1425	1425 Lugo 1-8	San Bernardino	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/5/2017	2	7/21/2017	1/21/2019	Yes	Yes
581	3501 Jamboree Rd	3501 Jamboree Rd	Newport Beach	SCE	LA	Workplace	CBRE-SemaConnect	7/5/2016	10	7/28/2017	1/28/2019	N/A	No
582	Melissa Court	710 Melissa Ct # 746	Barstow	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/5/2017	14	7/28/2017	1/28/2019	Yes	No
583	North Kern State Prison (NKSP)	2737 West Cecil Avenue	Delano	PGE	SJV	Publ Int	California Department of Corrections and Rehabilitation	1/11/2019	10	5/22/2019	11/22/2020	No	No
584	Avalon Fremont	39939 Stevenson Cmn	Fremont	PGE	SF	Multi-Family	AvalonBay Communities, Inc.	11/3/2016	22	7/28/2017	1/28/2019	No	No
585	Equity - 855 Brannan	855 Brannan St	San Francisco	PGE	SF	Multi-Family	Equity Residential	5/25/2017	10	7/29/2017	1/29/2019	No	No
586	Kern Valley State Prison (KVSP)	3000 West Cecil Avenue	Delano	PGE	SJV	Publ Int	California Department of Corrections and Rehabilitation	1/11/2019	10	5/29/2019	11/29/2020	No	No
587	CBI Campus-Host Paid Directly	9001 Towne Centre Dr	San Diego	SDGE	SD	Publ Int	Congregation Beth Israel	2/1/2017	4	8/2/2017	2/2/2019	N/A	No
588	Avalon La Jolla Colony	7205 Charmant Dr	San Diego	SDGE	SD	Multi-Family	AvalonBay Communities, Inc.	4/25/2017	13	8/8/2017	2/8/2019	No	No
589	1500-14 Geneva	1500 Geneva Ave # 14	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/21/2016	2	8/9/2017	2/9/2019	No	No
590	311 Corbet	311 Corbett Ave	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/21/2016	2	8/9/2017	2/9/2019	No	No
591	3809 20th St	3809 20th St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/21/2016	2	8/9/2017	2/9/2019	No	No
592	Avalon Santa Monica on Main	2000 Main St	Santa Monica	SCE	LA	Multi-Family	AvalonBay Communities, Inc.	1/23/2017	21	8/9/2017	2/9/2019	Yes	No
593	eaves Walnut Creek	1445 Treat Blvd	Walnut Creek	PGE	SF	Multi-Family	AvalonBay Communities, Inc.	12/6/2016	9	8/11/2017	2/11/2019	No	No
594	UCSB_Facilities Management_Parking lot 31 Area 375 A	375 Mesa Road	Santa Barbara	PGE	SF	Publ Int	UC SANTA BARBARA	12/5/2016	10	8/14/2017	2/14/2019	N/A	No
595	IQ Air REV	14351 Firestone Blvd	La Mirada	SCE	LA	Workplace	IQ Air REV	4/25/2017	5	8/14/2017	2/14/2019	No	No
596	UCSB_Facilities Management_Parking lot 31 Area 584 B	584 Mesa Rd	Santa Barbara	PGE	SF	Publ Int	UC SANTA BARBARA	12/5/2016	10	8/14/2017	2/14/2019	N/A	No
597	King St	157 E King St	San Bernardino	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/5/2017	2	8/17/2017	2/17/2019	Yes	Yes
598	CA State Prison, Los Angeles County (LAC)	44750 60th St W	Lancaster	SCE	LA	Workplace	California Department of Corrections and Rehabilitation	10/16/2018	10	4/25/2019	10/25/2020	No	No
599	11th Street	1077 W 11th St	San Bernardino	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/5/2017	2	8/21/2017	2/21/2019	Yes	Yes
600	City of Carlsbad -State Street Parking Lot	3045 State Street	Carlsbad	SDGE	SD	Publ Int	City of Carlsbad	7/28/2016	2	8/22/2017	2/22/2019	N/A	No
601	City of Carlsbad - Stagecoach Park	3420 Camino De Los Coches	Carlsbad	SDGE	SD	Publ Int	City of Carlsbad	7/28/2016	10	8/22/2017	2/22/2019	N/A	No
602	Lyon - Palomar Station	2157 Armorlite Drive	San Marcos	SDGE	SD	Multi-Family	Lyon Communities	3/9/2016	18	8/23/2017	2/23/2019	Yes	Yes
603	Turrill	1297 Turrill Ave # 1299	San Bernardino	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/5/2017	2	8/24/2017	2/24/2019	Yes	Yes
604	CA State Prison, Solano (SOL)	2100 Peabody Rd	Vacaville	PGE	SF	Workplace	California Department of Corrections and Rehabilitation	4/18/2018	20	3/22/2019	9/22/2020	No	No
605	Bixby Office Park	3020 Old Ranch Pkwy	Seal Beach	SCE	LA	Workplace	Parallel Capital Partners	3/28/2017	15	8/29/2017	2/28/2019	N/A	No
606	San Quentin (SQ)	San Quentin	San Quentin	PGE	SF	Workplace	California Department of Corrections and Rehabilitation	4/18/2018	8	3/28/2019	9/28/2020	No	No
607	Del West	28128 Livingston Ave	Valencia	SCE	LA	Workplace	Del West	2/27/2017	10	8/31/2017	2/28/2019	N/A	No
608	The Alhambra Group-Headquarters	41635 Enterprise Cir N Ste C	Temecula	SCE	LA	Workplace	The Alhambra Group	10/31/2016	9	8/31/2017	2/28/2019	N/A	No
609	Lynwood	1470 E Lynwood Dr	San Bernardino	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/5/2017	2	9/1/2017	3/1/2019	Yes	Yes
610	2nd Street EAST	205 E 2nd St	San Bernardino	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/5/2017	2	9/1/2017	3/1/2019	Yes	Yes
611	Keeton Construction	41635 Enterprise Cir N Ste A	Temecula	SCE	LA	Workplace	Keeton Construction Co. Inc	10/25/2016	10	9/5/2017	3/5/2019	N/A	No
612	CHW - Vista North Santa Fe	301 N Santa Fe Ave	Vista	SDGE	SD	Multi-Family	CHW	8/30/2017	5	9/5/2017	3/5/2019	Yes	Yes
613	Maplewod Office	1738 W 9th St	San Bernardino	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/5/2017	2	9/8/2017	3/8/2019	Yes	Yes
614	The Metro at Corona Bldg 3	422 North Main Street	Corona	SCE	LA	Multi-Family	Watermarke - Wermer Properties	6/10/2016	10	9/8/2017	3/8/2019	No	Yes
615	691 S Tustin	691 S Tustin St	Orange	SCE	LA	Workplace	California Department of Transportation (Caltrans)	4/10/2017	10	6/27/2017	12/27/2018	N/A	Yes
616	1340 Treat Blvd	1340 Treat Blvd	Walnut Creek	PGE	SF	Workplace	CBRE-SemaConnect	12/16/2016	10	9/20/2017	3/20/2019	N/A	No
617	Kendall Park Apartments	2490 Kendall Dr	San Bernardino	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/5/2017	4	9/22/2017	3/22/2019	Yes	Yes
618	Mountain Pass	94200 Clark Mountain Rd	Nipton	SCE	LA	Workplace	California Highway Patrol	4/12/2016	10	9/26/2017	3/26/2019	No	No
619	Parkloft Condominium Owners Association-	877 Island Ave	San Diego	SDGE	SD	Multi-Family	Parkloft Condominium Owners Association	8/4/2016	20	9/27/2017	3/27/2019	No	Yes
620	25520 Commercentre Dr.	25520 Commercentre Dr	Lake Forest	SCE	LA	Workplace	CBRE-SemaConnect	12/21/2016	10	9/28/2017	3/28/2019	N/A	No
621	Maplewood Homes (Whitney Young Clinic)	1755 Maple St	San Bernardino	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/5/2017	6	9/29/2017	3/29/2019	Yes	Yes
622	Pittsburgh USD - Facilities Office	3200 Loveridge	Pittsburg	PGE	SF	Publ Int	Pittsburgh Unified School District	7/27/2017	8	10/2/2017	4/2/2019	N/A	Yes
623	1500 Quail Street	1500 Quail St	Newport Beach	SCE	LA	Workplace	RiverRock Real Estate Group	6/22/2017	10	10/3/2017	4/3/2019	No	No
624	Chroma System Solutions Office	19772 Pauling	Foothill Ranch	SCE	LA	Workplace	Chroma System Solutions, inc	2/13/2017	10	10/3/2017	4/3/2019	N/A	No
625	Deseret	1050 Deseret Ave	Barstow	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/5/2017	3	10/6/2017	4/6/2019	Yes	Yes
626	6262 Lusk Blvd.	6262 Lusk Blvd	San Diego	SDGE	SD	Workplace	Bollert LeBeau (BLB Inc).	6/12/2017	10	10/10/2017	4/10/2019	N/A	No
627	South 7th	421 S 7th Ave	Barstow	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/5/2017	4	10/16/2017	4/16/2019	Yes	Yes
628	One Enterprise	1 Enterprise	Aliso Viejo	SCE	LA	Workplace	AEW Capital Management, L.P	3/22/2016	10	10/26/2017	4/26/2019	No	No
629	25510 Commercentre Dr.	25510 Commercentre Dr	Lake Forest	SCE	LA	Workplace	CBRE-SemaConnect	12/21/2016	10	10/27/2017	4/27/2019	No	No
630	BUWW Coverings California Headquarters	25767 Jefferson Ave	Murrieta	SCE	LA	Workplace	BUWW Coverings California	10/7/2016	10	10/31/2017	4/30/2019	N/A	No
631	Pittsburgh USD - District Office	2000 Railroad Ave	Pittsburg	PGE	SF	Publ Int	Pittsburgh Unified School District	7/27/2017	4	11/2/2017	5/2/2019	N/A	Yes
632	Pittsburgh USD - Pittsburgh High School	1750 Harbor St	Pittsburg	PGE	SF	Publ Int	Pittsburgh Unified School District	7/27/2017	10	11/2/2017	5/2/2019	N/A	Yes
633	Elan at River Oaks	345 Village Center Dr	San Jose	PGE	SF	Multi-Family	Shea Properties	4/4/2017	80	11/6/2017	5/6/2019	No	No
634	Oasis Senior Center REV	801 Narcissus Ave	Corona Del Mar	SCE	LA	Publ Int	City of Newport Beach	10/3/2017	6	11/9/2017	5/9/2019	N/A	No

635	Rio San Diego Tower	9095 Rio San Diego Dr	San Diego	SDGE	SD	Workplace	BlackRock	8/10/2017	10	11/9/2017	5/9/2019	N/A	No
636	25550 Commercentre Dr.	25550 Commercentre Dr	Lake Forest	SCE	LA	Workplace	CBRE-SemaConnect	12/21/2016	10	11/10/2017	5/10/2019	N/A	No
637	2 Polaris Way	2 Polaris Way	Aliso Viejo	SCE	LA	Workplace	CBRE	9/16/2016	10	11/10/2017	5/10/2019	N/A	No
638	1 Polaris Way	1 Polaris Way	Aliso Viejo	SCE	LA	Workplace	CBRE	9/16/2016	10	11/10/2017	5/10/2019	N/A	No
639	5 Polaris Way	5 Polaris Way	Aliso Viejo	SCE	LA	Workplace	CBRE	9/16/2016	10	11/10/2017	5/10/2019	N/A	No
640	4 Polaris Way	4 Polaris Way	Aliso Viejo	SCE	LA	Workplace	CBRE	9/16/2016	10	11/10/2017	5/10/2019	N/A	No
641	3 Polaris Way	3 Polaris Way	Aliso Viejo	SCE	LA	Workplace	CBRE	9/16/2016	10	11/10/2017	5/10/2019	N/A	No
642	Andalusia	13520 Third Ave	Victorville	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/5/2017	10	11/10/2017	5/10/2019	Yes	No
643	eaves San Rafael	300 Channing Way	San Rafael	PGE	SF	Multi-Family	AvalonBay Communities, Inc.	9/11/2017	4	11/13/2017	5/13/2019	No	No
644	Marina Park REV	1600 W Balboa Blvd	Newport Beach	SCE	LA	Publ Int	City of Newport Beach	10/3/2017	2	11/14/2017	5/14/2019	N/A	No
645	Davidson	1315 Davidson Ave	San Bernardino	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/5/2017	2	11/17/2017	5/17/2019	Yes	Yes
646	1220 Engracia Ave	1220 Engracia Ave	Torrance	SCE	LA	Workplace	State of California II	7/24/2017	10	11/29/2017	5/29/2019	N/A	No
647	City Hall REV	100 Civic Center Dr	Newport Beach	SCE	LA	Publ Int	City of Newport Beach	10/3/2017	7	12/4/2017	6/4/2019	N/A	No
648	Fenton - El Dorado Hills -V	3842 Pendiente Ct	San Diego	SDGE	SD	Multi-Family	H.G. Fenton Company	3/8/2017	8	12/4/2017	6/4/2019	No	No
649	REV-Athena WEST 1/6	P746 Athena Cir.	La Jolla	SDGE	SD	Publ Int	UCSD	6/1/2015	10	12/4/2017	6/4/2019	N/A	No
650	REV-Athena EAST 2/6	P742 Health Sciences Drive	La Jolla	SDGE	SD	Publ Int	UCSD	6/1/2015	10	12/9/2017	6/9/2019	N/A	No
651	625 W. Alluvial Avenue	625 W Alluvial Ave	Fresno	PGE	SJV	Workplace	Granum Partners	1/23/2017	10	12/5/2017	6/5/2019	N/A	Yes
652	Foothill Plaza -27442 Portola Parkway	27442 Portola Pkwy	Foothill Ranch	SCE	LA	Workplace	CBRE-SemaConnect	1/18/2017	10	12/20/2017	6/20/2019	N/A	No
653	HPO VV	15465 Seneca Rd	Victorville	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	5/15/2017	2	12/20/2017	6/20/2019	No	Yes
654	Williams -740 E Williams St	740 E Williams St	Barstow	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	12/26/2017	8	12/26/2017	6/26/2019	Yes	Yes
655	J Street	630 J Street	San Bernardino	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	12/27/2017	2	12/27/2017	6/27/2019	Yes	Yes
656	HACSB Main Office	715 E Brier Dr	San Bernardino	SCE	LA	Workplace	HACSB [Housing Authority of the County of San Bernardino]	10/28/2016	10	1/2/2018	7/2/2019	No	Yes
657	North E	4181 North E Street	San Bernardino	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	4/10/2017	2	1/5/2018	7/5/2019	No	Yes
658	Yucaipa Terrace	12435 6th St # 101-1005	Yucaipa	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	5/15/2017	2	1/5/2018	7/5/2019	No	Yes
659	REV-Hopkins Garage	P342 Level 2 Hopkins Drive	La Jolla	SDGE	SD	Publ Int	UCSD	12/9/2016	20	1/15/2018	7/15/2019	No	No
660	Newport Coast Community Center REV	6401 San Joaquin Hills Rd	Newport Coast	SCE	LA	Publ Int	City of Newport Beach	11/1/2017	8	1/15/2018	7/15/2019	No	No
661	REV-Hillcrest Arbor Hillcrest	294 West Arbor	San Diego	SDGE	SD	Workplace	UCSD	11/1/2017	6	1/15/2018	7/15/2019	No	No
662	30031 Ahern Ave	30031 Ahern Ave	Union City	PGE	SF	Workplace	Mizuho OSI	12/22/2016	10	1/17/2018	7/17/2019	No	No
663	NU_Scripps Ranch	9980 Carroll Canyon Rd	San Diego	SDGE	SD	Workplace	National University	2/28/2017	10	1/22/2018	7/22/2019	No	No
664	130 E Ortega St	130 E Ortega St	Santa Barbara	SCE	LA	Workplace	State of California II	7/25/2017	10	1/23/2018	7/23/2019	No	No
665	City of Long Beach-Fleet Yard	2600 Temple Ave	Long Beach	SCE	LA	Workplace	City of Long Beach	10/25/2017	10	1/26/2018	7/26/2019	No	No
666	Moxa Americas, Inc.Headquarters	601 Valencia Ave Ste 100	Brea	SCE	LA	Workplace	Moxa Americas, Inc.	12/7/2016	10	2/14/2018	8/14/2019	No	No
667	REV-P 703 ECUP	P703 Regents Road West Lot	La Jolla	SDGE	SD	Publ Int	UCSD	12/22/2016	10	2/15/2018	8/15/2019	No	No
668	NU_Administrative Headquarters	11355 N Torrey Pines Rd	La Jolla	SDGE	SD	Workplace	National University	2/28/2017	10	2/21/2018	8/21/2019	No	No
669	Stanton Maintenance Station	8122 Katella Ave	Stanton	SCE	LA	Workplace	California Department of Transportation (Caltrans)	4/10/2017	9	7/19/2017	1/19/2019	N/A	Yes
670	4540 W Century Bl	4540 W Century Blvd	Inglewood	SCE	LA	Workplace	State of California II	7/25/2017	10	2/26/2018	8/26/2019	No	No
671	Cresleigh Homes Corp- Garnet Creek	5002 Jewell St	Rocklin	PGE	SF	Multi-Family	Cresleigh Homes Corp	1/5/2016	10	3/8/2018	9/8/2019	No	No
672	100 Broderick	100 Broderick St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
673	106 Sanchez	106 Sanchez St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
674	1260 Broadway	1260 Broadway	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
675	1301 Leavenworth	1301 Leavenworth St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
676	1340 Taylor	1340 Taylor St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
677	1520 Gough	1520 Gough St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
678	1801 Gough	1801 Gough St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
679	1840 Clay	1840 Clay St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
680	240 Cumberland	240 Cumberland St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
681	2500 Van Ness	2500 Van Ness Ave	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
682	2600 Van Ness	2600 Van Ness Ave	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
683	2677 Larkin	2677 Larkin St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
684	2898 Jackson	2898 Jackson St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
685	2975 Van Ness	2975 Van Ness Ave	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
686	3210 Gough	3210 Gough St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
687	3783 20th St	3783 20th St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
688	3820 Scott	3820 Scott St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
689	500 Stanyan	500 Stanyan St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
690	691 O'Farrell	691 Ofarrell St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
691	78 Buchanan	78 Buchanan St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
692	915 Pierce	915 Pierce St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
693	950 Franklin	950 Franklin St	San Francisco	PGE	SF	Multi-Family	PowerTree Services	10/24/2016	2	3/13/2018	9/13/2019	No	No
694	NU_Library System Facility	9393 Lightwave Ave	San Diego	SDGE	SD	Workplace	National University	2/28/2017	10	3/21/2018	9/21/2019	No	No
695	Foothill Plaza - 27422 Portola Parkway	27422 Portola Pkwy	Foothill Ranch	SCE	LA	Workplace	CBRE-SemaConnect	1/18/2017	10	3/26/2018	9/26/2019	N/A	No
696	371 West 3rd St	371 W 3rd St	San Bernardino	SCE	LA	Workplace	State of California II	7/25/2017	10	3/30/2018	9/30/2019	No	No
697	Building #22, 13970 Stowe Dr	13970 Stowe Dr	Poway	SDGE	SD	Workplace	General Atomics	7/21/2016	10	4/3/2018	10/3/2019	N/A	No
698	1690 Scenic Drive	1690 Scenic Ave	Costa Mesa	SCE	LA	Workplace	Klein Investments Family	6/9/2017	10	4/23/2018	10/23/2019	N/A	No
699	Kaiser - Harbor City	25 South Vermont Ave	Harbor City	SCE	LA	Workplace	Kaiser Permanente	9/12/2017	20	4/30/2018	10/30/2019	N/A	No
700	Maintenance Station Costa Mesa (District 12)	1090 Bristol St	Costa Mesa	SCE	LA	Workplace	California Department of Transportation (Caltrans)	4/10/2017	10	7/19/2017	1/19/2019	N/A	No
701	Building #14, 14107 Stowe Dr	14107 Stowe Dr	Poway	SDGE	SD	Workplace	General Atomics	7/21/2016	10	5/14/2018	11/14/2019	N/A	No
702	The Vineyard Restaurant	605 S I St	Madera	PGE	SJV	Workplace	The Vineyard Restaurant	1/27/2016	10	5/21/2018	11/21/2019	N/A	Yes
703	Jefferson at Carmel Mountain Ranch	11832 Stoney Peak Dr	San Diego	SDGE	SD	Multi-Family	BlackRock	3/15/2018	10	5/25/2018	11/25/2019	No	No
704	REV-Rady	P357 John Jay Hopkins Drive	La Jolla	SDGE	SD	Publ Int	UCSD	6/1/2015	10	5/31/2018	11/30/2019	N/A	No
705	Avalon Campbell	508 Railway Ave	Campbell	PGE	SF	Multi-Family	AvalonBay Communities, Inc.	6/1/2018	20	6/1/2018	12/1/2019	Yes	No
706	The Plaza Pacific Beach	1801 Diamond St	San Diego	SDGE	SD	Multi-Family	The Plaza Pacific Beach	5/23/2017	18	6/25/2018	12/25/2019	No	No
707	Sequoia Property	17426 Sequoia St	Hesperia	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/16/2016	10	7/18/2018	1/18/2020	Yes	No
708	Sudberry_Terraces CP_Guild Mortgage	5887 Copley Dr Fl 4	San Diego	SDGE	SD	Workplace	Sudberry Properties, Inc.	5/31/2018	2	8/1/2018	2/1/2020	No	Yes
709	Redwood Terrace	8181 Redwood Ave., #101A-2030	Fontana	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/16/2016	20	8/3/2018	2/3/2020	Yes	No
710	Sunnyside Townhomes	15188 & 15212 Sequoia	Hesperia	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/16/2016	10	8/3/2018	2/3/2020	Yes	No
711	Sunrise Vista	755 E Virginia Way	Barstow	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/16/2016	20	8/3/2018	2/3/2020	Yes	No
712	44812 Sierra Highway	44812 Sierra Hwy	Lancaster	SCE	LA	Publ Int	GreenCommuter (Lancaster)	10/27/2017	10	8/8/2018	2/8/2020	No	No
713	Sunol	4751 Hwy 680	Sunol	PGE	SF	Workplace	California Highway Patrol	8/9/2017	10	8/9/2018	2/9/2020	No	No
714	Oakland - Traffic Management Center	111 Grand Ave	Oakland	PGE	SF	Workplace	California Highway Patrol	8/9/2017	10	8/23/2018	2/23/2020	No	No
715	San Jose - 297 West Hedding St	297 W Hedding St	San Jose	PGE	SF	Workplace	State of California II	7/25/2017	10	8/24/2018	2/24/2020	No	No

716 Merced - 1205 West 18th St	1205 W 18th St	Merced	PGE	SJV	Workplace	State of California II	7/25/2017	6	8/28/2018	2/28/2020	No	No
717 Modesto - 629 12th St	629 12th St	Modesto	PGE	SJV	Workplace	State of California II	7/25/2017	7	8/28/2018	2/28/2020	No	No
718 REV-SIO MS Hubbs	P007-discovery Way	La Jolla	SDGE	SD	Publ Int	UCSD	12/22/2016	10	8/28/2018	2/28/2020	No	No
719 Fresno - 2555 South Elm Ave	2555 S Elm Ave	Fresno	PGE	SJV	Workplace	State of California II	7/25/2017	10	8/28/2018	2/28/2020	No	No
720 San Juan Capistrano (District 12)	32941 Camino Capistrano	San Juan Capistra	SCE	LA	Workplace	California Department of Transportation (Caltrans)	4/10/2017	9	7/19/2017	1/19/2019	N/A	No
721 Bolsa Chica Maintenance Station	13072 Old Bolsa Chica Rd	Westminster	SCE	LA	Workplace	California Department of Transportation (Caltrans)	4/10/2017	10	7/20/2017	1/20/2019	N/A	No
722 San Diego - Garage	7179 Opportunity Rd	San Diego	SDGE	SD	Workplace	California Department of Transportation (Caltrans)	4/10/2017	10	7/28/2017	1/28/2019	N/A	Yes
723 Maintenance Station Santee (District 11)	8502 Railroad Ave	Santee	SCE	LA	Workplace	California Department of Transportation (Caltrans)	4/10/2017	2	7/31/2017	1/31/2019	N/A	Yes
724 Chico - 240 West 7th St	240 W 7th St	Chico	PGE	SJV	Workplace	State of California II	7/25/2017	10	9/28/2018	3/28/2020	No	No
725 REV-One Miramar	3712 MIramar N	San Diego	SDGE	SD	Multi-Family	UCSD	1/13/2017	10	10/4/2018	4/4/2020	No	No
726 REV-Campus Services Center	P678 - P680 Csc Greenhouse Lane	La Jolla	SDGE	SD	Publ Int	UCSD	12/9/2016	20	10/10/2018	4/10/2020	No	No
727 Cordelia East	3895 Interstate 80	Suisun	PGE	SF	Workplace	California Highway Patrol	8/9/2017	10	10/18/2018	4/18/2020	No	No
728 Santa Rosa - 606 Healdsburg Ave	606 Healdsburg Ave	Santa Rosa	PGE	SF	Workplace	State of California II	7/25/2017	10	10/18/2018	4/18/2020	No	No
729 Coral Tree Business Center	1210 E 223rd St # 1250	Carson	SCE	LA	Workplace	AEW Capital Management, L.P	9/1/2016	10	10/26/2018	4/26/2020	No	Yes
730 Arrowhead Woods	1650 W 16th St # 121-914	San Bernardino	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	8/15/2016	10	11/2/2018	5/2/2020	Yes	Yes
731 Desert Village	14469 Rodeo Dr # 1-46	Victorville	SCE	LA	Multi-Family	HACSB [Housing Authority of the County of San Bernardino]	3/29/2018	10	11/5/2018	5/5/2020	Yes	Yes
732 Kaiser - Redwood City	1150 Veterans Blvd	Redwood City	PGE	SF	Publ Int	Kaiser Permanente	8/3/2018	10	12/4/2018	6/4/2020	No	No
733 Brookhollow - 1600 E St. Andrew	1600 E Saint Andrew Pl	Santa Ana	SCE	LA	Workplace	THE BROOKHOLLOW GROUP	6/27/2017	10	12/4/2018	6/4/2020	No	Yes
734 3011 Townsgate Road	3011 Townsgate Rd	Westlake Village	SCE	LA	Workplace	CBRE-SemaConnect	9/6/2016	10	12/5/2018	6/5/2020	No	No
735 Avalon Ocean Avenue	1150 Ocean Ave	San Francisco	PGE	SF	Multi-Family	AvalonBay Communities, Inc.	11/3/2016	8	5/12/2017	11/12/2018	Yes	No
736 Avalon on The Alameda	1300 the Alameda	San Jose	PGE	SF	Multi-Family	AvalonBay Communities, Inc.	11/3/2016	31	4/4/2017	10/4/2018	No	No
737 AVA Nob Hill	965 Sutter St	San Francisco	PGE	SF	Multi-Family	AvalonBay Communities, Inc.	1/26/2017	16	4/4/2017	10/4/2018	No	Yes
738 Avalon Sunset Towers	8 Locksley Ave Ofc	San Francisco	PGE	SF	Multi-Family	AvalonBay Communities, Inc.	12/6/2016	4	3/24/2017	9/24/2018	No	No
739 Avalon at Cahill Park	754 the Alameda	San Jose	PGE	SF	Multi-Family	AvalonBay Communities, Inc.	9/19/2016	28	3/20/2017	9/20/2018	No	No
740 Avalon Silicon Valley	1257 Lakeside Dr	Sunnyvale	PGE	SF	Multi-Family	AvalonBay Communities, Inc.	6/22/2016	40	6/30/2016	12/30/2017	No	No
741 REV-School of Medicine	3105 Gilman Dr	La Jolla	SDGE	SD	Publ Int	UCSD	12/22/2016	10	12/28/2018	6/28/2020	No	No
742 REV-Torrey Pines Center South	10202 N. Torrey Pines	La Jolla	SDGE	SD	Publ Int	UCSD	12/22/2016	10	12/28/2018	6/28/2020	No	No
743 Vallejo - 1440 Marin St	1440 Marin St	Vallejo	PGE	SF	Workplace	State of California II	7/25/2017	10	10/25/2018	4/25/2020	No	No
744 Santa Fe Springs	13230 Firestone Blvd	Santa Fe Springs	SCE	LA	Workplace	California Department of Transportation (Caltrans)	4/10/2017	10	8/21/2017	2/21/2019	N/A	Yes
745 4821 Adohr - Camarillo (District 7)	4821 Adohr Ln	Camarillo	SCE	LA	Workplace	California Department of Transportation (Caltrans)	4/10/2017	10	8/28/2017	2/28/2019	N/A	No
746 320 S Sierra, San Bernardino, Dist. 8	320 S Sierra Way	San Bernardino	SCE	LA	Workplace	California Department of Transportation (Caltrans)	4/10/2017	10	8/29/2017	2/28/2019	N/A	Yes
747 San Diego - Lab	7177 Opportunity Rd	San Diego	SDGE	SD	Workplace	California Department of Transportation (Caltrans)	4/10/2017	10	9/19/2017	3/19/2019	N/A	Yes
748 Oakland - 1225 4th Ave	1225 4th Ave	Oakland	PGE	SF	Workplace	State of California II	7/25/2017	10	11/9/2018	5/9/2020	No	Yes
749 29595 W Latta Avenue	29595 W Latta Avenue	Cantua Creek	PGE	SF	Workplace	GreenCommuter	1/4/2019	6	12/12/2018	6/12/2020	No	No
750 6261 Katella Ave. - Warland Investments	6261 Katella Ave	Cypress	SCE	LA	Workplace	Warland Investments Company	2/28/2017	3	1/10/2019	7/10/2020	No	No
751 Kaiser - Milpitas	770 E Calaveras Blvd	Milpitas	PGE	SF	Publ Int	Kaiser Permanente	4/2/2017	5	1/22/2019	7/22/2020	No	No
752 Fontana - 13892 Victoria	13892 Victoria St	Los Angeles	SCE	LA	Workplace	California Highway Patrol	9/13/2017	10	12/14/2018	6/14/2020	No	No
753 Building #27, 12395 First American Way	12395 First American Way	Poway	SDGE	SD	Workplace	General Atomics	7/22/2016	10	12/19/2018	6/19/2020	No	No
754 1921 West Clinton Avenue	1921 West Clinton Avenue	Fresno	PGE	SF	Workplace	GreenCommuter	10/23/2018	7	12/6/2018	6/6/2020	No	No
755 Promenade at Creekside Housing Partners II, L.P.	660 Grand Ave.	San Marcos	SDGE	SD	Multi-Family	Promenade at Creekside Housing Partners, L.P.	12/19/2018	4	1/9/2019	7/9/2020	Yes	Yes
756 1808 N Batavia (District 12)	1808 N Batavia St	Orange	SCE	LA	Workplace	California Department of Transportation (Caltrans)	4/10/2017	10	2/22/2018	8/22/2019	N/A	Yes
757 Kaiser- Corona Admin Parking Garage	1830 California Ave	Corona	SCE	LA	Publ Int	Kaiser Permanente	3/5/2019	3	5/14/2019	11/14/2020	No	No
758 6795 North Palm Avenue	6795 N Palm Ave	Fresno	PGE	SJV	Workplace	Granum Partners	9/11/2018	10	4/16/2019	10/16/2020	No	Yes
759 6715 North Palm Avenue	6715 N Palm Ave	Fresno	PGE	SJV	Workplace	Granum Partners	9/11/2018	10	4/16/2019	10/16/2020	No	Yes
760 Fenton_REV - Little Italy - Vici	550 W Date St	San Diego	SDGE	SD	Multi-Family	H.G. Fenton Company	3/27/2019	21	3/29/2019	9/29/2020	No	No
761 Irvine - 6681 Marine Way	6681 Marine Way	Irvine	SCE	LA	Workplace	California Department of Transportation (Caltrans)	4/10/2017	4	5/8/2018	11/8/2019	N/A	No
762 17010 Apple Avenue HURON	17010 Apple Avenue	Huron	PGE	SJV	Workplace	Joel Leon and Romualdo Leon	10/23/2017	10	12/4/2018	6/4/2020	No	Yes
763 6641 Marine - Maintenance Station Toll Road (District 12)	6641 Marine Way	Irvine	SCE	LA	Workplace	California Department of Transportation (Caltrans)	9/21/2017	6	2/27/2019	8/27/2020	No	No
764 6521 Marine Way	6521 Marine Way	Irvine	SCE	LA	Workplace	California Department of Transportation (Caltrans)	3/8/2018	2	1/14/2019	7/14/2020	No	No
765 6523 Marine Way	6523 Marine Way	Irvine	SCE	LA	Workplace	California Department of Transportation (Caltrans)	3/8/2018	2	1/14/2019	7/14/2020	No	No
766 Gilroy North	12000 South Valley FWY	San Martin	PGE	SF	Workplace	California Highway Patrol	9/11/2018	10	4/24/2019	10/24/2020	No	No
767 Brea - 13571 W Central	13571 W Central Ave	Brea	SCE	LA	Workplace	California Department of Transportation (Caltrans)	9/12/2017	10	2/28/2019	8/28/2020	No	No
768 Benicia - 100 Industrial Way	100 Industrial Way	Buellton	SCE	LA	Workplace	California Department of Transportation (Caltrans)	1/11/2019	10	5/20/2019	11/20/2020	No	No
769 Equipment Repair - 66 Madonna	66 Madonna Rd	San Luis Obispo	SCE	LA	Workplace	California Department of Transportation (Caltrans)	12/15/2017	10	4/26/2019	10/26/2020	No	No
770 1993 Marina Blvd.	1993 Marina Blvd	San Leandro	PGE	SF	Workplace	California Department of Transportation (Caltrans)	8/24/2018	10	4/10/2019	10/10/2020	No	Yes
771 120 Rickard Street	120 Rickard St	San Francisco	PGE	SF	Workplace	California Department of Transportation (Caltrans)	6/4/2018	10	4/12/2019	10/12/2020	No	No
772 East Bay Region - 600 Lewelling	600 Lewelling Blvd	San Leandro	SCE	LA	Workplace	California Department of Transportation (Caltrans)	9/11/2018	10	4/10/2019	10/10/2020	No	No
773 Petaluma Yard	611 Payran St	Petaluma	SCE	LA	Workplace	California Department of Transportation (Caltrans)	9/11/2018	10	4/12/2019	10/12/2020	No	No
774 Queens Lane Yard - 500 Queens Lane	500 Queens Lane	San Jose	SCE	LA	Workplace	California Department of Transportation (Caltrans)	9/11/2018	10	5/8/2019	11/8/2020	No	No
775 Inglewood - 5160 W Imperial Hwy	5160 W. Imperial Highway	El Segundo	SCE	LA	Workplace	California Department of Transportation (Caltrans)	9/12/2017	6	2/22/2019	8/22/2020	No	No
776 Newport Beach - 3521 University Way	3521 University Way	Newport Beach	SCE	LA	Workplace	California Department of Transportation (Caltrans)	9/12/2017	10	4/8/2019	10/8/2020	No	No
777 Tustin - 15700 Tustin	15700 Tustin Village Way	Tustin	SCE	LA	Workplace	California Department of Transportation (Caltrans)	9/12/2017	10	3/11/2019	9/11/2020	No	No
778 Surface Lot - Fleet Lot 49	345 W Ash St	San Diego	SDGE	SD	Workplace	Department of General Services	6/9/2017	8	9/11/2018	3/11/2020	No	Yes
779 Mission Valley	7575 Metropolitan Dr	San Diego	SDGE	SD	Workplace	Department of General Services	6/9/2017	22	9/11/2018	3/11/2020	No	Yes
780 San Diego State Office Bldg.	1350 Front St	San Diego	SDGE	SD	Workplace	Department of General Services	6/9/2017	13	9/11/2018	3/11/2020	No	Yes
781 SD CalTrans Dist. 11 HQ Bldg.	4050 Taylor St	San Diego	SDGE	SD	Workplace	Department of General Services	6/9/2017	14	9/12/2018	3/12/2020	No	Yes
782 City Lot A Street	201 N. A Street	Arvin	PGE	SJV	Publ Int	CITY OF ARVIN	9/21/2017	10	5/6/2019	11/6/2020	No	No
783 City Hall	200 Campus Dr	Arvin	PGE	SJV	Publ Int	CITY OF ARVIN	9/21/2017	10	5/6/2019	11/6/2020	No	Yes
784 Beneficial State Bank Fresno	170 West Shaw Avenue	Fresno	SCE	LA	Workplace	GreenCommuter	2/19/2019	10	3/1/2019	9/1/2020	No	Yes
785 Fagbule Glass House	1930 East Shields Avenue	Fresno	SCE	LA	Workplace	GreenCommuter	2/19/2019	10	3/1/2019	9/1/2020	No	Yes
786 Covenant Church	6269 E Kings Canyon Rd	Fresno	SCE	LA	Workplace	GreenCommuter	2/19/2019	10	3/1/2019	9/1/2020	No	Yes
787 Word Community Church	2611 E Hammond Ave.	Fresno	SCE	LA	Workplace	GreenCommuter	2/19/2019	10	6/3/2019	12/3/2020	No	Yes
788 Praise Church	1600 Willow Ave	Fresno	SCE	LA	Workplace	GreenCommuter	2/19/2019	10	3/1/2019	9/1/2020	No	Yes
789 Beneficial State Bank Porterville	268 North Main Street,	Porterville	SCE	LA	Workplace	GreenCommuter	2/19/2019	6	3/1/2019	9/1/2020	No	Yes
790 1444 Fulton Street	1444 Fulton Street	Fresno	SCE	LA	Workplace	GreenCommuter (Make-Readies)	5/17/2019	4	6/3/2019	12/3/2020	No	Yes
791 101 N Sepulveda	360 N Pacific Coast Hwy	El Segundo	SCE	LA	Workplace	Lincoln Property Company Commercial Inc.	5/31/2016	10	5/31/2016	11/30/2017	No	No
792 Tustin Centre	1537 N. Tustin Ave	Santa Ana	SCE	LA	Workplace	Tustin Centre Property Owner, LLC	2/19/2019	10	7/19/2019	1/19/2021	No	No
793 43063 10th St. W.	43063 10th St. W.	Lancaster	SCE	LA	Publ Int	GreenCommuter	12/18/2018	10	10/1/2019	4/1/2021	No	No
794 43104 City Parkway	43104 City Parkway	Lancaster	SCE	LA	Publ Int	GreenCommuter	12/18/2018	10	10/1/2019	4/1/2021	No	No
							Total:	6901			116	170

Appendix D

Electric Vehicle Storage Accelerator
Final Report

See attached.

FINAL PROJECT REPORT

Electric Vehicle Storage Accelerator (EVSA)

Submitted to California Public Utilities Commission

September 2019

PREPARED BY:

Primary Author:
Kelsey G. Johnson, Project Manager

Nuvve Corporation
2468 Historic Decatur Road, Suite 200
San Diego, CA 92106
www.nuvve.com

Secondary Authors:
Oliver Garnett, Energy & Environmental Economics
Robbie Shaw, Energy & Environmental Economics
Eric Cutter, Energy & Environmental Economics

PREPARED FOR:
California Public Utilities Commission (CPUC)

CPUC / NRG SETTLEMENT

In 2012, the Federal Energy Regulatory Commission approved an agreement between NRG Energy and the CPUC to settle outstanding legal issues regarding the California energy crisis. The settlement requires NRG to invest $102.5 million to deploy electric vehicle charging infrastructure across the state. The EVSA project is one of several projects under the NRG Settlement and was implemented by Nuvve on behalf of EVgo and the CPUC. Under EVSA, NRG will spend $1 million and coordinate with stakeholders, to test four vehicle-grid integration use cases: interconnection, transformer upgrade deferral, emergency power backup, and the value of vehicle-to-grid integration services in California. For more information on the Settlement please see the CPUC's website here.

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- **Lawrence Berkeley National Lab:** Doug Black
- **Nuvve:** Marc Trahand, Jacqueline Piero, Lance Noel, John Horn
- **EVgo Services:** Bill Ehrlich

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EXECUTIVE SUMMARY

Background

The state of California leads the United States in deployment of electric vehicles (EVs) and renewable energy resources.[1,2] As the number of EVs plugging into the electrical grid increase, so does the demand for electricity. In order to achieve California's emissions reductions goals, the charging patterns of Level 2 (L2) or long dwell EVs must be evaluated in conjunction with the needs of a grid increasingly relying on variable renewable energy generators. California is already exploring ways to manage the grid through utility rate-design, signaling to EV charging providers and end-use customers the relative value of charging, including time-of use, day and seasonality. The strategic management of L2 EVs charging and discharging – known as vehicle-to-grid (V2G) – has the potential to be a core component of California's energy future by reducing emissions as renewables penetration increases and reducing costs to ratepayers by deferring upgrades to the grid to serve additional load.

The synergies between renewables and EVs in achieving broader reductions in emissions has been a significant area of interest to California regulators and policy makers. The Electric Vehicle Storage Accelerator (EVSA) Project was scoped to fill important gaps in understanding as the state evaluates the potential of V2G technology. The majority of research conducted thus far in California has focused on uni-directional, smart charging of an EV (V1G) – i.e. increasing, decreasing or stopping the charge rate. Fewer projects have examined the additional benefits, challenges and nuances of charging and discharging an EV battery through vehicle-to-grid (V2G). However, studies have shown V2G could have significantly more value to the grid and ratepayers than V1G, assuming driver willingness to participate and capability to discharge.[3] The EVSA project was developed to deepen the understanding around how V2G technology can be implemented in the most cost effective, safe and scalable manner in order to enable broader energy and transportation goals.

Project Purpose

The purpose of the EVSA project was to identify and evaluate key use cases of V2G technology that would benefit from additional analysis. With feedback from stakeholders, the project identified four key V2G "use cases" to evaluate:

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[1] California's continued electric vehicle market development, ICCT, May 2018. https://theicct.org/sites/default/files/publications/CA-cityEV-Briefing-20180507.pdf (accessed 8.24.19)

[2] U.S. Energy Information Administration, California, State Profile and Energy Estimates, Quick Facts. https://www.eia.gov/state/?sid=CA#tabs-4 (accessed 8.24.19)

[3] Clean vehicles as an enabler for a clean electricity grid, 15 May 2018. https://iopscience.iop.org/article/10.1088/1748-9326/aabe97/meta (accessed 8.25.19)

1. **Use Case 1: Interconnection of V2G Resources:** Execute the process required to interconnect[4] and receive permission to operate bi-directional electric vehicles on the distribution grid.
2. **Use Case 2: Transformer Upgrade Deferral**: Demonstrate the ability, and quantify the value of, managing EV charging and discharging based on local transformer load to avoid undue stress and upgrades.
3. **Use Case 3: Emergency Power Back-up:** Demonstrate the ability, and quantify the value of, an EV providing back-up power in the case of a power outage.
4. **Use Case 4: Workplace V2G Value Streams in California:** Demonstrate, and quantify the value of, an aggregation of V2G-capable EVs in a workplace setting to provide regulation up and down to the California Independent System Operator's (CAISO) ancillary services market. Examine other value streams available to V2G-capable EVs.

These four use cases strategically address key stages of V2G technology deployment – interconnection and quantifying the potential value streams from operations behind the meter, at the distribution level and at the transmission / wholesale market level. Following implementation, the use cases identified barriers to the scalable deployment of V2G technology in key areas (hardware, software, communications protocols, interconnection requirements) and added to previous research by quantifying the current and potential value streams V2G technology could capture.

A diverse array of stakeholders are involved with the implementation of V2G technology, including, but not limited to: automotive manufacturers (light duty and medium/heavy duty), charging station manufacturers, inverter manufacturers, aggregators, utilities, state and federal regulators, standards bodies, transmission system operators, community choice aggregators and EV drivers themselves. The successful scaling of V2G technology will therefore require the effort and attention of a diverse ecosystem and projects like EVSA are key inputs for those stakeholders as they consider how V2G technology will be a part of California's energy future.

Project Approach and Results

To test the four outlined use cases, the EVSA project installed eight V2G-capable L2 charging stations charging stations (referred to as electric vehicle supply equipment or EVSE) at various locations on the campus of University of California, San Diego (UCSD). Eight V2G-capable EVs L2 charging stations were then assigned to the eight EVSEs to make up the EVSA coalition, the details of which can be found in the table below.

EVSE Make/Model	Connector Type	Inverter Location	Vehicle Make/Model	Inverter (kW)	Vehicle Battery (kWh)	# of vehicles
Princeton Power Systems (PPS) CA-10	CHAdeMO	EVSE	Nissan LEAF	10	30	6

[4] A Rule 21 Interconnection Agreement is the formal agreement between SDG&E and customer that allows the customer's self-generating unit to discharge safely to the distribution grid. The agreement is the final stage in the interconnection process where SDG&E evaluates the potential impact of the unit on the distribution grid and confirms permission to operate.

Nuvve PowerPort	SAE J1772	EV	Honda Accord Plug-in Hybrid	2	6.7	2
			Total Capacity	64	193.4	8

Each of the eight project EVSEs were integrated with the Nuvve GIVe™ aggregation platform to enable the aggregated management of the charging and discharging cycles of the vehicles in accordance with the project use cases (#3 and #4). A key component of scalable V2G technology is understanding the charging trends of drivers in order to not only to strategically provide grid services, but also to fulfill the drivers' transportation needs. Therefore, each project vehicle was assigned to a driver from the UCSD community and used as a personal vehicle for the duration of the project. This set up allowed for the collection of realistic data regarding the transportation needs and charging trends of drivers in a workplace use case at a major University campus.

The majority of the EVSEs and EVs were installed on the UCSD micro-grid due to the micro-grid's unique jurisdiction allowing UCSD to self-approve installations. However, one of the six V2G-DC EVSE-EV pairs (PPS – LEAF) were deployed outside of the micro-grid in order to go through the process of gaining approval from distribution system operator (DSO), San Diego Gas and Electric (SDG&E), to interconnect to the distribution grid and discharge electricity. This set-up enabled the implementation of the Use Case #1: Interconnection.

Use Case #1: Interconnection

The goal of the first use case was to complete the interconnection process for bi-directional electric vehicles on the SDG&E distribution grid. The approval process is largely based on confirming the certification of the inverter involved meets the DSO's requirements (SDG&E), which are largely based on California's Rule 21 and its reference standard UL 1741 SA.[5]

The scope of the use case was to interconnect under both frameworks of V2G implementation:

1) ***V2G-DC*** – power conversion between the grid (alternating current - AC) and the EV battery (direct current – DC) occurs within an inverter located in the EVSE (Princeton Power CA-10) connected to the EV (Nissan LEAF).
2) ***V2G-AC*** – power conversion occurs in an inverter located on-board the EV itself (Honda Accord PHEV).

After working closely with SDG&E for almost a year, the V2G-DC implementation with a Nissan LEAF and Princeton Power CA-10 charging station outside of the UCSD micro-grid was successfully interconnected and given permission to operate. However, the proposed V2G-AC implementation with the Honda Accord PHEVs was ultimately not approved by SDG&E for operation. It is important to note Rule 21 and UL 1741 SA were developed for stationary inverters, therefore EVs with on-board inverters are physically incapable of complying. The inability of EVs with on-board inverter to interconnect under current regulatory regimes was identified as a key barrier to the scaling of V2G technology in California. The learnings from this use case were

[5] California Public Utilities Commission – Rule 21 Interconnection. https://www.cpuc.ca.gov/Rule21/ (accessed 8.25.19)

shared with stakeholders via the Rule 21 proceeding at the California Public Utilities Commission (R. 17-07-007). In August 2019, the Commission ruled to form a sub-working group to address the nuances of interconnecting an EV with an on-board, mobile inverter (V2G-AC).[6]

Use Case #2: Transformer Upgrade Deferral

The second use case was a scoped as a collaboration with another research project funded under the California Energy Commission's Electric Program Investment Charge (EPIC) grant program.[7] The first goal of the use case was to demonstrate the management of EV charging and discharging based on local transformer load to avoid undue stress by simulating EVs providing the following services: solar over-generation balancing, reverse power flow to mitigate peak load ramping and demand response. In addition, these services would be demonstrated for the first time using a suite of open communication protocols to execute V2G. To complete the demonstration portion of the Use Case #2, four additional EVSE-EV pairings were installed on the UCSD micro-grid, along with a local transformer. The EVSE-EV pairings included: 4 AeroVironment L2 EVSEs paired with 3 Chrysler Pacificas and 1 Honda Accord PHEV, all of which used on-board inverters (V2G-AC). The transformer was also integrated with an on-site solar array to get real-time solar generation input to inform the service dispatch signals. Despite set-up and operational challenges that caused delays, the demonstration portion of the project was ultimately successful in collecting the necessary amount of test data for modeling and proving the ability of open communication protocols to execute V2G, including the Society of Automotive Engineers (SAE) J3072 standard[8] which includes key safety requirements for V2G-AC vehicles to discharge.

The second goal of the use case was to quantify potential value streams available to V2G technology. Energy and Environmental Economics (E3) conducted the analysis by comparing the value streams provided by a simulated EV fleet under three charging scenarios: unmanaged, smart charging (V1G) and bi-directional managed charging (V2G). Within the charging scenarios the costs, benefits and net revenues were examined for the following services: (1) system/distribution capacity – reducing net load during peak hours, 2) load shifting to periods of lower energy costs or to reduce operational costs, and 3) ancillary services in CAISO markets. E3 simulated the services within two frameworks, a base case which reflects current market conditions and a high value case where renewable and energy storage penetration approaches the stated state goals. The key outputs of E3's analysis indicate V2G, when compared to V1G under the base case, will provide net benefits to California if it can be deployed for less than $407

[6] JOINT ADMINISTRATIVE LAW JUDGES' RULING ESTABLISHING SUBGROUP AND SCHEDULE TO DEVELOP PROPOSAL ON MOBILE INVERTER TECHNICAL REQUIREMENTS FOR RULE 21 AND NOTICING WORKSHOP, 23 August 2019. http://efile.cpuc.ca.gov/FPSS/0000138301/1.pdf (accessed 8.25.19)

[7] Chhaya, Sunil, Norman McCollough, Viswanath Ananth, Arindam Maitra, Ramakrishnan Ravikumar, Jamie Dunckley – Electric Power Research Institute; George Bellino – Clean Fuel Connection, Eric Cutter, Energy & Environment Economics, Michael Bourton, Kitu Systems, Inc., Richard Scholer, Fiat Chrysler Automobiles, Charlie Botsford, AeroVironment, Inc., 2019. Distribution System Constrained Vehicle-to-Grid Services for Improved Grid Stability and Reliability. California Energy Commission. Publication Number: CEC-500-2019-027. https://ww2.energy.ca.gov/2019publications/CEC-500-2019-027/CEC-500-2019-027.pdf (accessed 8.26.19)

[8] Interconnection Requirements for Onboard, Utility-Interactive Inverter Systems, Society of Automotive Engineers https://www.sae.org/standards/content/j3072_201505/ (accessed 8.28.19)

per EV per year (assumes the net value from system/distribution capacity value, generation capacity and ancillary services revenue are stacked). In areas of the grid with high system and distribution capacity value, the potential value to the grid could be as high as $1,100 per EV per year. E3's analysis included electricity costs, constraints on the vehicle state of charge (limited between 30 – 95%) and a battery degradation factor. These results indicate there are potentially significant incremental benefits of V2G over managed charging (V1G) and therefore a strong case for considering creating incentive structures for V2G technology.

Use Case #3: Emergency Back-up Power

The goal of the third use case was to demonstrate, and quantify the value of, an EV providing back-up power in the case of an emergency, such as an unexpected blackout or a coordinated Public Safety Power Shutoff (PSPS).[9] The use case demonstration was successfully completed and confirmed a Nissan LEAF can discharge electricity and power to a simulated residential home load (10 kW) via a Princeton Power CA-10 EVSE.[10] Although the vehicle used has a battery capacity of 30 kWh and was plugged into an EVSE with a 10 kW discharging capability, it was only able to power the load for 2 hours, instead of the estimated 3 hours. This is illustrative of the challenge of rating and monitoring the real capacity of an EV battery over time and will be a factor for consideration if EVs are relied upon to provide back-up power in the case of emergencies. In addition to the demonstration, the project also quantified the avoided cost of having a reliable power system in the event of a power interruption. By leveraging grid reliability indexes and analysis frameworks utilized by previous studies, the avoided cost of using an EV to serve as an emergency power source was quantified for two scenarios in SDG&E territory, a commercial and industrial (C&I) customer like UCSD and a residential home. The avoided cost to a representative C&I customer of using one EV to provide back-up power was valued at $168/year. The avoided cost of one EV at a residential home was $26/year. It is important to note, the SDG&E grid territory used has one of the best reliability indexes in the state and therefore the overall avoided cost is relatively low on an annual basis. However, in areas of the state with poor reliability indexes and especially in areas likely to be subject to increased Public Safety Power Shutoffs (PSPS) the value could be much greater by providing customers a safer, cleaner alternative to a diesel backup generator. Therefore, there is a strong argument for future analysis to understand how EVs, including medium/heavy duty models, can be leveraged to provide this type of service.

Use Case #4: Workplace V2G Value Streams in California

The fourth use case demonstrated the technical capability of an aggregation of V2G-capable EVs to provide regulation up and down to CAISO's ancillary services (AS) market and quantified the potential revenue through CAISO's settlement process. The vehicles were used by the project drivers and responded to simulated dispatch signals via the Nuvve GIVe™ aggregation platform

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[9] De-Energization (PSPS), California Public Utilities Commission (CPUC) https://www.cpuc.ca.gov/deenergization/ (accessed 8.29.19)

[10] The CA-10 EVSE is not capable of a "black start" and therefore required the vehicle to be plugged in prior to interrupting the grid power in order to maintain an uninterruptable power supply.

for one year from June 2018 to June 2019, therefore capturing seasonal variation in driver habits and in CAISO energy prices.

Successful implementation and high revenues from frequency regulation in other geographies made this use case an obvious choice to explore in California when the EVSA project was scoped in 2016. However, the use case had to be implemented under significant constraints due to the EVSA coalition not being able to participate live in the CAISO market. Participation was not possible first because the coalition did not meet minimum capacity requirements of 500kW and second, because behind-the-meter resources like EVs do not currently have a pathway to economically settle wholesale and retail meter readings. Therefore, even if the minimum capacity requirement was met, current settlement procedures would not allow for economical participation. Combined, these two constraints resulted in the coalition not being able actively participate in the AS market, receive a live dispatch signal from CAISO or have CAISO take into account the coalition's state of charge (SOC) when determining dispatch set points.

After months of evaluation and input from stakeholders it was decided the next best option was to dispatch the EVSA coalition using a historical CAISO Automated Generation Control (AGC) signal recorded from the Los Angeles Air Force Base (LAAFB) V2G project[11] in order to demonstrate the technical ability of EVs to respond to the 4-second set points of an AGC signal. Another important constraint was the aggregation platform used for dispatch was limited to symmetrical dispatch of regulation up and down, when in reality the two are separate products and therefore are bid and dispatched separately.

In addition to the market participation constraints, the EVSA coalition highlighted the real-world scenario of highly variable vehicle availability as a result of relying on personal use vehicles. The project vehicles were used as personal vehicles in a University workplace use case notable seasonal fluctuations of availability due to school breaks as well as staggered work schedules. Two key components impact vehicle availability for providing grid services, and therefore the value captured – driver commute distance and driver schedule (arrival and departure). Assuming an 8-hour workday, the vehicles were expected to be plugged in a maximum of 22% of the total hours in a month. On average, the vehicles fell below this monthly threshold 65% of the time, resulting in an average plug in time of 14% across the entire coalition over the duration of data collection. Although the total capacity of all eight EVSA vehicles would have been 64 kW, the maximum bid submitted throughout the course of the project was 35 kW due to the limited availability of the small coalition. This trend therefore significantly limited revenue generation potential from frequency regulation in a University workplace use case and could be improved with a fleet of vehicles plugged in for longer periods of time and more consistently.

Over the ten months of simulated dispatch (Sept 2018 – June 2019), E3 also evaluated the EVSA coalition's performance accuracy, non-compliance charges, and capacity and mileage settlements for regulation up and down. During the analysis period, the monthly performance accuracy

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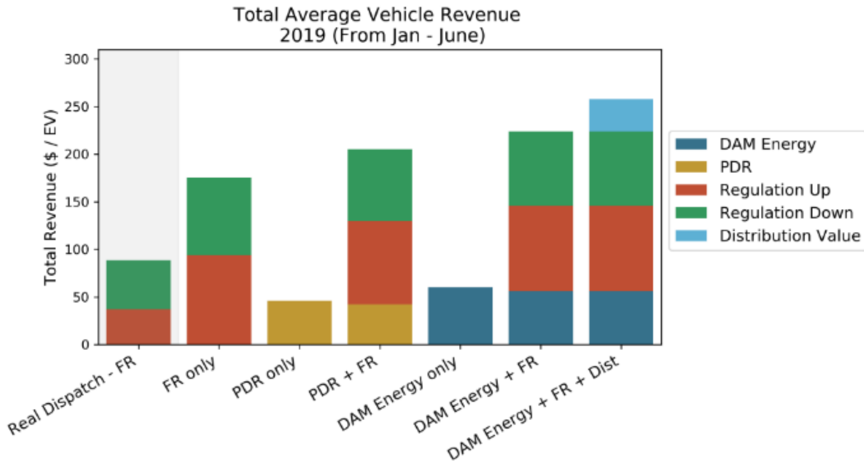
[11] Los Angeles Air Force Base Vehicle-to-Grid Demonstration – https://vehicle-grid.lbl.gov/project/los-angeles-air-force-base- vehicle-grid (accessed 8.15.19)

ranged from 38% to 60% for regulation up and 42% to 69% for regulation down. These results are well above CAISO's 25% minimum accuracy threshold and indicate the technical feasibility of EVs providing the service. The net revenues for the entire EVSA coalition, including the vehicles with below average availability, ranged between $3 – 20 per vehicle per month with an average $9.63 per month, or $115.57 per vehicle per year. These figures are in line with the results from the LAAFB project which reported monthly revenues from $5 – 55 per vehicle per month. However, the results are not directly comparable because LAAFB included EVSE-EV pairings with power ratings between 15 – 50 kW (compared to EVSA with a max power rating of 10 kW), submitted bids exclusively during evening hours and bid a larger percentage of time by operating on the weekends.

Overall, the results of the revenue analysis must be interpreted within the context of the market participation constraints and driver availability trends and recognize there is room for improvement. In addition, it is important to match use cases, and therefore vehicle availability, with the optimum service. The results above indicate a University workplace setting with a small number of light-duty vehicles is not the optimum use case match with frequency regulation service in California. However, a fleet with a more predictable schedule with actual market dispatch could achieve greater certainty around available bidding capacity and therefore optimize value streams.

E3 built upon their analysis completed under Use Case #2 and leveraged their RESTORE dispatch optimization tool to calculate the upper limit of revenue of the EVSA coalition over the project time frame by optimizing bidding and dispatch within the availability constraints discussed above. Based on RESTORE's optimization of operational data collected from January – June 2019, revenues were increased 133% overall, reaching almost $50 per EV per month in April 2019, when regulation down prices peaked. The increase in revenues can be attributed to RESTORE's perfect foresight regarding driver charging patterns and day-ahead market prices as well as the ability to submit separate bids for regulation up and down.

Finally, E3 also used RESTORE and the EVSA vehicle availability data to evaluate other revenue streams the coalition could have been dispatched against: CAISO's proxy demand response (PDR) mechanism, the day-ahead energy market (DAM) and distribution upgrade deferral value. Currently, behind-the-meter, distributed energy resources like V2G-capable electric vehicles only have access to the PDR mechanism. The figure below compares the total average vehicle revenue for six months of the project operation across the seven scenarios examined – the real dispatch of the EVSA coalition, the optimized dispatch by RESTORE and RESTORE's modeled results of combinations of other services. Revenue estimates are based on actual vehicle availability data for the University workplace use case and are therefore lower than what would be possible with a fleet with longer and more consistent plug-in hours.



These revenue estimates represent snapshot values under a rapidly evolving energy system and wholesale market. For example, forecasting analysis conducted by E3 under the project shows the value of frequency regulation is likely to decline in the future, while more volatile energy prices could bring greater energy market and PDR revenue opportunities. The PDR revenues above assume the baseline load profile is the underlying site load with no EV charging, rather than an unmanaged charging baseline which could increase PDR revenues further. Furthermore, this study looked only at day ahead PDR and energy markets in Q1 and Q2, which historically have lower energy prices than Q3 and Q4, thus providing a limited view to the potential of yearly value.[12, 13] Under PDR, EVs would also have access to the 5-minute real-time market which tends to have much larger prices swings but is naturally much harder to predict. Finally, with the growth in renewable generation, the PDR-Load Shift Resource (LSR) product under development by CAISO has the potential to provide even greater opportunities to arbitrage CAISO energy markets.

Conclusion and Next Steps

In the broader context of a worldwide push toward transportation electrification and more renewable energy production, the EVSA project confirmed the technical ability of V2G-capable electric vehicles to provide a range of services across key areas of grid operation – behind-the-meter, distribution and transmission. Specifically, the project EVs successfully demonstrated emergency back-up power, solar over-generation balancing, reverse power flow to mitigate peak load ramping, demand response and regulation up / down. The project executed and evaluated a key process requirement for scalable V2G deployment – interconnection – therefore providing key insights to regulatory proceedings that will help inform the California policy roadmap for V2G. The EVSA project also further highlighted some of the key barriers to accessing these value streams, including inapplicability of current interconnection standards for V2G-AC and

[12] 2017 Annual Report on Market Issues & Performance, pg. 5, California, ISO, June 2018. http://www.caiso.com/Documents/2017AnnualReportonMarketIssuesandPerformance.pdf (accessed 9.3.19)

[13] Q2 Report on Market Issues and Performance, California ISO, September 5, 2019. http://www.caiso.com/Documents/2019SecondQuarterReportonMarketIssuesandPerformance.pdf (accessed 9.3.19)

unresolved market settlement procedures (retail vs. wholesale), both of which are in the process of being discussed in state-level regulatory proceedings. A full overview of the barriers to V2G implementation in California can be found in the *California V2G Action Plan* in Appendix B of the EVSA Final Report.

Finally, the project quantified current and future services V2G technology could provide, demonstrating there is potential for both value in the form of revenue to the customer and value to the grid. The results of Use Case #4 indicate a small, highly unpredictable coalition in a University workplace use case is not a good fit for optimizing value from frequency regulation in California. Therefore, a key conclusion from the EVSA project is the need to strategically match the service being provided with the use case, and therefore the availability of the vehicles being used (fleet, workplace, residential, etc.). If the EVSA coalition followed a predictable fleet use case where the vehicles were plugged in for more hours and more consistently, revenue and value to the grid could be optimized further.

Overall, the most significant challenge for V2G technology is not further proving how its technical capabilities can provide benefits to the California grid, but rather translating those benefits into price signals and vehicle use cases to encourage private industry investment in the technology and EV driver participation. This challenge needs to be addressed in the context of the quickly evolving grid and energy markets in California and a specific focus of forth-coming stakeholder discussions around vehicle grid integration. It is critical to set an environment now for investment and innovation in V2G technology that will an enable a cleaner, more cost-effective grid for all Californians.

CHAPTER 1: Introduction

Project Background

The purpose of the Electric Vehicle Storage Accelerator (EVSA) project is to test whether vehicle-to-grid (V2G) technology is a viable and cost-effective energy storage resource able to provide services to the California grid. Understanding the potential of V2G technology is a critical component to inform the implementation of California's complementary policy goals of grid decarbonization and transportation electrification. Despite the recent commercial progress of fixed energy storage as a grid resource, the use of electric vehicles (EVs) as an energy storage resource has had modest momentum due to key hurdles to the development and commercialization of the technology ecosystem required to implement V2G. Key hurdles include, but are not limited to: availability of Rule 21-compliant inverters, availability of V2G-capable vehicles and charging stations, impact on EV battery warranty, and the quickly evolving landscape of energy markets and value streams in the state.

Therefore, the goal of the EVSA project was to further examine these key hurdles through the following objectives: (1) create a test environment for major automakers, Nissan, Honda and Fiat-Chrysler, to gain experience with V2G technology, (2) advance product readiness of bi-directional inverters needed in either the charging stations or on-board the vehicles themselves, (3) identify and test key V2G use cases, (4) inform public policy by leveraging the data and insights gained from the project.

With support from project and agency stakeholders, the EVSA Project Team developed and executed a set of use cases to demonstrate whether V2G can be an effective energy storage resource for California. The four use cases include:

USE CASE #	TOPIC	DESCRIPTION
1	Interconnection of V2G Resources	Execute the process required to interconnect and receive permission to operate bi-directional electric vehicles on the distribution grid.
2	Transformer Upgrade Deferral	Collaborate with the California Energy Commission's EPIC funded project EPC-14-086 to demonstrate the ability, and quantify the value of, managing EV charging and discharging based on local transformer load to avoid undue stress and upgrades.
3	Emergency Back-up Power	Demonstrate the ability, and quantify the value of, an EV providing back-up power in the case of a power outage.

4	Workplace V2G Value Streams in California	Demonstrate, and quantify the value of, an aggregation of V2G-capable EVs in a workplace setting to provide regulation up and down to the California Independent System Operator's (CAISO) ancillary services market. Examine other value streams available to V2G-capable EVs.

The EVSA project benefitted from a diverse array of project stakeholders that assisted in scoping the project's use cases listed above and providing valuable feedback to Project Team. The key project and agency stakeholders that contributed to the use case scoping, implementation as well as the project's quarterly project update calls include: Honda Motors, Nissan Motors, Fiat-Chrysler Automobiles, Electric Power Research Institute (EPRI), Kitu Systems, UC San Diego, San Diego Gas & Electric (SDG&E), Princeton Power Systems, MaxGen Services, California Independent System Operator staff, California Energy Commission staff and California Public Utilities Commission staff.

Project Setup

EVgo installed eight V2G capable EVSEs at various locations on the University of California, San Diego (UCSD) campus. Six of the eight EVSEs were commercially available, DC CHAdeMO 10 kW charging stations manufactured by Princeton Power Systems and were used to charge six, unaltered 2016 Nissan LEAFs (each with a 30 kWh battery). The other two chargers were SAE J1772 AC Level 2 stations manufactured by Nuvve and are used to charge two retrofitted Honda Accord Plug-in Hybrid Electric Vehicles (each with a 6.7 kWh battery). The Hondas and the AC stations are outfitted with additional communication modules to enable bi-directional energy flow and are capable of 2 kW power transfer via a mobile inverter on-board the Honda Accord vehicle. In total, the eight project vehicles had a capacity of 193.4 kWh and 64 kW.

Figure 1. EVSA Project Set-up

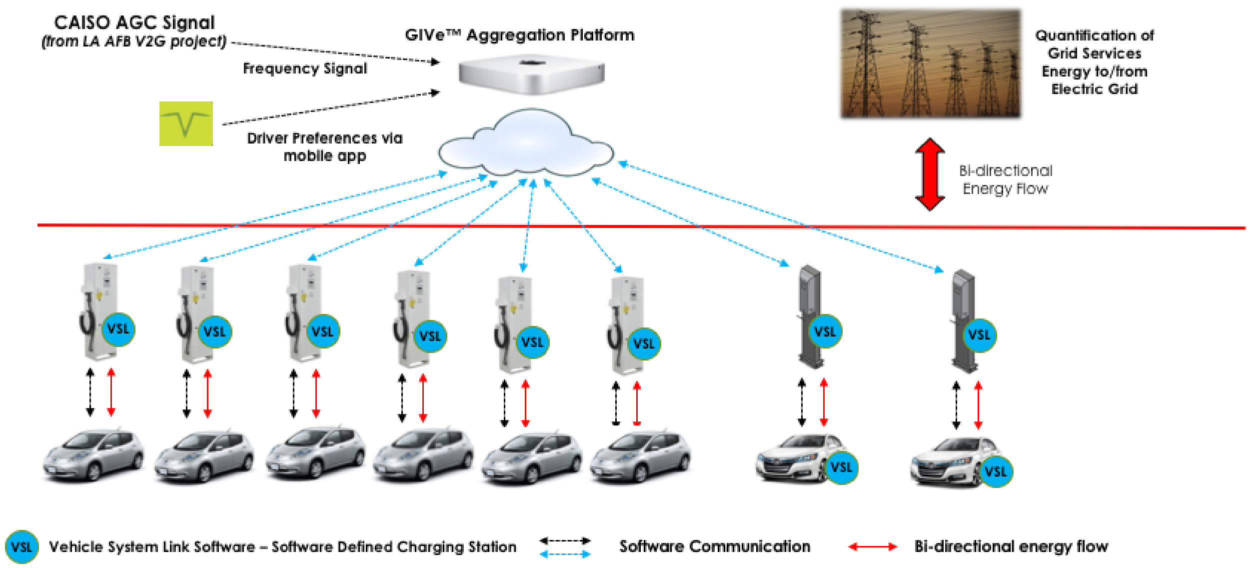


Figure 2. Installed EVSA stations

a) Nuvve PowerPorts at P703 Parking Lot

b) PPS CA-10 at Center Hall

c) PPS CA-10 at Hopkins

d) PPS CA-10 at Hopkins

e) PPS CA-10 at UCSD Police Department

f) PPS CA-10 at Scripps Institute of Oceanography

g) PPS CA-10 at UCSD Surplus Store

The project vehicles were used under a workplace charging use case and assigned to employees at the University of California, San Diego (UCSD) to be used as personal commute vehicles. Drivers were expected to be plugged in and available to provide regulation up and down during normal work hours (9 – 5 pm, Monday – Friday, ~40 hours per week total).

Installation

A unique component of the installation process of the EVSA charging stations was the need for a hardwire internet connection in the form of an ethernet cable from the charging station to the closest network switch at UCSD. A designated ethernet cable for each station required separate conduit runs for ethernet and electricity which increased the price of installation overall. The ethernet cable was a requirement because the charging stations used were first generation models, therefore the manufacturers had not implemented other options like Wi-Fi or cellular for data communications between the charging stations and the Nuvve GIVe™ aggregation platform.

Four out of the six EVSA project sites were installed in conjunction with the CPUC / NRG Settlement's deployment of "make ready" stubs at the UC San Diego campus.[14] Therefore, the installation costs for EVSA-specific infrastructure were only identifiable for two sites – Center Hall and Hopkins Parking Structure.

The total cost of installation at Center Hall was $16,434 for one Princeton Power CA-10 unit and the removal of an existing charging station. The total cost of installation at Hopkins Parking Structure was $11,271 for two Princeton Power CA-10 units and the removal of two existing charging stations. The installation at Hopkins leveraged existing conduits from prior stations and did not require any civil work. Therefore, the overall cost was significantly less than the

[14] CPUC/NRG Settlement Agreement. https://www.cpuc.ca.gov/General.aspx?id=5936

installation at Center Hall which required lengthy, new conduit runs and civil work to pour concrete pads for the charging station to be mounted to.

Table 1. Example of cost breakdown for Installations

Task	**Hopkins Price ($)**	**Center Hall Price ($)**
Engineering & Design	$1,700.00	$2,000.00
Installation & Logistics	$3,555.00	$6,960.00
IT / Ethernet Install and Testing	$300.00	$660.00
Electrical Labor	$2,720.00	$2,720.00
Project Management	$600.00	$600.00
Overhead & Profit	$2,396.25	$3,493.80
Total	**$11,271.25**	**$16,433.80**

Once the 7 charging stations located on the UCSD micro-grid were installed, they were inspected by UC San Diego given the University is the authority having jurisdiction for all assets installed on the campus micro-grid. Upon inspection and approval by UCSD inspectors, the stations commenced bi-directional operation. The 8th charging station located at the UCSD Surplus Store had to complete an interconnection application with SDG&E as part of Use Case #1 prior to engaging in bi-directional operation. Chapter 2 documents this process in detail.

CHAPTER 2: Interconnection of V2G Resources

Use Case Overview

The State of California's current interconnection rules and procedures have evolved around the rapidly increasing number of stationary storage and photovoltaic solar resources connecting to, and discharging to, the distributed grid. Therefore, a key area of exploration scoped under the EVSA project was to explore the process of interconnecting bi-directional electric vehicles within the current regulatory landscape developed around stationary storage resources. The scope of this use case was to work with project partner San Diego Gas & Electric (SDG&E) to submit and process Rule 21 Interconnection agreements[15] at two project sites outside of the UCSD micro-grid: (1) UCSD's Surplus Store Warehouse and (2) SDG&E's Century Park Campus. The goal of this use case was to document the experience of interconnecting the first V2G-capable vehicles in SDG&E territory in order to inform future revisions to the interconnection process to accommodate EVs.

The UCSD Surplus Store is located off of the main UCSD campus micro-grid and is a storage and shipping facility for the University with solar and stationary storage on site. The interconnection at this site was with a 2016 Nissan LEAF SV (30 kWh battery capacity) and a Princeton Power Systems (PPS) CA-10 station (V2G-DC scenario in Figure 3). The CA-10 is a 10-kW CHAdeMO DC charger with a UL1741-certified inverter located within the station.

SDG&E's Century Park Campus was the original site selected for the interconnection of a 2014 Honda Accord Plug-in Hybrid Electric Vehicle (6.7 kWh) and a Nuvve PowerPort station (V2G-AC scenario in Figure 3 below). The Honda has a 2-kW on-board inverter as well as a Vehicle Smart Link (VSL) communications module developed by Nuvve that allows the Honda to communicate with the PowerPort station. The PowerPort station is an 18 kW AC charging station with a J1772 cable.

[15] A Rule 21 Interconnection Agreement is the formal agreement between SDG&E and customer that allows the customer's self-generating unit to discharge safely to the distribution grid. The agreement is the final stage in the interconnection process where SDG&E evaluates the potential impact of the unit on the distribution grid.

Figure 3. Interconnection resources overview

Chapter 2 of this report details the interconnection process the EVSA Project Team experienced at the two sites and describes why only the configuration at the UCSD Surplus Store ultimately received permission to operate from SDG&E.

UCSD Surplus Store

The interconnection application for the V2G-DC setup at the UCSD Surplus Store was submitted to SDG&E in March 2017 by the UCSD Facilities Management team with assistance from the EVSA Project Team. The teams first attempted to submit the application through SDG&E's online portal. However, the online portal had required fields of information that were nonapplicable to the interconnection of a V2G resource and therefore could not be filled out. The applicant (UCSD) therefore could not proceed to subsequent windows in the online portal and could not submit the application online. Once it became clear the online application portal would not work for this situation, SDG&E provided UCSD and the Project Team with a pdf version of the interconnection application paperwork that allowed for more flexibility in the submission of information. The form required to be filled out was Form 142-05203 – Generating Facility Interconnection Application.

A key component of the application review process was to determine how the interconnection would be classified – i.e. classifying the type of operating modes of the resource (Form 142-05203 - Part 3 Describing the Generating Facility and Host Consumer's Electrical Facilities).[16] Determining the classification of the resource took a few months due to the resource not clearly fitting into the current frameworks SDG&E had available and because the interconnection site has a complicated metering set up with net energy metered solar and stationary storage behind a site SDG&E retail meter. After further evaluation, SDG&E determined the interconnection at the Surplus Store would be classified as non-NEM, parallel operation, continuous export generator eligible for multiple tariff.

[16] A copy of Form 142-05203 that was submitted to SDG&E can be found in Appendix A of this project report with all UCSD information removed.

Once the classification was determined, the forms were filled out and returned to SDG&E mid-August 2017. Following submission, the SDG&E Customer Generation team reviewed the application and asked clarifying questions, which were largely focused on clarifying the set-up of the metering at the Surplus Store for the on-site solar array in order to preserve its net-energy metering (NEM) status.

Upon review of the application, SDG&E discovered an omission in the paperwork submitted when the PPS CA-10 unit was originally installed at the site in late 2016. They require detailed drawings showing how the wiring will tap the existing buss tap in the main switchboard at the site. This required a specialized drawing that had not been submitted during the initial review process, despite the installation being tested and approved by SDG&E. The Project Team enlisted engineering firm MaxGen Services to draft the necessary drawing to be included with the site single lines in the interconnection application.

Once a satisfactory buss tap drawing was provided to SDG&E in September 2017, they requested review and approval of the disconnect switch installed at the site to ensure it was adequate. Once the disconnect switch was reviewed, SDG&E required confirmation of the UL 1741 certification of the inverter and the UL-field listing of the station overall. The inverter within the CA-10 unit was factory listed and was on California Energy Commission's Solar Equipment list as an approved inverter at the time (prior to the Rule 21 update to UL 1741 SA that went into effect on September 8, 2017). The CA-10 station however, was not factory listed and therefore needed to go through a field listing in order to receive permission to operate. The field listing required additional time to set-up a site testing date with the manufacturer, Princeton Power systems and their chosen National Recognized Testing Lab (NRTL), TUV Rheinland. Once the field testing was successfully executed the documentation was submitted to SDG&E.

After the certifications were reviewed, a series of corrections to the original application submitted by UCSD were required to ensure accuracy – specifically the name plate capacity of the inverter needed to be changed from 30 kW to 10 kW and the name of the inverter make/model needed to be updated. This issue arose due to UCSD staff having incorrect information when first attempting to fill out the application online in March 2017. The information was never updated in the SDG&E system despite the correct information being included in the pdf applications submitted later in the process. This is an example of an administrative delay in the process that will be mitigated with additional experience.

Once the application was fully reviewed and corrected in January 2018, the final authority having jurisdiction (AHJ) electrical release was scheduled by UCSD and was followed by a final field inspection by SDG&E. UCSD completed the electrical release and submitted to SDG&E on February 13, 2018. Final inspection by SDG&E occurred on February 16, 2018, but it failed due to no placards being installed on site to identify the disconnect switch of the station and to identify the location of the V2G station from the main electrical room on site. Prior to this point, no instructions had been provided indicating placards were required. Once additional detail regarding placard requirements were obtained from SDG&E, the necessary placards were installed and approved in early April 2018. The system received permission to operate (PTO) on April 24, 2018 and became the first V2G resource to interconnect to the SDG&E grid.

Century Park Campus

During the original scoping of the project, the Project Team and SDG&E agreed to deploy one of the three Honda Accord PHEVs participating in the project at SDG&E's headquarters in San Diego to deepen SDG&E's experience with vehicle-to-grid technology and showcase SDG&E's support for, and involvement in, the innovative technology. The other two Accords were to be deployed on the UCSD micro-grid and therefore did not require an interconnection application. The implementation plan at Century Park was to install a V2G capable Nuvve PowerPort charging station to charge/discharge the Accord, complete an interconnection application with SDG&E to allow for discharge and once completed, provide SDG&E employees access to the vehicle for off campus meetings and errands.

The goal at Century Park was to interconnect a bi-directional electric vehicle with an on-board, mobile inverter (V2G-AC in Figure 3 above). The goal was to further understand the differences between the interconnection and operation of a mobile inverter in an EV and stationary inverters found in solar panels, storage and V2G-DC charging stations. A key difference highlighted by the EVSA project is which certification standard the inverter is subject to. The Honda Accord PHEVs were engineered by Honda to comply with the Society of Automotive Engineers (SAE) J3072 standard, which references the IEEE 1547 standard for safety requirements such as anti-islanding, among others. SAE developed J3072 to specifically address the safe interconnection of mobile inverters and to take into consideration their different use cases, safety considerations and load planning implications as compared to stationary inverters. Therefore, SAE J3072 is different than the UL 1741 standard required by California's Rule 21 for all stationary inverters, although UL 1741 also references IEEE 1547 for safety requirements.[17]

Prior to the EVSA project, the 2014 Honda Accord PHEV's on-board inverter completing testing to IEEE 1547 at the National Renewable Energy Lab's (NREL) testing lab in Golden, CO and also at TUV Rheinland in Japan. The majority of requirements under IEEE 1547 were met, including anti-islanding, with the exception of one (high-order harmonics under one test condition), which was borderline. The Project Team and Honda representatives (Satoru Shinzaki, Project Manager) worked to socialize the test results with SDG&E's Clean Transportation Team, UCSD account representative and Customer Generation Team between July and September 2017 to emphasize the compliant safety components of the vehicle inverter and the limited impact the vehicle's 6.7 kWh battery and 2 kW inverter would have when discharging.

After months of discussion, SDG&E's Customer Generation team formally decided the vehicle would not be able to interconnect to the SDG&E grid and therefore would not be sited at Century Park because the vehicle's on board, mobile inverter did not comply with Rule 21 requirements (i.e. UL 1741). SDG&E's Clean Transportation team then worked internally to try to find another location to deploy the vehicle while still achieving the project objectives. SDG&E's Integrated Testing Facility was evaluated as a potential location that would allow for testing, but the option was also eventually not approved by SDG&E. Following these decisions, Honda did not see a

[17] At the time of evaluation, UL 1741 SA had not gone into effect therefore discussions were regarding UL 1741.

business case for further retrofitting this research vehicle to comply with UL 1741. In addition, more inverter retrofits did not fit into the timeline for this project.

Therefore, the third Honda Accord did not actively participate in the EVSA project. Instead, it fulfilled a valuable role as a loaner vehicle to the drivers of the other two Accords when the vehicles required maintenance.

Key Learnings

(1) *As currently written, UL 1741 / UL 1741 SA are not appropriate to apply to bi-directional electric vehicles with on-board, mobile inverters.*

UL 1741 and the Supplement A update covering California's smarter inverter requirements were not created with mobile inverters on-board electric vehicles in mind. Specifically, it includes physical certification requirements such as wire sizes and inverter mounting parameters to a building, etc. that are not applicable to vehicles. SAE J3072 was drafted to address the safety considerations (i.e. IEEE 1547) specific to the interconnection of electric vehicles. For example, J3072 includes a critical feature for safe interconnections by requiring the charging station to confirm the plugged in vehicle is compliant with required interconnection standards prior to discharging. This feature is not present in UL 1741 SA, therefore highlighting the insufficiencies of applying UL 1741 SA to onboard mobile inverters. That being said, SAE J3072 also needs to be updated to include the update to IEEE 1547.1, per stakeholder discussions in Working Group 3, under the CPUC's Rule 21 Interconnection Rulemaking 17-07-007.[18]

(2) *The lack of a vehicle-specific interconnection process caused delays.*

Delays in the project timeline occurred due to the Project Team not being able to successfully progress through the online SDG&E interconnection application portal. Administrative delays were therefore also incurred due to the use of pdf application documents and incorrect information not being updated in the portal after the submission of the pdf application.

(3) *The categorization of a bi-directional EV in conjunction with other resources behind the same meter at the UCSD Surplus Store was an important precedent set by SDG&E.*

SDG&E determined the interconnection at the Surplus Store would be classified as non-NEM, parallel operation, continuous export generator eligible for multiple tariff. This decision dictates the type of rate the vehicle is subject to and therefore dictates the value streams that vehicle could potentially capture through providing services. The precedent set by SDG&E under the EVSA project is important to highlight because the situation where multiple behind-the-meter (BTM) resources are interacting at one site will become

[18] California Rule 21 Working Group 3 Website: http://gridworks.org/initiatives/rule-21-working-group-2/

increasingly common as more commercial/industrial and residential customers deploy combinations of solar, storage and V2G-capable EVs.

(4) *Cost of interconnection for small (<10 kW), residential resource could be cost-prohibitive*

SDG&E requires an $800 processing fee for each interconnection application for resources behind different meters. Although this is not cost prohibitive to commercial & industrial systems potentially deploying several electric vehicles behind one meter, the cost could be prohibitive in the residential setting where customers are already price sensitive. In the future, automakers may be able to incorporate this cost into the overall price of the vehicle upon sale, assuming there is an ability to type test vehicle inverters in combination with a more streamlined interconnection process.

(5) *Few bi-directional charging stations with Rule 21-compliant inverters are commercially available.*

While Use Case #1 was being completed (2016 – 2017) there was only one bi-directional charging station manufacturer with Rule 21-compliant inverters available on the market – Princeton Power Systems and their CA-10 and CA-30 stations. Following the update to Rule 21 to include the smart inverter requirements on September 8, 2017, there were no Rule 21 compliant, bi-directional charging stations commercially available. This is still the case at the time of writing this report (Summer 2019). The lack of availability of compliant charging stations is a critical challenge for the progression of V2G technology in California. Once additional compliant stations are commercially available, California utilities will have additional incentive to dedicate time and resources to re-evaluate their interconnection processes for electric vehicles.

Recommendations

Overall, a more streamlined process for interconnecting bi-directional electric vehicles needs to be developed by distributed system operators across the state of California. The time and resources required to process one interconnection in SDG&E territory for a 10kW resource was not scalable to the millions of electric vehicles the state hopes to deploy by 2030.

With this high-level recommendation in mind, the key learnings regarding interconnection from the EVSA project were presented to Working Group 3 under the CPUC's Rule 21 Interconnection Rulemaking 17-07-007, Issue 23. The main recommendations to the working group that stemmed from the EVSA project were: 1) revise the online interconnection portals for the investor owned utilities (PG&E, SCE and SDG&E) to streamline the application process for bi-directional electric vehicles, and 2) create a sub-working group to address the specific nuances of interconnecting electric vehicles with mobile, on-board inverters (V2G-AC) and evaluate how current standards can be updated to ensure a safe and functional grid, 3) confirm the V2G-DC framework (in Figure 3) is sufficiently addressed by Rule 21 as currently written and 4) Bi-directional EVs are equivalent to storage.

Recommendation #2 was formally submitted as a motion to Rulemaking 17-07-007 and 18-12-006 (Development of Rates and Infrastructure for Vehicle Electrification, also known as the DRIVE OIR) by the California Energy Storage Association (CESA) for consideration by the CPUC.[19] The key area of focus for the sub-working group includes mapping the existing standards against each other (SAE J3072, IEEE 1547, UL 1741) and determine how well they can fulfill safety requirements for interconnection of a mobile inverter. The CPUC released a decision on recommendation #2 on August 23, 2019 establishing a Vehicle to Grid Alternating Current (V2G AC) interconnection subgroup in Rulemakings 17-07-007 and 18-12-006 in order to "discuss and identify existing standards to fulfill safety requirements for the interconnection of a mobile inverter."[20]

Recommendations #1, 3 and 4 are still under consideration by the CPUC under Rulemaking 17-07-007 at the time of writing.

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[19] MOTION OF THE CALIFORNIA ENERGY STORAGE ALLIANCE TO ESTABLISH SUB-GROUP AND SCHEDULE JOINT WORKSHOP IN RULEMAKINGS 17-07-007 AND 18-12-006 TO INTRODUCE SUB-GROUP PROPOSAL ON MOBILE INVERTER TECHNICAL REQUIREMENTS FOR RULE 21 INTERCONNECTION.
http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M294/K992/294992989.PDF

[20] JOINT ADMINISTRATIVE LAW JUDGES' RULING ESTABLISHING SUBGROUP AND SCHEDULE TO DEVELOP PROPOSAL ON MOBILE INVERTER TECHNICAL REQUIREMENTS FOR RULE 21 AND NOTICING WORKSHOP, Filed 8/23/19. Accessible: http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M311/K582/311582954.PDF

CHAPTER 3: Transformer Upgrade Deferral

Use Case Overview[21]

The second use case under the EVSA project was scoped as a collaboration with another project funded under the California Energy Commission's Electric Program Investment Charge (EPIC) focused on vehicle-to-grid (V2G) technology. The project was titled *Distribution System Aware Vehicle to Grid Services for Improved Grid Stability and Reliability* (CEC Project Agreement Number EPC-14-086). The *Distribution System Aware* and EVSA project had similar objectives in demonstrating V2G technology as well as quantifying the potential value of using the technology to provide an array of grid services. Therefore, the project teams saw synergies for technology development and integration, site development and overall collaboration on implementation. The result was the EVSA project providing budgetary support for the *Distribution System Aware* project in the form of payment for key technology licenses and research and development work required for the demonstration.

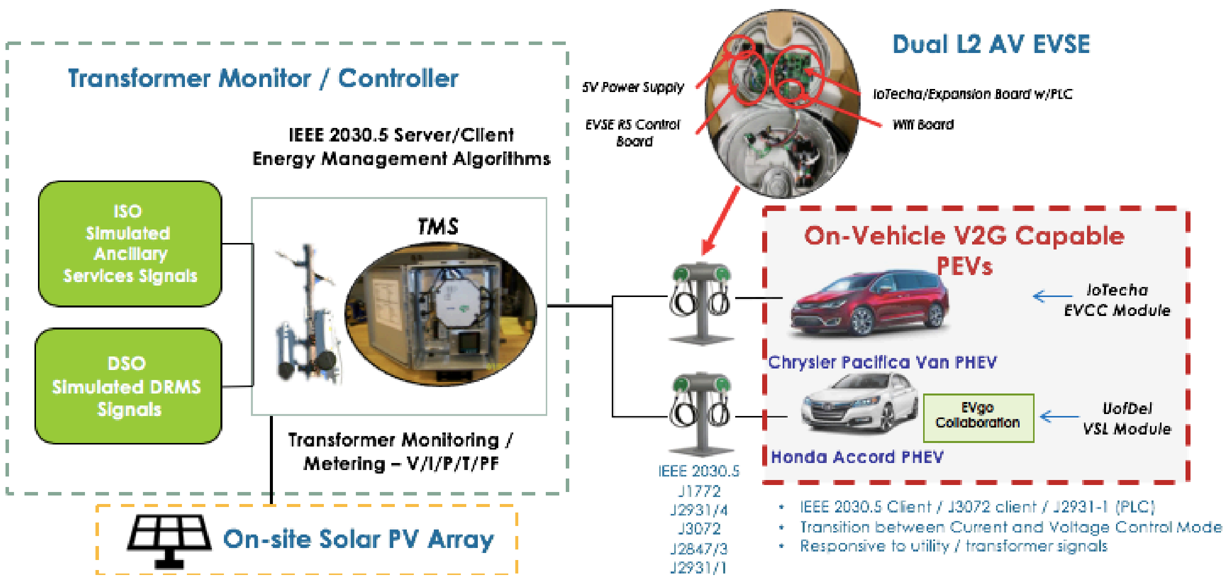
The *Distribution System Aware* project was the first ever end-to-end system implementation, demonstration and application of Society of Automotive Engineers' (SAE) standards to execute vehicle-to-grid technology, including SAE J3072, a key standard for confirming an EV with an on-board inverter can safely discharge to the grid. The project demonstrated several use cases, including PV over-generation balancing, reverse power flow to mitigate peak load ramping and demand response. All use case testing incorporated a 75 kVa transformer installed at the project site in order to simulate real-world scenarios involving EVs scattered around a representative residential neighborhood all sending and receiving power through a local transformer. Energy and Environmental Economics (E3) was then tasked with quantifying the value to the grid of implementing these various use cases and other grid services.

The use cases were demonstrated through the use of one Honda Accord PHEV and three Chrysler Pacificas with on board, mobile inverters. The vehicles remained stationary throughout the project testing and were charged by two dual-headed AeroVironment EVSE-RS Level 2 charging stations that had been retrofitted with communications modules to communicate charging/discharging commands from the local transformer management system (TMS) developed by EPRI to the vehicles themselves. All assets were located at the P703 parking lot at UC San Diego and included the on-site solar panel as part of a second life battery plus solar fast

[21] Please note, all content in this chapter draws heavily from the final report of the project titled *Distribution System Aware Vehicle to Grid Services for Improved Grid Stability and Reliability,* accessible here: https://ww2.energy.ca.gov/2019publications/CEC-500-2019-027/CEC-500-2019-027.pdf

charging plaza at UCSD operated by EVgo. The full demonstration set-up is shown in Figure 4 below.

Figure 4. Distribution System Aware Demonstration Set-up Diagram



The *Distribution System Aware* project was conducted in four phases:

1. Requirements, design, technology development
2. Technology integration, deployment, test
3. Analytical assessment of value and possible avenues to integrate into utility planning process
4. Technology dissemination / transfer

Phase 1: Requirements, Design and Technology Development

This phase involved developing technical requirements into functional specification, interfaces, architecture, and system test plans. Individual team members designed, tested, and implemented hardware and software components to prepare for the demonstration. The research team developed and used emulators wherever possible to simulate the system surrounding the component to accelerate system integration and create baselines for the on- site demonstration.

Phase 2: Technology Integration, Deployment, and Testing

In this phase, AeroVironment and Kitu Systems developed the electric vehicle supply equipment (EVSE) and control software, respectively; the University of Delaware (Honda) and Fiat Chrysler Automobile developed the on-vehicle software and hardware implementation while Iotecha completed the control card interface. The Electric Power Research Institute (EPRI) developed and integrated the transformer management system which constrains monitoring and control of the V2G operation to the local transformer and facility distribution service drop. The project team integrated the subsystems (EV, electric vehicle supply equipment, and transformer management system) and tested the entire system at Fiat Chrysler's Auburn Hills facility. Finally, the entire system was integrated at the University of California, San Diego campus test site where test and data collection activities were performed. Figure 5 and Figure 6 below show pictures of the installation at UCSD.

Figure 5. UCSD Site with all four project vehicles

Figure 6. UCSD Site – Installation of 2 dual-headed AeroVironment EVSEs

Phase 3: Value Assessment, Planning Pathways Assessment

The EPRI and E3 teams studied the project's value of grid services using a variety of techniques. The teams used a cost/benefit framework and simulation tools to analyze the value potential possible from V2G-capable EVs in a variety of scenarios that were demonstrated at the test site.

Researchers performed the planning pathways assessment by studying the ongoing planning activity managed by the CPUC, California ISO, and Energy Commission to identify what type of operational, scenario planning, and modeling assumptions would need to be created for this new class of flexible loads and resources to create procurement requirements for transmission and distribution system planners.

Phase 4: Technology Dissemination and Transfer Activities

The team performed numerous technology transfer activities as a part of this project to a broad range of stakeholders through multiple EPRI utility membership engagements, regional and national conferences, participation in standards development organization work groups, and application sharing of this technology into other Energy Commission and federally funded EV smart grid integration research and development programs.

The full methodology and results of the *Distribution System Aware* project can be found in the official CEC-published report released in March 2019. The EVSA report will only cover the high-level results and takeaways of the full report in the following section.

Summary of Results

According to the final report issued by the California Energy Commission, there were four key lessons learned from the *Distribution System Aware* project implementation and analysis:

1. The need for utility adoption of J3072 in order to enable the necessary communications and interconnection processes for onboard, mobile inverters on electric vehicles. This is in line with the conclusions drawn in Chapter 2 of this report based on the EVSA project's experience with the successful interconnection of a V2G-DC set-up and the failed interconnection of a V2G-AC set-up (as defined in Figure 3 of Chapter 2).

2. The transformer management system (TMS) developed by EPRI under the project proved to be effective in managing load in a residential transformer and community aggregation application through SEP 2.0 / IEEE 2030.5. This demonstrated an on-site management system can dispatch electric vehicles to fulfill various services needs and therefore provided another example of V2G implementation in addition to the methods used in the rest of the EVSA project which leveraged a cloud-based aggregation platform and non-standardized communications protocols for service implementation.

3. Conducting a local site electrical integration evaluation is required to identify transients affects that may impact the operation of the installed systems. The project ran into issues with communications between the TMS, EVSE and EVs being disrupted due to local site

circuit voltage and frequency. Additional refinement of vehicle communications and methods to prevent loss of communications will need to be pursued in future projects.

4. The preliminary valuation assessment conducted by Energy and Environmental Economics (E3) made a strong case for creating incentive structures for V2G technology. E3 examined value streams provided by a simulated EV fleet under three charging scenarios: unmanaged, smart charging (V1G) and bi-directional managed charging (V2G). Within the charging scenarios the costs, benefits and net revenues were examined for the following services: (1) system/distribution capacity – reducing net load during peak hours, 2) load shifting to periods of lower energy costs or to reduce operational costs, and 3) ancillary services in CAISO markets. E3 simulated the services within two frameworks, a base case which reflects current market conditions and a high value case where renewable and energy storage penetration approaches the stated state goals.

   The value and cost benefit assessment and modeling analysis show a cumulative maximum benefit of V2G to the grid (net of cost increment) to be between $450/year/vehicle to $1,850/year/vehicle. This is effectively approximately five times the value of V1G for similar grid service applications. It is important to note however, the high range of results ($1,850/yr/vehicle) did not place constraints on the state of charge of the vehicle batteries or the number of charge/discharge cycles, both of which are key components of implementing V2G to avoid negatively impacting battery health. When the battery degradation, state of charge limitations (between 30-95% SOC) and electricity costs are included, the upper range of value is $1,110/year/vehicle. Overall, E3 built upon much of the modeling and analysis completed under the *Distribution System Aware* project to inform their analysis conducted for the rest of the EVSA project (detailed in Chapter 5 of this report).

The *Distribution System Aware* project complemented the rest of the EVSA project by: (1) investigating the nuances regarding the technical implementation of V2G through the multitude of communication protocols available today, (2) providing additional examples regarding the challenges regarding interconnection of V2G-AC vehicles and the lack of appropriate standards and (3) quantifying value streams V2G could provide to California stakeholders in order to inform future regulatory discussions.

Please see the full project final report for additional detail.[22]

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[22] hhaya, Sunil, Norman McCollough, Viswanath Ananth, Arindam Maitra, Ramakrishnan Ravikumar, Jamie Dunckley – Electric Power Research Institute; George Bellino – Clean Fuel Connection, Eric Cutter, Energy & Environment Economics, Michael Bourton, Kitu Systems, Inc., Richard Scholer, Fiat Chrysler Automobiles, Charlie Botsford, AeroVironment, Inc., 2019. *Distribution System Constrained Vehicle-to-Grid Services for Improved Grid Stability and Reliability*. California Energy Commission. Publication Number: CEC-500-2019-027. https://ww2.energy.ca.gov/2019publications/CEC-500-2019-027/CEC-500-2019-027.pdf

CHAPTER 4: Emergency Back-Up Power

Use Case Overview

Evaluating the potential of V2G-capable electric vehicles (EVs) to provide back-up power in an emergency is a key component in understanding the full value of V2G technology to the California grid and stakeholders. The renewed interest in grid resiliency in light of climate change and ongoing wildfire threats has also increased the importance of understanding the back-up power capabilities of electric vehicles, especially as Public Safety Power Shutoffs (PSPS) become more commonplace. In order to evaluate the potential for EVs to provide this service, the use case executed the following tasks:

(1) Demonstrate the technical feasibility of a vehicle providing emergency power in the case of a power outage via an installed DC EVSE (Princeton Power Systems CA-10).

(2) Collect data during the demonstration including the duration of discharge, vehicle state of charge, kW, kWh, voltage and current.

(3) Quantify the value of service reliability from using an EV as a back-up energy resource based on the frameworks leveraged in the following academic papers:

- Kurtovich, M., Zafar, M., 2016. California Electric Reliability Investor-Owned Utilities Performance Review 2006-2015. California Public Utilities Commission.
- Sullivan, M., Schellenberg, J., & Blundell, M. (2015). Updated Value of Service Reliability Estimates for Electric Utility Customers in the United States (No. LBNL--6941E, 1172643). https://doi.org/10.2172/1172643
- Hanna, R., 2017. Business Cases for Microgrids: Modeling Interactions of Technology Choice, Reliability, Cost, and Benefit.

(4) Use the data collected during the demonstration to further evaluate the value of service reliability from using an EV.

This use case went through several iterations prior to settling on the final scope detailed above. The original scope was to deploy a vehicle and station at the UCSD Police Department and simulate how the resource could provide emergency back-up power. Following discussions with UCSD, it was decided the Police Department would not work for demonstration purposes because it was not possible to simulate a power interruption to test the set up given the sensitive nature of operations at the site.

The second iteration of the use case included the use of two CA-10 charging stations and two Nissan LEAFs located on the bottom floor of the Hopkins parking structure at UCSD. The following challenges were encountered:

- ***Lack of amperage available*** – The two vehicles sited at the Hopkins Parking structure (96A) would not generate enough amperage to successfully power the total structure load in the case of a power outage without causing a significant drop in voltage and potential damage to the building electrical infrastructure. This issue could have been avoided if the stations were installed with this use case in mind and their wiring was set up to power an appropriately sized critical load panel. However, it was out of budget to make adjustments to the electrical wiring of the stations.
- ***Three-phase equipment*** – The 10kW discharge from the CA-10 unit at 208V, single-phase would need to be stepped up to the overall system voltage of 480V 3-phase, 4-wire. This causes a reduction in amperage from 96A to 41.6A, therefore if any 3-phase equipment on the circuit would not be served, still try to run and likely trip their breakers.
- ***Coordination between stations*** – The two charging stations installed in Hopkins are connected to two different transformers, therefore making it very difficult to coordinate a response from both stations / cars, especially during a power outage (i.e. without internet to access the aggregator platform to send signals).

For these reasons, the third iteration of the use case was reduced to the use of one CA-10 charging station and one vehicle. In addition, the test site was relocated to Center Hall at UCSD to allow for easier access to the station, the vehicle and electrical infrastructure. However, there was a concern the CA-10 unit would not be able to execute the outlined discharge functionality due to the station not being engineered to complete a "black" or "dark" start after the interruption of power. Following conversations with Princeton Powers Systems, it was confirmed the station could provide back-up power, but only if the EV was plugged into the station and actively charging prior to the interruption of the grid power. This implementation set-up therefore allowed the EV to provide an uninterruptable power supply (UPS) to the station. In order to confirm the functionality of the CA-10, the Project Team arranged for a pre-test at UCSD and simultaneously worked with Honda Motors to identify Honda's Power Exporter[23] device as a back-up in case the CA-10 did not work. The pre-test was successful therefore the Honda Power Exporter was removed from scope.

Test Plan and Set-up

Once the pre-test was completed successfully, the test plan was finalized to include the following:

- Test #1 – Vehicle battery starts with ~100% State of Charge (SOC) and discharges to zero.
- Test #2 – Vehicle battery starts with ~50% SOC and discharges to zero.

Within each test, measure the following parameters:

- Length of time the load can be served (minutes)
- Voltage (V)
- Current (A)
- Power Factor (%)
- Active Power (kW)

[23] For additional information on the Honda Power Exporter please see the Honda website here.

- Total Energy Consumed (kWh)

In addition, the full test set-up was also reviewed and approved by UCSD. The test set-up included the use of an external load bank[24] that would simulate the representative load of a residential home (~10 kW). Figure 7 and Figure 8 below show the test set up between the grid, the CA-10 and the load bank. Figure 7 shows: 1) the CA-10 unit's connection to the grid via the top power terminal and an on-site AC disconnect switch and 2) the CA-10 unit's external power terminal that was wired to the load bank for the test.

Figure 7. Wiring Set-up between grid, CA-10 and load bank

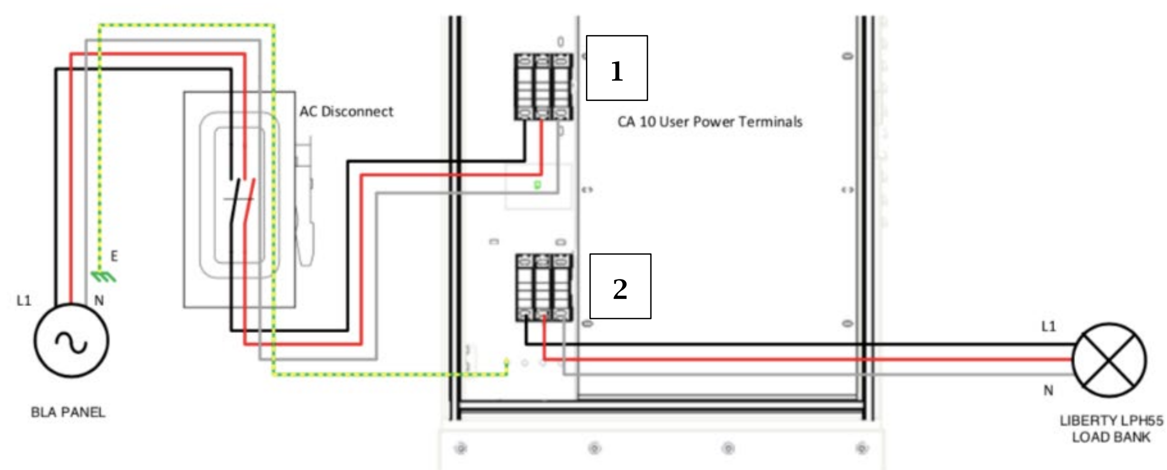
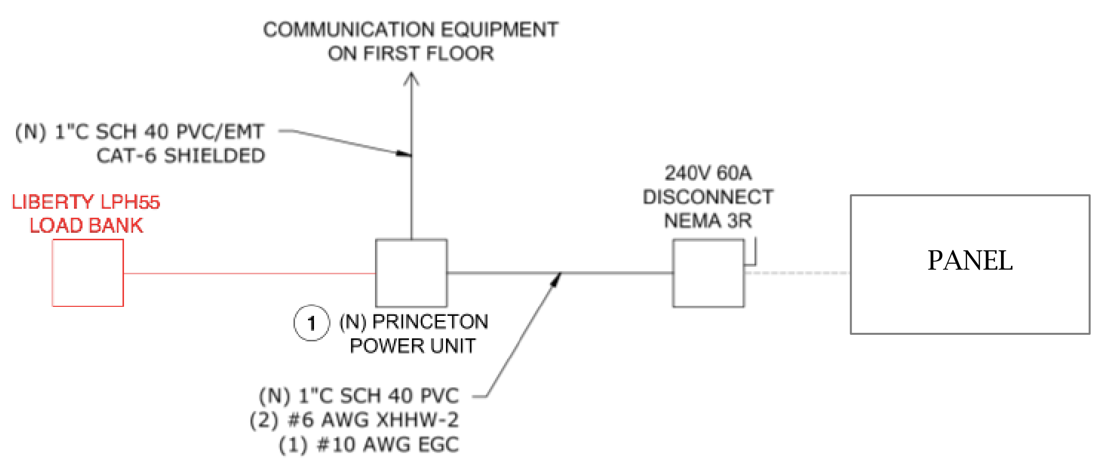


Figure 8. Excerpt from site-single line showing addition of load bank



[24] Liberty LPH55 load bank was used. LPH55 has a max load capacity of 55 kW, but for the test it was set at 10 kW at 46 amps to simulate a residential home load. Specification document available upon request.

A critical component in the test set-up was the presence of an uninterruptable power supply (UPS) that allows the charging station to stay energized once the grid connection is interrupted, thus allowing for a “black” or “dark” start. The CA-10 unit is not equipped with this functionality. Therefore, to execute the test the Nissan LEAF had to fulfill the role of a UPS by being plugged into the station and actively charging (EV battery contactors closed) prior to the power interruption.

Once the power was interrupted by flipping the AC disconnect switch to an off position, the CA-10 disconnected from the grid and internally switched to the battery supply of the Nissan LEAF through the CHAdeMo plug. The CA-10 then communicated with the LEAF to allow reverse power flow from the battery, which was then directed to the external power terminal hooked up to the load bank.

Figure 9 below capture some of the set-up process on test day.

Figure 9. Test day pictures of Project Team

a) Connecting the CA-10 to the external load bank

b) Load bank and wiring to data collector and CA-10

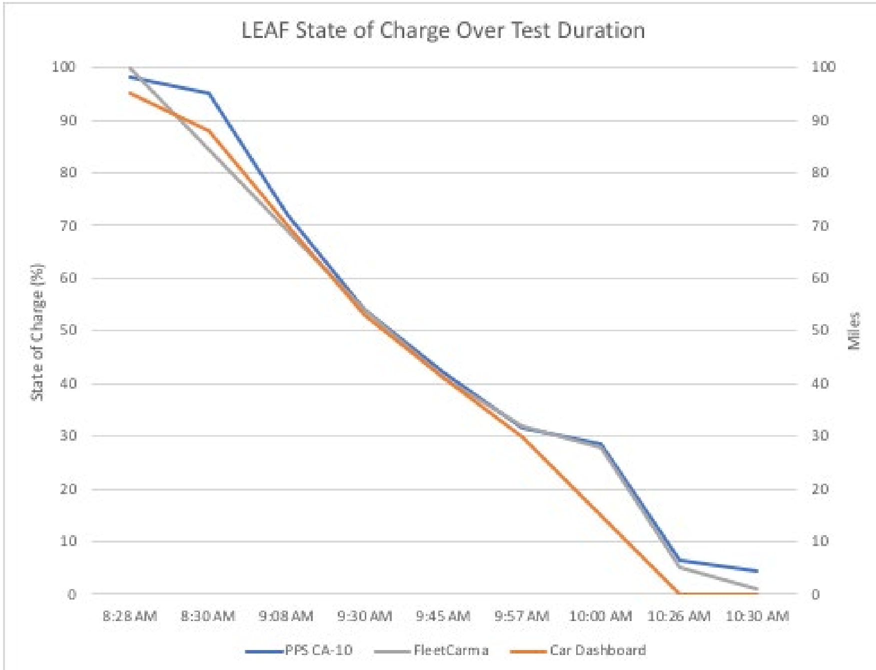
c) Project Team during test set-up with Nissan LEAF

Test Results

The test was conducted on Wednesday, June 5th, 2019 at the CA-10 station installed outside of UCSD’s Center Hall. The test started at 8:28 am with a 2017 Nissan LEAF (30 kWh battery) that had a 100% state of charge (SOC). Throughout the test the state of charge was tracked through three difference methods: 1) the CA-10 unit’s display panel (% SOC), 2) the car’s dashboard (miles) and 3) a FleetCarma device plugged into the vehicle’s OBDII port (% SOC).

Figure 10 below plots the reported changes in the state of charge over the course of test.

Figure 10. LEAF State of Charge over Test Duration



***Note**: x-axis intervals are uneven*

The test lasted 2 hours, 3 minutes and 25 seconds and discharged a total of 19.09 kWh. Over the course of the test, the average active power reading was 9.35 kW (which corresponds to the stations 10 kW rating, assuming some efficiency losses) and average power factor was 0.85. The vehicle consistently discharged until the Project Team discontinued the test once the vehicle dashboard registered 0-0-0 for approximately ten minutes. Although the PPS CA-10 and the FleetCarma device both registered the vehicle still having remaining range, the Project Team elected to discontinue to the discharge in order to not unnecessarily stress the battery.

Prior to starting the test, the hypothesis was the vehicle would stop discharging on its own when the battery hit ~30% SOC. This was based on operational experience while providing grid services where LEAFs stop responding to discharge signals when following a frequency regulation signal once the SOC approached 30%. However, under the EVSA test conditions the vehicle continued to discharge past 30% SOC until the test was stopped to avoid any unnecessary stress on the battery. Table 2 below shows the measurements taken via the Leaf Spy mobile application[25] on the test vehicle before (7:41 am) and after (10:37 am) the test. The results show there was no change in the State of Health (SOH) of the battery after the test was completed, although the battery temperature did increase over the course of the test, which is expected.

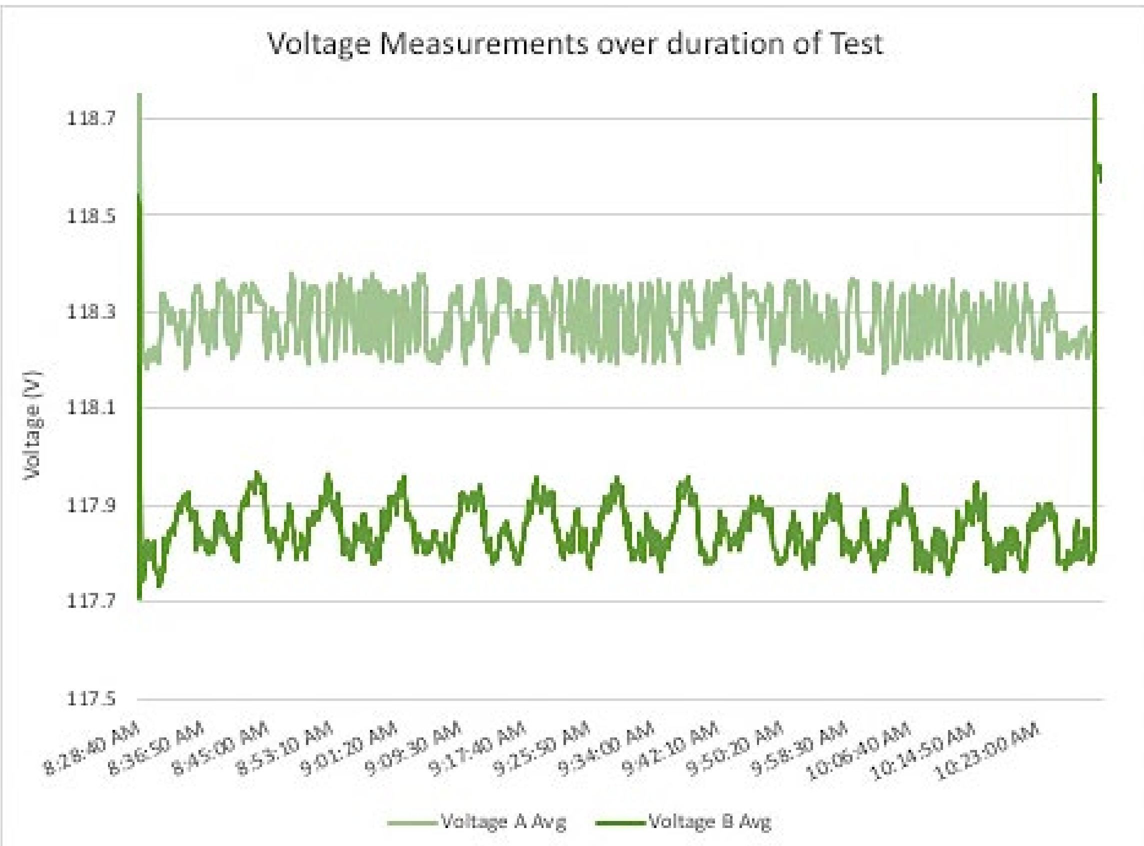
[25] The Leaf Spy application paired with a Bluetooth enabled smart phone and an OBDII Bluetooth adapter enables the ability to monitor the battery and other vehicle information from a Nissan LEAF. Note the Leaf Spy application is not approved by Nissan.

Table 2. Key Leaf Spy Readings Before and After Test

Measurement Time	SOH	V	Hx	mV	SOC	kWh	Max Temp	Min Temp
7:41	86.09	390.93	80.68%	17	93.10%	23.3	73	69.1
10:37	86.09	339.02	80.68%	16	10.90%	1.3	79	75.2

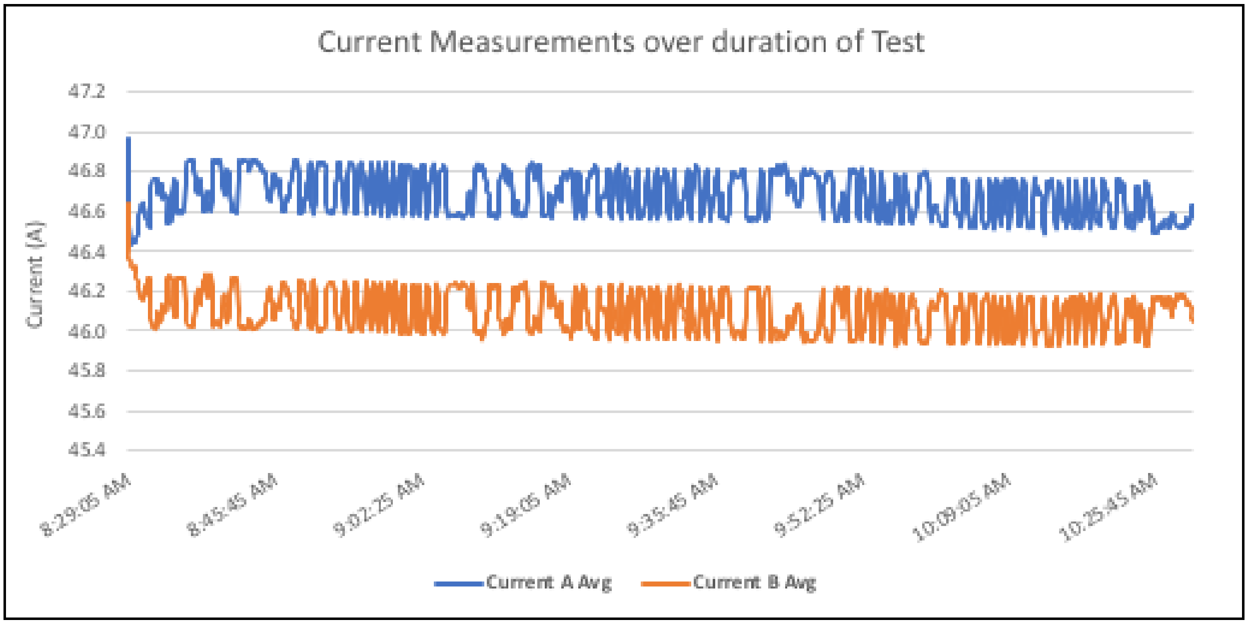
The test set-up also enabled the monitoring of voltage, current, average active power and power factor throughout the course of the test. Given the Princeton Power CA-10 unit is a split-phase charging station, each of the metrics were measured from phase to neutral at each of the station's two phases (labeled as A and B in the following figures).

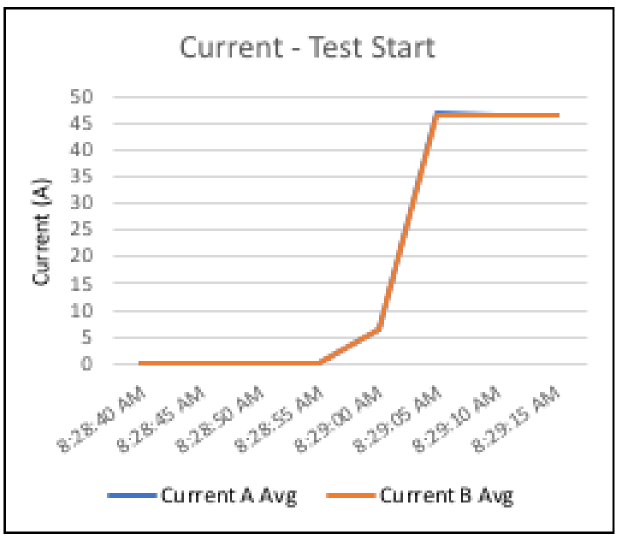
Figure 11. Test Voltage Measurements

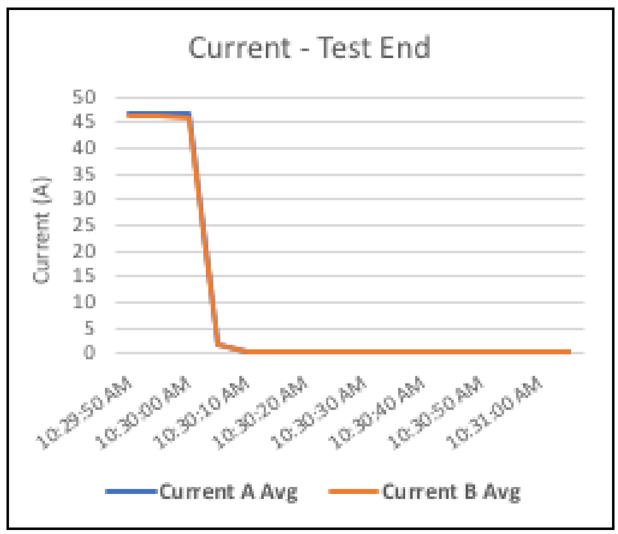


Voltage stayed in the expected band throughout the duration of the test, with spikes only occurring for a few seconds at the beginning (during station start-up) and end (during station shut down) of the test.

Figure 12. Test Current Measurements (Start, End, Duration)







The measured current also stayed within the expected band of operation, with a clear ramp up and ramp down during the beginning and end of the test.

Following the completion of the first test, the plan was to re-charge the vehicle using the same charging station unit to 50% SOC and run the test again. However, the charging station would not enter into manual charge mode once it was connected back to grid power. Due to time and budget constraints that would have been required to troubleshoot the issue, recharge the vehicle and then discharge again, the Project Team chose to not complete the second outlined test. In addition, the data gathered in the first test was sufficient for analysis and reporting purposes.

Cost Avoidance Analysis

This section of Chapter 4 quantifies the avoided cost of leveraging the battery in an electric vehicle (EV) to serve as an emergency backup generator during a power outage when connected to a bi-directional charging station and properly islanded for safety. Specifically, three scenarios are examined: 1) EVs on the University of California, San Diego (UCSD) micro-grid based on assumed battery capacity, 2) 1 EV at an average residence in San Diego Gas & Electric's (SDG&E) service territory based on assumed battery capacity and 3) EV at UCSD and a residence based on data collected and described in the Test Results section above.

The costs associated with power interruptions under the three scenarios are calculated by following the methods in Sullivan et al., 2015 which were developed through funding from the Office of Electricity Delivery and Energy Reliability, US Department of Energy. Sullivan et al uses standardized survey results from several U.S. utilities spanning many years[26] to build statistical and economical models to estimate customer damage functions due to power interruptions. The models take into account the following parameters: (i) the annual energy consumed at the given commercial or residential site, (ii) duration of the power interruption, (iii) time of year of the power interruption, and (iv) the type of customer (medium/large commercial and industrial (C&I), small C&I, residential). The EVSA project analysis leveraged the Sullivan et al model to quantify the avoided cost of having electric vehicle batteries as an emergency backup generator to both a medium / large C&I customer and a residential customer segments. The UCSD micro-grid falls into the medium and large C&I customer segment according to Sullivan et al because it consumes more than 50 MWh per year. A detailed description of the methods and model used can be found in Sullivan et al., 2015, however the key cost metrics used in this analysis are found below in Table 3 and Table 4.

Table 3. Interruption cost (U.S.2013$) for a median and large C&I customer.

Interruption Cost	Interruption Duration					
	Momentary	30 Mins	1 Hr	4 Hrs	8 Hrs	16 Hrs
Cost per Average kW	**$15.9**	**$18.7**	**$21.8**	**$48.4**	**$103.2**	**$203.0**

Table 4. Interruption cost (U.S.2013$) for a residential building.

Interruption Cost	Interruption Duration					
	Momentary	30 Mins	1 Hr	4 Hrs	8 Hrs	16 Hrs
Cost per Average kW	**$2.6**	**$2.9**	**$3.3**	**$6.2**	**$11.3**	**$21.2**

[26] Surveys make up a meta-dataset including 34 datasets from surveys fielded by 10 different utility companies of customers between 1989 and 2012.

In summary, longer interruptions result in higher costs and interruptions during the summer are more likely to incur costs. Table 3 above shows cost per event, cost per average kW, and cost per unserved kW for median and large C&I (defined as annual consumption greater than 50 MWh). For example, for one EV with a 30 kWh battery connected through a Princeton Power CA-10 unit (10 kW charge and discharge capacity), it is estimated the battery will be able to discharge to the grid for approximately 3 hours. The interruption cost during the 3-hr outage for a C&I customer can be interpolated using Table 3. For an interruption duration of 3 hours, the cost per average kW is $39.30, therefore the total cost for 10 kW is $393. This value does not take into account the probability of an outage occurring and for what duration. The following analysis takes those variables into consideration based on reliability metrics of the distribution grid.

1) EVs on the University of California, San Diego (UCSD) micro-grid

To further quantify a realistic avoided cost of having electric vehicles as emergency backup at UCSD, it is necessary to account for how often outages occur and how long they last. Therefore, this analysis leveraged standardized reliability metrics adopted by the California Public Utilities Commission to measure system performance on a local and state-wide basis (Kurtovich and Zafar, 2016). The specific metrics used are defined in Table 5 below.

Table 5. CPUC Reliability Metrics

Reliability Metric	Definition	Metrics for SDG&E Beach Cities Division
SAIFI	System Average Interruption Frequency Index – i.e. how often a customer experiences a sustained outage on an annual basis	0.627
MAIFI	Momentary Average Interruption Frequency Index – i.e. the average frequency of momentary outages (< 5 minutes) per year	0.343
SAIDI	System Average Interruption Duration Index – i.e. the total minutes of sustained outage per year	71

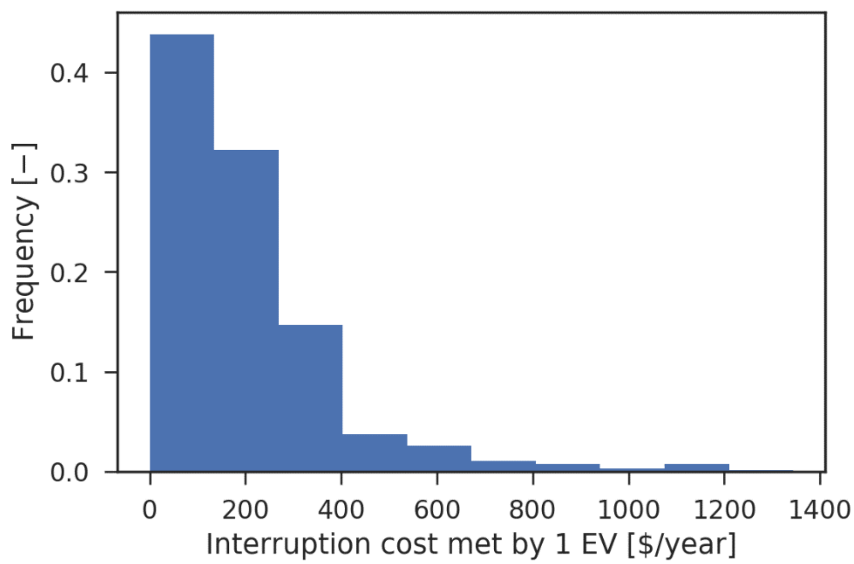
Source: Kurtovich and Zafar, 2016

The reliability metrics in Table 5 were used in Hanna 2017 to model the value of reliability in a microgrid-specific case study in north county San Diego. For context, this particular division of SDG&E territory shows a high level of reliability and consistently has some of the highest reliability performance in the State. By comparison, PG&E's Humboldt district has a 10-year average SAIDI of 664 (Kurtovich and Zafar, 2016).

The same framework used by Hanna was followed to determine the avoided cost to a micro-grid like UCSD. Using the reliability metrics identified by Kurtovich and Zafar 2016 for the SDG&E Beach Cities Division, a Monte Carlo Simulation (MCS) was used to create an outage time series by randomly sampling alternating periods of normal grid operation and outage along with a typical load profile of UCSD to represent how much power is needed from the grid. In order to capture the random behavior of grid outages, each individual year of simulation has a random distribution of outages in both number of events and duration. After hundreds of simulations, the statistics converge to the reliability metrics listed in Table 5 above.

Statistical convergence to the values in Table 5 was achieved after simulating 781 years in the MCS framework, with each year varying in terms of number, duration and timing of outage events. Once the average reliability is identified, cost per event values from Table 3 above are referenced to plot the interruption cost for each year. Figure 13 shows the interruption cost per year to a micro-grid like UCSD is generally under $400/year, with majority of the simulated years being less than $200. The average interruption cost across all years met by 1 EV at UCSD (assuming a 30 kWh battery and a 10 kW discharge capability over 3 hours) is $169/year. This metric could be multiplied by the number of cars to reach a total average avoided cost. For example, if all 6 Nissan LEAFs participating under the EVSA project were able to discharge during an interruption, the avoided cost to a customer like UCSD would be $1,014 / year.

Figure 13. Distribution of interruption cost met by 1 EV for all simulated years for UCSD

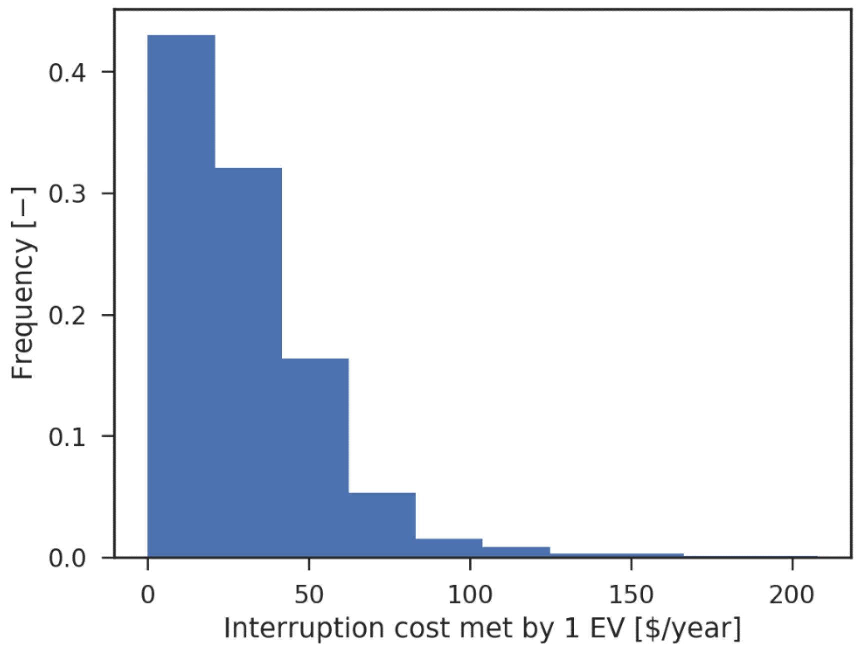


2) ***EVs at an average residence in San Diego Gas & Electric's (SDG&E) service territory***

The process in Scenario #1 was then repeated for a typical residential load profile provided by the Department of Energy.[27] The base residential load used was informed by weather data measured at San Diego Lindbergh field. The SAIFI, MAIFI, and SAIDI indices in Table 5 were also used for Scenario #2. The use values from Table 4 above are then referenced to plot the interruption cost for each year (Figure 14 below). A distribution of the annual interruption cost for all simulation years (n = 732) can be seen in Figure 14 where the interruption cost per year is generally under $50/year, with majority of the simulated year being less than $25. The results indicate the average interruption cost is $26/year. Therefore, the avoided cost value for a typical residence to use an EV to provide back-up power is $26/year.

[27] Commercial Reference Buildings [WWW Document], n.d. Energy.gov. URL https://www.energy.gov/eere/buildings/commercial-reference-buildings (accessed 3.6.19)

Figure 14. Distribution of interruption cost met by 1 EV for all simulated years for a residential load



The interruption cost for the residential setting is much lower because the cost per event, average kW, and unserved kWh are much lower for residential than commercial customers (see Table 3 and Table 4). It is important to note that while survey results from utilities are considered to be the standard approach for quantifying the cost of power outages (Sullivan et al 2015), it is difficult to account for biases caused by unknown human elements, survey biases, or inaccurate predictions. Nevertheless, the numbers reported in this study ($169/year for commercial and $26/year for residential), can be used as baseline references for quantifying the avoided cost of using EVs as emergency backup generators.

3) EVs at UCSD and residence based on actual testing results

The Test Results detailed above in Chapter 4 show one Nissan LEAF can discharge power for approximately 2 hours. These test results highlight the well-known fact that although the particular vehicle battery used is rated for 30 kWh, only a portion of the full capacity is actually useable. Based on the battery state of health (SOH) measurements taken at the beginning of the test, the battery only had 25.8 kWh worth of capacity available (86.09% of original 30 kWh). Therefore, it is not surprising the vehicle only discharged for 2 hours at an average of 9.35 kW, indicating the actual useable capacity of the battery was closer to 20 kWh. It is important to note however, the duration of discharge was potentially shortened artificially by the Project Team discontinuing the test once the vehicle dashboard indicated 0 miles for more than 10 minutes.

Table 6 compares the avoided cost calculations using the results of the demonstration (20 kWh discharge over 2 hours) with the calculations using the initial estimates (30 kWh discharge over 3 hours) described in scenarios 1 and 2 above. The incremental value between 2 hours and 3 hours of discharge duration is minimal due to grid interruptions rarely lasting over 2 hours based on the reliability indexes of this particular area of the grid.

Table 6. Avoided cost calculations based on estimated and actual vehicle capacity

Scenario	Avoided Cost (Estimate)	Avoided Cost (Actual)
1 EV at UCSD	$169/year	$168/year
6 EVs at UCSD	$1,014/year	$1,008/year
1 EV at SDG&E Residence	$26/year	$26/year

Additional Cost Considerations

In addition to the avoided costs quantified above, it is important to also evaluate the cost of implementation to set up an EV to provide backup power in a safe and reliable manner. There are two key components that need to be considered: 1) the cost of a black start-capable[28], bi-directional EVSE and 2) the installation cost of the EVSE and wiring required to safely discharge.

First, the EVSE (Princeton Power Systems CA-10) used for the testing of Use Case #3 cost $15,000. As described above, the EVSE is not black start capable and therefore the vehicle had to be plugged into the EVSE when the power from the grid was interrupted in order to maintain an uninterruptable power supply (UPS). Designing an EVSE for this use case that has a UPS and is therefore able to implement black start is a critical component of executing this use case on a commercial scale.

Second, the site design and engineering is a critical component of successfully implementing back flow from a bi-directional EV / EVSE. The capacity available for back flow from the vehicle(s) need to be matched with an appropriately sized load – often referred to as a critical load panel. For example, one 30 kWh EV can't physically power a large parking garage, but instead could power all the emergency lighting circuits in the building for a few hours if the circuits are set up properly. In addition, the site needs to be engineered in order to ensure the load of a discharging EV is properly islanded from the rest of the grid when grid power is interrupted. This function is usually achieved through an automatic transfer switch (ATS) between the critical load panel and the upstream load, whether that is the rest of a building or the grid itself. This cost consideration is highly dependent on the site in question and the target critical load for backup. Therefore, the scope of this analysis is unable to provide an estimate for consideration.

In addition to the two cost components above, the cost of the electric vehicles being used to provide backup power need to be considered as well. However, this component is also dependent on the specific site and whether the implementer is purchasing the EV(s) or leveraging existing

[28] Black start is defined by NERC as, "A generating unit(s) and its associated set of equipment which has the ability to be started without support from the System or is designed to remain energized without connection to the remainder of the System". URL https://www.nerc.com/files/glossary_of_terms.pdf (accessed 7.31.19)

EV(s). If the site is purchasing the EV(s) for the sole use of implementing back up power in the case of black out, it would take hundreds to thousands of years to recoup the full cost of an EV based on the values identified in this study ($169/year for commercial and $26/year for residential). However, if the EVs are already there (i.e., employee-owned EVs in a commercial setting) only the cost of the EVSE and its installation costs would need to be considered.

Suggestions for Future Analysis

The analysis presented here only examines one area of the California grid – San Diego Gas & Electric's Beach Division region. This area is one of the most reliable areas in all of California with some of the lowest reliability indexes per Kurtovich and Zafar (2016). Therefore, the avoided cost of an interruption is on average, lower than many other areas in California. The avoided cost of using an EV to provide emergency power could therefore be far more valuable in areas of the state with higher reliability indexes. Future analyses could examine the areas of the state where the avoided costs are the highest and cross reference those with the areas with the highest EV penetration in order to identify areas where this service could be most valuable for implementation to the utility.

The avoided costs examined here and originally quantified by Sullivan 2015 are focused on the perspective of the utility customer. Future research could focus on the perspective of other stakeholders, like the utility itself. Overall, further understanding the value of emergency back-up power to multiple stakeholders (both utilities, EV owners and others) is an important piece of the puzzle to understand as the state of California evaluates how vehicle-to-grid technology can aid the state in not only achieving its renewable energy and electric vehicle adoption goals, but also how to move towards a more resilient electricity system in the face of changing climate.

Conclusion

The Emergency Back-Up Power use case implemented under the EVSA project shows it is technically feasible to use a bi-directionally capable electric vehicle to provide back-up power when grid power is interrupted. However, the implementation comes with some key caveats – the need for an uninterruptible power supply (UPS), an appropriately located automatic transfer switch (ATS) and proper installation for safe, islanded operation.

Overall, based on the avoided cost values quantified in this study it is not economical to use an EV solely for providing emergency backup power in an area of the grid with high reliability. However, when combining different grid services EVs can provide to the grid (e.g., demand charge management, demand response, etc.), the overall economic value increases and can justify the set-up costs. In addition, in areas of California where grid power interruptions are more common, the value could be significantly greater, specifically in areas that might be subject to public safety power shutoff (PSPS) events. Additional research will be needed to further examine how electric vehicles (both light-duty and medium/heavy-duty, like school buses) could be leveraged during PSPS events by utilities to reduce the impact on customers.

CHAPTER 5: Driver Behavior

Overview

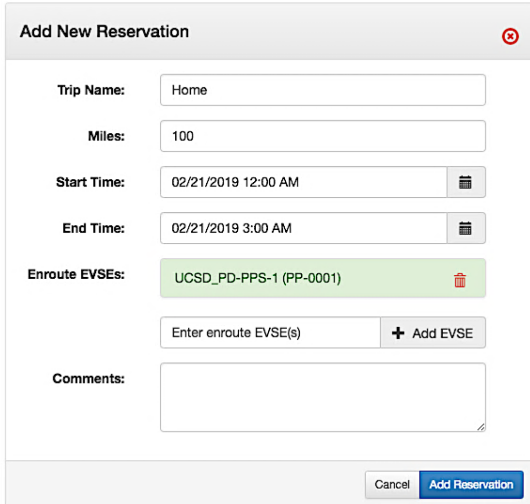
A key component of implementing V2G technology while also providing value is the strategic management of the vehicle battery's state of charge based on the driver's transportation needs and the service objective, which in the context of Use Case #4 is frequency regulation. Therefore, there is a direct correlation between how long the vehicle is plugged in and available to provide services and how much value can be captured. This correlation will vary depending on two main factors:

(1) ***Vehicle use case (fleet, workplace, home, etc.)*** – The EVSA project use case was a workplace demonstration of V2G technology. The majority of V2G research conducted in California to date has examined fleet applications for V2G, because they generally have more predictable driving and charging schedules that can allow for greater optimization of value streams. Therefore, the EVSA project provided important insight into how this technology could be deployed in a workplace setting and more specifically, on a large University campus. Under the EVSA project the vehicles were expected to follow a standard workplace schedule – plugged in for approximately 8 hours a day, 5 days a week. Given the project took place on a University campus, the schedules of the drivers were more flexible than a typical workplace with some drivers consistently arriving to work before 7 am and many departing before 3pm.

(2) ***Driver transportation needs*** – How much range does the driver need (desired range) and by when (departure time). The EVSA project provided the drivers with a mobile application and web interface that would allow them to populate their daily transportation needs. These inputs then provided the basis for when the vehicles would be able to provide grid services (frequency regulation) or when they would need to be strictly charging for an upcoming trip.

Figure 15 below is a screen shot of the mobile application entry fields used by the drivers. Please note, the Honda Accord drivers did not leverage the trip scheduling functionality because they are plug-in hybrids.

Figure 15. Mobile application trip scheduling interface



Therefore, this section of the report focuses on examining the relationship between driver behavior, vehicle availability and the amount of time (and therefore value) each vehicle was able to capture. The trends are examined both on an individual vehicle level across the eight project vehicles (2 Honda Accords, 6 Nissan LEAFs) as well as on an aggregate coalition level and covers project operations starting in June 2018 and until the data collection time frame ended in June 2019.

Individual Vehicle Availability

The following graphs visually show the percentage of time on average each of the EVSA project vehicles were in various statuses in each hour of the day over the course of the project data collection period. Each vehicle is split up into two graphs for comparison purposes, one that covers the first six months of operation (June 2018 – December 2019) and a second covering the second six months (January 2019 – June 2019).

Figure 16 – Figure 23 follow the same legend shown below. The more orange a vehicle shows in each hour, the more time it was available to provide frequency regulation as a grid service and therefore contribute to revenue generation.

Figures 16 – 23 Legend

- Charging for a Trip
- Grid Services
- Not Communicating
- Not Connected
- Station Response Error

Figure 16. P703 Parking Lot – Nuvve PowerPort (M00031) & Honda Accord PHEV

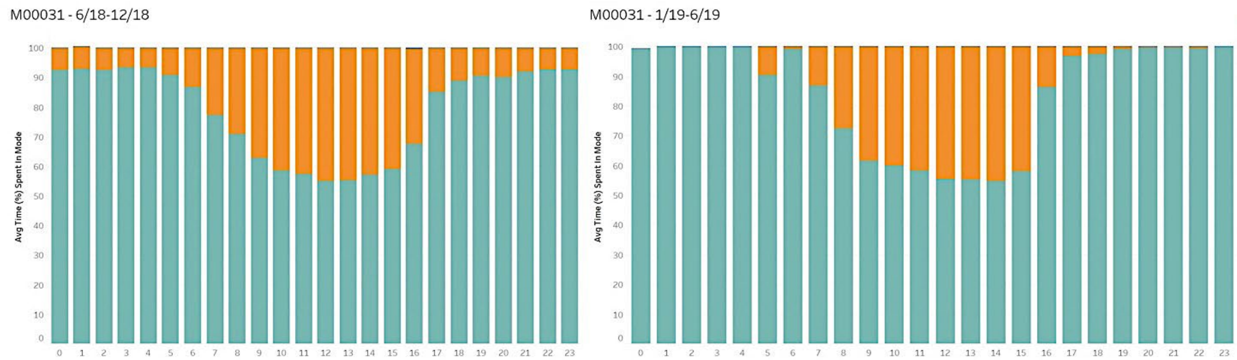


Figure 17. P703 Parking Lot – Nuvve PowerPort (M00041) & Honda Accord PHEV

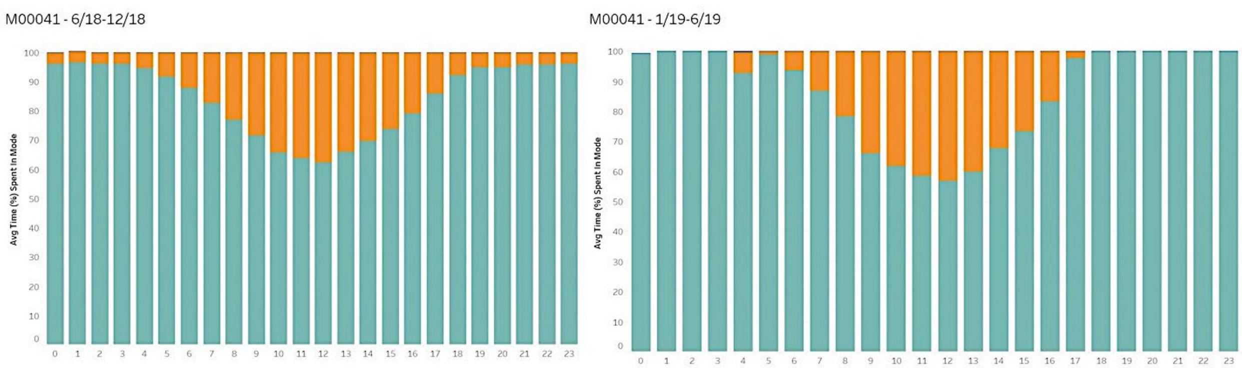


Figure 18. Police Department – PPS CA-10 (PP-0001) & Nissan LEAF

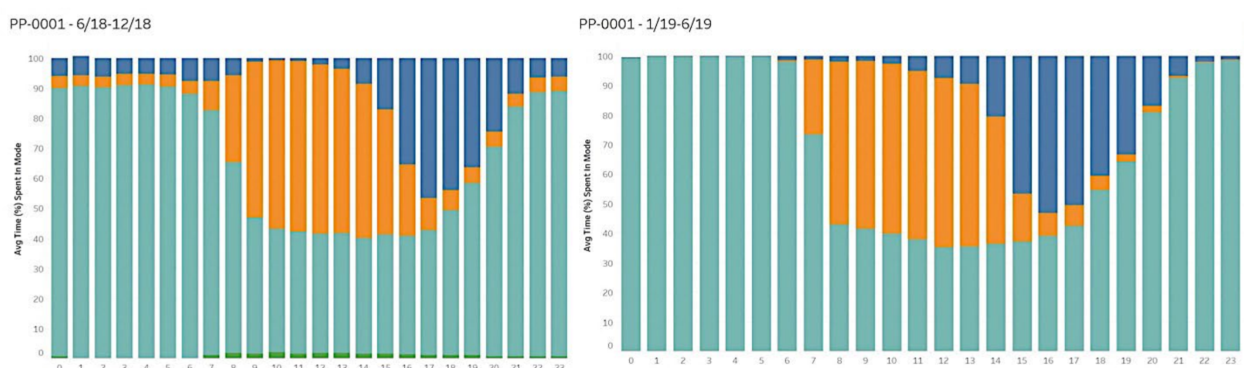


Figure 19. Scripps Institute of Oceanography – PPS CA-10 (PP-0002) & Nissan LEAF

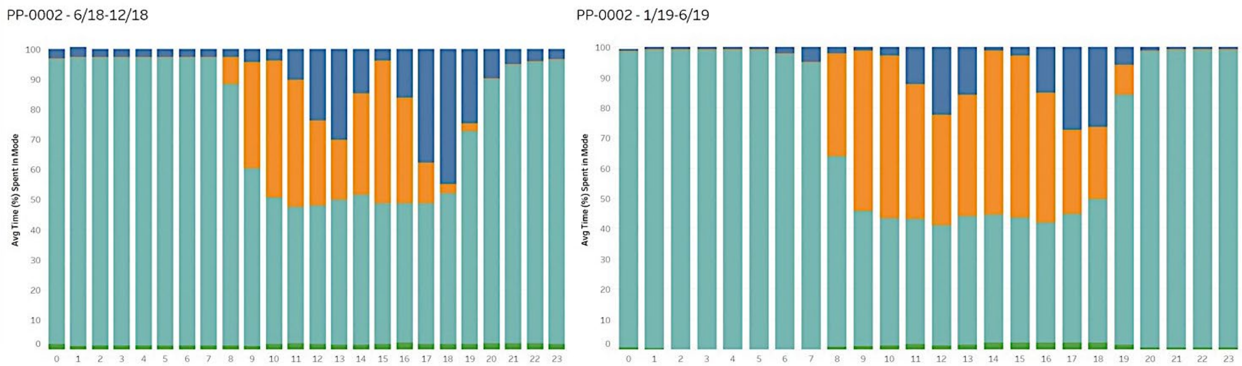


Figure 20. Hopkins Parking Structure (1) – PPS CA-10 (PP-0003) & Nissan LEAF

Figure 21. Trade Street – PPS CA-10 (PP-0004) & Nissan LEAF

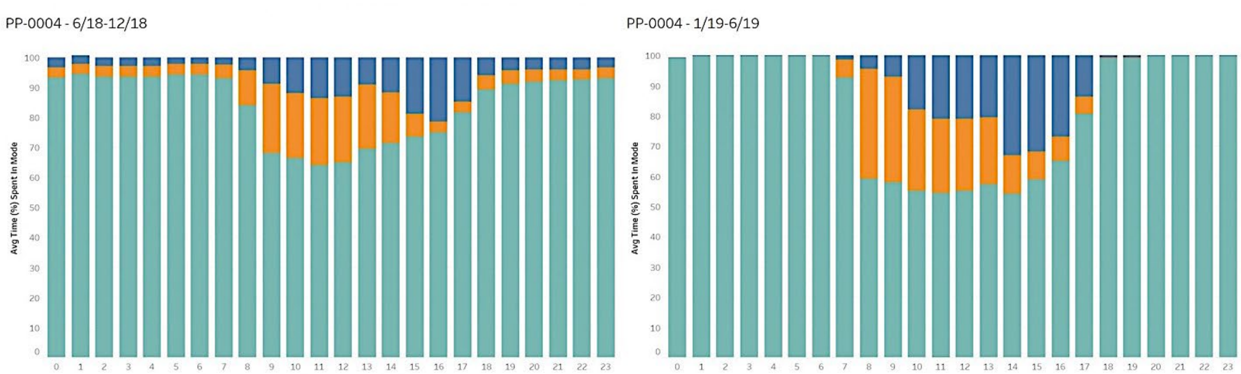


Figure 22. Center Hall – PPS CA-10 (PP-0005) & Nissan LEAF

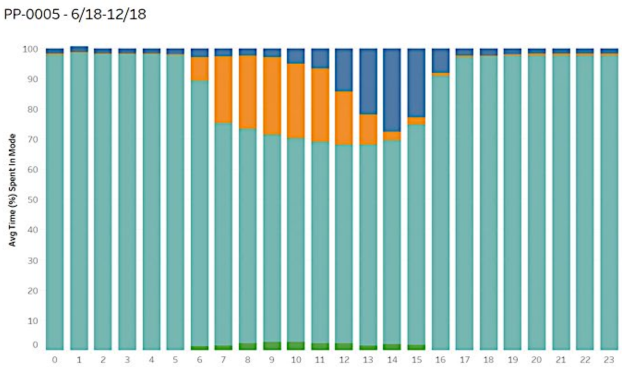


Figure 23. Hopkins Parking Structure (2) – PPS CA-10 (PP-0006) & Nissan LEAF

Overall the project vehicles show a consistent trend of being plugged in during work hours, with a clear peak occurring across the majority between the hours of 9 am and 1pm. PP-0001, 2, 3, M00031 and M00041 where the best performing vehicles in the coalition because they had the most consistent charging patterns over the course of the data collection period. On the other hand, PP-0004, 5 and 6 were significantly less consistent with plugging in and were not reliable contributors to fulfilling regulation up and down bids. Only one of the six Nissan LEAF drivers did not use the trip scheduling function on the mobile application consistently (PP-0003). As noted previously, the Honda Accords drivers (M00031 and M00041) did not use trip scheduling.

Only slight changes are seen when comparing the first and last six months of data collection – the primary being less time spent in grid services (orange) or charging mode (blue) in non-work hours. The main reason for this was due to many drivers leaving their vehicles plugged in overnight while on vacation, a practice that was discontinued in the second half of data collection in order to make the dataset more realistic.

Coalition Availability

Figures 24 and 25 show the average availability of all eight project vehicles on an hourly basis (hours 0 – 23) from June 2018 to June 2019 on a monthly basis. The following key trends are seen:

2018

- **June – July** have comparatively low percentage of time spent providing Grid Services (GI – orange). This is primarily due to operational challenges the coalition experienced following the introduction of the recorded AGC signal, which resulted in the vehicles' batteries filling up quickly, the stations ceasing to communicate with the Nuvve aggregator and then entering into Not Connected (NC – teal) for extended periods of time until the system was reset and resumed normal operation.

- **August** had the highest percentage of time spent providing Grid Services over the data collection time frame. This was due to several of the vehicles being plugged in outside of normal work hours due to driver vacations and driver turnover.

- **September – December** percentages appeared to stabilize and start to show a consistent pattern of availability. However, November and December trended lower due to the holidays and many of the drivers taking time off and / or having more unpredictable work schedules.

2019

- **January – June** show a consistent pattern of drivers on average starting to plug in around 7 am, reaching a peak of availability between 11 am and 1pm and then vehicle start to unplug between 3pm and 5pm.
- Vehicle availability peaked at around 50% of total available time in the month during the months of February, April and May. This correlates to University holiday schedules and therefore driver work patterns – i.e. a decrease in March due to spring break and a decrease in June due to the start of the summer holidays.

The figures follow the same legend coding the figures above.

Legend Figures 24 - 25

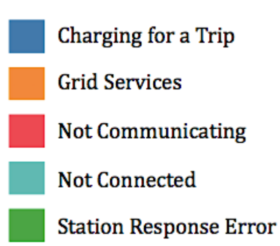


Figure 24. EVSA Coalition Average Hourly Availability, June 2018 – December 2018

Figure 25. EVSA Coalition Average Hourly Availability, January 2019 – June 2019

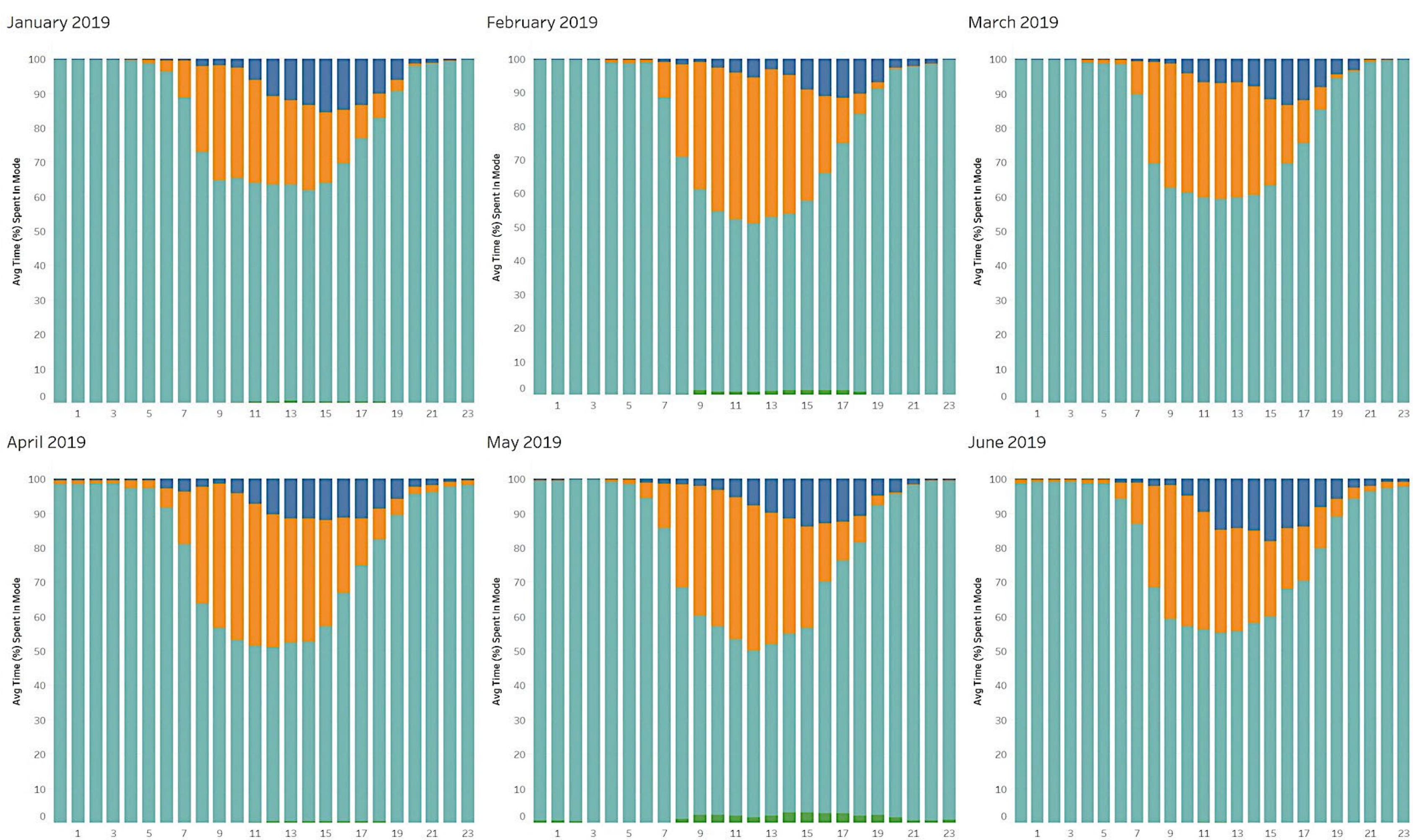


Figure 26 and 27 below show how on average only half of the EVSA coalition vehicles were available to provide regulation up and down during peak workday hours. Figure 26 shows the availability profile of the coalition over the first six months of operation (June – December 2018). June and July are the lowest due to operational issues experienced with the Princeton Power stations during that time. August is inflated due to drivers leaving their vehicles plugged in while on vacation. November has surprisingly low availability that directly corresponds to low revenue in Figure 36 in Chapter 6.

Figure 26. Average number of vehicles available for grid services hourly (June – December 2018)

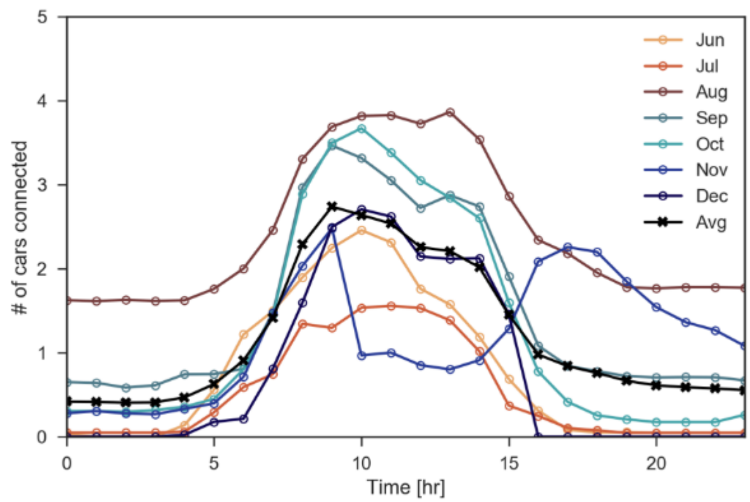
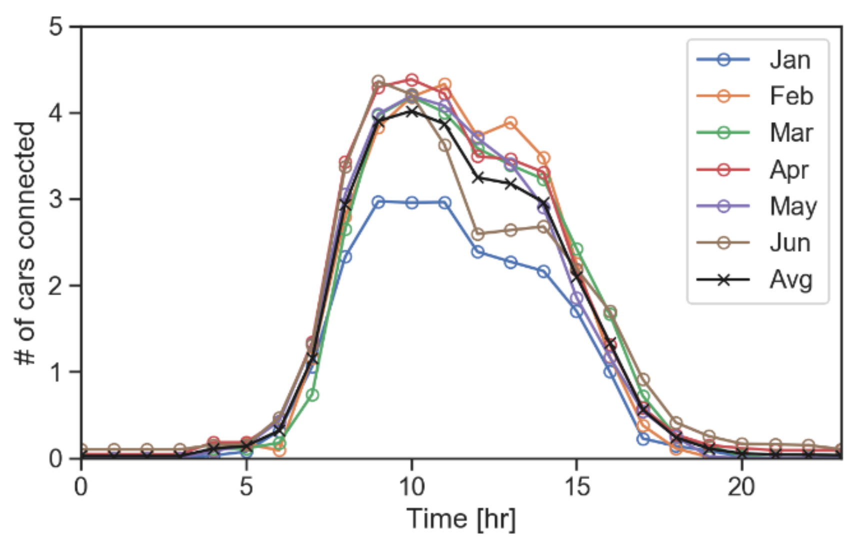


Figure 27 below shows the availability profile of the coalition over the last six months of operation (January – June 2019). Overall there was an increase in consistency of the vehicles plugging in across the months and during predictable hours. Regardless however, on average only half of the coalition was plugged in and available to provide grid services in any given hour.

Figure 27. Average number of vehicles available for grid services hourly (Jan – June 2019)



Trip Scheduling

The following graphs compare (1) the average percentage of time the 8 project vehicles plugged in during each month with (2) the average percentage of time each vehicle provided grid services (in "Grid Services" mode, as described above) and actively responded to AGC set-points. The *Trip Scheduling* analysis is conducted across all hours in a week from June 2018 – June 2019, including weekends, even though the vehicles are only expected to charge during standard work hours. The following graphs split up the examined time frame into two segments (June – December 2018 and January – June 2019) in order to compare driver behavior between the first and last six months of project data collection.

The percentage of time providing grid services is influenced by the following:

1. How many hours a vehicle is plugged in for
2. How demanding the driver's transportation needs are in terms of:
    a. Desired departure time
    b. Miles requested by the desired departure time

The maximum correlation between the two parameters examined is 1:1 – i.e. if the vehicle's average percentage of daily plugged in time in 25%, it cannot provide grid services for more than 25% of overall time. However, a 1:1 ratio is unrealistic as it does not include time spent charging to meet transporation needs.

Each dot (O) on Figure 28 and Figure 29 represents one vehicle's performance for each month. Each dot is labeled with the corresponding month number (1 for January, 2 for February and so on). Each vehicle is designated a specific color which allows the viewer to see the availability trends that develop for certain vehicles. For example, in Figure 28, PP-0003 (green dot) had the highest availability for August and September 2018. The second six months of data collection (Jan – Jun 2019) show an overall improvement in availability as the distribution of the dots shifted up and to the right indicating the vehicles were on average available more often for grid services than in the first six months of operation. This corresponds directly with the increase in revenue seen in Figure 36 in Chapter 6.

Key observations:

- From June – December 2018, **75%** of each vehicle availability per month fell below 22% of expected plug in time (assumed 40 work hours per week).
- From January – June 2019, the coalition improved with **56%** of the vehicle availability per month falling below the 22% of expected plug in time.
- The EVSA vehicles were plugged in for less than 40 hours a week **65%** of the time over the duration of data collection.
- Over the duration of data collection, the eight vehicles were plugged in **14.15%** of the time on average (3.4 hours / day).

Figure 28. Time plugged in vs. time providing grid services (Jun – Dec 2018)

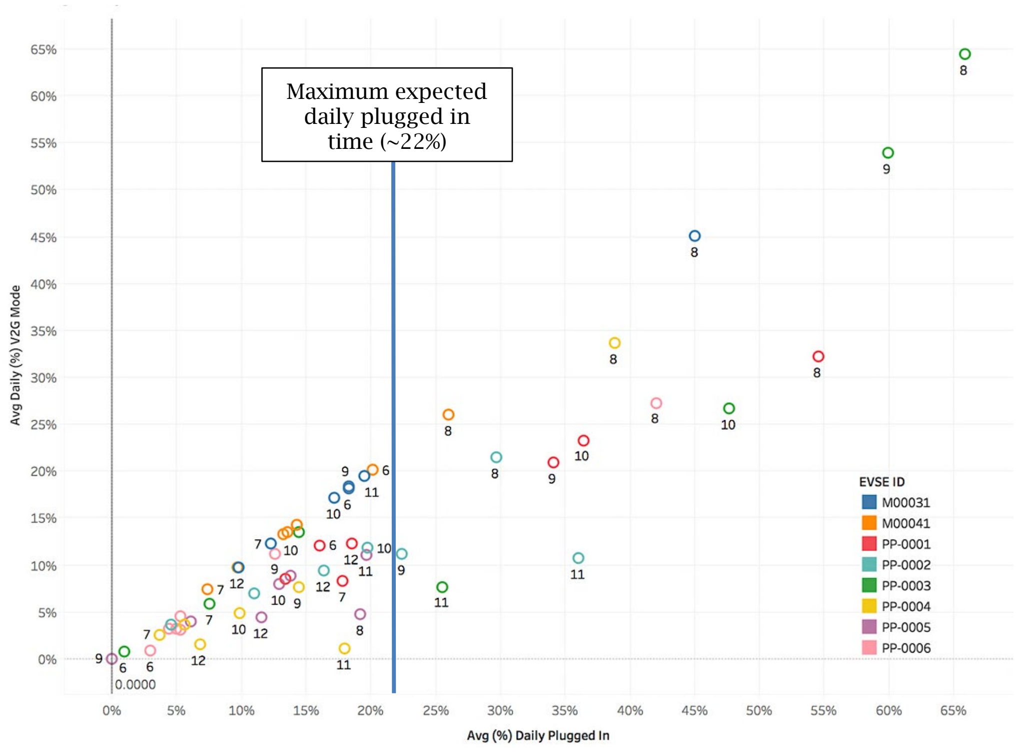
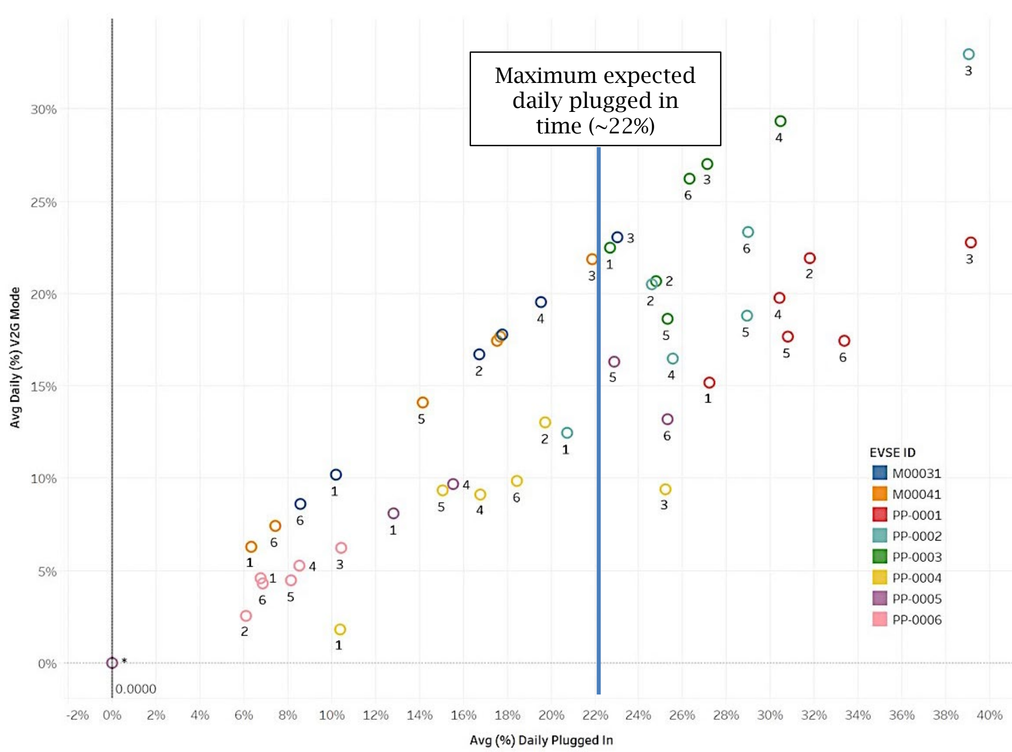


Figure 29. Time plugged in vs. time providing grid services (Jan – Jun 2019)



CHAPTER 6: Workplace V2G Value in California

Overview

The fourth use case of the EVSA project had three key objectives:

1) Demonstrate the technical capabilities of an aggregation of V2G-capable EVs in a workplace setting to provide regulation up and down to the California Independent System Operator's (CAISO) ancillary services market.
2) Quantify the potential revenue of those V2G-capalbe EVs providing regulation up and down based on demonstration data.
3) Quantify potential additional value streams V2G-capable EVs can provide based on demonstration data.

Chapter 6 has its own Table of Contents because the fourth use case was the most substantial scoped under the EVSA project and therefore occupies a significant amount of the final report. Section 6.1 – 6.5 detail the key results and processes for Objectives #1 and #2 above. Section 6.6 then covers the results of Objective #3. Prior to reading Chapter 6, it is recommended to read Chapter 5 as it provides critical context for the Chapter 6 results.

Chapter 6 Table of Contents

6.1 – Executive Summary

The purpose of the Electric Vehicle Storage Accelerator (EVSA) project is to test whether vehicle-to-grid (V2G) technology is a viable and cost-effective energy storage resource able to provide services to the grid. Through a stakeholder feedback process conducted in 2016, the project scoped four use cases[29] for implementation in order to evaluate specific aspects of V2G technology. This report addresses the interim results of the fourth use case – the evaluation of potential revenue from leveraging electric vehicle (EV) batteries to provide frequency regulation up and down in the California Independent System Operator (CAISO) ancillary services market.

Regulation up and down was identified as the key service to demonstrate under the EVSA project based on stakeholder feedback, available technology and the successful operation of electric vehicles as resources in other frequency regulation markets worldwide.[30] Therefore, exploring the technical feasibility and potential revenues streams of regulation up and down in California was a valuable exercise to achieve the following project goals: 1) inform CAISO service development around electric vehicles as resources, 2) identify barriers to V2G operation and 3) identify high-priority fleet use cases and services from a technical, policy and regulatory perspective in order to optimize the integration of EV load on the California grid.

The implementation of all four use cases include the use of 8 project vehicles – 2 Honda Accord Plug-in Hybrids and 6 Nissan LEAFs – resulting in a total capacity of 193.4 kWh and 64 kW. The project vehicles were used under a workplace charging use case and assigned to employees at the University of California, San Diego (UCSD) to be used as personal commute vehicles. Each vehicle was assigned to a bi-directional charging station installed on the UCSD campus and drivers were expected to be plugged in and available to provide regulation up and down during normal work hours (9 – 5 pm, Monday – Friday, ~40 hours per week total).

The Nuvve GIVe™ aggregation software platform simulated participation in the CAISO regulation up and down markets by sending a recorded CAISO Automated Generation Control (AGC) signal from the Los Angeles Air Force Base (LAAFB) V2G project[31] to the charging stations while the vehicles were plugged in. The EVSA project was unable to gain access to a live AGC signal because: 1) the project's size did not meet the minimum capacity requirement of 500 kW and 2) each AGC signal is custom tailored to a participating resource by taking into account real-time inputs from the market, like seasonal trends, and status of the resource itself, such as the state of charge (SoC). CAISO staff indicated the main objective of the EVSA project should be to demonstrate EVs can meet the performance requirements for providing regulation up and down and stated a signal with characteristics of an AGC signal would suffice to achieve that objective. Therefore, after

[29] Use Case 1: Interconnection of V2G-capable vehicles, Use Case 2: Transformer Upgrade Deferral (as scoped under EPC 14-086 - Distribution System Constrained Vehicle-to-Grid Services for Improved Grid Stability and Reliability), Use Case 3: Emergency power back-up using a V2G-capable vehicle, Use Case 4: Quantification of the value of V2G in CA – frequency regulation.

[30] Examples include but are not limited to: PJM in the United States, Energinet in Denmark, Tennet in the Netherlands.

[31] Los Angeles Air Force Base Vehicle-to-Grid Demonstration – https://vehicle-grid.lbl.gov/project/los-angeles-air-force-base-vehicle-grid

several months of discussions with CAISO and other stakeholders it was determined the best available option to simulate regulation up and down services would be to leverage the recorded AGC signal from the LAAFB V2G project.

The GIVe™ platform dispatched the vehicles' battery capacity based on the AGC signal as well as the capacity bids submitted by the EVSA project team to the platform 24-hours ahead of time to simulate participation in the Day Ahead Market (DAM). The project team assessed the available capacity for bidding based on drivers' daily trip scheduling in the project mobile application and historical availability trends. During the time frame examined (September 12, 2018 – June 30, 2019), capacity bids were placed on 208 work days (out of the total 292 days).

The small size of the EVSA coalition, both in total capacity (64 kW) and number of vehicles (8), resulted in a narrow margin of error for bidding accuracy. The margin was further impacted by half of the project drivers following consistent work / charging schedules and the other half being highly variable. This unpredictability resulted in a maximum hourly bid of 35 kW, or 55% of the 64-kW total rated capacity of the coalition. The range of driver predictability provided key insight into high and low performing user profile types in a workplace charging – frequency regulation use case on a University campus. The behavior of the user profiles identified will inform future VGI deployment at a larger scale where predictability of vehicle availability will improve as the number of vehicles aggregated increases.

Based on the project design detailed above, Energy and Environmental Economics, Inc. (E3) analyzed the performance of the EVSA coalition from September 11, 2018 – June 30, 2019 and calculated the potential revenue by following the settlement calculations outlined in CAISO's Business Practice Manuals (and detailed in the body of the report). The analysis simulated the settlement process by evaluating the coalition's performance accuracy, non-compliance charges, and capacity and mileage settlements for regulation up and down. It is important to acknowledge the impact of using a historical signal on the performance and revenue results of the coalition. Without a live signal, dispatch requests were not adjusted in real-time to account for the resource's SoC as they would have been by CAISO during live market participation. For example, when the coalition's SoC approached "full", there was no feedback to adjust the dispatch commands away from charging. Therefore, the coalition would try to fulfill a charging request and fail to do so as the SoC approached full. Situations like this, among other factors, contributed to the triggering of non-compliance charges during 33% of the hours bid, which correlated to a 16% reduction in capacity settlement for both regulation up and down.

The performance accuracy results indicated the coalition did perform well above the minimum accuracy threshold of 25%, with the resource ranging from 38% to 60% for regulation up and 42% to 69% for regulation down. However, while well above the minimum threshold and on the upper end of the system average (30% – 60%[32]), the results are still low when compared to performance

[32] https://www.caiso.com/Documents/Jul31_2014_Order755MarketDesignReport_ER12-1630_ER14-971.pdf

scores of stationary battery storage (~90%[33]). Additional analysis is needed to determine exactly why this is the case, but this study indicates that in addition to the limitations of using a recorded AGC signal, prediction of available vehicle capacity is a major factor. The improvement of vehicle availability and the forecasting of that availability would reduce non-compliance charges and improve coalition performance significantly. Forecast accuracy should improve with more experience and a larger aggregation of vehicles than was included in this project. Overall, the net revenue for the 64 kW capacity coalition varied between $3 - 20 per vehicle per month with an average $9.63 per month or $115.57 per vehicle per year. During the timeframe examined, the EVSA coalition earned a total of $577.87 (September 12 – June 30, 208 workdays).

The EVSA revenues were then extrapolated into the near future using E3 market price forecasts developed from CPUC Integrated Resource Planning (IRP) scenarios to compare energy prices with frequency regulation prices. The results showed winter, fall and spring follow similar trends where the energy prices drop during the daylight hours and there is an increase in regulation up and down prices during the middle of the day. Summer shows more constant energy prices throughout the day, with a spike in regulation up prices in the late afternoon/evening. E3's analysis also projects EV ancillary services (AS) revenues in California for both a base case and high value case. The results show AS prices, and consequently EV revenues, are projected to grow until the mid-2020's for both cases, followed by a drop in EV revenue before increasing renewables gradually drive AS prices back up through 2040. Although the forecast shows a sharp reduction in revenue, there is a high level of uncertainty regarding the exact timing and rate of decline.

The EVSA project examined regulation up and down as one of the many potential value streams for grid integrated vehicles in California. Successful implementation and high revenues from frequency regulation in other geographies made this use case an obvious choice to explore in California when the project was scoped in 2016. Overall, the results of this report demonstrate the technical feasibility of V2G capable electric vehicles providing regulation up and down in the CAISO ancillary services market. However, due to poor vehicle availability and use of a historical AGC signal, the revenue quantifications should be interpreted with the relevant context and used to inform additional VGI research being conducted in California to further examine the different use cases, services and fleet types that bring the most value to rate payers.

[33] Energy Storage in PJM exploring Frequency Regulation Market Transformation, 2017 https://kleinmanenergy.upenn.edu/sites/default/files/Energy%20Storage%20in%20PJM.pdf

6.2 – Introduction

6.2.1 Background on Project and Data Collection

Earlier this year, the Electric Power Research Institute (EPRI) and Energy & Environmental Economics (E3) co-authored a report exploring the grid and ratepayer benefits of distribution aware Vehicle-Grid Integration (VGI)[34]. The project highlighted the enormous revenue potential for EVs that can perform smart charging (V1G) and the additional benefit of vehicle-to-grid (V2G) technology that enables bi-directional power flow between EVs and the grid. Among the many benefit streams analyzed, Ancillary Services (AS) is one that EVs are well suited to provide due to their fast ramp rate and response time compared to other resources. However, the complexity of ancillary service provision, particularly frequency regulation, is difficult to simulate through current modelling techniques. The data collected through the Electric Vehicle Storage Accelerator (EVSA) project allows for a much deeper analysis of the frequency regulation revenue opportunity in California. As the manager of the EVSA project on behalf of EVgo, Nuvve has collected operational data from 8 project vehicles responding to a historical CAISO Automated Generation Control (AGC) signal over the past six months. E3 analyzed the performance of the coalition based on this data and calculated how a coalition of EVs might be compensated through a detailed review of current CAISO market rules. This report therefore builds upon prior VGI studies with a specific focus on the revenue opportunity for frequency regulation in California under a workplace charging scenario. Specifically, the report intends to use the data gathered through the EVSA project to:

1. Assess the performance accuracy of the EV coalition and identify the likelihood of disqualification from either the regulation up or regulation down market due to underperformance.

2. Calculate the revenue and non-compliance charges for the EV coalition based on data collected during the project.

3. Perform a revenue outlook given past performance and E3's AS market price forecasts.

6.2.2 The Electric Vehicle Storage Accelerator (EVSA) setup

This section briefly describes key aspects of how the project was set up to mimic frequency regulation market participation.

EVgo installed eight V2G capable EVSEs at various locations on the University of California, San Diego (UCSD) campus. Six of the eight EVSEs are commercially available, DC CHAdeMO 10 kW

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[34] Distribution System Constrained Vehicle to Grid Services for Improved Grid Stability and Reliability [EPC-14-086]. https://www.energy.ca.gov/2019publications/CEC-500-2019-027/CEC-500-2019-027.pdf

charging stations manufactured by Princeton Power Systems and are used to charge six, unaltered 2016 Nissan LEAFs (each with a 30 kWh battery). The other two chargers are SAE J1772 AC Level 2 stations manufactured by Nuvve and are used to charge two retrofitted Honda Accord Plug-in Hybrid Electric Vehicles (each with a 6.7 kWh battery). The Hondas and the AC stations are outfitted with additional communication modules to enable bi-directional energy flow and are capable of 2 kW power transfer via a mobile inverter on-board the Honda Accord vehicle.

To simulate the AGC signal used by CAISO to control generation output, a recorded AGC signal was used due to obtain a live signal for research purposes. This is because 1) resources under the 500 kW minimum capacity requirement cannot participate in the regulation market[35] and 2) each AGC signal is customized to the resource it is controlling, using inputs such as real-time state of charge (SoC). After exploring several AGC signal input options with UCSD, CAISO, and other state-funded projects examining AS market participation, it was determined a recorded signal was the best available proxy for the EVSA project to achieve its goals.

The AGC signal recording chosen was taken from the LA Air Force Base (LAAFB) V2G project[36] in which an EV coalition of 34 light- and medium- duty plug-in electric and hybrid vehicles (EVs/PHEVs) participated in CAISO's frequency regulation market and was sent a live AGC signal. A recording of that signal was provided by Lawrence Berkeley National Lab (LBL), the principal investigator on the LAAFB V2G project, and included 1-second interval recordings of the AGC signal sent to the EV coalition from April 2016 – October 2017. LBL indicated certain portions of the data set were not recommended to be used for the EVSA project's purpose due to operational nuances and therefore were excluded from consideration for EVSA dispatch. After removing these sections of the signal, the EVSA project team conducted further analysis to identify the trends in energy requested by the signal's set-points. The analysis showed the signal was not symmetrical over time and requested extended periods of max regulation down requests and max regulation up requests. The Project Team therefore decided to edit the LAAFB signal to be more symmetrical between regulation up and regulation down requests. This decision was made for two reasons:

(1) Following discussions with CAISO, it was determined the priority of the EVSA project should be to demonstrate the technical feasibility of EVs providing regulation up and regulation down while maintaining performance requirements. Therefore, it was determined the use of any representative AGC signal would achieve that goal.

(2) A key input of a resource's AGC set-points is the real-time SoC of that resource – i.e. if a battery's SoC is approaching full, subsequent set points will take that into account. The AGC set-points provided from the LAAFB project therefore took into consideration those resources' SoC but sending the same set-points to the EVSA

[35] CAISO Tariff Appendix K, A 1.1.1

[36] Los Angeles Air Force Base Vehicle-to-Grid Demonstration – https://vehicle-grid.lbl.gov/project/los-angeles-air-force-base-vehicle-grid

resources would not take into consideration their real-time SoC. Using the original, asymmetrical LAAFB signal would therefore have unrealistically filled up or drained the EVSA resource batteries based on the SoC (and other market inputs) of the LAAFB resources which were used under a different use case (fleet vehicles vs. workplace charging). Given this limitation, the best option for the demonstration was to select a more symmetrical signal in order to achieve the technical feasibility priority indicated by CAISO.

Therefore, the recording selected for the EVSA project from the overall LAAFB signal consisted of one 4-hour section from June 3, 2016 18:00:00 - 22:00:00, and a 10-hour section from September 6-7, 2016 18:00:00 - 04:00:00. The two recordings were spliced together and are played on a 14-hour loop to simulate a real AGC signal for the EVSA coalition to follow. The loop plays for all 24 hours of the day therefore, introducing daily randomness around what the coalition is asked for in any given hour. The recording was normalized and scaled to the Bid Capacity submitted by the aggregation administrator (Nuvve).

During the demonstration the aggregation administrator acted as a scheduling coordinator and submitted regulation capacity bids through Nuvve's GIVe™ aggregator platform. Drivers entered their expected departure times and desired vehicle range in miles for departure from UCSD on a daily basis into the project mobile application. The parameters were used by the aggregation administrator to place regulation capacity bids one day ahead on an hourly basis. Instead of submitting separate bids for regulation down and regulation up, the GIVe platform was configured to submit one bid for both regulation up and regulation down capacity bids. Drivers have the ability to request to drop out of frequency regulation mode and charge their vehicles in the case of an emergency at any time via the project mobile application, reducing the available regulation capacity of the coalition.

There are several limitations with the method used to create a dispatch signal to simulate regulation up and down market participation. First, the signal is imperfect because it is not live and therefore does not take into account the various inputs CAISO uses to determine a resource's set points, including, but not limited to the resource's SoC, wholesale energy demand and seasonal/daily variation due to weather and other macro-level events. Further detail is provided in Section 1.3 of the report regarding the limitations of this analysis due to the use of a recorded signal. In order to execute the outlined scope of the project on time and in budget, the Project Team evaluated all available options for a dispatch signal with feedback from stakeholders (including CAISO staff) and chose the best available option to meet project goals.

6.2.3 The Data

Nuvve's GIVe aggregator software records charging session data every second for each EV while it is connected to its corresponding charging port at the UCSD site. An aggregated coalition dataset of the 8 project vehicles was provided and used for most of the analysis. The individual vehicle datasets were used for additional sensitivity testing. A list of the variables used in the analysis from the coalition dataset are below:

- **Power Requested** – The dispatch request as dictated by the recorded AGC signal (kW)
- **Power Provided** – The telemetry signal of current coalition output (kW)
- **Bid Capacity** – The total capacity bid placed for that hour (kW)
- **Power Capacity Up** – Total power capacity available for discharging based on the state of charge of all available vehicle batteries' in the coalition (kW)
- **Power Capacity Down** – Total power capacity available for charging based on the state of charge of all available vehicle batteries' in the coalition (kW)

Data acquisition began in mid-June 2018 however, a few months of operational fine-tuning was required once the historical AGC signal was introduced to the coalition of project vehicles. This resulted in a formal bidding strategy being introduced in mid-September 2018. Consequently, to provide a fair assessment of performance and revenues under normal operation the analysis only includes data after 23:59 on 11th of September 2018. Where multiple records existed in a one second timestamp, the oldest value was discarded to remove duplicate timestamps reducing the dataset size by 0.23%. No additional data filtering was carried out.

Market prices and system data over the analysis period were extracted from CAISO's Open Access Same-Time Information System (OASIS) for the CAISO expanded region over the study period.[37]

[37] CAISO BPM for Market Instruments - https://bpmcm.caiso.com/Pages/BPMDetails.aspx?BPM=Market%20Instruments

6.3 – Frequency Regulation

6.3.1 Methodology Overview

In October 2011 Order 755 was issued by the Federal Energy Regulatory Commission (FERC) directing independent system operator's (ISO's) to create a two-part payment system for frequency regulation.[38] Resources providing frequency regulation service are now compensated for the capacity they provide, and for the performance of the resource in response to the regulation signal. The purpose of Order 755 was to remedy discrimination in the procurement of regulation resources by accounting for the ability of a resource to accurately follow regulation signals.[39] [40]

An EV coalition, as a Non-Generating Resource (NGR), would likely participate in CAISO's frequency regulation market through Regulation Energy Management (REM). Under REM an NGR has its state of charge (SoC) managed by CAISO, by dispatching energy from the real time market. All energy charged and discharged from the EV coalition and the REM energy dispatched to maintain the SoC of the coalition would be settled at the RTM locational marginal price (LMP). For this analysis only settlements from Regulation Capacity, Regulation Mileage, and Regulation Non-Compliance are calculated for regulation up and down. All other charges for grid management, flexible ramping, energy, and other miscellaneous charges are ignored. We summarize the current net payment from CAISO to a resource for regulation services in the following equation (Equation 1):

$$Revenue = [RC \times RCP] + [RMM \times AM \times MP] - NCC$$

Where:

RC = Regulation Capacity Bid (MW)

RCP = Regulation Capacity Price ($/MW)

RMM = Resource Mileage Multiplier

AM = Adjusted Mileage of the resource accounting for under response

MP = Market price for mileage ($/Mile)

NCC = Non-Compliance Charges ($)

CAISO procures regulation capacity daily in day–ahead and hour-ahead forward markets or auctions. A resource will be compensated for the capacity it provides at the market clearing price. In addition, CAISO pays each procured MW of capacity a mileage payment. The mileage payment

[38] Frequency Regulation Compensation in the Organized Wholesale Power Markets, FERC Stats. & Regs. ¶ 31,324 (2011) (Order 755), rehearing denied, 138 FERC ¶ 61,123 (2012) (Order 755-A).

[39] Cal. Indep. Sys. Operator Corp., 140 FERC ¶ 61,206 (2012); Cal. Indep. Sys. Operator Corp. 142 FERC ¶ 61,233 (2013).

[40] http://www.caiso.com/Documents/Jul31_2014_Order755MarketDesignReport_ER12-1630_ER14-971.pdf

is based on the clearing price for Mileage in the procurement hour, the amount of mileage the resource undergoes, and a mileage multiplier which is a function of a resource's accuracy when following the AGC signal. Non-Compliance charges are a penalty that reduce a resource's capacity compensation if the resource is not adhering to market rules.[41] These rules are discussed in more detail in the Regulation Non-Compliance section of this report.

The equations and methods published by CAISO that define its regulation compensation are used to evaluate the revenue potential for the EVSA coalition over the study period. In addition, an assessment of performance will indicate whether the EV coalition is at risk of disqualification from providing regulation services and will provide a mileage revenue estimate. An analysis of the bidding behavior will indicate when regulation non-compliance conditions might be triggered resulting in revenue reduction penalties and will shed additional light on how the current bidding strategy might be improved to increase revenue potential for the fleet during the remainder of the project data collection time frame.

6.3.2 Performance Accuracy and Resource Mileage Multiplier

This section describes the performance accuracy and resource mileage multiplier calculations. The resource mileage multiplier is defined below[42]:

$$RMM = SMM \times \left[\frac{10}{Ramp\ rate}\right] \times \left[\frac{Resource\ Performance}{System\ Performance}\right]$$

Where:

RMM = Resource Mileage Multiplier

SMM = System wide mileage multiplier based on system performance accuracy during the prior week

Ramp rate = The number of minutes required for the resource to reach certified capacity (integer from 1 to 10)

Resource Performance = The rolling 30-day average of the performance accuracy of the resource

System Performance = The 7-day rolling average of system wide performance accuracy

Performance accuracy is a metric from 0 to 1 that evaluates how well a resource follows the AGC dispatch signal. Performance accuracy is measured for all four second AGC instructions over each 15-minute period, which is then used to calculate a rolling 30-day weighted average value.

[41] CAISO Settlements Guide: Regulation Non-Compliance, https://www.caiso.com/Documents/RegulationNon-Compliance.pdf

[42] As defined in BPM for Market Operations – Appendices, Section J.2

The RMM is designed to better compensate those resources that ramp faster and follow the AGC dispatch signal more closely than other resources on the system. Mileage compensation is usually around 10% of capacity compensation and therefore is not a significant driver of revenue for the market participant. The main importance of performance accuracy for a resource is whether it drops below the minimum threshold of 25% which triggers a requirement to recertify the resource within 90 days. The EV coalition in the LAAFB project was decertified for the regulation down market in January 2017 for this reason.[43] Therefore, this section focuses largely on the performance accuracy metric.

For a detailed description of all resource mileage multiplier and performance accuracy calculation equations, see the Business Practice Manual for Market Operations[44], the Business Requirements Specification document for Pay for Performance Regulation,[45] and the subsequent update following the one-year review in 2014.[46] These equations were followed closely, however on occasion simplifying assumptions were required, which are discussed below:

Data resampling

The AGC signal is sent by CAISO every 4 seconds and therefore the most granular assessment of performance accuracy by CAISO is at 4 second intervals. The Nuvve dataset is a 1 second interval timeseries and therefore must first be resampled to 4 second interval data prior to calculation. Resources participating in frequency regulation have a Remote Intelligent Gateway (RIG) installed (or similar device) to communicate data to CAISO through direct telemetry. The RIG uses the real time updated value (most recent measurement of output) to measure the Point of Delivery power provided by the resource.[47] As discussed, the AGC signal used for this study was 14 hours of a recorded AGC signal from the LAAFB V2G project with 1 second granularity. The signal is played on loop throughout the entire study period but is only logged as Power Requested when the vehicles are plugged in and providing grid services. It is therefore challenging to identify the last 1 second timeslot within each 4-second interval as a vehicle could plug in at any point within a 4 second interval. For simplicity, the mean value in each 4 second period was taken to resample the timeseries. As a sensitivity the absolute maximum value in each four second period was used to resample the data rather than the mean, this increased final revenues by 0.32%.

Dispatch Operating Point assumed to always be zero

CAISO defines instructed up and instructed down regulation signals through the difference between the AGC set point and the Dispatch Operating Point (DOP). The DOP is the expected generation trajectory of a resource as it ramps from one Dispatch Operating Target (DOT) to the

[43] Department of Defense; Task Order 012: Plug-In Electric Vehicle, Vehicle-to-Grid, December 2017, page 15; SCE Department of Defense Vehicle-to-Grid Final Report, page 9

[44] https://bpmcm.caiso.com

[45] CAISO, "Business Requirements Specification - Pay For Performance Regulation," May 2013

[46] CAISO, "Business Requirements Specification - Pay For Performance Enhancement," December 2014

[47] See section 14.1.3 of BPM for Direct Telemetry: https://bpmcm.caiso.com/Pages/BPMDetails.aspx?BPM=Direct%20Telemetry

next. A DOT is a dispatch instruction, separate from the AGC signal, that is sent every five minutes via CAISO's Automated Dispatch System.[48] The DOT will depend on the resource's Preferred Operating Point (POP) that was submitted alongside its regulation capacity bid for the scheduled hour. The DOT will also depend on what other services the resource may be providing. For example, for resources providing energy in the Real-Time Market, their DOT will incorporate what generation output they were scheduled to provide based on their energy market bid. The AGC signal will then fluctuate around the level of generation output the resource is operating at to meet the next DOT. Since the EV coalition in the EVSA demonstration project is only providing frequency regulation, and no POP is submitted alongside the capacity bids, we assume (and confirmed with CAISO representatives) that DOT and therefore DOP is always zero.

Correlation of AGC signal with SoC and market and system data

For resources providing regulation service through REM, CAISO will manage the resource's SoC to ensure its value is maximized during scheduled hours. The AGC signal will adjust depending on a resource's SoC to ensure the resource can always provide sufficient regulation up or down service depending on CAISO's needs. Since the AGC signal used for the EVSA project is a recording, it does not account for the SoC of the EVSA coalition. By not accounting for the SoC, the performance accuracy score for the coalition is adversely impacted and the instructed mileage is likely higher than it might be with a real AGC signal. Consequently, there were periods during the study where the AGC signal instructs the coalition to provide regulation down even when some of the vehicles in the coalition are unable to provide it because their SoC is close to 100%, and vice versa. Under this scenario, the coalition cannot follow the AGC signal closely and would therefore receive a poor performance accuracy score. Under live market conditions where an AGC signal accounts for the coalition's SoC, a smaller instructed down signal would have been sent to the coalition resulting in an improved performance accuracy metric during these periods.

Since the AGC signal is a recording it also does not correlate with regulation market prices or system mileage values over the analysis period. Despite this, real CAISO market prices for this period were still used instead of prices from the same period as the AGC signal recording. This was done to evaluate the volatility in revenue of the vehicle coalition over this time due to market price fluctuation.

Resource certification

Each resource providing regulation services to CAISO must be certified.[49] During certification a resource's ramp rate is assigned. Since no certification has been carried out for the EVSA

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[48] See sections 7.2.3.4 and 7.2.3.6 of the CAISO BPM for market operations https://bpmcm.caiso.com/Pages/BPMDetails.aspx?BPM=Market%20Operations

[49] CAISO Tariff, Section 8.3.4 and Appendix K, part A

coalition, a value of 1 minute is assumed for the ramp rate which is typical for other similar resources such as battery storage.[50]

Minimum mileage for performance accuracy calculation

A performance accuracy calculation is made for each 4-second interval when a resource is providing frequency regulation. CAISO will only perform the calculation if the instructed mileage of the AGC signal in that 4-second interval is over a minimum threshold of 0.1 MW or 0.1% of the resource's regulation capacity.[51] If the mileage is less than this threshold the performance calculation is skipped for that 4 second interval. Since this project is a demonstration and has a maximum capacity of 64 kW, the minimum threshold of 0.1% of the regulation capacity is used instead.

Performance Accuracy analysis

During the analysis period, the monthly performance accuracy test calculated at the start of each month ranged from 38% to 60% for regulation up and 42% to 69% for regulation down. The rolling 30-day average scores fall within a similar range and at no point was the minimum accuracy threshold of 25% close to being crossed. Therefore, over the study period it is unlikely the coalition would have been at risk of decertification. The rolling 30-day average performance scores can be seen in Figure 30 along with the corresponding daily total instructed mileage shown in Figure 31.

[50] http://energystorage.org/energy-storage/energy-storage-benefits/benefit-categories/grid-operations-benefits

[51] CAISO, "Business Requirements Specification - Pay For Performance Regulation," May 2013, page 14, ID# PFPR-BRQ017

Figure 30. Rolling performance accuracy

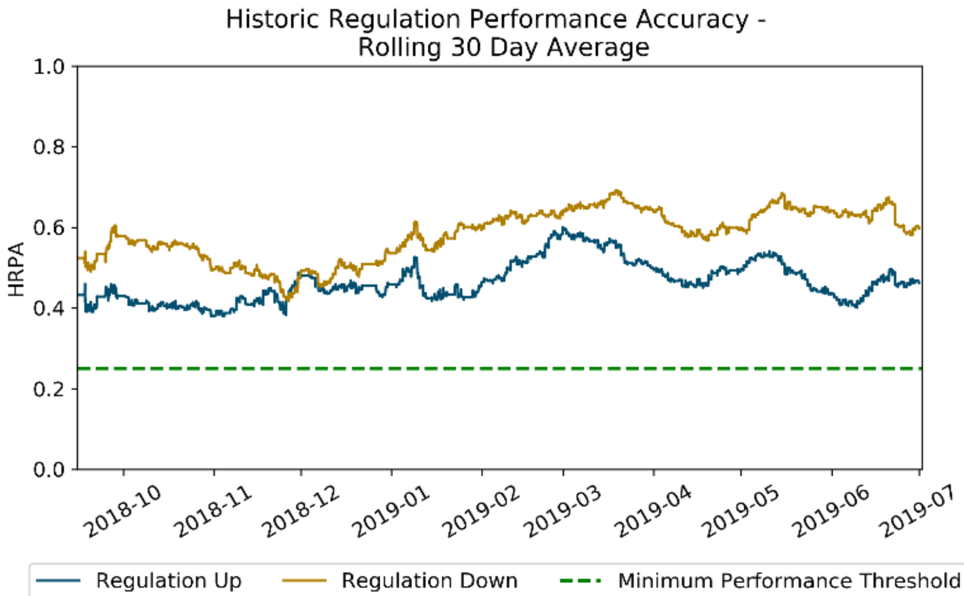
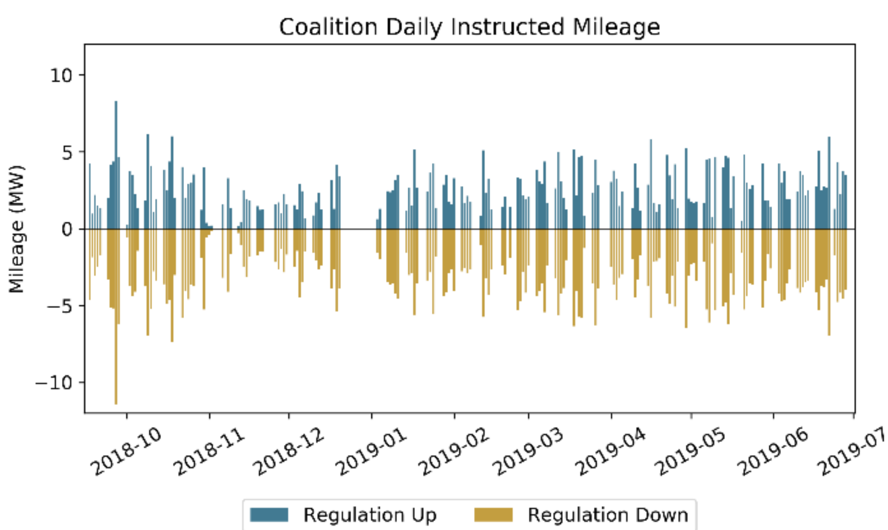


Figure 31. Total daily instructed mileage



As discussed in the project background, the AGC signal is scaled to the bid capacity and therefore days with larger bids tend to result in higher mileage. Furthermore, mileage will be adjusted if the AGC signal is not sent on certain days primarily on weekends and holidays as well as for occasional maintenance.[52] Overall, the mileage settlement is influenced by the vehicle availability, the signal and the accuracy of bidding.

[52] Note that only the performance accuracies from the 16th of September are shown in figure 1 as before this date there is a lack of available data to calculate a rolling average causing these scores to be very volatile. For newly certified resources, CAISO uses the average 30-day performance accuracy of all available certified resources as the default

These results show the coalition generally performed marginally better when responding to regulation down instructions suggesting signals directing the coalition to charge were easier to follow. Regulation down performance appears to have declined from an initial high of close to 60% in mid-September to a low around the end of November, while regulation up performance remained relatively constant. The EV coalition in the LAAFB project was disqualified from the regulation down market due to poor performance, although this was found to largely be due to incorrect user input of the regulation down operating limit rather than an inability of the hardware to follow the ACG signal[53].

Another key finding is the performance accuracy for the EV coalition, while well above the minimum threshold and on the upper end of the system average (30% – 60%[54]), is still low when compared to performance scores of stationary battery storage (~90%[55]).

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performance accuracy initially to avoid early stage volatility - See BPM for Market Operations – Appendices, Section J.3 pg 302.

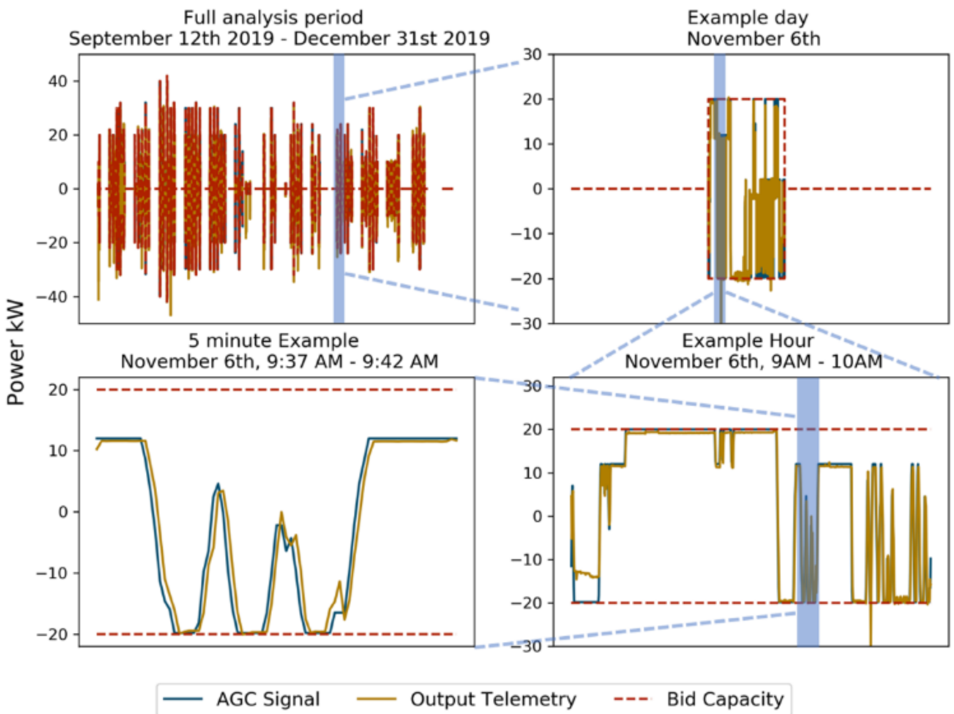
[53] Department of Defense; Task Order 012: Plug-In Electric Vehicle, Vehicle-to-Grid, December 2017, page 15, SCE Department of Defense Vehicle-to-Grid Final Report, page 9

[54] https://www.caiso.com/Documents/Jul31_2014_Order755MarketDesignReport_ER12-1630_ER14-971.pdf

[55] Energy Storage in PJM exploring Frequency Regulation Market Transformation, 2017 https://kleinmanenergy.upenn.edu/sites/default/files/Energy%20Storage%20in%20PJM.pdf

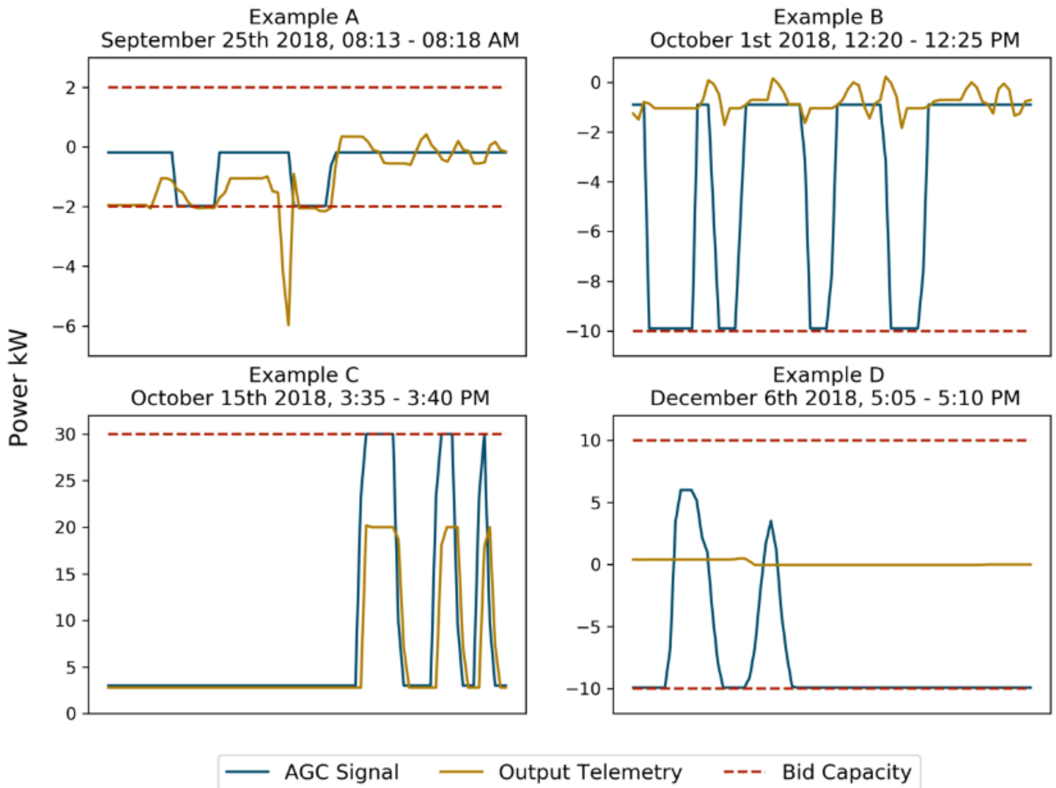
Figure 32 shows the EV coalition following the AGC signal under different time horizons and highlights how the coalition has the capability to follow the AGC signal very closely under normal operations.

Figure 32. AGC signal and output telemetry of the coalition under different time frames



As discussed in 6.3.1 Methodology Overview, under regulation energy management the performance accuracy would likely be improved as the live AGC signal would account for the coalition SoC. However, this would probably not improve the performance drastically. Given the highly granular nature of the dataset it can be challenging to explore what else might be driving this lower performance. The are no known hardware or software limitations that would prevent an EV coalition from achieving performance accuracy as high as battery storage resources. The 15-minute performance scores were used to identify some examples of low performance periods and these are shown in Figure 33.

Figure 33. Example of low performance accuracy resource behavior for the coalition



Example A shows a situation where a symmetrical 2 kW bid was submitted for both regulation up and down while four vehicles were connected (2 LEAFs and the 2 Honda Accords). In aggregate, the four vehicles followed the signal with relative accuracy, however the spike in the output telemetry seen at ~8.:15 am on 9/25/18 was due to a spike in power from one of the Princeton Power stations immediately following the initial plug of the vehicle. The spike occurred over the course of 4 seconds until the station then started following the AGC signal. Unfortunately, spikes in power to the full capacity (in this case 10kW, which ends up being tempered down to 6kW in aggregate as shown in the graph by the discharging of the other vehicles online at the same time) are not uncommon when a vehicle first plugs into a charging station.

Examples B, C, and D all highlight the greatest challenge with EV aggregation and likely the main driver of low performance – the challenge in predicting when EVs will be connected and available for dispatch to the grid. Examples B, C and D all capture when a bid was placed and that bid exceeded the actual capacity available. The performance accuracy suffers when the capacity bid placed relies on fewer vehicles, since one vehicle dropping out of the coalition would have a larger relative impact. Scaling the coalition to thousands of EVs will diminish the impact of inaccurately predicting vehicle availability, as has been demonstrated with Nuvve's larger scale pilot projects in Europe.[56] The impact of inaccurate capacity bidding is discussed further in AS Capacity Bidding section.

Finally, it should be noted that the methodology for assessing performance varies between ISO's across the US. Sadeghi-Mobarakeh has demonstrated[57] that the same resource behavior under different performance assessment methods can result in very different performance accuracies. Sadeghi-Mobarakeh identifies the CAISO performance accuracy metric is very sensitive to the magnitude of the AGC set point for example. In an informational report CAISO has already suggested other ISO performance accuracy metrics could be used to refine their own methodology[58]. However, conducting sensitivities using performance metrics from other US ISO's is beyond the scope of this report.

Resource Mileage Multiplier and Adjusted Mileage

Using the rolling 30-day average performance accuracy found in the previous section, the Resource Mileage Multiplier (RMM) was calculated in each 15-minute interval for the data set provided (September 11th, 2018 – June 30th, 2019). Resources certified in Regulation Up and Down have resource-specific Mileage Up or Down multiplier that is used by the. Market to determine the maximum Mileage a resource could be awarded.[59] The distribution of mileage multipliers across all 15-minute intervals is plotted in Figure 34.

[56] Nuvve GIVe™ Platform, the World's Largest Aggregator Participates in TenneT's Frequency Regulation Market in the Netherlands. https://www.prnewswire.com/news-releases/nuvve-give-platform-the-worlds-largest-aggregator-participates-in-tennets-frequency-regulation-market-in-the-netherlands-300262624.html (accessed 9.10.19)

[57] Performance Accuracy Scores in CAISO and MISO Regulation Markets: A Comparison Based on Real Data and Mathematical Analysis. Ashkan Sadeghi-Mobarakeh, IEEE Transactions on Power Systems, Vol 33 No 3, May 2018

[58] CAISO Order 755 Market Design Report page 12

[59] CAISO Business Practice Manual, Market Operations,, Attachment J – Calculation of Weekly Mileage Multipliers

Figure 34. Mileage multipliers for the EV coalition and the system

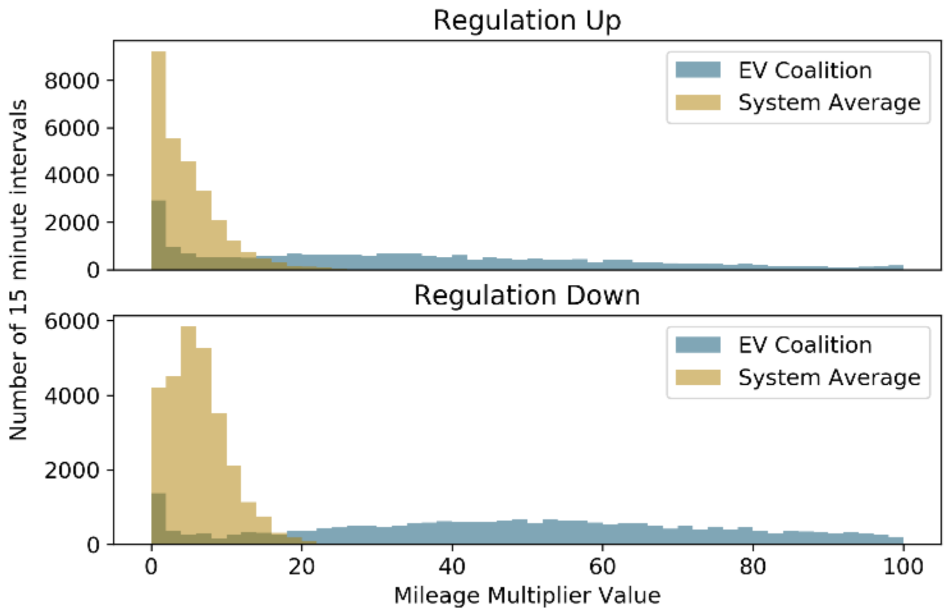


Figure 34 above compares the EVSA coalition mileage multiplier values to the overall system average. The system mileage multiplier is a quantity reflecting expected mileage from 1 MW of regulation up or regulation down capacity in a given hour. As is evident from Figure 34, the mileage multipliers for the EV coalition span a much broader range than the system average mileage multiplier value over the same time period. This indicates an EV coalition has the potential to perform well above the system average and be awarded higher resource specific mileage multiplier (RMM) due to the coalition's faster relative ramp capability and accuracy as compared to the overall system accuracy.

These metrics can now be combined with market prices to calculate the mileage compensation, which will be discussed in the Revenue and Outlook section. However, before revenues can be calculated, the regulation capacity bids will be analyzed along with the non-compliance charges.

6.3.3 AS Capacity Bidding

The regulation capacity bids submitted through the GIVe™ aggregator platform are the main driver of revenue for the coalition, not only because capacity settlements are the largest source of revenue, but also because the capacity bids directly impact performance accuracy, mileage compensation, and whether non-compliance charges are incurred. This section analyzes the capacity bids submitted during the EVSA project to shed light on the bidding performance, highlight periods of undersupply and oversupply, and calculate the reduction in incentive due to regulation non-compliance.

Bidding analysis

Optimal bidding of regulation capacity requires the coalition administrator to accurately predict when EV owners will arrive and depart from the charging site, what state of charge EVs will arrive with, and the state of charge needed for each EV before leaving the charging site. To inform this, participating drivers enter their expected driving schedule at the start of the week which is recorded on the GIVe aggregator platform and is used by the administrator to submit Capacity bids. The two variables 'Power Capacity Up' and 'Power Capacity Down' in the dataset represent the instantaneous available power for regulation up and regulation down respectively. Comparing these variables with the Capacity Bid allows us to measure the accuracy of the bidding since accurate bidding would result in the capacity bid following the Power Capacity Up / Down values closely. It should be noted that the GIVe aggregator platform was first deployed on other electric systems with only one regulation market, therefore, the software currently does not allow separate bids for regulation up and down. For example, when a bid of 10 kW is submitted via the GIVe software, it translates to + 10 kW for regulation up (discharging) and – 10 kW for regulation down (charging). This means comparing Power Capacity Up / Down to the Capacity bid is likely to overstate bidding inaccuracy.

The histogram in Figure 35 shows the average regulation capacity undersupply and oversupply for each hour on a weekday over the analysis timeframe (September 12th – June 30th). Zero in this figure means the capacity bid exactly matches the capacity available, a positive value means the capacity available is larger than the capacity bid and a negative value means there is a shortfall in capacity in that hour on average over the study period.

Figure 35. Average hourly undersupply and oversupply of regulation capacity over the analysis timeframe

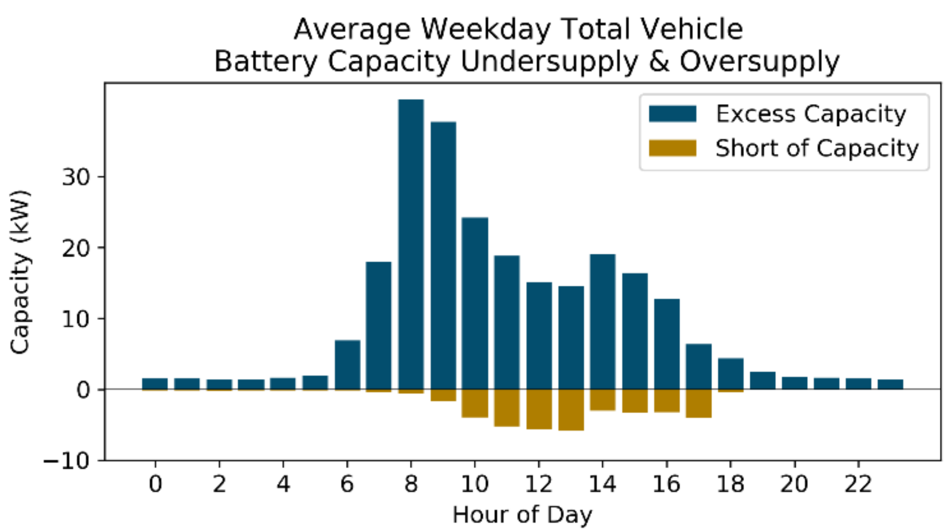


Figure 35 highlights there is often excess capacity available that has not been bid into the regulation market. The coalition is rarely short of capacity in the morning hours and usually has large excess, sometimes close to 30 kW or half the total coalition, indicating morning bids are conservative. In the afternoon it is more likely that capacity bids are too aggressive resulting in the coalition being short on regulation capacity. This suggests drivers may be arriving on site earlier than scheduled or with an SoC closer to 50% than anticipated. In the later hours drivers may be leaving the site earlier or decide they need a higher SoC before leaving work than they initially thought, resulting in less free capacity for regulation. Note, the non-zero average weekday capacity for hours 0-6 and 18-24 are due to some project drivers leaving their vehicles plugged in overnight or while they are on vacation or out of town for travel. In a typical workplace scenario, the capacity would be zero during non-work hours. Finally, it should be noted that the UCSD site is not representative of a typical workplace, with a third of the drivers consistently arriving before 8 am and departing before 3pm, a third following standard work hours and the final third having very inconsistent schedules. Additional detail regarding the vehicle availability can be found in Chapter 6 of this report.

6.3.4 Regulation Non-Compliance

CAISO's Regulation Performance Monitoring (RPM) program continuously audits performance of all units scheduled to provide Regulation to ensure availability of the service in real-time. The RIG installed on site detects the status of the resource and transmits data to the CAISO's Energy Management System (EMS) every 4 seconds. Regulation non-compliance charges will be incurred if, during an hour where the resource has been scheduled to provide regulation service any of the following conditions are met:

+ **Off Control –** The resource is not switched on.
+ **Communication Error** – There is a communication error from the RIG.
+ **Constrained Limits** – The resource cannot provide sufficient operating range to match its scheduled capacity bid.
+ **Out-of-Range** – The resource is currently generating outside the scheduled regulation range.

For this analysis it is assumed the resource is always switched on and there are no communication errors with CAISO. Therefore, only the last two conditions are used to calculate non-compliance charges.

The Out-of-Range condition is triggered when the resource generates at more than 10 MW outside the scheduled regulation range continuously for at least fifteen consecutive minutes.[60] For the purposes of this study a value of 10% of bid capacity was used instead. Only two out-of-range non-compliance events occurred, one event lasted for 60 minutes, and the other lasted for 15

[60] .See BPM Configuration Guide: Regulation No Pay Quantity Pre-calculation, version 5.3 pg 10

minutes. These events resulted in non-compliance charges being levied impacting the overall results.

The expected regulation range for the Constrained Limits condition is known from the resource's final hour ahead energy schedule and the final hour ahead scheduled regulation capacity. The effective regulation range is determined in real-time by the RIG and communicated to CAISO.[61] Non-compliance charges for the Constrained Limits condition in a given hour are calculated as follows:

$$NCC = \left[\frac{time}{60}\right] \times [Exp\_rng - Eff\_rng] \times RMP$$

Where:

NCC = Non-compliance charge for constrained limits

time = The amount of time in minutes that the resource had insufficient operating range during the scheduled hour

Exp_rng = Expected operating range during the scheduled hour

Eff_rng = Effective operating range during the scheduled hour

RMP = Regulation market price (from the same market the capacity compensation was awarded)

The capacity oversupply and undersupply in the Bidding analysis section was used as the difference between the expected range and effective operating range. This method assumes the Power Capacity Up and Power Capacity Down variables would be transmitted by the RIG to provide the effective operating range of the EVSA coalition. Since these variables do account for the state of charge of all coalition vehicles and the dynamic Preferred Operating Point or each car, they closely represent the available capacity for regulation.

Table 7 below is a summary table of the calculated non-compliance penalties and the total time non-compliance flags that would be recorded in ISO's regulation performance monitoring program. The Total row represents the time where either one or both regulation up and down is non-compliant.

[61] CAISO Settlements Guide: Regulation Non-Compliance, https://www.caiso.com/Documents/RegulationNon-Compliance.pdf

Table 7. Non-compliance time and charges

	Total time condition triggered (hours)		Non-compliance Charges per vehicle (% of total revenue)
	Constrained Limits	Out-of-Range	
Regulation Down	440	0.00	15%
Regulation Up	487.5	1.25	18%
Total	535	1.25	16%

Of the 6,984 hours between September 12, 2018 to June 30, 2019, there were 1,638 hours in which a capacity bid was placed, therefore the resource is triggering non-compliance charges 33% of the time when providing regulation services. This corresponds to a reduction in capacity settlement of 16% for both regulation up and regulation down. The non-compliance charges incurred by the EV coalition in the LAAFB project were 17% of capacity settlement for regulation up and 8% for regulation down.[62] These lower figures may reflect the more predictable driving schedules of the LAAFB fleet since the vehicles only participated in the frequency regulation market for short periods of time (around 2 hours) to avoid impacting fleet duties.

As discussed previously, non-compliance charges would decrease with a larger fleet that reduces the probability of undersupply in a given hour by utilizing greater driving schedule diversity of a larger coalition. An improved bidding strategy would also greatly reduce non-compliance events. For example, submitting a capacity bid with a POP slightly above zero closer to when vehicles are expected to leave the site would allow the vehicles to steadily charge without needing to drop out the coalition. This approach could accommodate drivers needs whilst also maximizing bid capacity and would also likely improve performance accuracy.

CAISO documentation does not clarify whether resources that consistently trigger no-pay conditions but maintain a performance accuracy well above the minimum threshold would still be at risk of disqualification from the market. Furthermore, CAISO's non-compliance rules have largely been designed around gas generators and hydro resources that have dominated AS markets over the last 20 years. If many new resources with variable capacity and constantly changing POPs such as EVs were to enter AS markets, it may prompt CAISO to reevaluate its non-compliance rules.

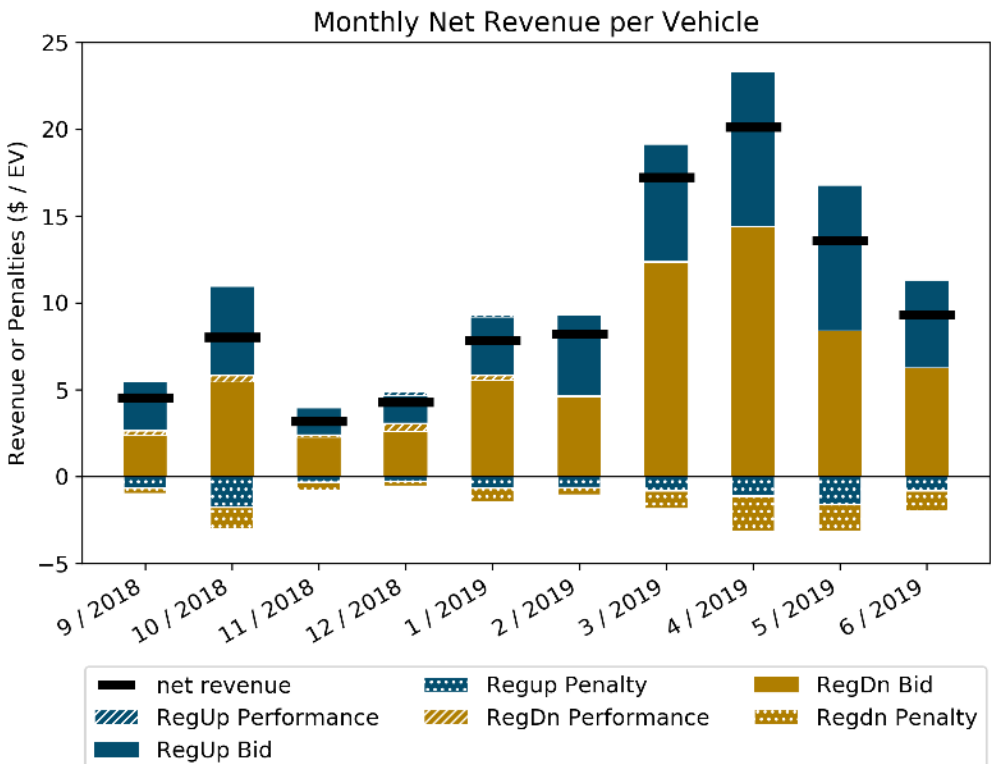
Now the performance, mileage, bids, and non-compliance charges have been analyzed, the Revenues and Outlook section will calculate net revenues for the coalition using market price data for the analysis period.

[62] SCE Department of Defense Vehicle-to-Grid Final Report, Appendix I-1

6.4 – Revenues and Outlook

Using market price data from OASIS and the metrics calculated in the previous section the final net revenue is calculated using Equation 1. Figure 36 shows a weekly breakout of revenues per vehicle for all complete weeks in the dataset.

Figure 36. Vehicle monthly net revenues, September 2018 – June 2019



Net revenue for the coalition varies between $3 - 20 per vehicle per month with an average $9.63 per month or $115.57 per vehicle per year. The LAAFB project reported revenues for their coalition ranging from 5 to 55 $ per vehicle per month. These vehicles participated in frequency regulation for 5 hours per day on average, but the fleet consisted of much larger vehicles such as Trucks, Vans, and Busses with EVSE with power ratings between 15 and 50 kW, enabling much larger capacity bids. The low end of the monthly revenue range reported from the LAAFB project (5 $ per vehicle per month) is likely to be from the Nissan Leaf's in their fleet which aligns with the findings here. Results from the EPRI study discussed in Chapter 3 showed AS benefits could be as high as 200 $ per year per vehicle for an EV with a 10 kW charger when the vehicle is able to participate in the market around 21 hours per day (V2G technology available at work and at home) and bidding is perfectly optimized. Since the data spans from mid-September until late December, seasonal variation in regulation market prices, and therefore revenues, is not captured, which may raise the annual revenue estimate.

As mentioned, this revenue estimate excludes other charges that would normally make up a full frequency regulation settlement statement including flexible ramping, grid management, energy charges, and other miscellaneous CAISO charge codes. Scheduling Coordinator Identification Charges incurred during the LAAFB project were around $1000 per month.[63] The EVSA EV coalition would need to scale to at least 200 cars to outweigh this cost.

The results highlight that most revenues come from the capacity market with a relatively even split between regulation up and down. Regulation market prices were relatively stable during the analysis period so weekly variation in revenue is more a function of driver availability.[64] The mileage compensation is more volatile and primarily driven by total instructed mileage and the performance accuracy of the coalition during the week. As discussed in the previous section, non-compliance charges reduce revenues by around 20% but this would likely be smaller with a larger, more predictable fleet and more sophisticated bidding strategy.

In the next section, the revenues calculated will be extrapolated into the near future using E3 market price forecasts and the prospects of an EV coalition competing in future regulation market will be discussed.

AS market outlook

Revenues from EV participation in CAISO's ancillary service markets will likely vary over time as the ancillary service market evolves. E3 utilized system planning cases from the CPUC Integrated Resources Planning (IRP) proceeding to develop hourly energy and ancillary service prices.[65] With resource portfolios from the IRP cases, the AuroraXMP production simulation model is used to produce energy and ancillary service prices for a base and high value case for V2G. The reference plan, designed to limit statewide greenhouse gas (GHG) emissions to 42 million metric tons (42 MMT), is used for the base case (Figure 37). Cases with more aggressive GHG and renewable portfolio standard (RPS) targets produce more volatile market prices that provide higher revenues for flexible resources like energy storage and V2G enabled EVs. A CPUC IRP scenario achieving an 80% RPS is used to develop hourly prices for the high value case (Figure 38).[66] Note that the negative prices during the middle of the day and the high prices in the evening compensate flexible resources that can reduce the evening ramp.

[63] SCE Department of Defense Vehicle-to-Grid Final Report, Appendix I-1

[64] http://www.caiso.com/Documents/MarketPerformanceReportforOctober2018.pdf

[65] CPUC IRP Proceeding information available at: http://www.cpuc.ca.gov/irp/

[66] Details on the 42 MMT reference plan and additional sensitivities, including the 80% RPS case are available at: http://cpuc.ca.gov/irp/proposedrsp/

Figure 37. Average Hourly Energy Prices in 2030 – Base Case

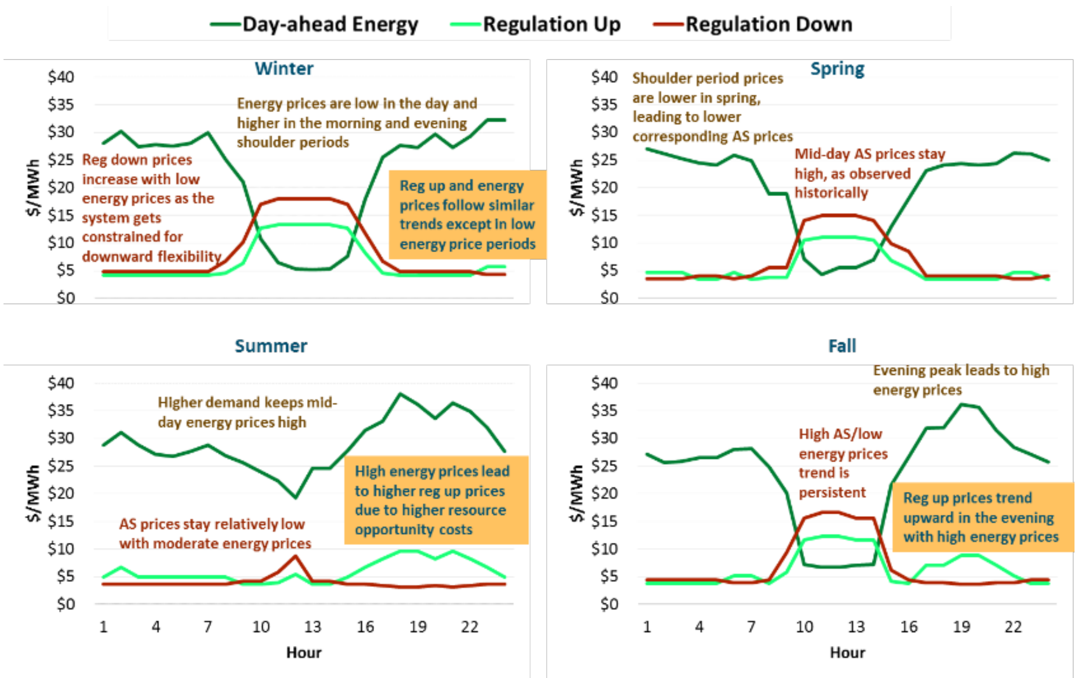
	Hour																							
Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	54.55	53.91	54.76	54.70	54.23	54.32	55.54	55.98	55.93	50.54	50.16	50.92	50.25	47.47	42.92	49.01	51.92	52.89	55.94	54.64	54.19	54.41	55.96	55.39
2	51.67	52.02	52.01	51.55	51.60	51.83	53.87	54.15	52.10	43.31	39.58	39.03	39.10	39.95	37.07	40.50	49.67	50.90	53.08	53.40	52.29	51.04	52.86	51.50
3	48.43	47.91	47.61	47.63	47.41	47.87	49.10	49.01	37.50	33.93	30.38	20.97	19.35	27.16	28.61	34.70	44.12	47.98	48.98	49.50	49.65	49.49	48.85	48.13
4	42.35	42.91	42.97	42.70	42.40	43.14	43.69	36.22	27.46	23.45	20.36	4.09	-2.32	11.41	24.31	32.02	37.81	44.13	46.73	46.54	46.47	46.56	46.41	43.83
5	42.15	42.57	42.44	42.44	42.45	42.86	41.66	31.41	21.33	20.21	17.26	16.05	16.96	18.10	24.73	31.22	34.32	42.16	45.06	45.87	45.66	46.49	46.76	43.48
6	45.15	45.93	45.98	45.90	45.14	45.15	43.20	38.85	30.47	28.79	26.33	21.45	22.31	24.90	32.23	34.95	42.26	48.10	50.12	48.42	47.35	49.71	49.60	45.47
7	49.38	49.86	50.59	50.31	51.60	52.87	48.33	44.28	38.90	36.17	35.61	35.44	34.72	35.22	41.21	44.10	47.59	51.18	53.84	53.42	50.89	52.72	51.86	50.41
8	53.44	53.09	52.51	51.42	52.14	52.25	50.87	44.99	38.58	37.64	37.01	36.29	37.48	37.01	43.42	46.16	49.10	54.80	56.96	54.62	51.93	53.97	53.80	52.25
9	52.61	52.31	51.28	50.12	50.51	51.22	50.32	45.33	39.61	38.39	35.85	36.48	36.50	38.03	43.22	47.12	50.07	55.03	54.94	53.82	54.99	55.30	53.88	52.94
10	49.41	49.14	48.40	47.90	48.07	49.05	50.66	49.81	39.49	39.51	34.44	34.23	34.37	36.71	40.92	45.72	49.15	50.85	52.71	53.36	52.29	52.89	51.44	49.54
11	50.74	50.87	51.70	51.61	51.44	51.33	52.04	50.98	45.54	43.55	43.10	40.24	39.31	38.56	40.92	47.23	50.26	50.85	52.20	51.67	51.38	52.23	52.14	51.37
12	54.77	54.62	54.04	53.46	53.45	53.04	54.35	54.87	55.22	52.71	53.53	51.31	48.50	46.95	44.02	49.76	50.81	53.44	55.59	54.94	55.45	54.35	55.46	55.16

Figure 38. Average Hourly Energy Prices in 2030 – High Value Case

	Hour																							
Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	42.26	42.65	44.15	45.26	45.88	46.92	44.20	45.59	50.18	36.22	22.99	19.80	20.50	20.27	24.99	35.29	41.22	41.00	40.26	39.33	39.75	40.02	40.79	42.30
2	42.19	42.86	44.01	44.42	44.90	44.32	44.58	43.22	38.69	26.16	-0.17	-7.78	-8.07	-8.56	-8.32	20.98	36.97	37.85	38.49	38.91	38.86	41.08	42.65	42.60
3	37.14	37.94	37.91	37.52	36.71	36.01	34.59	35.18	15.95	0.53	-28.74	-30.00	-30.00	-30.00	-30.00	-17.12	25.71	32.14	33.55	34.93	34.57	35.03	36.99	37.17
4	31.40	30.43	31.19	31.20	29.66	30.89	26.57	19.79	0.58	-24.58	-30.00	-30.00	-30.00	-30.00	-30.00	-30.00	14.60	20.26	29.52	28.67	31.48	33.33	36.46	34.42
5	30.01	30.01	28.27	26.91	26.39	24.63	25.40	10.12	-1.49	-13.75	-14.67	-24.44	-22.88	-16.91	-9.36	-1.57	23.03	23.42	33.48	30.48	30.85	36.80	42.87	34.74
6	39.43	38.03	38.68	38.62	38.63	38.04	34.96	28.01	16.61	-0.11	-8.55	-16.69	-21.32	-22.23	10.58	19.66	28.80	30.46	40.77	42.29	37.66	40.51	45.99	40.80
7	46.48	47.44	47.84	47.89	47.80	48.79	42.31	34.50	20.17	18.27	17.55	9.41	0.28	6.70	28.47	37.61	43.38	53.65	69.86	64.66	54.89	51.13	52.89	47.58
8	52.62	52.21	52.34	51.59	51.12	51.25	48.87	36.59	21.26	19.60	7.74	-5.96	-7.01	2.40	30.41	43.01	44.40	64.91	82.78	75.45	60.48	62.87	62.23	51.45
9	54.22	52.46	49.61	46.70	47.38	48.33	49.81	35.89	20.28	12.84	-2.06	-6.09	-7.51	-3.49	25.09	37.51	48.83	78.91	75.23	63.94	64.11	58.06	57.81	54.96
10	47.01	46.90	45.81	45.12	43.01	44.49	52.31	42.04	13.29	-0.05	-22.96	-25.67	-25.85	-18.75	20.61	37.70	54.40	71.15	79.24	67.13	56.06	52.97	48.31	48.79
11	43.81	43.42	43.25	43.31	43.59	43.80	46.82	46.48	26.54	16.28	-3.50	-13.00	-6.97	-2.71	25.09	38.58	44.28	44.17	43.90	43.09	45.52	47.51	48.79	44.30
12	42.92	43.35	44.12	45.57	45.58	45.32	42.94	45.15	45.34	36.75	28.50	27.39	27.29	30.21	34.07	40.56	45.41	46.20	44.24	43.77	42.25	42.73	44.70	43.41

The relationship of frequency regulation prices to energy prices under higher renewable penetrations is illustrated in Figure 39 below by season. Currently frequency regulation prices are driven primarily by fossil fuel plants as the marginal resource. Fuel costs, start-up costs, minimum run-times and minimum operating levels dictate the marginal prices that conventional power plants can bid into the market without losing money. Positive energy prices pose an opportunity cost for fossil plants to provide regulation up and negative energy prices would pose an operating cost for fossil plants to provide regulation down. In contrast to fossil plants, energy storage and dispatchable solar can provide frequency regulation with minimal operating costs. Energy storage can also benefit by bidding into the regulation market – for example, by providing regulation down, a storage device can get paid to charge.

Figure 39. Relationship of Energy and Frequency Regulation Prices (Base Case)

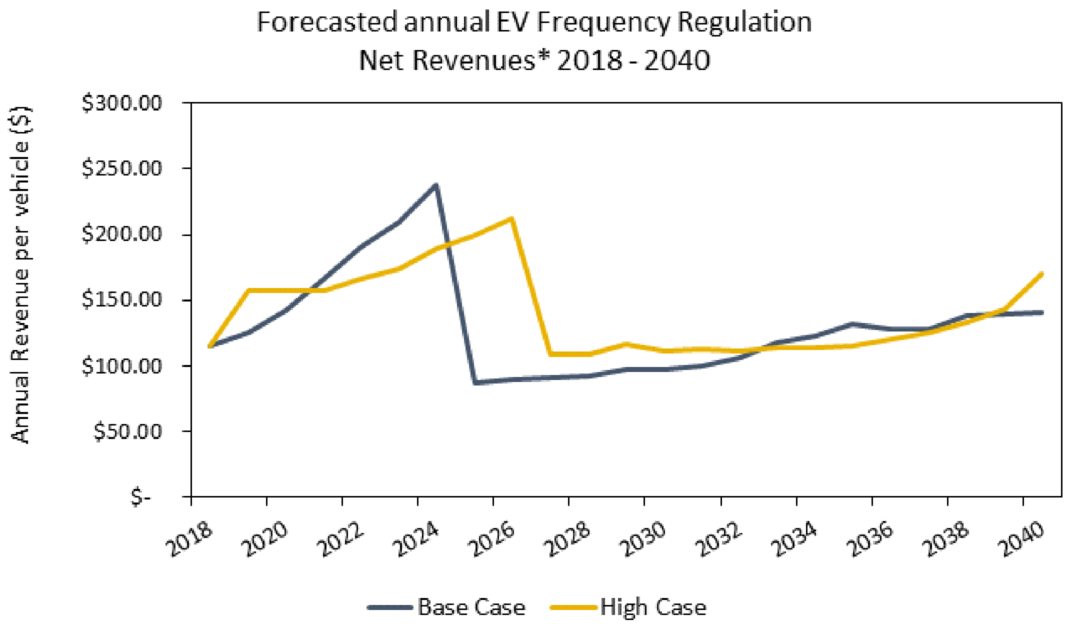


The market for frequency regulation is relatively small, approximately 350 MW each for regulation up and regulation down, for a total of 700 MW. The market for frequency regulation may increase modestly with higher penetrations of renewables, but grid needs for other services such as load-following and flexible ramping will be more pronounced (services that can also be provided by V2G). In both the base and high value case, market prices for frequency regulation are projected to increase gradually with increases in natural gas and greenhouse gas (GHG) prices. Then prices are forecast to decline as energy storage built to meet California's IOU storage mandate of 1,325 MW saturates the market and displaces fossil plants as the marginal resource.[67] The precise timing and slope of this price decline are difficult to predict. In the base case we assume prices begin to decline in 2024, and in the high case, 2027. After this, increasing marginal energy costs caused by a rise in natural gas and GHG prices gradually push up prices again for frequency regulation.

The corresponding frequency regulation revenues for EVs are shown in Figure 40.

[67] AB 2514: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200920100AB2514

Figure 40. Forecasted EV AS Revenue



* Revenues are in nominal dollars

We assume a 5% reduction in capacity revenue due to non-compliance charges since commercial operations will likely involve a more sophisticated bidding approach. AS prices and consequently EV revenues are projected to grow until the mid-2020's. The decline in frequency regulation prices result in a sharp drop in EV revenue in 2024 in the base case and 2027 in the high case. Revenues then steadily rise through 2040. In this period, we expect EV drivers to look for other revenue streams beyond frequency regulation such as capacity or energy markets and new reserve markets for load following, flexible ramping or load shifting, all of which can also be provided with V2G. In addition, future seasonal and time of day variation in energy and AS markets will lead EV aggregators to place more strategic bids in to capture revenues in higher value markets.

6.5 – Conclusions and Recommendations

Based on the calculations in this report the EVSA coalition at UCSD would have earned on average $116 per vehicle per year in revenue (after penalties) from a combination of frequency regulation capacity, mileage, and non-compliance settlements. Taking into consideration the hours of participation and average EVSE power rating of the EVSA coalition, these revenues are aligned with previous California-specific studies and those achieved by the LAAFB EV coalition. Performance accuracy for both regulation down and regulation up did not fall below the minimum threshold to trigger decertification, staying within 35 – 70% over the study period. Further analysis would be needed to fully understand why performance accuracy is still lower than battery storage systems, but initial analysis suggests that in addition to the limitations of using a recorded AGC signal, prediction of available regulation capacity is a major factor.

Additional detail regarding the availability trends of the coalition can be found in Chapter 6 of this report.

Non-compliance charges were applied during 33% of total regulation service hours for the EV coalition, primarily due to the Constrained Limits condition, and resulted in a 16% reduction in capacity settlement. Several strategies could be employed to reduce the non-compliance charges: (1) Improve the accuracy of bidding by leveraging a more sophisticated probabilistic analysis of driving schedules to determine available capacity, (2) Submit capacity bids with a slightly negative POP (preferred charging) during hours of the day when vehicles are more likely to need to charge to meet trip requirements, therefore resulting in fewer vehicles dropping out of the coalition and would reduce non-compliance charges (assuming actual participation in CAISO market), (3) Adjust the aggregation platform to submit asymmetrical bids and submit mostly regulation down bids in the afternoons to overlap when the drivers need to charge, (4) Increase the size of the coalition of EVs in order to increase driving schedule diversity, (5) Include workplaces with more typical working hours and driving schedules to make capacity more predictable, (6) leverage vehicles with larger batteries (40kWh becoming standard for battery electric vehicles).

The small size of the EVSA coalition (64 kW maximum capacity) meant the minimum capacity limit of 500 kW for frequency regulation participation was ignored. This study has also excluded other fees and charges related to flexible ramping, grid management, energy charges and other miscellaneous CAISO charge codes that constitute a complete settlement statement for frequency regulation. Grid management charges can significantly reduce profitability and a much larger EV fleet would be needed for commercially viable operations. The study has also assumed the EV coalition would pass resource certification, interconnect, and have a fully functioning remote intelligent gateway to communicate with CAISO.

Market rules have a strong impact on revenue and the risk of disqualification for frequency regulation and these could be altered by CAISO in the future. Regulation energy management is the likely product an EV coalition could use to participate in the frequency regulation market. It is unclear whether REM would allow CAISO to regulate the SoC of each individual EV or the coalition as a whole, which would impact performance accuracy. The calculation for performance accuracy varies across ISO's and CAISO has already indicated it may align its approach with that of NYISO, PJM, and MISO. Ensuring that the performance accuracy metric adequately accounts for response time and is not too sensitive to the magnitude of the AGC set point would be favorable for fast ramping resources with less predictable capacity such as an EV coalition. Non-compliance rules also have a large impact on resource revenue. The current non-compliance framework accounts for drivers dropping out of the coalition or an EV adjusting its POP whilst providing regulation service by applying non-compliance charges to reduce the capacity settlement. However, it is not clear from current CAISO documentation whether consistently violating non-compliance conditions might lead to further action from CAISO such as decertification. Given how often the Constrained Limits condition is triggered by the coalition, CAISO may adjust the condition and the associated charge calculations if EVs became more prevalent in the regulation market. Assisting CAISO in the development of these rules would facilitate more dynamic resources such as EV coalitions entering the Californian regulation market.

As California adds more renewable energy to its electric grid to achieve state goals, market prices are likely to become more volatile and the demand for frequency regulation will increase. At the same time, we envision more energy storage entering the frequency regulation market through the 2020's. As the ancillary service market becomes more saturated a tipping point is likely to be reached where gas generators are no longer the marginal resource and AS market prices fall sharply. Frequency regulation therefore may not offer the best revenue opportunity for EV coalitions in California in the long term. As E3 has found through the EPRI study, alternate revenue streams will be available to an EV coalition which can strengthen the business case for V2G and make EVs even more valuable as an asset to the grid.[68] System and distribution capacity deferral as well as load shifting (energy arbitrage), particularly in later years during days when solar overgeneration is occurring, are all services provided by V2G technology that could offer enormous grid value. These value streams are explored in the second phase of the EVSA analysis detailed below in Chapter 6, Section 6.6.

[68] The EPRI study also finds significant incremental benefit of V2G over managed one-way charging of EVs.

6.6 Simulating Additional Revenue Streams

6.6.1 Methodology Overview

Background

In the previous chapter the potential performance and revenue of the EVSA coalition participating in the CAISO frequency regulation market was analyzed in depth. This chapter will evaluate the following using the same set of operational data collected during the EVSA project, but only focuses on the operational data collected from January 1, 2019 – June 30, 2019:

1. Calculate the potential upper limit of revenue from frequency regulation under optimized bidding and dispatch.

2. Evaluate other potential revenue streams the EVSA coalition could have been dispatched against, including revenue streams that are currently available and those that may theoretically be accessible to bi-directional electric vehicles in the future.

3. Simulate the unmanaged charging profiles of the EVSA coalition to calculate the relative grid cost of providing frequency regulation service.

To conduct this analysis, EVSA travel and dispatch data collected over the analysis period (January 2019 - June 2019) was combined with market prices to simulate charging sessions in E3's RESTORE dispatch optimization tool.

Additional Revenue Streams

Various studies have shown that Vehicle Grid Integration (VGI) technologies have the potential to provide significant grid value.[69,70,71,72] Some of the key benefits identified in these studies include: reducing the need for additional generation capacity, avoiding additional transmission and distribution infrastructure build out, savings in generation operating cost, and reducing the need for grid balancing services. However, there are currently limited pathways in California for monetizing the full value of VGI, particularly at the wholesale level. Consequently, although several demonstrations have been performed, only one commercially operating bi-directional EV

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[69] Estimated Value of Smart / Managed Charging of Electric Vehicles for a Vertically Integrated Utility, https://ieeexplore.ieee.org/document/8450258

[70] Distribution System Constrained Vehicle to Grid Services for Improved Grid Stability and Reliability [EPC-14-086]. https://www.energy.ca.gov/2019publications/CEC-500-2019-027/CEC-500-2019-027.pdf

[71] Clean vehicles as an enabler for a clean electricity grid, https://iopscience.iop.org/article/10.1088/1748-9326/aabe97

[72] Value to the Grid From Managed Charging Based on California's High Renewables Study, https://ieeexplore.ieee.org/document/8477179

aggregation currently participates in the CAISO market.[73] Part of this chapter involves exploring additional potential revenue streams / grid benefits bi-directional electric vehicles could pursue.

There have been several efforts at the California state and U.S. federal level to support integration of Distributed Energy Resources (DERs) into wholesale markets. These efforts have largely focused on the integration of energy storage systems, but some recent initiatives are beginning to address EVs explicitly, specifically CAISO's Energy Storage and Distributed Energy Resources (ESDER) stakeholder initiatives.[74] ESDER has so far been through 3 phases, with the most recent phase gaining CAISO board approval in September 2018, and development of phase 4 currently under way. One of the more significant achievements of ESDER is the facilitation of access of BTM storage resources to CAISO energy markets through the Proxy-Demand-Resource (PDR) and the Reliability-Demand-Response-Resource (RDRR) products.[75]

CAISO's PDR Program currently allows demand response providers to bid load curtailment into the wholesale energy market when the price is above a certain threshold – or meets the "net benefits test" (NBT).[76] The NBT is a monthly calculation performed by CAISO to determine the price threshold for when it is economically optimal to dispatch demand response resources in the day ahead and real-time energy markets. In September 2018, the CAISO Board approved PDR – load shift resource (PDR-LSR), which allows BTM battery storage to submit separate bids for load consumption. This will allow BTM storage to be compensated for charging (i.e. increasing site load) during periods of over-generation when wholesale energy prices are negative. The additional value provided by the PDR-LSR product could be significant in the future as renewables integration increases demand for load curtailment. However, because this analysis focuses on the September 2018 – July 2019 period of EVSA project operation, during which there were very few hours where energy prices dropped below zero, the PDR-LSR program was not modelled.

The RDRR product allows emergency responsive demand response resources to participate in the energy market. RDRR allows resources to respond economically in the day-ahead timeframe and curtail real-time load when required under a system or local transmission/distribution system emergency. However, RDRR resources are required to have a sustained response period or maximum response time of at least 4 hours which may be challenging for EV aggregations to provide.[77] RDRR resources are also prohibited from submitting Ancillary Service market bids,

[73] EMotorWerks provides CAISO with 30 MW of DR through smart EV charging.
https://www.utilitydive.com/news/emotorwerks-provides-caiso-with-30-mw-of-dr-through-smart-ev-charging/532110/ (accessed 8.29.19)

[74] ESDER Phase 3 includes a methodology for measuring the performance of sub-metered EV Supply Equipment (EVSE) in response to CAISO dispatch signals. Section 5.4, page 23 http://www.caiso.com/Documents/DraftFinalProposal-EnergyStorage-DistributedEnergyResourcesPhase3.pdf

[75] ESDER Phase 1 Final proposal http://www.caiso.com/Documents/RevisedDraftFinalProposal-EnergyStorageDistributedEnergyResources.pdf

[76] Net Benefits Test Methodology http://www.caiso.com/Documents/FinalProposal-DemandResponseNetBenefitsTest.pdf

[77] http://www.caiso.com/Documents/ReliabilityDemandResponseResourceOverview.pdf

making it a less attractive product if EV aggregators are seeking to stack multiple value streams in the future. Therefore, this revenue stream was not evaluated.

E3 explored additional sources of revenue currently available to bi-directional electric vehicles and the potential revenue available based on EVSA operational data if no barriers to realizing that value existed. A summary of the different revenue streams considered for this analysis is shown in Table 8.

Table 8. Potential revenue streams considered for the EVSA coalition and E3's value estimates based on recent modelling

Market Product / Potential Revenue Stream	Availability to EV Aggregations	Value Today	Value by 2025
Proxy Demand Response (PDR)	Currently	Med	Med
PDR-Load Shift Resource (PDR-LSR)	Near term	Med	High
Day Ahead Market for Energy (DAME)	Mid term	Med	High
Frequency Regulation (FR)	Mid term	High	Low
Distribution Value (Dist)	Long term	Med	High

As described, for this analysis PDR-LSR prices were very similar to PDR prices due to the very small number of negatively prices hours over the modelling period. Consequently, the PDR-LSR revenue stream was not modelled but was left in Table 8 to highlight its high potential value in the near future for EV aggregations.

Retail Rates

Although this analysis focuses on wholesale market participation, the EV coalition is still a BTM resource and under current rules would be subject to retail rates for any grid imports. Since the EVSA demonstration focused on providing Frequency Regulation within the CAISO wholesale market with no co-optimization for retail rates, this chapter will do the same for consistency. However, it is important to note retail rates in the SDG&E territory can have peak to off-peak differentials as high as 0.27 $/kWh or 270 $/MWh – far higher than any wholesale prices in most hours of the year.[78] The peak to off-peak price differential for these tariffs would almost certainly outweigh potential revenues from wholesale markets and make a stronger value proposition for behind the meter bill management than wholesale market participation.[79] The UCSD micro-grid however, is subject to a specific SDG&E rate that is notably less in $/kWh cost than SDG&E's other commercial rates. Therefore, the co-optimization of wholesale market participation with the

[78] SDG&E residential rates https://www.sdge.com/whenmatters

[79] SDG&E commercial rates http://regarchive.sdge.com/tm2/ssi/inc_elec_rates_comm.html

UCSD micro-grid's rate would likely offer a better value proposition than a customer on a standard commercial rate in SDG&E territory.

RESTORE simulations

RESTORE is a linear optimization price taker model that was developed to quantify the value of solar, storage and other DERs in the transition to a low-carbon, high-renewables grid.[80] The tool has been used extensively since 2014 by developers, technology companies, state agencies, and utilities across the country and has undergone numerous updates and enhancements through California Energy Commission funding.[81] For this study, the model was used to simulate optimal charging and discharging of the EVSA aggregation against various price streams described in the section 0. The RESTORE cases modelled are described in Table 9 and were designed to address the three objectives outlined in section 0.

Table 9. Cases split by revenue stream

	Revenue Stream				
Case Name	PDR	Frequency Regulation	Energy	Distribution	Case Description
Unmanaged [1]					EVs are charged without VGI known as "dumb" or unmanaged charging
AS [2]		✔			The EVSA provides frequency regulation Ancillary Service (AS) in CAISO
PDR [3]	✔				The EVSA participates in the Proxy Demand Response (PDR) CAISO market
PDR-AS [3]	✔	✔			The EVSA participates in PDR and provides AS
DAME [3]			✔		The EVSA participates in the CAISO Day Ahead Market for Energy (DAME)
DAME-AS [3]		✔	✔		The EVSA participates in the DAME and provides AS
Dist [3]				✔	The EVSA is dispatched to minimize distribution infrastructure upgrades
Dist-AS [3]		✔		✔	The EVSA is dispatched to minimize distribution infrastructure upgrades and provide AS

[80] More information on the tool can be found here: https://www.ethree.com/tools/restore-energy-storage-dispatch-model/

[81] CEC Solar + Storage Workshop https://ww2.energy.ca.gov/research/mod_tool_max_solar_storage/documents/

Dist-DAME-AS [3]		✔	✔	✔	The EVSA is dispatched to minimize distribution infrastructure upgrades, provide AS, and participate in the DAME

Notes: (1.) Case used for section 0 (2.) Case used for section 0, (3.) cases used for section 0

The unmanaged case forces each EV to charge as soon as they connect to the EVSE at the UCSD site, replicating unmanaged or "dumb" charging. The avoided costs associated with this type of charging will then be calculated and compared with the real EVSA charging profiles. The FR case simulates participation in the Frequency Regulation market allowing RESTORE's dispatch algorithm to optimally bid EV capacity into the market based on prices and charging needs. The results from the FR case provide an upper bound revenue estimate for the EVSA aggregation had it been dispatched optimally with perfect advance knowledge of driver schedules. The remaining cases all explore other revenue streams, described in section 0, that are or could be available to the EVSA aggregation.

For simplicity, the RESTORE analysis focused on modelling the six Nissan LEAF vehicles within the EVSA fleet, using the same 10kW DC charger and vehicle characteristics as described in section 0. In order to compare actual EVSA coalition results to the RESTORE run results on a per vehicle basis, the EVSA coalition results were divided by 6. Since the Nissan LEAF vehicles were the most active in the coalition and contributed the most revenue, dividing by 6 (rather than the total of 8 EVSA vehicles) only slightly inflates the per vehicle numbers by distributing the results from the 2 Honda Accords across the 6 LEAFs.

Data and preprocessing

This section describes the data processing required for some of the main inputs into the RESTORE model:

- EVSA charging session data required to simulate when each EV is available for charging and its SOC on arrival and departure
- CAISO market prices for both proxy demand response and frequency regulation
- The price signal for deferring distribution infrastructure upgrades
- The avoided costs used to calculate the grid costs for charging

EVSA Charging Session Data

The EVSA travel and charging session data collected for each driver over the analysis period enabled RESTORE to simulate each charging session with similar information to what was available to the aggregation operator during the demonstration. To utilize the EVSA travel data in RESTORE, various data processing steps were required. As described in section 0, the aggregation operator mimicking the scheduling coordinator has access to information about each drivers' expected departure time, and desired EV range on departure from UCSD. To simulate dispatch against new revenue streams in a realistic way, RESTORE was provided with similar information:

- Arrival SOC: The State of Charge (SOC) on arrival at UCSD
- Departure SOC: the SOC on departure from UCSD
- EV availability: the periods of time where each EV was available to either charge or provide grid services while on the EVSA site

The EVSA dataset includes 1-second interval SOC data which was recorded whenever the EV was connected to a charging station. This data was resampled to 15-minute interval data (RESTORE's required format) by taking, in each 15-minute interval, the first recorded SOC value as the arrival SOC and the final recorded SOC value as the departure SOC. EV availability was calculated by quantifying the amount of time the vehicles spent in the following states: (1) when the vehicle was charging to meet driver transportation needs, provided the reason for charging was not classed as "emergency" where the driver had manually overridden any previous commands in order to charge the vehicle for an unplanned trip or (2) charging and discharging to provide grid services.

RESTORE has perfect foresight over the optimization window, and therefore its dispatch algorithm has an advantage over day-ahead market bidding by knowing the exact vehicle SOC on arrival and relying on charging schedules that will not be changed last minute by the driver. However, fixing the start and end SOC for each charging session in order to meet driver transportation needs prevents RESTORE from shifting charging between charging sessions. This negates some of the advantage RESTORE has over a real aggregator from perfect foresight and is a major benefit of using real charging session data that was not explored in previous VGI studies.

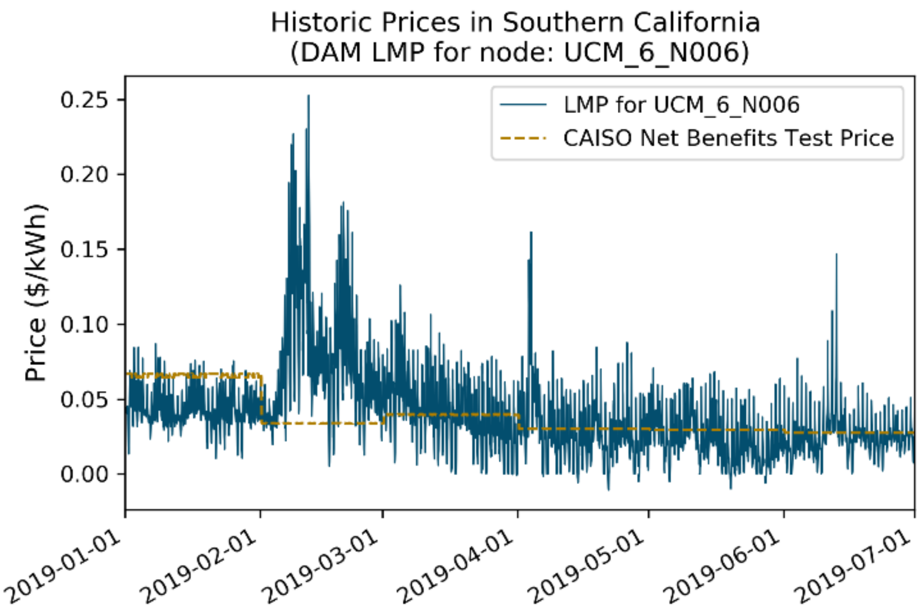
CAISO Market Price Processing

To establish the PDR price signal, the day ahead locational marginal price (LMP) for nodes in the UCSD area were pulled from CAISO's OASIS platform.[82] The monthly net-benefits test (NBT) results for dispatching demand response resources were used to find the net LMP price to represent the PDR signal.[83] Figure 41 shows how frequently the LMP for the UCSD area exceeds the NBT price.

[82] CAISO Open Access Same-time Information System (OASIS), http://oasis.caiso.com/mrioasis/logon.do

[83] CAISO, Demand Response net benefits test http://www.caiso.com/informed/Pages/StakeholderProcesses/CompletedClosedStakeholderInitiatives/DemandResponseNetBenefitsTest.aspx

Figure 41. The LMP and NBT prices, the PDR price is the LMP price whenever the LMP exceeds the NBT



RESTORE can use the PDR price stream to bid EVSA load curtailment capacity into the day ahead market for energy as a DR resource. The analysis also looked at the increase in revenues assuming the EVSA had full access to CAISO energy markets rather than via PDR. The full day ahead LMP prices were used for these model runs. The frequency regulation prices used in RESTORE were the same as those described in section 0, RESTORE does not include AS Mileage revenue or penalties in total frequency regulation revenue.

Distribution Deferral Price Signal

To establish a dispatch signal to defer distribution infrastructure upgrades, distribution upgrade costs published by the CPUC as part of a technical potential study for solar in 2012 were used.[84] These costs vary widely by location, for this analysis a value of 40 $/kW-yr was used to represent distribution avoided costs associated with a typical SDG&E planning area. The distribution value was allocated to specific hours of the year using a representative feeder load and the Peak Capacity Allocation Factor methodology.[85] This quantification of value assumes a future distribution-level market that would compensate resources for providing distribution deferral services. That value is assumed to be closely linked to the distribution upgrade costs cited above.

[84] https://www.cpuc.ca.gov/uploadedFiles/CPUC_Website/Content/Utilities_and_Industries/Energy/Reports_and_White_Papers/LDPVPotentialReportMarch2012.pdf

[85] The PCAF method was first developed by PG&E in their 1993 General Rate Case that has since been used in many applications in California planningFor example, PCAFs were used recently in a CPUC report quantifying distributed PV potential in California: https://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=7695

Avoided Costs

To measure the cost of serving different charging load shapes, the hourly 2018 / 2019 CPUC avoided costs were used. For a detailed description of the methodology for calculating the hourly avoided costs see the CPUC Avoided Cost 2019 Update documentation.[86]

6.6.2 Results

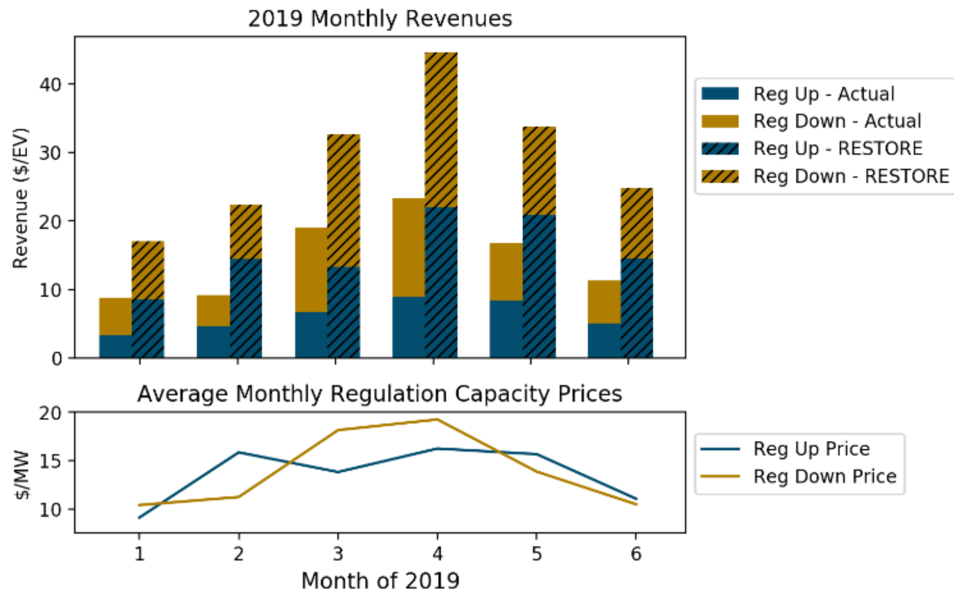
Frequency Regulation and bidding analysis

The EVSA demonstration submitted regulation capacity bids based on past vehicle availability trends and decisions regarding when vehicles would provide grid services versus when they would charge were largely dictated by driver transportation needs. With a more sophisticated bidding strategy incorporating market prices and larger, more predictable fleets the revenue from ancillary services could be higher than what was quantified in Section 6.3 above. This analysis uses the same driving schedules and prices collected from the EVSA demonstration in order to simulate frequency regulation bidding using the RESTORE model. The results provide a useful upper bound on revenue potential if driving schedules were highly predictable and a bidding strategy was employed that aimed to maximize revenue in addition to meeting all driving needs.

Figure 42 provides a monthly revenue comparison between RESTORE and the revenues calculated from the actual EVSA dispatch.

[86] https://www.cpuc.ca.gov/General.aspx?id=5267

Figure 42. Comparison of Actual versus RESTORE simulated frequency regulation revenue by month



Over the 2019 period, RESTORE was able to increase revenues from regulation capacity bids by 98% overall. The regulation up market is where RESTORE was able to achieve the greatest improvements, with between 72% - 143% increase on actual monthly bid revenue over the period. These results indicate that regulation up bidding was overly cautious, a possible reason for this may be the increased risk of depleting the battery by overbidding regulation up which requires vehicles to discharge and not meeting driver transportation needs. The overall month to month trend for both the RESTORE case and the real EVSA results indicate revenue tends to primarily be driven by market prices.

The higher revenues in the RESTORE model runs compared to the calculations from the actual EVSA demonstration can be attributed to the following factors:

1) Perfect foresight advantage of RESTORE

2) Bidding strategy and asymmetric bidding

Perfect foresight advantage of RESTORE

RESTORE has perfect foresight over the driving schedule and therefore can place bids without the risk of vehicles dropping out the coalition. In addition, RESTORE can take advantage of additional bidding time when a driver departs later than planned. Given the small size of the EVSA coalition predicting the probability of a driver dropping out is challenging and so the aggregation operator would rightly bid cautiously. Consequently, RESTORE can bid much more aggressively to maximize revenue than the EVSA Project Team did, both in terms of the quantity of bids placed and the capacity of each bid placed. Unfortunately, no data was available on how often drivers would deviate from their planned travel times, so it is difficult to quantitatively evaluate the perfect foresight advantage of RESTORE over driving schedule.

Having perfect foresight over AS prices is also an advantage of RESTORE. However, participation in the day ahead market is being simulated rather than the real time market, so this information would also have been available to the aggregator. Based on prior comparisons of RESTORE revenue estimates with perfect and imperfect foresight, and review of historic data from real storage assets, E3 uses a 15% discount to reflect revenues with imperfect foresight.

Bidding strategy and asymmetric bidding

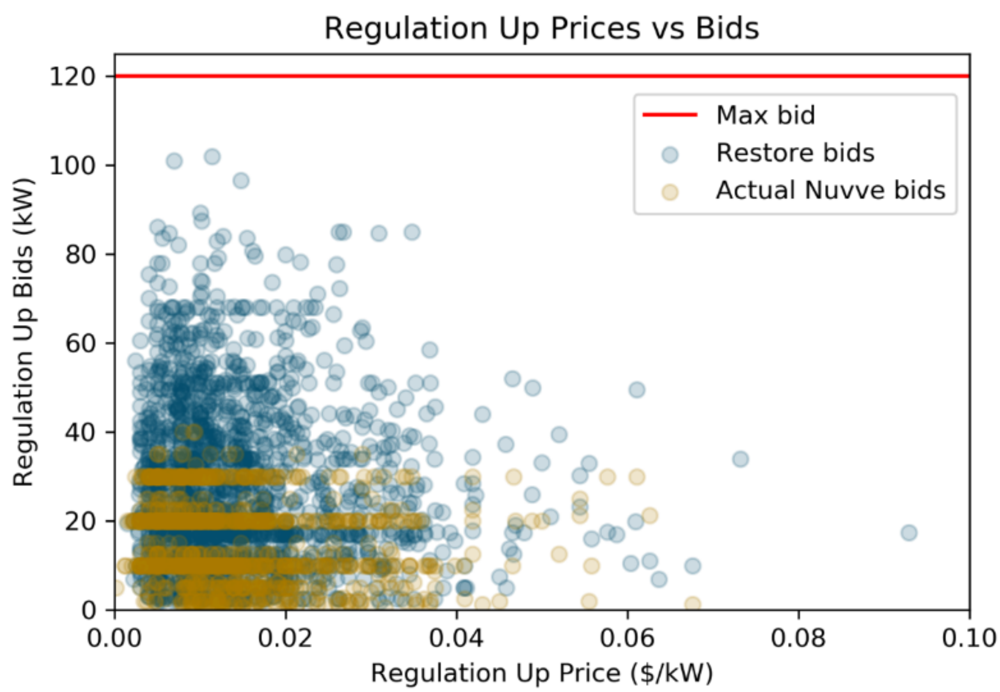
As mentioned at the start of this section, the objective of the RESTORE dispatch algorithm is to maximize revenue for the coalition using market price and EV driving schedule information. EVSA bids were dictated by drivers' transportation needs alone and did not account for market price trends. Accounting for market price information and using a revenue maximizing bidding algorithm, similar to energy storage management systems employed by storage developers, would likely provide a significant boost to revenues.[87]

RESTORE is able to take advantage of the separate CAISO markets for regulation up and down by submitting different bids for regulation up and down, unlike the Nuvve bidding platform (see section 0), which dramatically increases the available bidding capacity. Since no other revenue sources are being simulated this primarily applies to regulation up, where RESTORE can bid double the charging capacity for regulation up if the vehicle is planned to be charging during the bid hour. There were few instances of the vehicle discharging during a period of high regulation down prices in order to bid double regulation down during a discharge hour. Bidding double capacity during charge / discharge hours is a strategy employed by storage operators and could plausibly be achieved by a large EV coalition with sophisticated vehicle prediction and bidding strategy algorithms.

The figure below plots regulation up prices against average revenue per EV per hour in order to visualize how effectively regulation bids were placed to maximize revenue. If more capacity is bid during high priced hours, then the revenue in that hour will be higher indicating more effective bidding. The theoretical maximum revenue achievable is indicated by the red line corresponding to if every vehicle in the fleet was charging at 10 kW (for a total of 60 kW) and RESTORE placed 120 kW Reg Up bid per vehicle.

[87] Energy Storage Management Systems 2015-2019: Applications, Players and Forecast https://www.greentechmedia.com/articles/read/us-energy-storage-management-systems-market-to-grow-tenfold-by-2019#gs.z2blt9

Figure 43. Regulation up prices vs bids placed

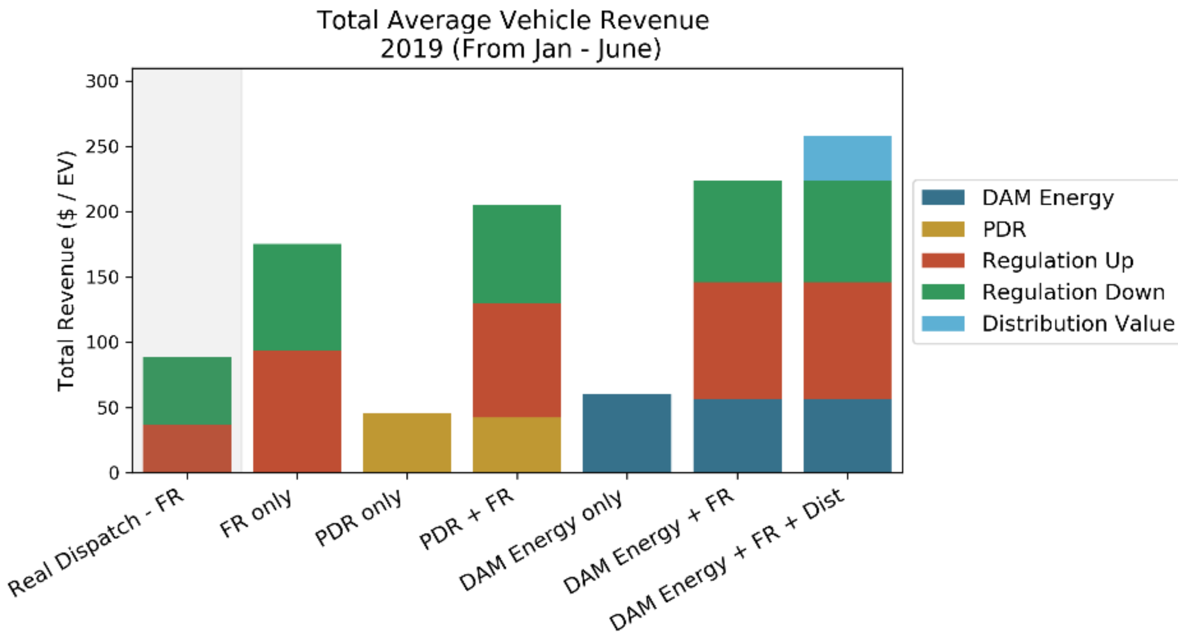


It is clear from this figure that RESTORE bids much more capacity than the Nuvve aggregation operator did during the operation of the EVSA project demonstration. The maximum bid during the EVSA demonstration across all Nissan Leaf's was 40kW whereas the maximum bid RESTORE made was 102 kW regulation up. As mentioned, this is due to perfect foresight and separate bidding of regulation up and regulation down in the RESTORE. In addition, RESTORE will bid in various increments depending on whether the vehicles are charging or discharging in a particular hour, whereas the EVSA bids were predominantly placed in 10kW increments based on the rated charging capacity of the available charging stations as seen by the distinct lines the EVSA bids follow (yellow).

Alternate revenue streams

Total revenue results for 2019 from the alternate revenue stream analysis are shown in Figure 44. The far-left bar highlighted in grey shows the revenues calculated using the actual EVSA dispatch with all other results being RESTORE runs.

Figure 44. Comparison of different revenue streams in RESTORE, grey highlighted bar on the left are the real calculated revenues from section 0



The results above can be interpreted as bookend revenue estimates the EVSA fleet could hypothetically achieve by pursuing alternate revenue streams with a larger, more predictable EV fleet, and a more aggressive revenue maximization focused bidding approach. The results highlight the value of frequency regulation in California today compared with other potential revenue sources. The PDR market provides around 25% of the revenue obtainable from frequency regulation. When co-optimizing PDR with frequency regulation price signals, revenue from each source drops only slightly which is expected since participation in PDR rarely inhibits an EV's ability to provide regulation in at least one direction. PDR also manages to capture most of the revenue from the Day Ahead Energy Market. This is unsurprising given the LMP prices often exceeded the net-benefits test over the analysis period as seen in Figure 41. However, the analysis only covers January – June 2019, which historically is when energy prices are lowest. [88, 89]

Dispatching to avoid distribution system upgrades also provides a modest boost to revenue without any significant impact on other revenue streams based on the modelled distribution system value of 40 $/kW-yr. Distribution peaks often occur in the afternoon periods, which does not coincide well with the typical driving profiles of the EVs at the UCSD site. However, it should be noted that distribution system impacts can vary drastically depending on location. This

[88] 2017 Annual Report on Market Issues & Performance, pg. 5, California, ISO, June 2018. http://www.caiso.com/Documents/2017AnnualReportonMarketIssuesandPerformance.pdf (accessed 9.3.19)

[89] Q2 Report on Market Issues and Performance, California ISO, September 5, 2019. http://www.caiso.com/Documents/2019SecondQuarterReportonMarketIssuesandPerformance.pdf (accessed 9.3.19)

analysis employed simplified and less data intensive techniques than a full distribution system study and assumes the distribution system value would be a reasonable indicator of a future mechanism designed to compensate for distribution system support.

It should be noted these revenue estimates represent snapshot values under a rapidly evolving energy system and wholesale market. As discussed in section 0, E3's price forecasting indicates the value of frequency regulation is likely to decline in the future, while more volatile energy prices could bring greater energy market, and by extension, PDR revenue opportunities. The PDR revenues assume the baseline load profile is the underlying site load with no EV charging, rather than an unmanaged charging baseline which could increase PDR revenues further. Furthermore, this study looked only at day ahead PDR and energy markets. Under PDR, EVs would also have access to the 5-minute real-time market which tends to have much larger prices swings but is naturally much harder to predict. Finally, with the growth in renewable generation, the PDR-LSR product which is likely to become available in the near future, will provide even greater opportunities to arbitrage CAISO energy markets.

A final caveat is that these revenue estimates ignore the complications of retail rates which currently still apply to PDR programs, and potentially any other wholesale market participation using assets located behind-the-meter. If a time-of-use (TOU) rate were to be included in the price signal in this study, the relative size of the price differential would likely outweigh revenue opportunities in most hours of the year and significantly alter the dispatch. However, exploring these impacts is beyond the scope of this study.

6.6.3 Unmanaged charging and Avoided cost analysis

This final section compares the cost of serving the real EVSA load with the cost of serving the EVSA load if it were unmanaged. A simple and useful estimate for the grid costs of serving the EVSA charging load can be calculated using the CPUC hourly avoided costs streams described in section 6.6.1. An unmanaged charging shape was simulated to measure the relative benefits of the EVSA managed charging profile. Figure 45 summarizes the charging pattern for the real EVSA and if the EVSA charging were unmanaged. The heatmap is the average weekday charging load in each hour over a month. Red indicates higher charging and blue indicates no / lower charging.

Figure 45. Heatmaps of average weekday charging load by month

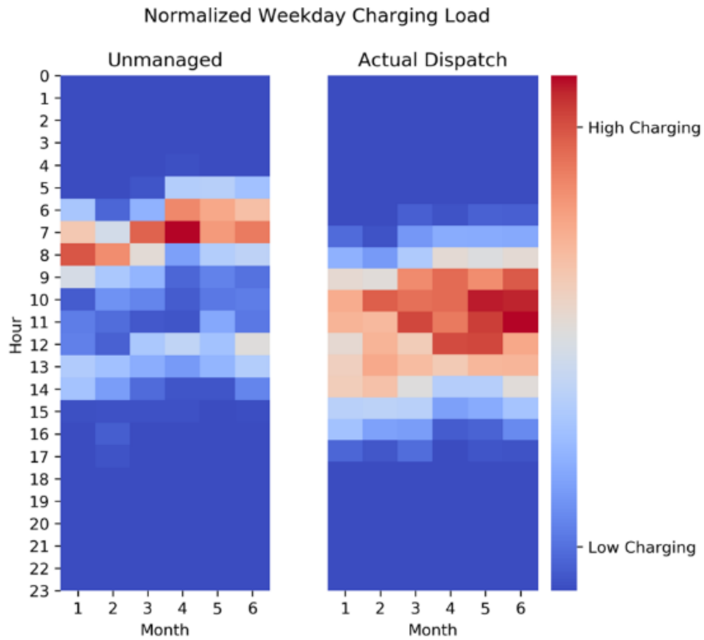
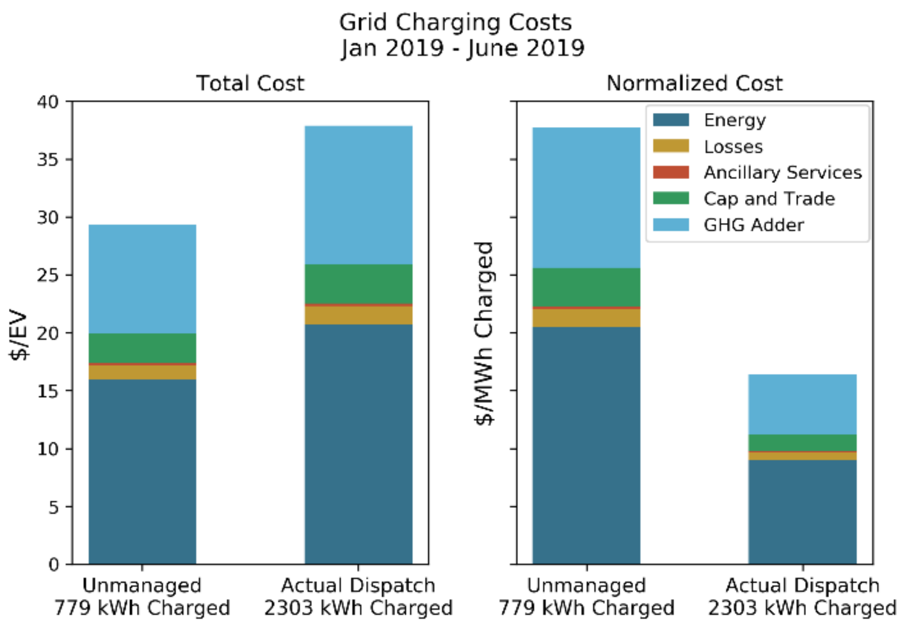


Figure 45 shows how the actual EVSA charging load is more evenly spread over all morning hours, whereas in the unmanaged charging case load is more concentrated as soon as vehicles arrive and plug in on site. Under the unmanaged case it also appears the bulk of daily charging often occurred in a single hour which is probably due to the high charger power (10kW) of the Nissan LEAF chargers relative to its battery size (30 kWh).

The unmanaged charging heatmap also highlights how variable the EVSA charging sessions and driving patterns are throughout the year. In most workplaces it would be typical to see more of the unmanaged charging load consistently concentrated around 9 am when most drivers usually arrive from their morning commutes. For typical workplaces, the unmanaged charging load is already quite beneficial for the Californian grid since morning charging coincides with lower system and distribution load and high solar generation. The UCSD site appears to have more drivers arriving earlier in the morning and also after lunch. Consequently, the unmanaged charging profiles put more strain on the grid than typical workplaces might. This suggests, VGI technologies might provide even more benefit in workplaces like UCSD than typical 9 – 5 offices.

Figure 46 below calculates the total costs of serving the actual dispatch of the EVSA load profile over the project duration as compared to an unmanaged scenario where the vehicles simply charge until full upon plugging in. Since the EVSA aggregation was also providing Ancillary Services to the grid (charging and discharging) as well as charging for the driver transportation needs, actual EVSA operations resulted in almost three times as much charging as would have occurred in an unmanaged charging scenario (Unmanaged charging 779 kWh/EV, actual EVSA charging: 2,303 kWh/EV). Consequently, when normalizing the charging cost on a per MWh of charging basis, the cost of serving the actual EVSA charging profile is much lower. It is important to note these results only include the cost to serve the charging load and do not include the benefit the EVSA aggregation provides to the grid through frequency regulation.

Figure 46. Avoided costs of charging under actual EVSA dispatch and under a simulated unmanaged charging.



The primary cost components to serve the charging load are from energy and GHG emission costs. These cost components are all driven by the marginal generation resource and are therefore closely correlated. Generally, energy costs are lower during periods of low system load and high renewables generation which usually is in the mid-morning to early afternoon hours in California. Charging during these hours therefore results in lower energy and emissions costs than charging outside of these hours.

It is important to note that there are no transmission, distribution, or generation capacity costs in Figure 46. This is because in the 2019 CPUC avoided costs, peak system and distribution loads occur during the July – September period which is outside of the EVSA data collection period. The cost of serving load in certain hours during these months could add significant grid costs to the results shown above.

6.6.4 Conclusions and Recommendations

This chapter has explored the upper revenue potential of the EVSA aggregation from frequency regulation, alternate sources of revenue, and the cost of serving the EVSA aggregation load.

Section 6.6.2 demonstrated that the EVSA aggregation has the potential to nearly double frequency regulation capacity bid revenues. These increases could be achievable by employing a bidding strategy that maximizes revenue based on market price and driver schedule data, and by improving driver schedule prediction potentially through aggregating more vehicles.

Results from the analysis of alternate revenue streams (section 6.2.2) showed the PDR market currently offers around 25% of the value obtainable from frequency regulation. EVSA participation in PDR over the 2019 analysis period captures a majority of the value from obtainable from full access to the day ahead energy market. Since prices over the analysis period rarely dropped below zero the PDR-LSR value potential was not analyzed. However, based on market price forecasts this product could enable even greater revenues from the energy market by 2025. A major uncertainty which this analysis does not explore is whether a future EVSA aggregation would have to pay retail rates for charging. Currently retail rates do still apply and this would significantly impact the economics of PDR participation. Distribution deferral value from the EVSA aggregation could also have provided an additional $30 per EV in revenue over the analysis period. However, many regulatory hurdles must be overcome before this revenue stream could become accessible.

Finally, section 6.6.3 analyzed the grid costs of the EVSA load against a simulated unmanaged EVSA charging load shape. The EVSA load shape was much more evenly spread across morning hours compared to the unmanaged load which was highly concentrated around 7am. Overall, while the total cost to serve the EVSA load was narrowly higher than the simulated unmanaged load profile, the cost per kWh of charging was significantly lower. This cost estimate does not include the major grid benefit the EVSA aggregation provides through frequency regulation which results in more charging occurring than simply charging to replenish the electric miles driven.

GLOSSARY

Term / Acronym	Definition
AC	Alternating current
AGC	Automated generation control - describes the signal dispatched by CAISO to resources participating in regulation up and down
AHJ	Authority having jurisdiction
AS	Ancillary Services
ATS	Automatic transfer switch
BTM	Behind-the-meter
C&I	Commercial and industrial - applicable to the type of utility customer and rates an asset is subject to
CAISO	California Independent System Operator
CEC	California Energy Commission
CESA	California Energy Storage Association
CHAdeMO	The trade name of a quick charging method for battery electric vehicles delivering up to 62.5 kW by 500 V, 125 A direct current via a special electrical connector
CPUC	California Public Utilities Commission
DAM	Day-ahead energy market
DC	Direct Current
DER	Distributed Energy Resource (i.e. electric vehicles)
DOP	Dispatch Operating Point
DOT	Dispatch Operating Target
DSO	Distribution System Operator (i.e. SDG&E)
E3	Energy & Environmental Economics
EMS	Energy Management System (CAISO)
EPIC / EPC	Electric Program Investment Charge - grant program ran by CEC.
EPRI	Electric Power Research Institute

ESDER	Energy Storage and Distributed Energy Resources Proceeding at CAISO
EV	Electric Vehicle (includes both Plug-in Hybrid Electrics and Battery electric vehicles)
EVSA	Electric Vehicle Storage Accelerator
EVSE	Electric vehicle supply equipment
FERC	Federal Energy Regulatory Commission
FR	Frequency regulation (regulation up and down)
GHG	Greenhouse gas emissions
IEEE	Institute of Electrical and Electronics Engineers - a professional association for electronic engineering and electrical engineering
IRP	Integrated Resource Planning - CPUC proceeding
ISO	Independent system operator - i.e. CAISO
kW	Kilowatts, a measure of Power
kWh	Kilowatt-hour, a measure of Energy
LAAFB	Los Angeles Air Force Base
LMP	Locational marginal price (CAISO)
MCS	Monte Carlo Simulation - used in Use Case #3
MISO	Midcontinent Independent System Operator
MW	Megawatt
MWh	Megawatt-hour
NBT	Net benefits test used to set threshold for PDR mechanism
NEM	Net-energy metering
NGR	Non-Generating Resource
NRTL	National Recognized Testing Lab
NYISO	New York Independent System Operator
OASIS	Open Access Same-Time Information System - CAISO's publicly available data access system

PDR	Proxy Demand Response - mechanism for behind the meter resources to access the day-ahead energy market
PDR-LSR	Proxy Demand Response-Load Shift Resource
PG&E	Pacific Gas & Electric
PHEV	Plug-in Hybrid Electric Vehicle (applicable to Honda PHEV)
PJM	The transmission system operator in Pennsylvania, Jersey, Maryland
POP	Preferred Operating Point
PPS	Princeton Power Systems
PSPS	Public Safety Power Shutoff
PTO	Permission to operate
RDRR	Reliability-Demand-Response-Resource
REM	Regulation Energy Management
RIG	Remote Intelligent Gateway
RMM	Resource Mileage Multiplier
RPM	Regulation Performance Monitoring
RPS	Renewable Portfolio Standards
SAE	Society of Automotive Engineers
SAE J1772	Charging protocol used for level 2 charging stations
SAE J3072	Charging protocol used for on-board mobile inverters
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric
SOC	Vehicle battery state of charge (%)
SOH	State of Health
TMS	Transformer Management System
TOU	Time-of-use rate
UCSD	University of California, San Diego
UL	Underwriter's Laboratory
UPS	Uninterruptable power supply

V1G	Term used to refer to smart charging, or managed uni-directional charging.
V2G	Vehicle to Grid
V2G-AC	Power conversion occurs in an inverter located on-board the EV itself (Honda Accord PHEV).
V2G-DC	Power conversion between the grid (alternating current - AC) and the EV battery (direct current – DC) occurs within an inverter located in the EVSE (Princeton Power CA-10) connected to the EV (Nissan LEAF).
VGI	Vehicle-Grid Integration - includes both V1G and V2G

APPENDIX A: FORM 142-05203

SDG&E Generating Facility Interconnection Application for UCSD Surplus Store

APPENDIX B: California V2G Action Plan

Deliverable for the Electric Vehicle Storage Accelerator (EVSA) Project under the CPUC-NRG Settlement

Vehicle to grid (V2G) technology has significant potential to be a key component in helping the State of California successfully reach its renewable energy generation and electric vehicle (EV) adoption goals. Aligning the charging and discharging of an increasing number of electric vehicles with the demands of the grid will help to optimize renewable production, reduce stress on grid infrastructure and take advantage of a growing storage resource with the potential to be cheaper to deploy and operate than stationary storage.

This V2G Action Plan details the policy priorities, additional technology research and development, standards development and testing needed in order to realize the benefits of V2G in California. It also discusses the future opportunities for grid integrated vehicles in the state for consideration of stakeholders. The recommendations included here are drawn from the implementation of the Electric Vehicle Storage Accelerator (EVSA) project as well as other vehicle grid integration (VGI) projects completed and ongoing in the state.

Interconnection

California needs a standardized, streamlined interconnection process for EVs in order to take advantage of their full potential to provide services to the grid. In addition, the two configurations for V2G deployment need to be evaluated for improvements separately.

> ***DC stationary inverter configuration (V2G-DC):*** Working Group 3 within the California Public Utilities Commissions (CPUC) Rulemaking 17-07-007 determined stationary inverters placed within a charging station as part of a V2G-DC system are sufficiently addressed by Rule 21 as written. Although no changes to Rule 21 are required, there will be a steep learning curve for both utilities and interconnection applicants as familiarity with the technology increases. It is therefore critical for lessons learned to be socialized across utilities in order to streamline processes across the state and identify bottlenecks for targeted policy solutions.
>
> ***AC mobile inverter configuration (V2G-AC):*** Existing interconnection rules are written for stationary inverters and assume the same device will always be operating in the same location. When the inverter is on board an electric vehicle, this is not true. The safety standards currently required by Rule 21 (UL 1741 SA) do not fully address the safety and operational requirements of the V2G-AC mobile inverter configuration. In addition, there is no UL certification for automotive components. The Society of Automotive Engineers (SAE) developed a complimentary automotive standard to fill this gap, but it is not yet recognized by investor-owned utilities in California. The CPUC has convened a dedicated subgroup to R. 17-07-007 Working Group 3 to address this issue. Once the subgroup

produces recommendations, California should continue to address the barriers to the V2G-AC opportunity to open as many avenues as possible for V2G and VGI.

Smart Inverter Standard Implementation

As a subset of interconnection, the smart inverter working group should re-examine smart inverter requirements through the lens of an intermittently available resource. For example, while V2G-DC system can certainly produce or absorb reactive power when the EV is present, the EVSE by itself cannot meet that requirement when the EV is not present, even though the inverter is located in the EVSE. Technical requirements must consider this unique characteristic or risk excluding V2G from VGI efforts in California.

Regulatory Status

V2G currently has no consistent definition as a resource type in California. This leads to differing interpretations by industry and government which can lead to delays and confusion related to interconnection, metering schemes, technical requirements, permitted functions, and market participation allowance. A regulatory designation will remove some of the ambiguity around V2G and provide a signpost for treatment in these other areas. It will also accelerate progress integrating this new source of flexibility into resource and system planning. Rulemaking 17-07-007, Working Group 3 recommended by consensus that V2G-capable EVs be defined as storage. This recommendation should be accepted and reflected in Rule 21 language.

Market Access

Aggregation addresses a variety of barriers to market participation at the distribution and transmission levels for EVs and other small distributed energy resources (DERs), but some key challenges remain.

Metering: Transmission System Operators (TSOs) and distribution utilities all over the United States, including California, are still wrestling with implementation of FERC order 841. Although the California Independent System Operator's (CAISO) Distributed Energy Resource Provider (DERP) path was developed to allow DERs into ancillary services markets inaccessible via the Proxy Demand Response mechanism, the DERP path for an aggregation of EVs behind retail meters remains unclear in practice. Behind the meter resources such as EVs are currently prevented from accessing ancillary services markets due to an inability to count and compensate their participation due to a lack of methodology to settle the wholesale and retail meter measurements. CAISO's ESDER 4 proceeding took steps to acknowledge the load curtailment activities of EVs but did not fully address the metering challenge. CAISO's ESDER proceeding and / or the CPUC's VGI Working Group should take this issue up again and consider new, more innovative metering solutions such as roaming accounts that look beyond the current accounting methods.

Aggregation: DER aggregations should be assessed and audited at the aggregation level for wholesale grid services within the relevant geographical scope for the service being provided. While telemetry requirements can theoretically remain at the unit level, although there is a high potential to be cost prohibitive, qualification testing and performance audits should be at the aggregation level. It should be possible to use one set of metered data for settling with the wholesale market and another set of telemetry data that is used and modified by the distribution company. It is important to look beyond current demand response models to scenarios when EVs and V2G may become an essential element of duck curve mitigation with a focus on wholesale load shift products and set an environment for that to be possible and feasible.

Sub-Metering Methodology

When the FERC 841 question is resolved, the next question will be how to distinguish between energy purchased to sell back to the grid and energy purchased for the retail end use of driving the car. The data streams necessary for this calculation may not be available via one actor and this may be one of several cases that require a new level of association and data sharing between auto manufacturers and utilities. Particularly if states reallocate road taxes to electric bills as EVs become more common, the retail rates charged on energy used for driving and energy used for grid services could be different, and the taxes and fees embedded in those rates may go to different entities, making this parsing an absolute necessity.

In addition, there is also a need to re-evaluate recent studies conducted on submetering in the context of bi-directional EVs in California. Current retail rate schedules and metering schemes will incentivize different behavior and choices by owners of bi-directional EVs as compared to uni-directional EVs due to the ability to strategically discharge. Evaluating the likely behavior of bi-directional EVs in this context will identify whether there are disincentives for these resources to provide the desired value of grid support and whether additional thought needs to be given to other compensation/incentive mechanisms.

Involvement of Automakers in the V2G and VGI conversations

The voice of the automotive industry must be present in VGI and V2G proceedings and policy development. In many ways the grid is the customer of V2G and VGI, but the needs and priorities of the EV owner and the safety and warranty concerns of the automotive industry must be the first constraint on operations. In addition, privacy requirements, safety standards, and an existing regulatory infrastructure within which all automakers work must be reconciled with those of the utility industry rather than subsumed. This is a larger and longer conversation than the interconnection of mobile inverters and both industries will need to be remain open to accepting new solutions unfamiliar to either party in order to successfully integrate V2G technology.

Standards

Though V2G-capable EVSEs are not yet common as a commercial product, the technology for the EVSE component of both AC and DC V2G systems is beyond the R&D stage. A primary barrier to commercial production and widespread introduction is the continuing evolution of relevant charging and related communications standards, as well as the differing technical safety standards for discharging devices by state and by country. Lack of harmonization across geographies inhibits economies of scale and interoperability as governments and utilities seek to fit EVs and V2G into their energy transition plans. However, harmonization is not a small project given the different layers of communication and technical requirements applicable to vehicles and charging stations that straddle not only the automotive and electrical domains, but state and national regulations, and hardware and software integration.

Interconnection and smart inverter requirements include similar elements across geographies but are not harmonized in a deliberate way that will allow the same EVSE or EV to be sold and successfully interconnect in multiple states. This is a significant barrier that must be addressed in a cooperative effort across state lines if economies of scale and commercial momentum is to be achieved. California and other geographies with previous experience of the potential destabilizing effects of large amounts of distributed resources have attempted to analogize both traditional power plant requirements and new responsive functionalities that are widely believed to be a necessary component of the energy transition. However, V2G was never specifically addressed in California's requirements. In addition, the implementation of Phase 2 and 3 of smart inverter functionalities remains unclear and subject to delays at the time of writing. This lack of certainty is currently impeding development of Rule 21 compliant EVs and EVSEs necessary for scaling V2G technology in California.

If V2G is to be a fully commercial solution, standards organizations and governments must also consider the impacts of coordination (or lack thereof) in EVSE/EV-related communications standards and inverter/electrical system-related communications standards. Phase 2 of California's smart inverter standard requires IEEE 2030.5 for communication between the inverter and the distribution system operator (DSO). Other potential standards for EVSE communications such as ISO15118 between the EV and EVSE and OCPP between the EVSE and the charge point operator (CPO) will need to be reconciled with smart inverter communications requirements if pushed as requirements for EV infrastructure by state regulators. Neither 15118 nor OCPP currently allows for bi-directional communications or functionalities, and a conflict between EV communications design with inverter requirements could leave EV and EVSE manufacturers unable to design systems that meet all applicable standards. Therefore, policymakers are encouraged to carefully consider the impacts of mandating communications standards. While such a move might provide clarity and potentially move the industry forward, it will also determine the path innovation takes and remove industry leadership from technology development and commercialization.

Grid Services of the Future

The inherent flexibility of V2G-capable EVs as highly distributed grid resources situated at the edge of the distribution grid presents a range of use cases that only grows as the energy transition proceeds. As new paradigms for integration of distributed resources emerge, V2G may allow EVs to facilitate the DSO role as utilities become more active managers of their grids. Based on trends seen in California, other states and other countries, some potential services V2G technology could provide in the future include the following:

- Resiliency/emergency power in which EVs are not only a potential back-up generator for individual homes and shelters during planned outages, but also need to be charged well in advance of any outage for evacuation purposes. EVs can be part of disaster planning in both preparation and response.
- Hybrid-Generator systems in which EVs serve a role similar to on-site storage in leveling out the utilization factors of peaking turbines.
- Local/distribution level markets and centralized DSO-TSO coordinated markets in which EVs bid as resources of both demand response and flexibility for community-level renewable energy balancing and flexible connection size.
- Local voltage control in which EVs can work in constrained transmission and generation environments to address voltage and reactive power needs where they start.

The overarching policy goal must be to create an environment for innovation in V2G technology. The actions laid out in the plan highlight near term steps to foster this innovation in a rapidly changing energy landscape. Therefore, instead of defining a path of V2G integration and market participation, it is recommended policy makers seek to open as many paths as possible for the implementation and scaling of V2G technology allowing new, unforeseen business models to emerge and scale.