Report
03/01/2018

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March 1, 2018

VIA: ELECTRONIC MAIL

Mr. Greg Shafer, Director
Division of Economics
Florida Public Service Commission
Room 225E – Gerald L. Gunter Building
2540 Shumard Oak Boulevard
Tallahassee, FL 32399-0850

Re: Tampa Electric Company's Summary of 2017 DSM Program Accomplishments

Dear Mr. Shafer:

Enclosed for filing is Tampa Electric Company's Summary of 2017 Demand Side Management Program Accomplishments, including an Appendix A (DSM Energy Education and Awareness Activities of 2017).

Thank you for your assistance in connection with this matter.

Sincerely,

James D. Beasley

JDB/pp
Enclosure

cc: Paula K. Brown (w/o enc.)

TECO® TAMPA ELECTRIC
AN EMERA COMPANY

2017

DEMAND SIDE MANAGEMENT PROGRAM ACCOMPLISHMENTS

FILED: March 1, 2018

TAMPA ELECTRIC COMPANY-SUMMARY OF 2017 DEMAND SIDE MANAGEMENT PROGRAM ACCOMPLISHMENTS

Tampa Electric received approval of its 2015-2024 Demand Side Management ("DSM") goals in Docket No. 130201-EI, Order No. PSC-14-0696-FOF-EU, issued December 16, 2014. The company received approval of its 2015-2024 DSM Plan on August 11, 2015 in Docket No. 150081-EG, Order No. PSC-15-0323-PAA-EG. Tampa Electric transitioned to the DSM programs within the 2015-2024 DSM Plan on November 3, 2015 pursuant to receiving final approval of the supporting DSM standards on September 24, 2015.

In 2017, Tampa Electric achieved all the annual and cumulative residential, commercial and combined DSM goals. The company achieved the following demand and annual energy ("AE") reductions identified at the generator:

2017 Residential Goals		Actual Residential DSM Achieved	
SkW:	2.2 MW	SkW:	4.7 MW
WkW:	5.2 MW	WkW:	6.9 MW
AE:	4.8 GWh	AE:	14.9 GWh

2017 Commercial Goals		Actual Commercial DSM Achieved	
SkW:	2.7 MW	SkW:	10.4 MW
WkW:	1.6 MW	WkW:	9.2 MW
AE:	8.0 GWh	AE:	30.2 GWh

2017 Combined Goals		Actual Combined DSM Achieved	
SkW:	4.9 MW	SkW:	15.1 MW
WkW:	6.8 MW	WkW:	16.1 MW
AE:	12.8 GWh	AE:	45.2 GWh

Tampa Electric also received approval for and initiated the new ENERGY STAR for new Multi-Family Residences Program and added electric vehicle training to the Energy Education, Awareness and Agency Outreach Program. The company also transitioned on December 15, 2017 from Compact Fluorescent Lamps ("CFL") to Light Emitting Diode ("LED") lamps in the energy kits supplied by two of the company's programs and made significant progress with Research and Development ("R&D") efforts with electric vehicles, battery storage and commercial low-income weatherization.

A summary of 2017 energy education and awareness activities, electric vehicle student curriculum and the R&D battery report from the University of South Florida are included as appendices to this report. The R&D reports for electric vehicles and commercial low-income weatherization are not complete at this time.

For 2018, Tampa Electric remains committed to offering DSM programs that advance the policy objectives of FEECA, are directly monitorable and yield measurable results and are cost-effective to deliver. The company will continue its advertising campaign of bill inserts, print media and television advertisements aimed at educating customers on opportunities to participate in programs to assist in meeting their energy efficiency requirements. Tampa Electric will be starting the recently Commission approved conversion process of approximately 207,000 existing metal halide and high pressure sodium street and outdoor luminaires to light emitting diode luminaires over the next five years. Tampa Electric will also be enhancing the Residential Customer Assisted Audit Program by migrating the existing program to an improved platform which will afford all of the company's residential customers the ability to access individualized energy efficiency recommendations, energy usage comparisons and forecasts, integrated special purpose energy calculators and specific tips and advice for implementing residential energy efficiency measures.

The attached pages present individual program participation levels and summaries that demonstrate the company achieved its annual residential, commercial and combined DSM goals as described in Rule 25-17, (4), Florida Administrative Code.

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: RESIDENTIAL ALTERNATE AUDIT (aka Walk-Thru Audit or EA Free)
Program Start Date: May 1981
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	628,392	628,392	6,000	1.0%	8,304	8,304	1.3%	2,304
2016	640,090	640,090	12,000	1.9%	6,902	15,206	2.4%	3,206
2017	651,770	651,770	18,000	2.8%	5,501	20,707	3.2%	2,707
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017, Note 1

Participants 5,501

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.07	0.08	385.07	413.18
Winter kW Reduction	0.08	0.09	445.58	478.11
Annual kWh Reduction	395	417	2,172,895	2,294,577

Utility Cost per Installation ($): 314
Total Program Cost of the Utility ($000): 1,728.3
Net Benefits of Measures Installed During Reporting Period ($000): (1,855.6)
Note 1: Demand and energy savings not included in achievements

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: RESIDENTIAL CUSTOMER ASSISTED AUDITS
Program Start Date: June 1996
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	628,392	628,392	500	0.1%	658	658	0.1%	158
2016	640,090	640,090	1,000	0.2%	1,017	1,675	0.3%	675
2017	651,770	651,770	1,500	0.2%	409	2,084	0.3%	584
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017, Note 1

Participants 409

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.05	0.06	21.68	23.26
Winter kW Reduction	0.06	0.07	24.95	26.77
Annual kWh Reduction	296	313	121,064	127,844

Utility Cost per Installation ($): 126
Total Program Cost of the Utility ($000): 51.5
Net Benefits of Measures Installed During Reporting Period ($000): 80.6
Note 1: Demand and energy savings not included in achievements

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: RESIDENTIAL RCS AUDIT (Computer Assisted - Paid)
Program Start Date: January 1981
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	628,392	628,392	1	0.0%	5	5	0.0%	4
2016	640,090	640,090	2	0.0%	9	14	0.0%	12
2017	651,770	651,770	3	0.0%	4	18	0.0%	15
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017, Note 1

Participants 4

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.07	0.08	0.28	0.30
Winter kW Reduction	0.08	0.09	0.32	0.35
Annual kWh Reduction	395	417	1,580	1,668

Utility Cost per Installation ($): 1,396
Total Program Cost of the Utility ($000): 5.6
Net Benefits of Measures Installed During Reporting Period ($000): (6.0)
Note 1: Demand and energy savings not included in achievements

Demand Side Management Annual Report

Utility:	Tampa Electric Company
Program Name:	RESIDENTIAL CEILING INSULATION
Program Start Date:	November 1982
Reporting Period:	Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	628,392	494,802	1,000	0.2%	3,057	3,057	0.6%	2,057
2016	640,090	491,745	2,000	0.4%	1,293	4,350	0.9%	2,350
2017	651,770	490,452	3,000	0.6%	945	5,295	1.1%	2,295
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 945

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.26	0.28	244.76	262.62
Winter kW Reduction	0.37	0.40	351.54	377.20
Annual kWh Reduction	848	895	801,360	846,236

Utility Cost per Installation ($):	316
Total Program Cost of the Utility ($000):	298.2
Net Benefits of Measures Installed During Reporting Period ($000):	621.3

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: RESIDENTIAL DUCT REPAIR
Program Start Date: September 1992
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	628,392	480,750	750	1.9%	1,895	1,895	0.8%	1,145
2016	640,090	478,855	1,500	1.9%	1,293	3,188	0.8%	1,688
2017	651,770	477,562	2,250	1.9%	1,176	4,364	0.8%	2,114
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 1,176

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.17	0.18	201.10	215.78
Winter kW Reduction	0.22	0.23	255.19	273.82
Annual kWh Reduction	298	315	350,448	370,073

Utility Cost per Installation ($):	186
Total Program Cost of the Utility ($000):	219.0
Net Benefits of Measures Installed During Reporting Period ($000):	252.1

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: RESIDENTIAL ELECTRONICALLY COMMUTATED MOTORS
Program Start Date: November 2011
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	628,392	628,392	5	0.0%	4	4	0.0%	(1)
2016	640,090	640,090	15	0.0%	0	4	0.0%	(11)
2017	651,770	640,090	35	0.0%	0	4	0.0%	(31)
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.15	0.16	0.00	0.00
Winter kW Reduction	0.14	0.15	0.00	0.00
Annual kWh Reduction	388	410	0	0

Utility Cost per Installation ($):	0
Total Program Cost of the Utility ($000):	0.0
Net Benefits of Measures Installed During Reporting Period ($000):	0.1

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: ENERGY EDUCATION, AWARENESS AND AGENCY OUTREACH
Program Start Date: May 2011
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	628,392	628,392	500	0.1%	1,412	1,412	0.2%	912
2016	640,090	640,090	1,000	0.2%	461	1,873	0.3%	873
2017	651,770	640,090	1,500	0.2%	975	2,848	0.4%	1,348
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017, Note 1

Participants 975

	Per Installation @ Meter	Per Installation @ Generator	Program Total @ Meter	Program Total @ Generator
Summer kW Reduction	0.03	0.03	24.38	26.15
Winter kW Reduction	0.05	0.05	44.85	48.12
Annual kWh Reduction	342	361	333,450	352,123

Utility Cost per Installation ($): 174
Total Program Cost of the Utility ($000): 169.6
Net Benefits of Measures Installed During Reporting Period ($000): (98.7)
Note 1: Demand and Energy did not require any adjustment during this report as all 975 participants received kits with CFLs

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: ENERGY STAR for NEW MULTI-FAMILY RESIDENCES
Program Start Date: June 2017
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	0	0	0	0.0%	0	0	0.0%	0
2016	0	0	0	0.0%	0	0	0.0%	0
2017	201,074	3,820	600	15.7%	0	0	0.0%	(600)
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.36	0.39	0.00	0.00
Winter kW Reduction	0.24	0.26	0.00	0.00
Annual kWh Reduction	1,239	1,308	0	0

Utility Cost per Installation ($): 0
Total Program Cost of the Utility ($000): 0.0
Net Benefits of Measures Installed During Reporting Period ($000): 0.0

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: ENERGY STAR for NEW HOMES (formerly RESIDENTIAL NEW CONSTRUCTION)
Program Start Date: Closed New Construction and opened ENERGY STAR November 2015
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	628,392	4,361	100	2.3%	2,494	2,494	57.2%	2,394
2016	640,090	3,870	300	7.8%	403	2,897	74.9%	2,597
2017	651,770	2,953	550	18.6%	640	3,537	119.8%	2,987
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 640

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.53	0.57	339.84	364.65
Winter kW Reduction	0.49	0.53	313.60	336.49
Annual kWh Reduction	2,489	2,628	1,592,960	1,682,166

Utility Cost per Installation ($): 901
Total Program Cost of the Utility ($000): 576.9
Net Benefits of Measures Installed During Reporting Period ($000): 585.2

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: RESIDENTIAL HEATING AND COOLING
Program Start Date: July 2000
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	628,392	628,392	1,000	0.2%	5,214	5,214	1.0%	4,214
2016	640,090	640,090	2,000	0.3%	3,693	8,907	1.0%	6,907
2017	651,770	651,770	2,950	0.5%	3,341	12,248	1.0%	9,298
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 3,341

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.10	0.11	340.78	365.66
Winter kW Reduction	0.33	0.36	1,112.55	1,193.77
Annual kWh Reduction	371	392	1,239,511	1,308,924

Utility Cost per Installation ($): 159
Total Program Cost of the Utility ($000): 532.2
Net Benefits of Measures Installed During Reporting Period ($000): 1,328.6

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: NEIGHBORHOOD WEATHERIZATION
Program Start Date: March 2008
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	628,392	109,703	5,000	4.6%	7,912	7,912	7.2%	2,912
2016	640,090	111,745	10,750	9.6%	5,495	13,407	12.0%	2,657
2017	651,770	113,784	17,000	14.9%	6,550	19,957	17.5%	2,957
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017, Note 1

Participants 6,550

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.24	0.26	1,578.55	1,693.78
Winter kW Reduction	0.34	0.36	2,207.35	2,368.49
Annual kWh Reduction	1,223	1,291	8,010,650	8,459,246

Utility Cost per Installation ($): 530
Total Program Cost of the Utility ($000): 3,471.9
Net Benefits of Measures Installed During Reporting Period ($000): (6,773.6)
Note 1: Demand and Energy adjusted to recognize 107 participants receiving LED lamps, 6,443 received CFLs

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: ENERGY PLANNER
Program Start Date: September 2007
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	628,392	628,392	1,000	0.2%	1,088	1,088	0.2%	88
2016	640,090	640,090	2,000	0.3%	910	1,998	0.3%	(2)
2017	651,770	651,770	3,000	0.5%	574	2,572	0.4%	(428)
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 574

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	2.01	2.16	1,154.89	1,239.19
Winter kW Reduction	3.13	3.36	1,798.92	1,930.24
Annual kWh Reduction	242	256	138,908	146,687

Utility Cost per Installation ($) Note 1:	7,013
Total Program Cost of the Utility ($000):	4,025.6
Net Benefits of Measures Installed During Reporting Period ($000):	9,071.4

Note 1: Utility costs based upon total program costs and total participation

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: RESIDENTIAL WALL INSULATION
Program Start Date: March 2008
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	628,392	628,329	28	0.0%	122	122	0.0%	94
2016	640,090	639,905	56	0.0%	5	127	0.0%	71
2017	651,770	651,580	84	0.0%	5	132	0.0%	48
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 5

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.10	0.11	0.52	0.56
Winter kW Reduction	0.23	0.24	1.13	1.21
Annual kWh Reduction	399	421	1,995	2,107

Utility Cost per Installation ($): 125
Total Program Cost of the Utility ($000): 0.6
Net Benefits of Measures Installed During Reporting Period ($000): 1.6

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: RESIDENTIAL WINDOW REPLACEMENT
Program Start Date: March 2008
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	628,392	619,895	500	0.1%	1,811	1,811	0.3%	1,311
2016	640,090	629,783	1,000	0.2%	1,417	3,228	0.5%	2,228
2017	651,770	640,046	1,500	0.2%	1,482	4,710	0.7%	3,210
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 1,482

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.31	0.33	460.90	494.55
Winter kW Reduction	0.21	0.23	314.18	337.12
Annual kWh Reduction	1,121	1,184	1,661,322	1,754,356

Utility Cost per Installation ($):	398
Total Program Cost of the Utility ($000):	589.1
Net Benefits of Measures Installed During Reporting Period ($000):	1,846.3

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: RESIDENTIAL WINDOW FILM
Program Start Date: March 2008
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	628,392	625,431	0	0.0%	379	379	0.1%	379
2016	Program was retired on November 3, 2015.							
2017								
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.00	0.00	0.00	0.00
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	0	0	0	0

Utility Cost per Installation ($):
Total Program Cost of the Utility ($000):
Net Benefits of Measures Installed During Reporting Period ($000):

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: RESIDENTIAL HVAC RE-COMMISSIONING
Program Start Date: November 2011
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	628,392	627,437	0	0.0%	138	138	0.0%	138
2016			Program was retired on November 3, 2015.					
2017								
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.00	0.00	0.00	0.00
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	0	0	0	0

Utility Cost per Installation ($):
Total Program Cost of the Utility ($000):
Net Benefits of Measures Installed During Reporting Period ($000):

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: FREE COMMERCIAL/INDUSTRIAL AUDIT
Program Start Date: July 1983
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,277	700	0.9%	913	913	1.1%	213
2016	80,875	80,875	1,400	1.7%	764	1,677	2.1%	277
2017	81,532	81,532	2,150	2.6%	1,211	2,888	3.5%	738
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017, Note 1

Participants 1,211

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.09	0.10	112.62	120.51
Winter kW Reduction	0.09	0.10	113.83	121.80
Annual kWh Reduction	817	859	989,387	1,040,835

Utility Cost per Installation ($): 228
Total Program Cost of the Utility ($000): 275.9
Net Benefits of Measures Installed During Reporting Period ($000): (204.2)
Note 1: Demand and energy savings not included in achievements

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMPREHENSIVE COMMERCIAL/INDUSTRIAL AUDIT
Program Start Date: May 1981
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,277	4	0.0%	1	1	0.0%	(3)
2016	80,875	80,875	8	0.0%	4	5	0.0%	(3)
2017	81,532	81,532	12	0.0%	0	5	0.0%	(7)
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017, Note 1

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.09	0.10	0.00	0.00
Winter kW Reduction	0.09	0.10	0.00	0.00
Annual kWh Reduction	817	859	0	0

Utility Cost per Installation ($): 0
Total Program Cost of the Utility ($000): 0.4
Net Benefits of Measures Installed During Reporting Period ($000): (3.3)
Note 1: Demand and energy savings not included in achievements

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL CEILING INSULATION
Program Start Date: March 2008
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,026	50	0.1%	41	41	0.1%	(9)
2016	80,875	79,985	100	0.1%	14	55	0.1%	(45)
2017	81,532	79,971	150	0.2%	5	60	0.1%	(90)
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017, Note 1 Participants 5

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.20	0.21	0.99	1.05
Winter kW Reduction	0.00	0.00	0.02	0.02
Annual kWh Reduction	5,448	5,731	27,240	28,656

Utility Cost per Installation ($): 1,200
Total Program Cost of the Utility ($000): 6.0
Net Benefits of Measures Installed During Reporting Period ($000): 59.6
Note 1: Savings from measured data

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL CHILLERS
Program Start Date: March 2008
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	7,733	5	0.1%	7	7	0.1%	2
2016	80,875	8,851	10	0.1%	5	12	0.1%	2
2017	81,532	8,887	15	0.2%	7	19	0.2%	4
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017, Note 1

Participants 7

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	26.89	28.78	188.26	201.44
Winter kW Reduction	20.17	21.58	141.20	151.08
Annual kWh Reduction	54,215	57,034	379,505	399,239

Utility Cost per Installation ($): 4,591
Total Program Cost of the Utility ($000): 32.1
Net Benefits of Measures Installed During Reporting Period ($000): 62.1
Note 1: Savings from measured data

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: CONSERVATION VALUE
Program Start Date: April 1991
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,277	2	0.0%	4	4	0.0%	2
2016	80,875	80,875	4	0.0%	2	6	0.0%	2
2017	81,532	81,532	6	0.0%	0	6	0.0%	0
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017, Note 1

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	178.95	191.48	0.00	0.00
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	4,877	5,131	0	0

Utility Cost per Installation ($): 0
Total Program Cost of the Utility ($000): 2.0
Net Benefits of Measures Installed During Reporting Period ($000): 266.0
Note 1: Savings from measured data

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL COOL ROOF
Program Start Date: May 2011
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,128	20	0.0%	45	45	0.1%	25
2016	80,875	80,681	40	0.0%	25	70	0.1%	30
2017	81,532	81,313	60	0.1%	13	83	0.1%	23
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017, Note 1

Participants 13

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	8.55	9.15	111.19	118.97
Winter kW Reduction	0.53	0.56	6.86	7.34
Annual kWh Reduction	32,350	34,032	420,550	442,419

Utility Cost per Installation ($): 15,258
Total Program Cost of the Utility ($000): 198.3
Net Benefits of Measures Installed During Reporting Period ($000): 95.5
Note 1: Savings from measured data

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL COOLING - DX
Program Start Date: July 2000
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,277	100	0.1%	234	234	0.3%	134
2016	80,875	80,875	200	0.2%	9	243	0.3%	43
2017	81,532	81,532	300	0.4%	0	243	0.3%	(57)
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017, Note 1

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.00	0.00	0.00	0.00
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	0	0	0	0

Utility Cost per Installation ($): 0
Total Program Cost of the Utility ($000): 5.3
Net Benefits of Measures Installed During Reporting Period ($000): 10.5
Note 1: Savings from measured data

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL COOLING - PTAC
Program Start Date: March 2008
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,277	0	0.0%	0	0	0.0%	0
2016	This portion of Commmercial Cooling was retired on November 3, 2015.							
2017								
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.00	0.00	0.00	0.00
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	0	0	0	0

Utility Cost per Installation ($):
Total Program Cost of the Utility ($000):
Net Benefits of Measures Installed During Reporting Period ($000):

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL DEMAND RESPONSE
Program Start Date: March 2008
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	12,302	1	0.0%	4	4	0.0%	3
2016	80,875	12,937	2	0.0%	0	4	0.0%	2
2017	81,532	13,383	3	0.0%	0	4	0.0%	1
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017, Note 1

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.00	0.00	0.00	0.00
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	0	0	0	0

Utility Cost per Installation ($), Note 2: 0
Total Program Cost of the Utility ($000): 3,712.3
Net Benefits of Measures Installed During Reporting Period ($000): 1,270.7
Note 1: Savings from measured data
Note 2: Utility costs based upon total program costs and total participation

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL DUCT REPAIR
Program Start Date: March 2008
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	70,369	250	0.4%	257	257	0.4%	7
2016	80,875	70,112	500	0.7%	96	353	0.5%	(147)
2017	81,532	70,016	750	1.1%	3	356	0.5%	(394)
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017, Note 1 Participants 3

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.07	0.08	0.21	0.23
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	327	344	981	1,032

Utility Cost per Installation ($): 1,592
Total Program Cost of the Utility ($000): 4.8
Net Benefits of Measures Installed During Reporting Period ($000): 473.7
Note 1: Savings from measured data

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL ELECTRONICALLY COMMUTATED MOTORS
Program Start Date: November 2011
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,277	5	0.0%	85	85	0.1%	80
2016	80,875	80,875	10	0.0%	1,225	1,310	1.6%	1,300
2017	81,532	81,532	15	0.0%	202	1,512	1.9%	1,497
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017, Note 1

Participants 202

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.24	0.25	47.67	51.01
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	32	34	6,464	6,800

Utility Cost per Installation ($): 135
Total Program Cost of the Utility ($000): 27.3
Net Benefits of Measures Installed During Reporting Period ($000): 504.0
Note 1: Savings from measured data

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: INDUSTRIAL LOAD MANAGEMENT
Program Start Date: September 1999
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	79,457	820	1	0.1%	0	0	0.0%	(1)
2016	80,875	848	2	0.2%	0	0	0.0%	(2)
2017	81,532	816	3	0.4%	0	0	0.0%	(3)
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017, Note 1

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.00	0.00	0.00	0.00
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	0	0	0	0

Utility Cost per Installation ($), Note 2: 0
Total Program Cost of the Utility ($000): 16,969.9
Net Benefits of Measures Installed During Reporting Period ($000): 0.0
Note 1: Savings from measured data
Note 2: Utility costs based upon total program costs and total participation

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL LIGHTING - CONDITIONED SPACE
Program Start Date: January 1991
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,277	25	0.0%	86	86	0.1%	61
2016	80,875	80,875	50	0.1%	159	245	0.3%	195
2017	81,532	81,532	75	0.1%	228	473	0.6%	398
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017, Note 1

Participants 228

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	14.73	15.76	3,358.21	3,593.29
Winter kW Reduction	11.47	12.27	2,614.70	2,797.73
Annual kWh Reduction	58,550	61,595	13,349,400	14,043,569

Utility Cost per Installation ($): 2,015
Total Program Cost of the Utility ($000): 459.4
Net Benefits of Measures Installed During Reporting Period ($000): 9,346.5
Note 1: Savings from measured data

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL LIGHTING - UNCONDITIONED SPACE
Program Start Date: March 2008
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,277	5	0.0%	16	16	0.0%	11
2016	80,875	80,875	10	0.0%	60	76	0.1%	66
2017	81,532	81,532	15	0.0%	338	414	0.5%	399
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017, Note 1

Participants 338

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	8.00	8.56	2,702.99	2,892.20
Winter kW Reduction	8.00	8.56	2,702.99	2,892.20
Annual kWh Reduction	41,018	43,151	13,864,084	14,585,016

Utility Cost per Installation ($): 685
Total Program Cost of the Utility ($000): 231.7
Net Benefits of Measures Installed During Reporting Period ($000): 662.4
Note 1: Savings from measured data

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL OCCUPANCY SENSORS
Program Start Date: March 2008
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,277	15	0.0%	2	2	0.0%	(13)
2016	80,875	80,875	30	0.0%	12	14	0.0%	(16)
2017	81,532	81,532	45	0.1%	4	18	0.0%	(27)
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017, Note 1

Participants 4

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	47.53	50.85	190.11	203.42
Winter kW Reduction	38.02	40.68	152.09	162.73
Annual kWh Reduction	97,062	102,109	388,248	408,437

Utility Cost per Installation ($): 5,567
Total Program Cost of the Utility ($000): 22.3
Net Benefits of Measures Installed During Reporting Period ($000): 9.6
Note 1: Savings from measured data

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL LOAD MANAGEMENT- EXTENDED
Program Start Date: January 1988
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,277	1	0.0%	0	0	0.0%	(1)
2016	80,875	80,875	2	0.0%	0	0	0.0%	(2)
2017	81,532	81,532	3	0.0%	0	0	0.0%	(3)
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	92.00	98.44	0.00	0.00
Winter kW Reduction	60.00	64.20	0.00	0.00
Annual kWh Reduction	0	0	0	0

Utility Cost per Installation ($): 0
Total Program Cost of the Utility ($000): 0.0
Net Benefits of Measures Installed During Reporting Period ($000): 0.0

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL LOAD MANAGEMENT- CYCLIC
Program Start Date: January 1988
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,277	1	0.0%	0	0	0.0%	(1)
2016	80,875	80,875	2	0.0%	0	0	0.0%	(2)
2017	81,532	81,532	3	0.0%	0	0	0.0%	(3)
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	13.20	14.12	0.00	0.00
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	0	0	0	0

Utility Cost per Installation ($), Note 1: 0
Total Program Cost of the Utility ($000): 7.1
Net Benefits of Measures Installed During Reporting Period ($000): 0.0
Note 1: Utility costs based upon total program costs and total participation

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL/INDUSTRIAL REFRIGERATION (ANTI-CONDENSATE)
Program Start Date: March 2008
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	8,028	1	0.0%	0	0	0.0%	(1)
2016	80,875	8,088	2	0.0%	0	0	0.0%	(2)
2017	81,532	8,153	4	0.0%	0	0	0.0%	(4)
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.80	0.86	0.00	0.00
Winter kW Reduction	1.32	1.41	0.00	0.00
Annual kWh Reduction	12,933	13,606	0	0

Utility Cost per Installation ($): 0
Total Program Cost of the Utility ($000): 0.3
Net Benefits of Measures Installed During Reporting Period ($000): 0.0

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: STANDBY GENERATOR
Program Start Date: January 1991
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	2,304	1	0.0%	4	4	0.2%	3
2016	80,875	2,449	2	0.1%	0	4	0.2%	2
2017	81,532	2,430	3	0.1%	6	10	0.4%	7
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017, Note 1

Participants 6

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	504.50	539.82	3,027.00	3,238.89
Winter kW Reduction	504.50	539.82	3,027.00	3,238.89
Annual kWh Reduction	50,450	53,073	302,700	318,440

Utility Cost per Installation ($), Note 2: 497,301
Total Program Cost of the Utility ($000): 2,983.8
Net Benefits of Measures Installed During Reporting Period ($000): 8,876.7
Note 1: Savings from measured data
Note 2: Utility costs based upon total program costs and total participation

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: THERMAL ENERGY STORAGE
Program Start Date: November 2015
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	7,733	1	0.0%	0	0	0.0%	(1)
2016	80,875	7,791	3	0.0%	0	0	0.0%	(3)
2017	81,532	7,845	6	0.1%	1	1	0.0%	(5)
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 1

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	101.00	108.07	101.00	108.07
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	468	492	468	492

Utility Cost per Installation ($):	11,659
Total Program Cost of the Utility ($000):	11.7
Net Benefits of Measures Installed During Reporting Period ($000):	78.0

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL WALL INSULATION
Program Start Date: March 2008
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,277	2	0.0%	0	0	0.0%	(2)
2016	80,875	80,875	4	0.0%	0	0	0.0%	(4)
2017	81,532	81,532	6	0.0%	0	0	0.0%	(6)
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.50	0.54	0.00	0.00
Winter kW Reduction	0.39	0.42	0.00	0.00
Annual kWh Reduction	682	717	0	0

Utility Cost per Installation ($): 0
Total Program Cost of the Utility ($000): 0.1
Net Benefits of Measures Installed During Reporting Period ($000): 0.0

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL WATER HEATING
Program Start Date: March 2008
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,277	1	0.0%	0	0	0.0%	(1)
2016	80,875	80,875	2	0.0%	0	0	0.0%	(2)
2017	81,532	81,532	3	0.0%	0	0	0.0%	(3)
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.63	0.68	0.00	0.00
Winter kW Reduction	0.33	0.35	0.00	0.00
Annual kWh Reduction	4,735	4,981	0	0

Utility Cost per Installation ($):	0
Total Program Cost of the Utility ($000):	0.3
Net Benefits of Measures Installed During Reporting Period ($000):	0.0

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL WINDOW FILM
Program Start Date: March 2008
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,277	0	0.0%	18	18	0.0%	18
2016			Program was retired on November 3, 2015.					
2017								
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.00	0.00	0.00	0.00
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	0	0	0	0

Utility Cost per Installation ($):
Total Program Cost of the Utility ($000):
Net Benefits of Measures Installed During Reporting Period ($000):

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL/INDUSTRIAL EFFICIENT MOTORS
Program Start Date: March 2008
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	12,302	0	0.0%	0	0	0.0%	0
2016				Program was retired on November 3, 2015.				
2017								
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.00	0.00	0.00	0.00
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	0	0	0	0

Utility Cost per Installation ($):
Total Program Cost of the Utility ($000):
Net Benefits of Measures Installed During Reporting Period ($000):

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL LIGHTING - EXIT SIGNS.
Program Start Date: May 2011
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,277	0	0.0%	2	2	0.0%	2
2016	Program was retired on November 3, 2015.							
2017								
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.00	0.00	0.00	0.00
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	0	0	0	0

Utility Cost per Installation ($):
Total Program Cost of the Utility ($000):
Net Benefits of Measures Installed During Reporting Period ($000):

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL HVAC RE-COMMISSIONING
Program Start Date: November 2011
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,277	0	0.0%	250	250	0.3%	250
2016	Program was retired on November 3, 2015.							
2017								
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.00	0.00	0.00	0.00
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	0	0	0	0

Utility Cost per Installation ($):
Total Program Cost of the Utility ($000):
Net Benefits of Measures Installed During Reporting Period ($000):

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL ENERGY RECOVERY VENTILATION
Program Start Date: May 2011
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,277	0	0.0%	0	0	0.0%	0
2016			Program was retired on November 3, 2015.					
2017								
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation @ Meter	Per Installation @ Generator	Program Total @ Meter	Program Total @ Generator
Summer kW Reduction	0.00	0.00	0.00	0.00
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	0	0	0	0

Utility Cost per Installation ($):
Total Program Cost of the Utility ($000):
Net Benefits of Measures Installed During Reporting Period ($000):

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: COMMERCIAL ROOF INSULATION
Program Start Date: May 2011
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,277	0	0.0%	2	2	0.0%	2
2016	Program was retired on November 3, 2015.							
2017								
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation @ Meter	Per Installation @ Generator	Program Total @ Meter	Program Total @ Generator
Summer kW Reduction	0.00	0.00	0.00	0.00
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	0	0	0	0

Utility Cost per Installation ($):
Total Program Cost of the Utility ($000):
Net Benefits of Measures Installed During Reporting Period ($000):

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: RESIDENTIAL PV
Program Start Date: April 2011
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	628,392	628,392	60	0.0%	53	53	0.0%	(7)
2016				Program was retired on December 31, 2015.				
2017								
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.00	0.00	0.00	0.00
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	0	0	0	0

Utility Cost per Installation ($):
Total Program Cost of the Utility ($000):
Net Benefits of Measures Installed During Reporting Period ($000):

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: RENEWABLE - SOLAR WATER HEATING
Program Start Date: April 2011
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	628,392	628,392	15	0.0%	54	54	0.0%	39
2016	Program was retired on December 31, 2015.							
2017								
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.00	0.00	0.00	0.00
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	0	0	0	0

Utility Cost per Installation ($):
Total Program Cost of the Utility ($000):
Net Benefits of Measures Installed During Reporting Period ($000):

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: RENEWABLE - LOW-INCOME WATER HEATING
Program Start Date: April 2011
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	628,392	125,678	5	0.0%	0	0	0.0%	(5)
2016	Program was retired on December 31, 2015.							
2017								
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.00	0.00	0.00	0.00
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	0	0	0	0

Utility Cost per Installation ($):
Total Program Cost of the Utility ($000):
Net Benefits of Measures Installed During Reporting Period ($000):

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: Commercial PV
Program Start Date: April 2011
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	80,277	80,277	5	0.0%	1	1	0.0%	(4)
2016	Program was retired on December 31, 2015.							
2017								
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.00	0.00	0.00	0.00
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	0	0	0	0

Utility Cost per Installation ($):
Total Program Cost of the Utility ($000):
Net Benefits of Measures Installed During Reporting Period ($000):

Demand Side Management Annual Report

Utility: Tampa Electric Company
Program Name: RENEWABLE - PV FOR SCHOOLS
Program Start Date: April 2011
Reporting Period: Annual 2017

a	b	c	d	e	f	g	h	i
Year	Total Number of Customers	Total Number of Eligible Customers	Projected Cumulative Number of Program Participants	Projected Cumulative Penetration Level % [(d/c)x100]	Actual Annual Number of Program Participants	Actual Cumulative Number of Program Participants	Actual Cumulative Penetration Level % [(g/c)x100]	Actual Participation Over (Under) Projected Participants (g-d)
2015	79,457	301	1	0.3%	1	1	0.3%	0
2016	Program was retired on December 31, 2015.							
2017								
2018								
2019								
2020								
2021								
2022								
2023								
2024								

Annual Demand and Energy Savings - 2017

Participants 0

	Per Installation		Program Total	
	@ Meter	@ Generator	@ Meter	@ Generator
Summer kW Reduction	0.00	0.00	0.00	0.00
Winter kW Reduction	0.00	0.00	0.00	0.00
Annual kWh Reduction	0	0	0	0

Utility Cost per Installation ($):
Total Program Cost of the Utility ($000):
Net Benefits of Measures Installed During Reporting Period ($000):

Comparison of Annual Achieved kW and kWh Reductions
with Public Service Commission Established Goals
Savings at the Generator

Utility: TAMPA ELECTRIC COMPANY

Residential

Year	Winter Peak MW Reduction Total Achieved	Winter Commission Approved Goal	Winter % Variance	Summer Peak MW Reduction Total Achieved	Summer Commission Approved Goal	Summer % Variance	GWh Energy Reduction Total Achieved	GWh Commission Approved Goal	GWh % Variance
2015	12.3	2.6	473.1%	10.8	1.1	981.8%	21.2	1.8	1177.8%
2016	7.7	4.1	187.8%	5.1	1.6	318.8%	13.2	3.5	377.1%
2017	6.9	5.2	132.0%	4.7	2.2	212.0%	14.9	4.8	310.9%
2018									
2019									
2020									
2021									
2022									
2023									
2024									

Commercial/Industrial

Year	Winter Peak MW Reduction Total Achieved	Winter Commission Approved Goal	Winter % Variance	Summer Peak MW Reduction Total Achieved	Summer Commission Approved Goal	Summer % Variance	GWh Energy Reduction Total Achieved	GWh Commission Approved Goal	GWh % Variance
2015	8.1	1.2	675.0%	11.7	1.7	688.2%	12.5	3.9	320.5%
2016	2.9	1.3	223.1%	4.4	2.5	176.0%	17.8	6.0	296.7%
2017	9.2	1.6	578.1%	10.4	2.7	385.5%	30.2	8.0	377.9%
2018									
2019									
2020									
2021									
2022									
2023									
2024									

Combined

Year	Winter Peak MW Reduction Total Achieved	Winter Commission Approved Goal	Winter % Variance	Summer Peak MW Reduction Total Achieved	Summer Commission Approved Goal	Summer % Variance	GWh Energy Reduction Total Achieved	GWh Commission Approved Goal	GWh % Variance
2015	20.4	3.8	536.8%	22.5	2.8	803.6%	33.7	5.7	591.2%
2016	10.6	5.4	196.3%	9.5	4.1	231.7%	31.0	9.5	326.3%
2017	16.1	6.8	237.0%	15.1	4.9	307.6%	45.2	12.8	352.8%
2018									
2019									
2020									
2021									
2022									
2023									
2024									

Comparison of Cumulative Achieved kW and kWh Reductions
with Public Service Commission Established Goals
Savings at the Generator

Utility: TAMPA ELECTRIC COMPANY

Residential

	Winter Peak MW Reduction			Summer Peak MW Reduction			GWh Energy Reduction		
Year	Total Achieved	Commission Approved Goal	% Variance	Total Achieved	Commission Approved Goal	% Variance	Total Achieved	Commission Approved Goal	% Variance
2015	12.3	2.6	473.1%	10.8	1.1	981.8%	21.2	1.8	1177.8%
2016	20.0	6.7	298.5%	15.9	2.7	588.9%	34.4	5.3	649.1%
2017	26.9	11.9	225.8%	20.6	4.9	419.7%	49.3	10.1	488.3%
2018									
2019									
2020									
2021									
2022									
2023									
2024									

Commercial/Industrial

	Winter Peak MW Reduction			Summer Peak MW Reduction			GWh Energy Reduction		
Year	Total Achieved	Commission Approved Goal	% Variance	Total Achieved	Commission Approved Goal	% Variance	Total Achieved	Commission Approved Goal	% Variance
2015	8.1	1.2	675.0%	11.7	1.7	688.2%	12.5	3.9	320.5%
2016	11.0	2.5	440.0%	16.1	4.2	383.3%	30.3	9.9	306.1%
2017	20.2	4.1	493.9%	26.5	6.9	384.2%	60.5	17.9	338.2%
2018									
2019									
2020									
2021									
2022									
2023									
2024									

Combined

	Winter Peak MW Reduction			Summer Peak MW Reduction			GWh Energy Reduction		
Year	Total Achieved	Commission Approved Goal	% Variance	Total Achieved	Commission Approved Goal	% Variance	Total Achieved	Commission Approved Goal	% Variance
2015	20.4	3.8	536.8%	22.5	2.8	803.6%	33.7	5.7	591.2%
2016	31.0	9.2	337.0%	32.0	6.9	463.8%	64.7	15.2	425.7%
2017	47.1	16.0	294.5%	47.1	11.8	398.9%	109.9	28.0	392.3%
2018									
2019									
2020									
2021									
2022									
2023									
2024									

TAMPA ELECTRIC-SUMMARY OF 2017
DEMAND SIDE MANAGEMENT PROGRAM ACCOMPLISHMENTS

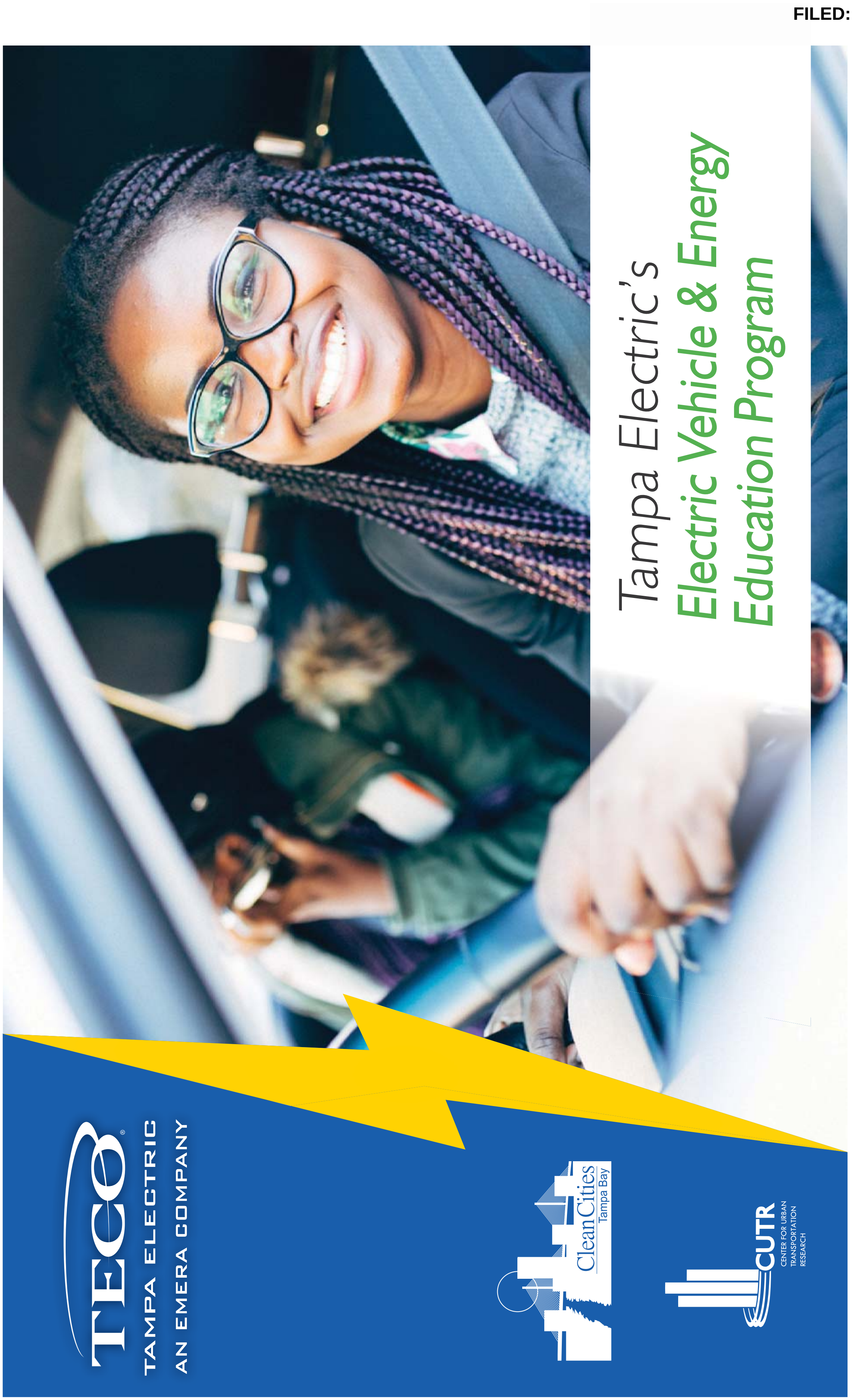
Appendix A

DSM Energy Education and Awareness Activities of 2017

Tampa Electric Company participated in over 71 designated energy education and awareness events across the company's service area in 2017. These events do not include the daily interactions of energy education that Tampa Electric Team Members have with customers through email or phone calls, one-on-one discussions nor with customers that are participating in one of Tampa Electric's Commission approved DSM programs. These events cover educating all ages, income classes and rate classes of customers on energy education and awareness. Several highlighted events include:

- USF Engineering Expo (USF College)
- Farm Night BBQ
- 70th Annual Fiesta Day
- Winter Haven Community Fest Family Fun Festival
- Ruby Lake HOA
- Manatee Festival of the Arts
- Lifestyles after 50
- Go Green Night at Amalie Arena
- 21st Annual Downtown Development Forum
- ISES Solar Energy Fair
- Bark in the Park
- Valencia Lakes Community Resources Expo
- Sun City Center 2017 Spring Trade Show
- The Greater Temple Terrace Chamber of Commerce Business Expo
- HCC 2017 Sustainability Expo
- Festa Italiana
- Kids Rock Science – Stem Fair at MOSI
- Met Life
- Exo Fest
- Nova Southeastern University Tampa Campus
- EPC's Clean Air Fair
- 7 Rivers Water Festival
- Port Area Safety Fun Fest
- Science Night at Lawton Chiles
- 14TH Annual Neighborhoods Conference
- Port Tampa Community Center Summer Camp
- Back 2 School Fair at Ruskin
- Back 2 School Fair at Plant City
- 2017 5th Annual Kids Day – Beasley
- Back 2 School Fair at East Tampa (Middleton High School)

- Back 2 School Fair at North Tampa (Shaw Elementary School)
- Lifestyles After 50 Fun Fest
- Back 2 School Fair at West Tampa
- Pleasant Grove Senior's Group
- Homeruns and History
- 3rd Annual Tampa Bay Kids Fest
- Temple Terrace National Night Out
- Tampa Night Out
- Health Fest
- The Clubhouse at Ballentrae
- Florida Birding and Nature Festival
- Scarecrow Festival
- Temple Terrace Fire Dept. Annual Open House
- Stride for Strays
- Health Fair – Community Picnic
- Met Life
- Easterseals- Walk with me
- 2017 Ruskin Seafood Festival
- City of Auburndale Fire Dept.
- Fisherman's Cove
- Channelside Academy of Math and Science
- Employee Health Fair - **
- Great American Teach-in
- The Greater Mulberry Chamber of Commerce
- County Aire Mana
- Trot Thru The Terrace
- Tiny Home Show
- 44th Annual Temple Terrace Arts & Crafts Festival
- Sustany Foundation – Catch the Buzz
- Pig Jam
- 2017 Fall Business Expo
- EPCAR Housing Fair
- 5th Annual Winter Fall


Tampa Electric's
Electric Vehicle & Energy
Education Program
TECO
TAMPA ELECTRIC
AN EMERA COMPANY
Clean Cities
Tampa Bay
CUTR
CENTER FOR URBAN
TRANSPORTATION
RESEARCH

Welcome to Tampa Electric's Electric Vehicle and Energy Education Program that introduces students to the

Plug-in Electric Vehicle Student Readiness Guide

Tampa Electric is proud to be the first electric utility in the country to partner with the University of South Florida, the Center for Urban Transportation Research and local high schools to offer the Electric Vehicle and Energy Education Program, an innovative energy-education program focused on teaching students about electric vehicle (EV) technology.

This Readiness Guide provides students with information about the various types of EVs on the market, public and private charging options and how to maximize EV mileage with each charge by driving efficiently. In addition, students will learn how saving energy can benefit everyone by deferring or eliminating the need to build costly power plants to satisfy a growing demand for electricity.

Tampa Electric's Electric Vehicle and Energy Education Program was approved by the Florida Public Service Commission (FPSC) in May 2017. For over the past three decades, the FPSC has encouraged utilities to promote cost-effective conservation and the use of renewable energy to reduce the use of fossil fuels and defer the need for new power plant construction. The end goal is to ensure utilities utilize a balanced mix of energy resources that enable them to produce reliable and cost-efficient electricity to meet the needs of all consumers.

The FPSC recognizes that consumer choice plays an important role in reducing the growth rates of electrical demand and energy in Florida. Consumers support electric energy conservation through a variety of actions in addition to energy education of EVs, such as constructing smaller, more efficient homes, buying energy-efficient appliances, installing energy-efficiency upgrades to existing homes and installing renewable energy generating systems.

Tampa Electric expects the focus on conservation and renewable energy to continue playing an important role in Florida's energy future.

CONTENTS

1. Introduction

More EVs are being added to the roadways every day.

New student drivers need to be familiar with recognizing and understanding the basics of these vehicles. This guidebook provides an introduction to these vehicles as well as an in-depth overview of the energy efficiency benefits of driving electric vehicles.

The guidebook is designed to introduce new student drivers to the basics of electric vehicle technologies, including the vehicles, charging equipment, and important considerations for EV driving and ownership. Provided in the instructor's manual are best practices and planning methods for EV owners.

At the end of this course, students will understand the basic components of EVs, the different types of charging equipment, ways to conceptualize the efficiency of EVs, and guidelines for operating and maintaining EVs to maximize energy efficiency benefits.

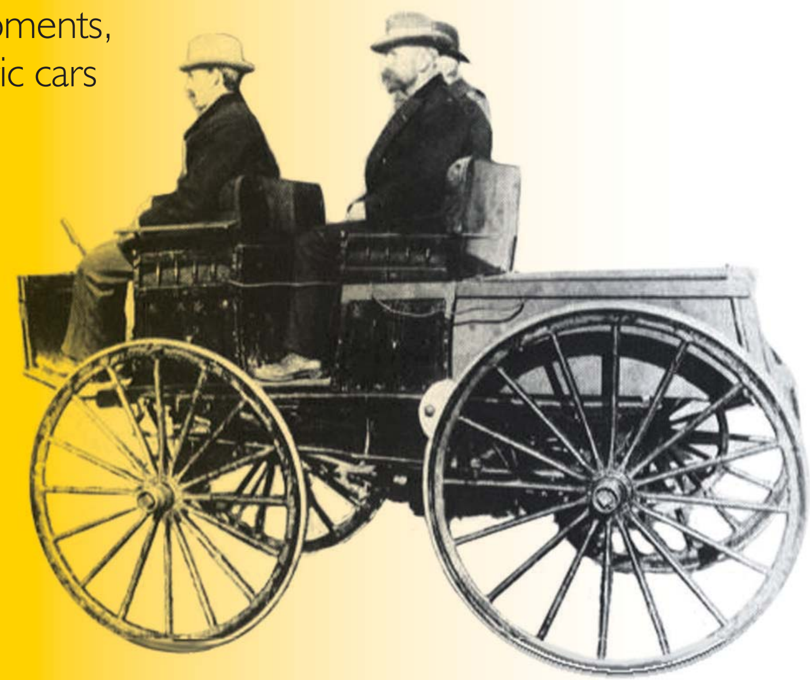
The History of the Electric Car

More than 100 years ago, EVs dominated the roads!

During the 1900s, a series of technological developments, from the battery to the motor, led to the first electric cars appearing on the roads.

The first successful EV was introduced in the United States by chemist William Morrison in 1890-91, who designed and engineered a six-passenger vehicle capable of traveling at 14 miles per hour. Battery technology and storage capability continued to develop and improve after Morrison's debut.

By the turn of the 20th century, EVs achieved mass-market appeal, comprising about a third of all passenger cars on the road.



Iowa chemist William Morrison builds the first successful American EV.

Around the same time period, a new type of vehicle was introduced to the market that used liquid fuel, such as gasoline or diesel, to power an internal combustion engine (ICE). Unlike EVs, these liquid fuel-powered vehicles were noisy, emitted exhaust and required the driver to manually change gears.

Compared to the new gasoline-powered cars, EVs were quiet, emission-free and easy to drive. Owning and recharging EVs also became easier as households gained better access to electricity.

*Early electric vehicle –
1922 Detroit Electric Automobile*

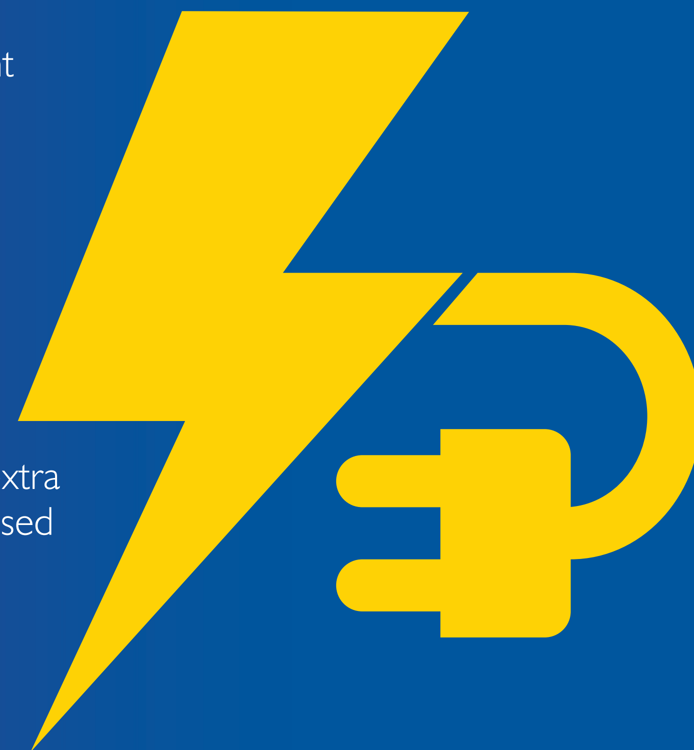
Technology 101

On the surface, electric cars today look like gasoline-powered cars, but instead of powering an internal combustion engine with gasoline or diesel to move the vehicle, EVs run on electricity stored in a battery system that powers the vehicles through electric motors.

There are different types of EVs, ranging from those that supplement an internal combustion engine with an electric motor to models that run on pure electricity.

Plug-in Hybrid Electric Vehicles (PHEVs)

What makes a plug-in hybrid electric vehicle (PHEV) different from a regular hybrid is the capability to charge the vehicle from an electric power source. PHEVs have an internal combustion engine, which runs on fuel, and an electric motor, which is charged by plugging the vehicle into an electric power source. Plug-in hybrids can be charged with a charging station or a regular wall outlet, by the internal combustion engine, or by regenerative braking, which allows the vehicle to recapture some of the car's kinetic energy and use it to recharge the battery. The extra energy is stored in the vehicle's battery system and can be used to provide additional power during starts and acceleration. PHEVs use electricity as the main source of power until the battery is completely depleted, then the vehicle switches over to running solely on the combustion engine.



Since PHEVs typically have larger batteries than regular hybrids, they can travel on pure electricity for a limited range (today's models average 10 to 40 miles).

By supplementing with electricity, PHEVs help to reduce harmful tailpipe emissions and petroleum consumption, which makes PHEVs a more environmentally friendly and energy-efficient choice over conventional fueled combustion vehicles.

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All-Electric Vehicles (EVs)

All-electric vehicles – sometimes called battery-electric vehicles – operate on pure electricity and do not contain an internal combustion engine. Instead, EVs have one or more electric motors that are powered by energy stored in the vehicle's battery.

The battery pack is charged by plugging the vehicle into an outlet connected to an electric power source. Since EVs have no internal combustion engine, they do not emit any tailpipe emissions and are sometimes referred to as zero-emission vehicles.

An EVs range varies (some of today's versions average between 100 and 250 miles), depending on the vehicle model, the way the vehicle is driven and the driving conditions.

Plug-in hybrid and all-EVs come in a variety of different models: low-speed utility vehicles, compact cars, sedans, trucks, transit buses and even high-performance sports cars.

Driving Behavior to Maximize EV Range and Efficiency

The distance (in miles) that an EV can drive on a full battery charge, referred to as EV range, is listed on the EPA fuel economy label of the car. For the vehicle range test, EVs are tested on city and highway driving conditions, assuming that the typical EV will have the battery charged only to 90 percent. Just like with regular liquid-fueled combustion vehicles, the range of an EV can vary significantly based on how the vehicle is driven.

EV range can decrease by 15% to 20% just by increasing the speed from 60 to 70 miles per hour!

The speed at which the vehicle is driven is an important factor that affects the range of the vehicle. Vehicle drag, or wind resistance, is proportional to the square of velocity and impacts a vehicle's efficiency. Even a slight increase in speed results in a significant increase in drag, especially at higher speeds. A vehicle needs more energy to overcome added wind resistance at higher speeds. As a result, fast driving will increase energy consumption and reduce vehicle range. The energy efficiency of an EV usually decreases rapidly at speeds above 50 miles per hour. For example, the range of an EV can decrease by 15% to 20% just by increasing the speed from 60 to 70 miles per hour. So avoiding unnecessarily high speed can help extend the range of an EV.

Fast acceleration also increases energy consumption.

It takes much more momentum and energy to accelerate the car faster than it does to accelerate gradually. Therefore, fast acceleration increases vehicle energy consumption and reduces range for both gasoline and electric cars. The use of cruise control to maintain a constant speed on the highway in most cases will also reduce energy consumption of the vehicle. Accelerating gradually and maintaining steady speed while driving will increase the range of an EV.

All EVs are equipped with regenerative braking systems.

When the brake pedal is pressed on an EV, a regenerative braking circuit switches the electric motor to operate in reverse of the direction of the wheels, thus performing in the same manner as a power generator producing electric energy. The energy is used to recharge the vehicle battery and extend vehicle range.

Keeping a vehicle well-maintained can improve the service life of the vehicle & can extend vehicle range!

In addition to regenerative brakes, all EVs have regular friction brakes as backup. When the driver brakes hard, the regenerative braking is not able to stop the car fast enough, so the friction brakes are applied as well. Friction brakes waste all the energy they produce in slowing the vehicle in the form of heat. Therefore, braking hard in an EV reduces the efficiency of the regenerative braking system and reduces potential vehicle range. To maximize the efficiency of the regenerative braking system and extend the range of the car, drivers should coast to a stop as much as possible instead of braking hard.

Keeping a vehicle well-maintained is a smart approach to improve the service life of the vehicle, but can also extend vehicle range. For example, under-inflated tires add to rolling resistance, requiring more energy to be spent on moving the vehicle and reducing fuel efficiency and vehicle range. Additionally, electric cars with a thermal management system may use coolant to cool the battery. A low coolant level may result in the battery operating at a temperature higher than is required for optimal battery performance. Simply maintaining proper tire inflation and checking fluid levels can extend vehicle range by a few miles each charge.

Heating and air conditioning (A/C) systems require a lot of energy, which can affect the range of the vehicle.

Unlike a regular gasoline vehicle, where only air conditioning affects fuel efficiency while heat comes "free", heating in an EV drains the battery and reduces vehicle range the same way as the A/C. Wise use of climate control and other vehicle accessories that run on electricity (such as the entertainment system) can improve vehicle efficiency and extend vehicle range. For example, to extend the range of the vehicle, EV drivers should avoid driving in extreme weather conditions (if possible), pre-condition or pre-heat the vehicle cabin before taking a trip while the vehicle is still plugged in (this can be done by programming the vehicle or through a smart-phone app), and use seat warmers instead of the cabin heater (which heats the passengers more efficiently).

Modern vehicles allow the driver to switch between several driving modes that control vehicle dynamics and comfort features. One driving mode may maximize vehicle performance – at the expense of fuel consumption – while others can emphasize ride comfort, fuel economy, or other priorities, at the expense of performance. The driver can select the desired driving mode from the vehicle settings menu or sometimes with the press of a button.

Most EVs come with an economy mode or similar feature that allows the driver to maximize fuel economy and extend vehicle range. Under this mode, the vehicle limits acceleration rate, tones down gas pedal response, and may limit other performance features of the car to save energy. Economy mode may also alter A/C and heater functions to optimize fuel consumption. If extending vehicle range is the goal, EV drivers should consider using the economy mode as often as possible.

Range Anxiety:

[reynj], [ang-zahy-i-tee]

plural: **anxieties** *noun*

1. Range anxiety is the fear of not having enough battery charge to reach a destination.

While gasoline vehicles also have a limited range, range anxiety is used primarily in reference to EVs.

Range anxiety is often cited as one of the major obstacles to EV adoption. While EVs do have lower range, require longer recharging time and include more unease about availability of charging infrastructure than gasoline vehicles, many studies suggest that the anxiety over EV range is over-exaggerated. Most of the personal daily trips in the U.S. can be accomplished by the currently available EVs on a single battery charge, without a need to recharge the vehicles during the day. According to the National Household Travel Survey, an average driver in the U.S. drives 29 vehicle-miles per day. Most EVs on the market today have a range well above that number.

Range anxiety will become less of an issue as charging infrastructure expands and battery technology improves to extend the range of battery-electric cars.

EV drivers can use the following tips to reduce the fear of running out of charge –

Trip planning: Fully charge the EV before a trip; plan the route minding trip distance, required stops, and the availability and location of charging infrastructure along the route, if needed.

Learn to interpret state of charge information provided by the car: All electric cars display dynamic information on the battery state of charge in the form of an estimated range of the vehicle under the current driving conditions. This information coupled with route familiarity can provide adequate confidence to the driver about the vehicle's capabilities.

Use strategies to maximize vehicle range: Use accessories wisely (A/C, heating, entertainment system, etc.); avoid driving in extreme weather conditions if possible; use economy mode; avoid fast acceleration and hard braking; do not drive unnecessarily fast; avoid hauling cargo on the roof; remove excess weight; and other strategies discussed earlier.

One key point to keep in mind about the built-in EV range display is that the displayed range represents an estimate.

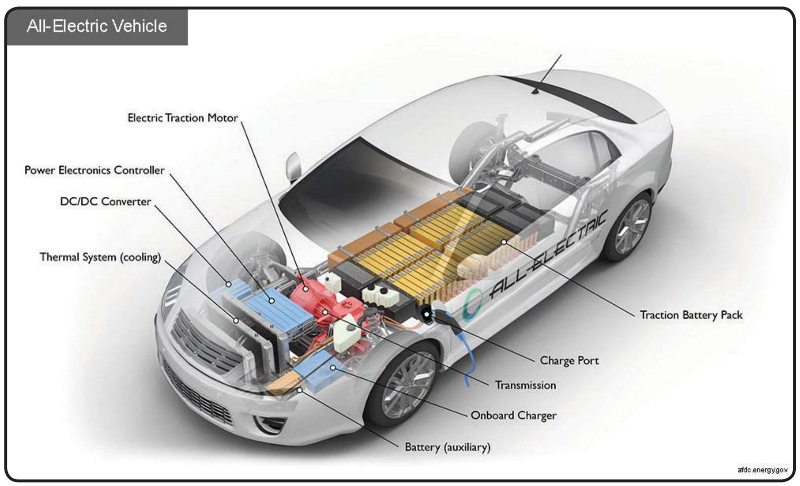
This estimate is calculated based on a number of factors including battery capacity, climate conditions, terrain, vehicle dynamics and driving style. The estimate may lead to an inaccurate prediction, especially if any of the above parameters change.

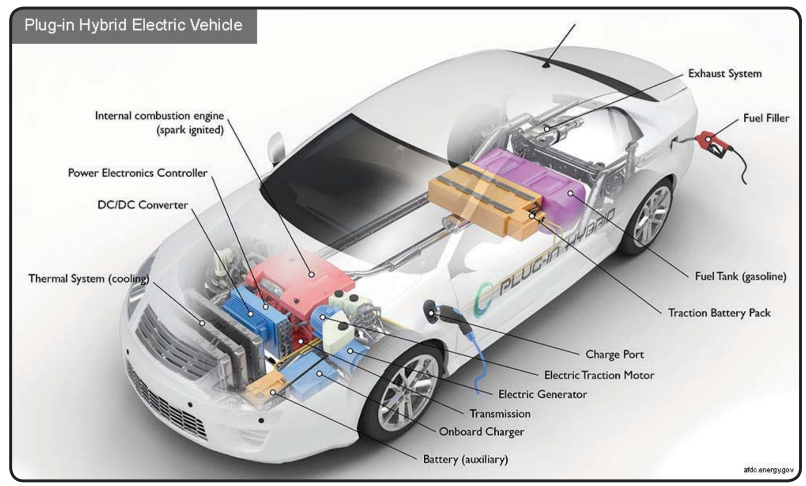
For example, the remaining range of 40 miles on a level road may not be enough to reach a destination 20 miles away that is on the top of a steep hill. However, there is no reason to lose confidence in the vehicle range estimator simply because of this "mistake" in range prediction. Knowing how dynamic vehicle range is estimated and learning to interpret the information provided by the vehicle is essential to getting the most out of the EV charge.

IV. Operating Electric Vehicles

Vehicle Drive Components: EV vs. Internal Combustion Engines

EVs and regular liquid fuel-powered combustion vehicles differ significantly in the number of moving parts. An electric motor has only one moving part, the shaft, rotated by an electric magnet and requiring little or no maintenance. An internal combustion engine, on the other hand, has hundreds of moving parts including pistons, valves, a crankshaft, fan belts, a timing belt, an oil pump, a fuel pump, fuel injectors, a cooling pump, a thermostat and other parts. None of those parts are necessary in an EV. However, the components of plug-in vehicles (the electric system including battery, motor, and electronics) will require some maintenance, which is discussed in detail below.



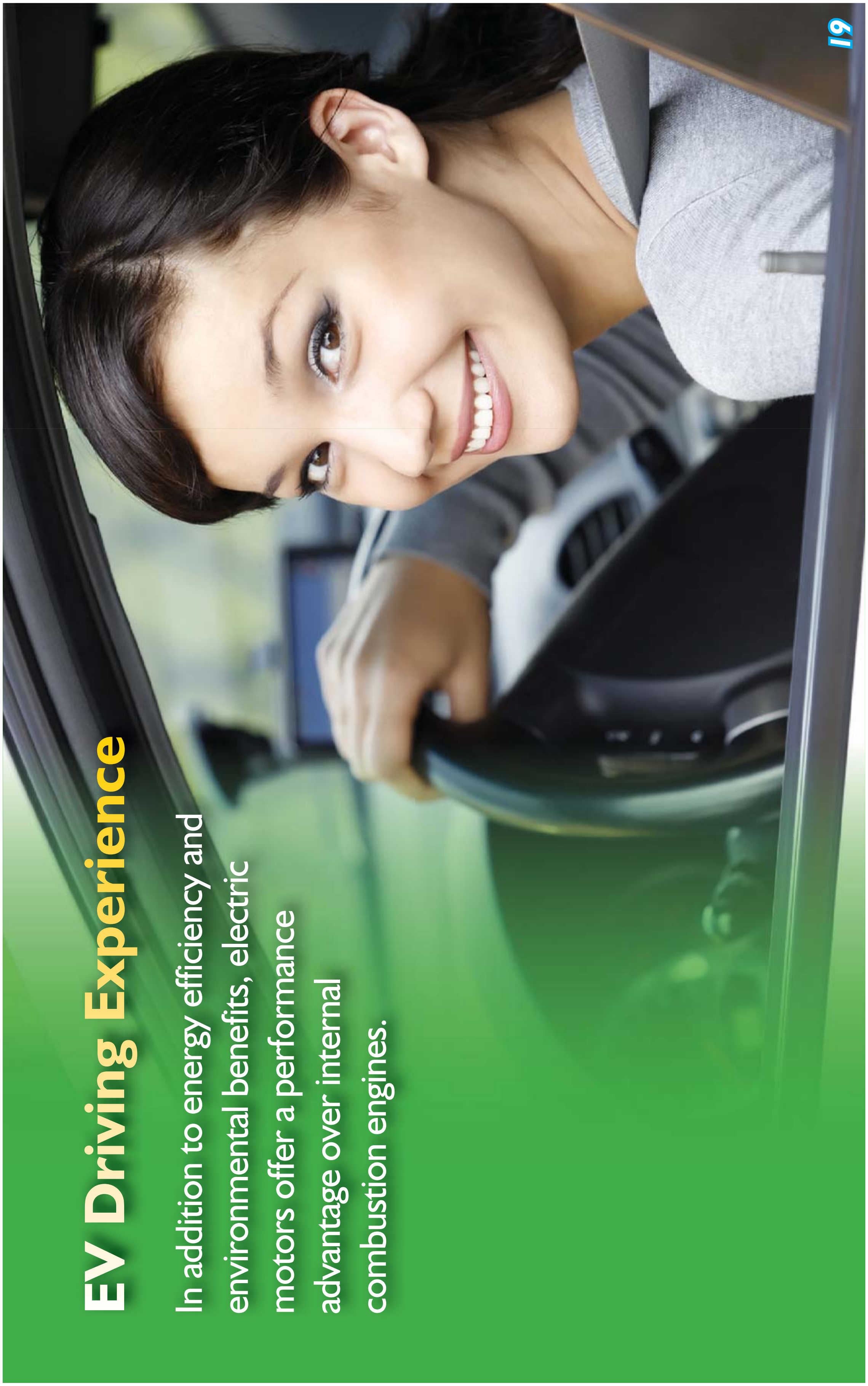


Regular liquid fuel–powered combustion vehicles use multi-speed transmissions since internal combustion engines generate usable torque and power in a rather narrow spectrum of engine speed. Therefore, a multi-speed transmission with varying gear ratios is required to keep the engine in its optimal power band. Electric motors, on the other hand, generate maximum torque at relatively low speeds and have a much wider band of usable power. As a result, EVs often have no gearboxes but use a single lowering gear ratio. This does not mean that electric cars cannot have multiple gears; they are simply not necessary.

Because of this, much simpler drive-train design and fewer moving parts, EVs typically require less maintenance than vehicles with internal combustion engines. Since electric cars use regenerative braking, the brakes last much longer and require less maintenance on EVs than on regular gasoline vehicles.

Overall, EVs are simpler, have fewer moving parts, are more energy-efficient, and are typically lower in maintenance.

Battery maintenance in electric cars may vary based on the specific cell chemistry and design. Some vehicle manufacturers use liquid cooling systems to maintain an optimal operating temperature for the batteries. These cooling systems may require regular scheduled maintenance. The batteries used in EVs have a limited number of charging cycles, after which battery performance and capacity degrades significantly, however batteries are generally designed to last the expected life of the vehicle. Several manufacturers offer battery warranties up to 100,000 miles. If the battery needs to be replaced outside of warranty, it will likely be a significant expense.


EV Driving Experience
In addition to energy efficiency and environmental benefits, electric motors offer a performance advantage over internal combustion engines.
19

Internal combustion engines have a lag in reaching maximum engine rotation.

When an accelerator in a gas-powered vehicle is pressed (even when it is floored), the engine speed slowly rises to its maximum torque threshold before it can deliver maximum performance and speed up the car. Electric motors, on the other hand, deliver maximum torque at low speed and provide no delay in torque delivery. Due to this low-end torque and no lag in throttle response, EVs accelerate very quickly.

Since EVs do not typically use multi-speed gearboxes, they provide a much more efficient torque delivery (i.e., with less torque loss) from the motor to the wheels. Some current electric drive systems use several motors (two to four) that are attached directly to the wheels. This design allows the elimination of drive shafts and differentials, as well as minimizes the mechanical losses between the motor and the wheels.

Electric motors also operate much quieter than their ICE counterparts.

The noise produced by a moving vehicle is a combination of engine, tire and wind passage noise. While EVs practically eliminate engine noise, they still produce tire and wind noise, especially at moderate and high speeds. However, at low speed, EVs can be extremely quiet.

EV Safety

EVs are so quiet that in 2016 the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) required all newly produced light-duty and hybrid EVs to make audible noise when traveling forward or in reverse, at speeds up to 19 miles per hour. This law is meant to improve pedestrian safety due to the increased risk of pedestrians failing to hear an approaching EV due to its low noise level.

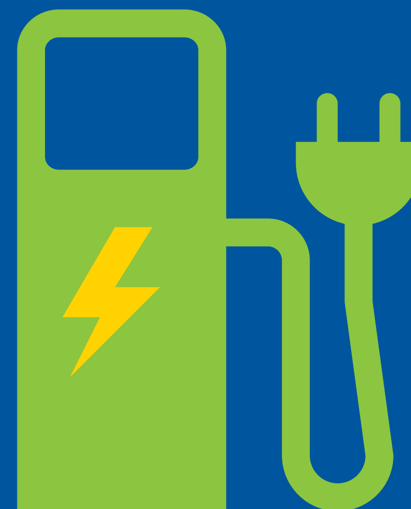
With regards to other safety considerations, plug-in vehicles have to follow all the same safety standards as conventional vehicles. In addition to those standards, manufacturers are required to comply with requirements unique to plug-in cars, such as measures to reduce chemical leaks, protecting battery packs in the event of an accident and separating the chassis – the vehicle's frame – from the electric system to prevent the transfer of electric energy to the passenger or outside through touching the body of the vehicle. In the event of an accident involving a PHEV, the vehicles are manufactured with features that automatically shut down the high-voltage electric system to ensure the safety of the passengers and emergency first responders.

V. Electric Vehicle Charging

Types of Charging Stations

EVSE comes in three different levels of charging:

- **Level 1**
- **Level 2**
- **Direct Current (DC) Fast Charger**

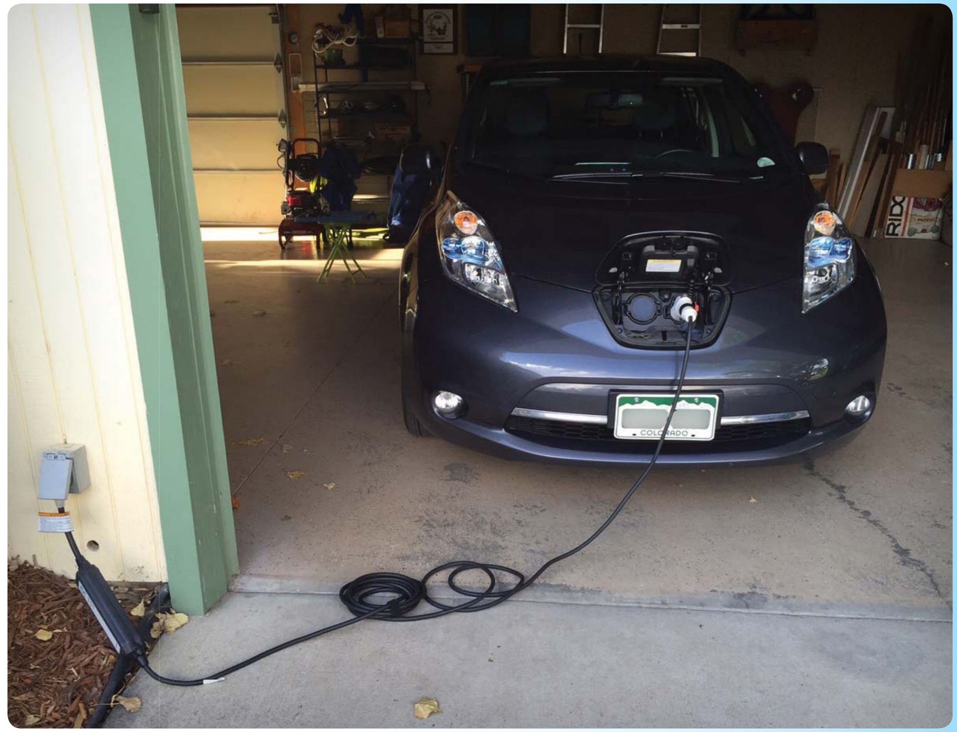


The different charging levels are determined by the rate of charging, or the time it takes to charge the vehicle's battery. Charging times depend on a few factors, including the size of the battery, the type of battery and level of charge.

Level 1 and 2 charging provide alternating current electricity to the vehicle, and the vehicle's on board charger converts that alternating current to DC, which is used to charge the battery system. DC fast charging uses an inverter to first convert alternating current electricity from the utility to direct current that is then sent directly to the vehicle's battery.

Level I Charging

Level I EVSE use a 120-volt (V) AC plug, and most EVs will come standard with a Level I cord set. A standard three-prong household plug (a NEMA 5-15 connector) is on the end of the cord, which is plugged into the outlet. On the other side of the cord is a J1772 standard connector, which is used to plug into the EV. This lower level of charging can be done from an ordinary household outlet, or comparable outlet at a business or even a motel.



Level I charging offers the slowest charging rates, and is best suited for overnight charging. While different factors affect the rate of charging (including battery type and vehicle), Level I adds about 2 to 5 miles of range to a plug-in EV per hour of charging time.

Level 2 Charging

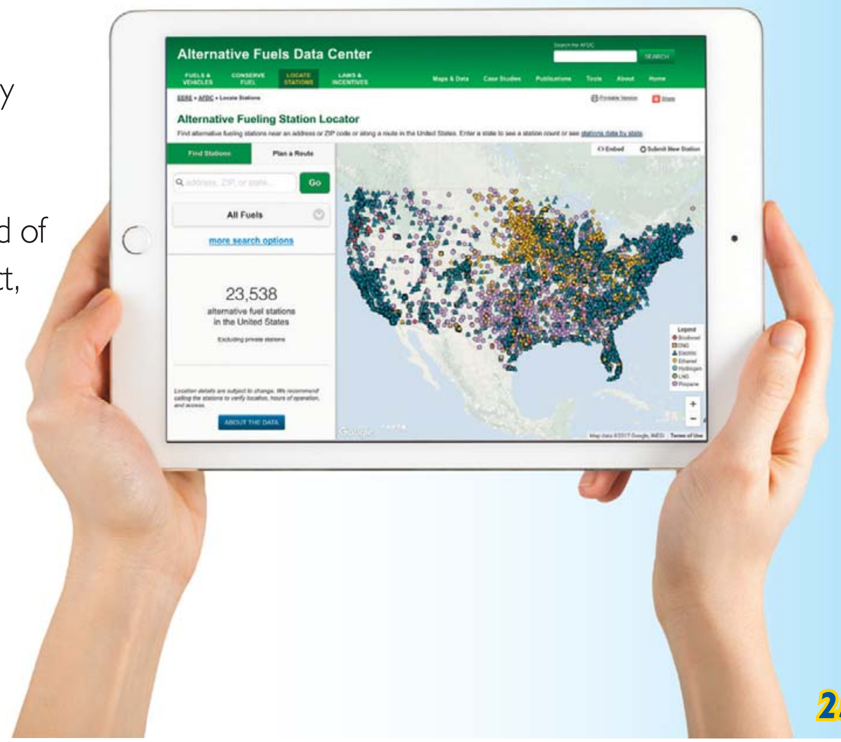
On the vehicle, there is no difference between the Level 2 and Level 1 charging equipment connector. However, Level 2 charging equipment uses 240 volts or 208 volts, which requires a different outlet than an ordinary household outlet. Depending on the type of battery, charger structure, and circuit capacity, Level 2 charging inputs between 10 to 20 miles of range to a plug-in EV per hour of charging time.

Level 2 charging is ideal for home, workplace, or public charging, and on average can fully charge a depleted battery overnight.

DC Fast Charging

Direct current fast charging (DCFC) equipment, which charges through either a 208- or 480-volt input, allows for vehicles to charge at a much faster rate than Level 1 or 2 charging. Many all-EV models are equipped with the capability to charge with DC fast charging, which makes it easy to add significant range to an EV in a short amount of time. Because DCFC allows for rapid charging, DCFC stations are typically found in areas with heavy traffic to allow EVs to travel longer distances.

With fast charging, the speed of charging is very different when charging an empty battery versus a full battery. When the battery is almost depleted, electricity can flow quickly and recharge the battery at a much faster rate. As the battery fills up, the rate of charging decreases. Charging the battery to around 80% instead of a full charge preserves the life and efficiency of the battery. In fact, some DC fast charging stations automatically stop the charging process when the battery reaches that level.



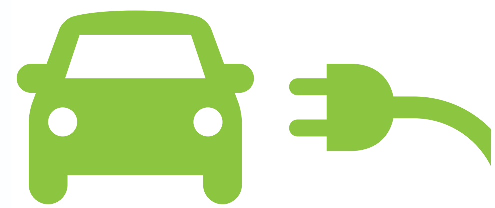
Thousands of public EV charging stations are available all around the United States. To locate public access charging stations, drivers can download the Alternative Fuel Data Center (AFDC) Station Locator mobile application. The AFDC Station Locator can also be accessed online at **https://www.afdc.energy.gov/locator/stations**.

Charging Costs: *Charging an EV at Home*

Many EV drivers will be able to complete their daily trips by charging their vehicle at home overnight, using either Level 1 or Level 2 charging.

The cost of charging an EV depends on the size of the vehicle battery, while the cost per 100 miles is determined by the energy efficiency of a particular model. However, with an average energy efficiency of 30 kilowatt-hour (kWh)/100 miles for current EVs on the market, and an average residential electricity cost of 10 cents per kWh, it will cost an EV owner, on average, around $3.00 to put 100 miles-worth of charge in an EV charged at home. To compare, if a combustion vehicle fueled with gasoline has a fuel efficiency of 20 MPG, and gasoline is priced at $2.50 per gallon, it will cost the owner of that vehicle, on average, $12.50 to go 100 miles.

It costs an EV owner, on average, around $3.00 to put 100 miles worth of charge at home.



The electric rate applied to home charging the vehicle is the same rate for each kWh used for all the other electric uses in the home (e.g., lighting, cooking, water heating, air conditioning, TV, cell-phone charging). Many electric utilities offer programs with rates that vary throughout the day. Some energy-savvy customers have already figured out that controlling or altering the time when they use energy results in significant savings, even when they do not own an EV. They lower their overall electric bill by taking advantage of time-of-use rates or ***dynamic pricing rates***, which mimic the real-time price of power. These customers maximize their savings by making simple adjustments to use more energy during off-peak hours and in exchange for this, the electric utility provides lower rates for using electricity during these times.

Charging Etiquette

While charging infrastructure continues to expand across the U.S., there are still plenty of areas lacking enough public charging stations to accommodate EV growth. Lack of infrastructure, combined with the longer time to fuel EVs compared to gasoline-powered vehicles, makes it necessary to establish best practices for fair sharing of EV charging infrastructure. The following informal rules of charging etiquette were developed by the EV community in order to ensure fair and considerate use of charging resources.

1. Safety first

Practice safe charging. Tuck the cord under the car while charging to avoid creating a tripping hazard and always return the connector back to its holster after unplugging the car. Avoid overstretching the cord and/or driving over it.

2. Leave charging site as clean (or better than) when you arrived

Do not leave trash at the charging site. Be courteous to other users. Consider wiping down the charging station after use with a clean cloth or paper towel.

3. EV spots are for EVs

EV charging spots are designated exclusively for EV use (EVs or plug-in hybrids). Regular vehicles with internal combustion engines are not allowed in EV spots, regardless of how frequently the EV spots are used.

4. Charge only when necessary

Do not charge if you do not need a charge. Leave the spot available for an EV driver who might need a charge to complete his or her trip.

5. Don't occupy an electric car charging space if you are not charging

Only occupy a charging spot when your car is being charged. Once the car is fully charged or sufficiently charged to reach your destination, unplug and move your car. Charging spots are not intended for parking.

6. All electric vehicles are equal

Priority is not given to one type of EV over another when accessing the charging station. Owners of all-EVs often feel they should get preferential treatment over PHEVs since plug-in hybrids have gasoline-powered engines as back-up. Owners of battery-EVs do not have the right to unplug PHEVs. Charging preference is given to the vehicle that arrives first. An EV driver can politely ask the driver of a plug-in hybrid to trade places in line if needed.

7. It's OK to ask for a charge

If a charging spot is being used and you are able to park next to it, you can leave a note to the driver asking to plug in your EV when he or she is done. Leaving your vehicle's charge port open when parked next to an occupied charging spot is a common signal to plug in your vehicle after the other driver's charging session is complete. This rule mostly applies to free public charging stations. When some form of payment or the use of a membership card is required, this rule may not be appropriate.

8. Do not unplug someone else's EV

Do not unplug another driver's vehicle unless the charge is complete, which can be seen by a blinking green state of charge indicator on the dashboard.

Just as with good manners, these rules are informal, suggestive in nature and based on common sense. However, some large employers offering EV charging facilities to their employees have adopted similar etiquette rules for participants in their workplace charging programs.

VI. Energy Conservation

When it comes to efforts to conserve energy in your house, are you doing your part?

Do you walk through the house turning every light on, or leave video games running after moving on to a new activity? If you or your family members are like this, consider following some of these simple tips to start conserving energy and keep more money in your pocket.

Heating and Cooling

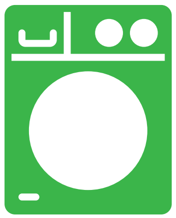
- When cooling your home, set the temperature between 78-80°F
- Set the temperature at 68-70°F for heating
- When away from home, set the thermostat a few degrees higher
- Close exterior doors when leaving the home at any time
- Close windows to the outside when cooling or heating
- Use ceiling fans in occupied rooms only
- Set fans at low speed and rotate clockwise in winter
- Change filters monthly and make sure they are installed correctly (look for the airflow direction arrow on the filter)
- Close shades and drapes during the day to help keep heat outside during the summer and open them in the winter to assist in heating
- Turn off lights when not needed as they produce additional heat in the home
- Try to minimize the amount of cooking/baking, clothes drying, or using the dishwasher in the heat of the day
- Close your chimney damper when not in use

Water Heating

- Turn down the water heater temperature to 120°F (140°F if you have a dishwasher)
- Take showers instead of baths
- Take shorter showers
- While brushing your teeth, use cold water and turn the water off while you are actually brushing
- Once a year, flush the sediment out of the bottom of your water heater
- Turn off your water heater when your home is vacant for two or more days

Kitchen

- Check your refrigerator and freezer settings, then set to the manufacturer's recommended temperature
- Close the refrigerator and freezer doors and minimize the amount of time they are open
- Clean refrigerator and freezer coils regularly
- Wipe down the seals of the refrigerator and freezer to prevent cold air from escaping
- Unplug unused refrigerators or freezers
- Use a microwave for cooking if possible
- Run the dishwasher when fully loaded



Laundry

- Do only full loads of laundry
- Clean your dryer's lint trap before each load
- Wash clothes in cold water

Lighting

- Use natural daylight if possible
- Turn off lights when you leave the room
- Turn off unnecessary lighting

Miscellaneous Ways to Conserve

- Turn off computers, monitors, and electronics when not in use
- Check and adjust irrigation and/or pool pump timers for appropriate run times during seasons

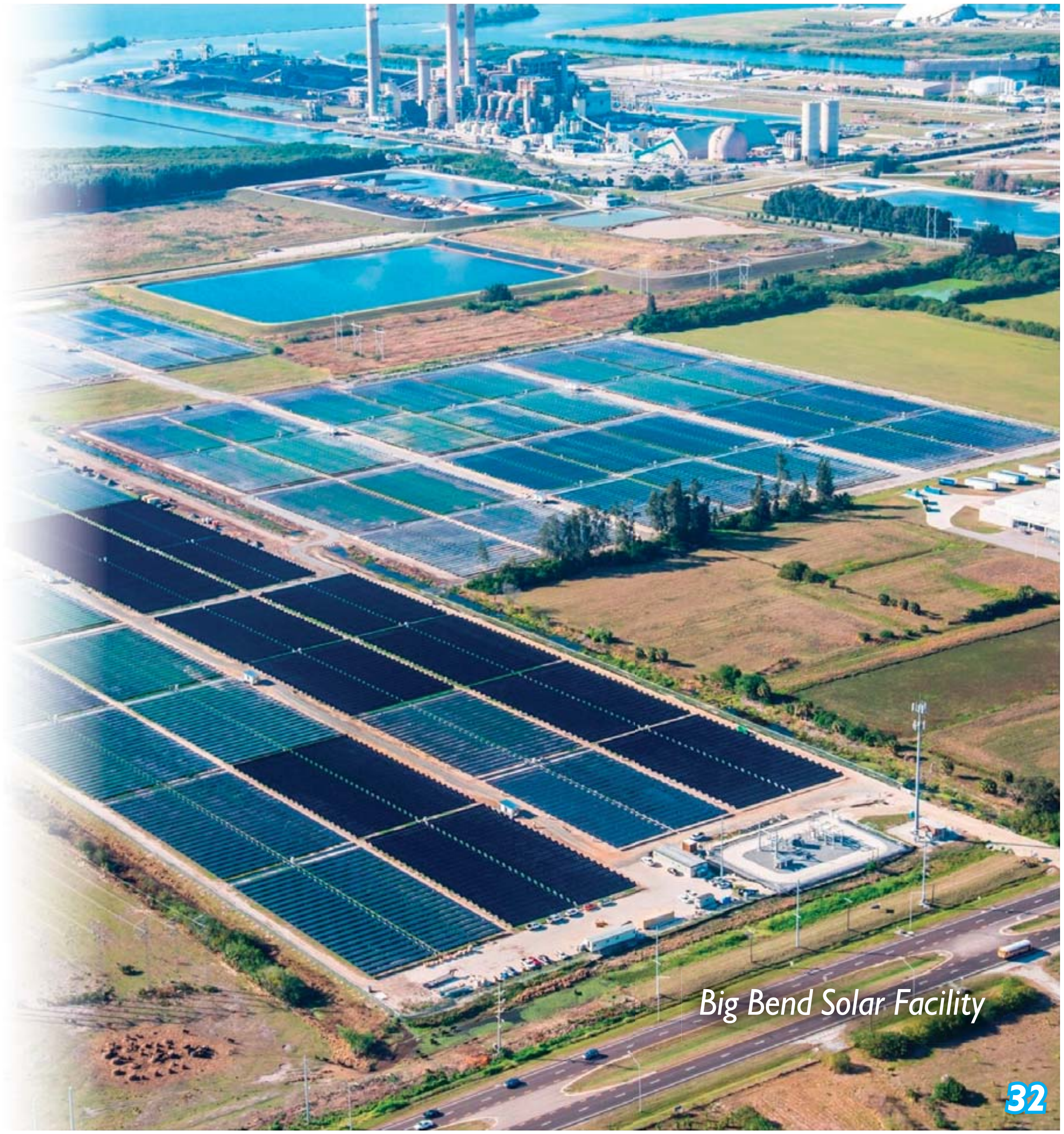
VII. Renewable Energy

We use energy for just about everything.

We use it to drive to school, surf the internet, take a warm shower and even to play video games. But did you know that most of the energy that we use today is non-renewable? This means that it is not endless; it will eventually run out! We must be careful about how much we use.

Big Bend Solar near the Manatee Viewing Center

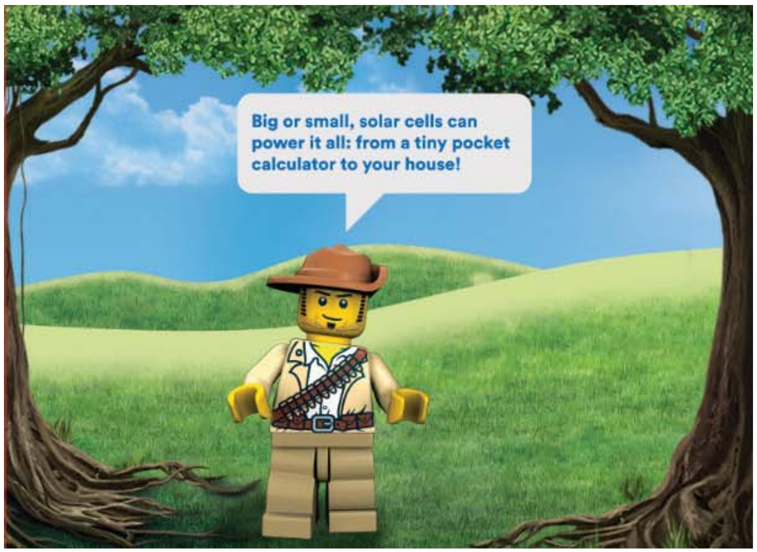
Tampa Electric completed construction of Tampa Bay's largest PV array near the company's Manatee Viewing Center in Apollo Beach in early 2017. The array can generate up to 23 megawatts (MW) of electricity from the sun and features more than 200,000 thin-film solar panels spread across 106 acres of land.



Big Bend Solar Facility

LEGOLAND® Florida Solar

Earth Day 2014 marked the day representatives from LEGOLAND and Tampa Electric flipped the switch on a Tampa Electric-owned, 30-kilowatt (kW) PV array installed atop LEGOLAND'S Imagination Zone. This system can generate enough electricity from the sun to power three average-sized homes and offset about 40 tons of carbon dioxide per year – equivalent to planting more than nine acres of trees.



LEGOLAND is also home to a Tampa Electric-installed, 1.8-MW PV array located over the park's preferred parking lot, providing partial shade to over 600 cars. Tampa Electric's first large-scale installation in Polk County produces enough electricity to power approximately 200 homes. Tampa Electric owns the system and the electricity fed into the grid that supports all Tampa Electric customers. Construction was completed in December 2016.

Cape Sharp Tidal Project at the Bay of Fundy

Cape Sharp Tidal is a partnership between Emera and OpenHydro to explore the clean-energy potential of the Bay of Fundy, home to the world's highest tides. In November 2016, the Cape Sharp team successfully deployed and grid-connected the first 2-MW turbine in a pilot. A second deployment is planned for later in 2017. This is an important demonstration project exploring the potential of tidal energy.

VIII. Summary

Best Practices

Following these common practices will help drivers make the most of their EVs.

1. Observe the speed limit

The fuel efficiency of most EVs declines significantly at speeds above 50 MPH. Unnecessarily fast driving not only increases fuel cost, but is also unsafe.

2. Avoid fast acceleration

Fast acceleration increases energy consumption and reduces fuel efficiency of the vehicle. Avoiding fast acceleration and other aggressive driving habits will improve fuel efficiency and extend driving range.

3. Do not brake hard

Anticipate braking and whenever possible, coast to a stop. This will maximize the efficiency of an EVs regenerative braking system and extend driving range.

4. Keep the vehicle well-maintained

Proper maintenance habits, including maintaining proper tire pressure, fluid level checks, and battery upkeep, will allow the battery and electric drive components to operate to their full capacity, ensuring best performance and fuel economy of the vehicle.

5. Use climate control wisely

Intensive use of heating or air conditioning significantly reduces vehicle range. Consider pre-heating or pre-conditioning the vehicle before a trip while the vehicle is still plugged in. Avoid driving in extreme weather conditions that require intensive use of climate control.

6. Use economy mode when driving

Economy mode reduces EV fuel consumption and maximizes vehicle range by optimizing the vehicle's performance and climate control features. Economy mode can often be engaged with the press of a button.

7. Plan your trip

Prepare to fully charge the battery before a trip, and know the trip distance and availability of public charging stations along the route. Remember, you can use the AFDC Station Locator app to find the closest public charging stations.

8. Learn to interpret the built-in range display

All EVs have a built-in display that shows the remaining range of the vehicle. While the displayed range represents an estimate, this information coupled with route familiarity can provide adequate driver confidence and avoid range anxiety.

9. Charge the vehicle off-peak

Charging the vehicle during off-peak hours, preferably at home, helps drivers take advantage of the lowest electricity rates, thus reducing EV driving cost per mile. Additionally, off-peak charging helps utility companies balance demand, reduce societal energy costs, and generate environmental benefits.

10. Follow charging etiquette rules

Be courteous to fellow EV drivers and respectfully share limited EV charging infrastructure.

Key Terms and Definitions

All-electric vehicles/battery-electric vehicles
Vehicles that operate on 100 percent battery-electric power.

Alternating current
A type of electric current that reverses direction a number of times per second.

Alternative Fuel Data Center (AFDC) Station Locator
Online and mobile mapping application that identifies alternative fueling stations near an address or zip code.

Alternative fuel vehicles
Vehicles that are powered by at least one non-petroleum based fuel, which includes electricity, hydrogen, natural gas, propane, biodiesel, and ethanol. A full list of alternative fuels can be found at https://www.afdc.energy.gov/fuels/.

CHAdeMO
Proprietary name for a quick charging method for battery-EVs.

Charging cycle
The process of charging and discharging a rechargeable battery.

Charging Rate
The rate of charge at which an electric charging station can recharge the vehicles' batteries. Charging rate is measured in miles of range provided to the vehicles' batteries per hour of charging.

Chassis
The basic frame of a vehicle.

Daily Range
The mileage, on average, that a vehicle is used on a daily basis.

DC Fast Charging
A charging process that uses direct current to rapidly charge a plug-in vehicle. Also referred to as DC quick charge, Level 3 charging, and Level 4 charging.

Direct current
Electric current that runs continually in one direction and can be produced by a battery or another electric source.

Dynamic pricing rates
Different rates are offered by the utility based upon preset times of the day. During off-peak times, the prices will be lower versus during on-peak, when the price could be substantially higher.

Economy mode
When a vehicle is in economy mode—not all vehicles are equipped with this mode—it changes the way the vehicle operates to maximize fuel economy and extend range.

– continued

Electric vehicle supply equipment
All the equipment used to supply electricity to a vehicle, including electrical wiring, grounding equipment, the EV connectors, attachment plugs, and any equipment used to transfer energy from an external power source to a vehicle.

Hybrid vehicles
Vehicles that are powered by an internal combustion engine and an electric motor. Regular hybrid vehicles cannot be plugged into an electric power source for recharging.

Inductive charging
A process that uses wireless technology and an electromagnetic field to transfer energy between two objects.

Internal combustion engine
An engine that creates power by burning liquid or gaseous fuels such as gasoline or diesel.

Kilowatt-hours (kWh)
A measure of electrical energy.

Level 1 Charging
Provides charging to a plug-in vehicle through a 120-volt alternating current plug and circuit. Using a household plug to charge a vehicle is a form of Level 1 charging.

Level 2 Charging
Supplies charging to a vehicle using 208 volts or 240 volts, which is the same voltage that an electric clothes dryer or household oven requires.

MPG illusion
A misperception about fuel efficiency that the amount of fuel consumed by a vehicle changes as a linear function of MPG.

Plug-in hybrid electric vehicle
Hybrid vehicles that have both an internal combustion engine and an electric motor that can be charged by plugging into an electrical outlet or charging station.

Range anxiety
The fear of not having enough battery charge in an EV to reach a destination.

Regenerative braking
A process that allows the EV to recapture some of the car's energy and use it to recharge the battery.

SAE Combo Charging System
A fast charging method for battery-EVs that sends a high-voltage direct current using a special connector.

Tailpipe emissions
Air pollutants that are released through a vehicle's tailpipe.

– continued

Tesla Supercharger
A proprietary fast charging method used solely by Tesla, an EV manufacturer.

Torque
A measure of force acting on an object that causes that object to rotate.

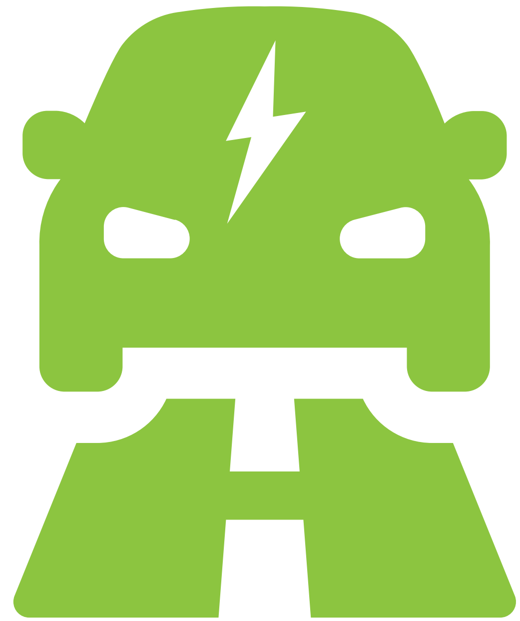
U.S. DOT National Highway Traffic Safety Administration
An agency of the executive branch of the United States government that addresses vehicle transportation-related safety considerations and regulations.

U.S. Environmental Protection Agency
An agency of the executive branch of the United States government that develops and enforces regulations regarding human health and the environment.

Vehicle propulsion energy
The way that vehicles create force resulting in movement, which involves a source of mechanical power (such as an engine or motor) and the way the vehicle uses this power to create force.

Vehicle range
The distance a vehicle can travel before needing to be refueled or recharged. For EVs, this refers specifically to the distance an EV can travel on a full charge.

Zero-emission vehicle
A vehicle that emits no tailpipe pollutants.



SAFE DRIVING!

Notes

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TEC072417 .4M DP

Technical Progress Report

Evaluate Battery Energy Storage as a DSM program

Prepared for TECO

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September 20, 2017

Table of Contents

Project Tasks

The current project includes the followings Tasks:

1. **Task 1- Battery Selection**: USF will assist TECO in the selection of Batteries for Electric storage.
    a. Review literature
    b. Select type of batteries commercially used
    c. Comparison of batteries based on performance/cost (capital and life cycle).
    d. Environmental impact
    e. Ambient conditions
    f. Maintenance requirements vs. TECO's expected participation
    g. Risk tolerance
    h. Intended system lifetime beyond study period
    i. Load profile impact on power vs. capacity tradeoffs
    j. Battery cycling tolerance, particularly as related to flexible operational demands
2. **Task 2- Identify a commercial facility** for testing Battery Energy Storage- USF will assist TECO to identify a commercial facility for testing
    a. Develop criteria for customer selection
    b. Recommend load types best suited for battery storage
    c. Evaluate economic impacts of potential operational modes on target facilities in conjunction with TECO Resource Planning
    d. USF will do economic evaluation for the customer side; TECO will do economic evaluation on the utility side
3. **Task 3- Vendor Selection** for Installation of Battery energy Storage system-
    a. Develop conceptual design, incorporating high level components, operational modes, power quality controls and battery performance requirements
    b. Assist with EPC (Engineering, Procurement, and Construction) contractor discussions of technology and battery system constraints
    c. Conceptual design of the system
4. **Task 4- Performance Testing of Storage system**
    a. Assist with acceptance testing of system
    b. Develop tests to verify system performance
5. **Task 5 - Operational modes and mode switching**
    a. The modes of battery charging and discharging will be determined in consultation with TECO on the basis of past data and future planned power production.
    b. Charging and discharging will be based on Peak and off-peak timings.
6. **Task 6- Data collection and Analysis of Data**- USF will specify a data acquisition system at the selected facility and will collect and analyze the data. USF will be responsible for developing the software package for this project.
7. **Task 7- Quarterly reports**
    a. Real vs. expected dispatch of battery system
    b. Changes in facility demand (peak loads and energy consumption)
    c. Battery specific status, e.g. depth of discharges, expected remaining cycle life, expected remaining service days
    d. Stakeholder comments (e.g. facility manager and TECO grid operator)
    e. Lessons learned, deviations from planned system operation/use, general comments over reporting period
    f. Performance report

The following sections provide a progress report of Task 1.

Introduction

Approximately 40% of the electricity demand in the U.S. is consumed by residential and commercial buildings[1]. This presents an opportunity for energy storage. Depending on the nature of a building's electricity demand, its load profile and the availability of on-site renewables, different forms of energy storage can be appropriate. Air conditioning loads, for example, are generally best handled by thermal energy storage in the form of ice or chilled water. Non-thermal loads such as electric motors and lighting, on the other hand, are most efficiently supplied by battery storage systems.

This report will focus on battery storage (BES) systems, including a summary of the benefits to various stakeholders, a review of basic principles, descriptions of various battery chemistries, calculations on the life cycle costs and recommendations of which battery chemistry is best suited for a given situation.

Benefits to Stakeholders

Battery storage is a value-adding product that can benefit every stakeholder in the electricity market. Both the electric utility and the energy consumer can derive economic benefit from proper use of electricity storage.

Electric Utility

On the utility end, battery storage can provide one or more of several services. They can be used for frequency regulation, where they act as both a power source and sink to adjust to grid conditions. In fact, with switching times on the order of 10-100 milliseconds, they can be even more effective than thermal power plants for maintaining a constant grid frequency[2].

In combination with solar power using photovoltaics (PV), battery storage systems can mitigate PV's negative effect on power quality (i.e. they can prevent voltage spikes and drops caused by fast-moving clouds that cause solar production to change quickly). If the storage system is properly sized, then the solar fluctuation can be absorbed by the battery charging system and discharged at a controlled rate, preventing negative impacts on the grid.

Even when solar power is not used, battery energy storage can improve the utilization of base- and intermediate-load thermal power plants while reducing the need for peak power plants. By allowing the customer to charge their batteries during periods of low demand, utility equipment utilization is improved during off-peak periods; meanwhile, discharging during periods of high demand reduces the peak load that the utility must meet. This reduces the risk of brownouts/blackouts on the grid scale, while also reducing the customer's energy bill (by charging the system using solar, or at night when energy is inexpensive, and discharging the batteries when demand is high rather than buying electricity at peak-demand prices).

Finally, because battery storage can be located at the point of use, the utility can derive economic benefit by deferring upgrades to generation, transmission and distribution[2]. For example, a congested distribution node can be decongested by meeting a portion of the peak demand with the batteries instead of directly through the grid.

Electric Power Consumer

Selection of battery storage technology for buildings depends on variables that include the energy and power demands during different days of the year and storage autonomy needed for the system. The type of buildings that are under consideration in this project include office buildings, schools, hospitals, and hotels. As each of these buildings has different electric power demand profiles during their operation hours, the design of a battery storage system depends on the type of building chosen. USDOE has defined reference buildings for different types of structures with their representative power demand profiles. Using the DOE reference buildings data, a representative power demand profile for each of the types of buildings under consideration is presented for winter and summer work days in Figure 1 and Figure 2. A large office building shows the biggest demand difference between day and night due to the nature of activities, while a hotel shows two peaks during both the seasons. As the type of application and the nature of the building demand influences the battery storage system (BESS) selection, the actual electricity use and demand profile will be criteria for selecting the project building.

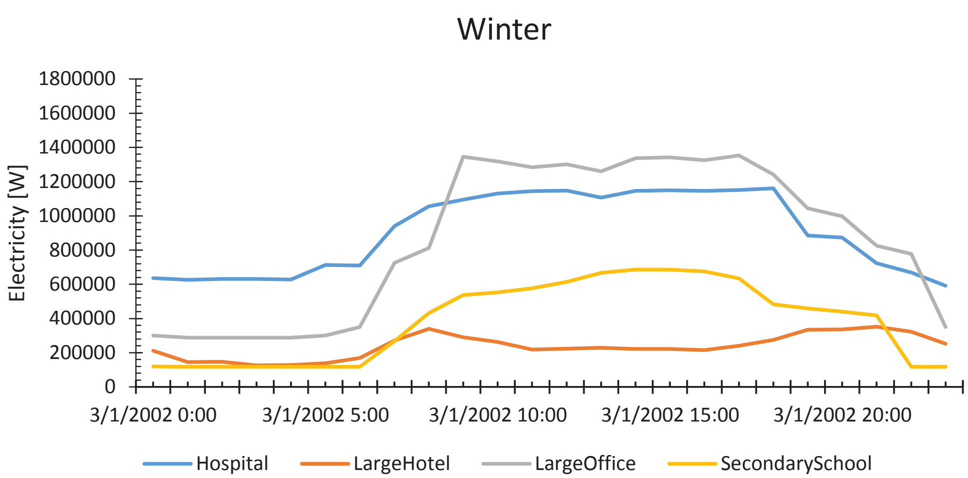

Figure 1. Demand during a typical winter work day in Tampa

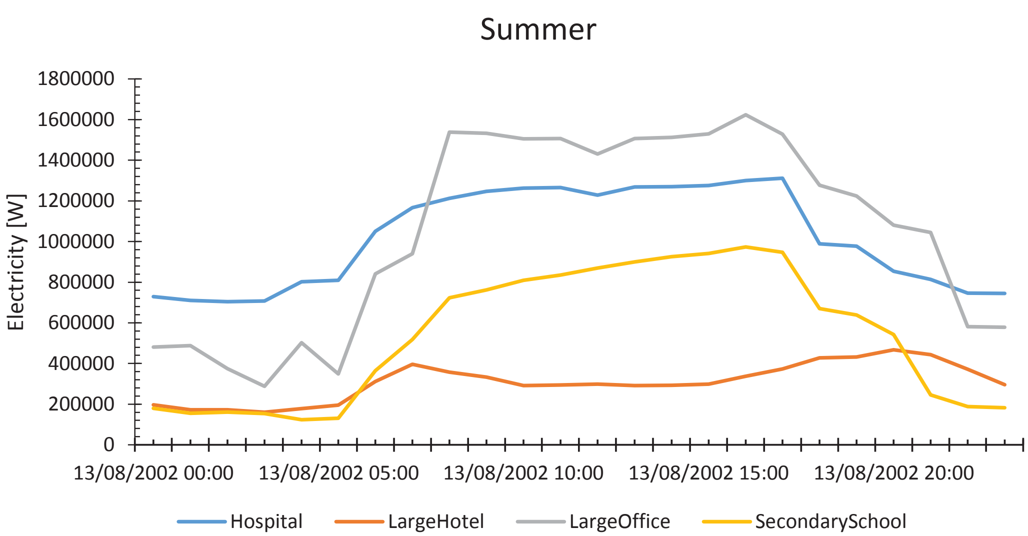

Figure 2. Demand during a typical summer work day in Tampa

The benefits of battery energy storage to the electric consumer are quite simple, but they rely on the use of specific rate structures, specifically the Time of Use (TOU) rates (Figure 3). By charging the battery system during off-peak times when electric rates are lower (approximately $0.04/kWh) and discharging during peak times ($0.065/kWh), the cost of energy consumption during peak times can be reduced by approximately 50%. These benefits are even larger when adding the reduction for demand charges: if a facility's billing demand normally takes place during peak hours, then a total of $10.25/kW is paid. If the billing demand is kept the same, but the peak billing demand is reduced by 50% by shifting that load onto off-peak times, then demand charges can be reduced by about 30%.

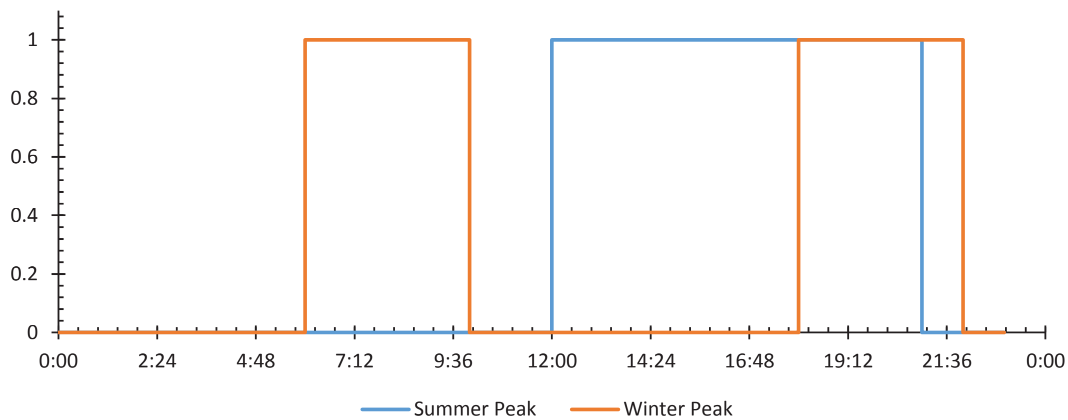

Figure 3. Two-season peak pricing window for Tampa

As an example, consider a facility with an average demand of 100 kW and a billing demand of 200 kW that coincides with utility peaks and lasts for 4 hours each day. Monthly energy consumption is about 24,000 kWh during peak hours and 48,000 kWh during nonpeak hours, for a total of 72,000 kWh per month. Billing demand is 200 kW, and peak billing demand is also 200 kW. Electric costs for this facility are $1530, $1932, and $2050 for peak energy, nonpeak energy, and demand charges, respectively, for a total of $5512 per month.

Now consider the same facility with 100 kW of battery storage. Billing demand is still 200 kW, but peak billing demand is now only 100 kW. Monthly energy consumption is now 12,000 kWh during peak hours and 61,300 kWh during nonpeak hours, totaling 73,300 kWh per month (note that the 1300 kWh increase in total energy consumption is due to efficiency losses within the battery). Electric costs for this modified facility are $765, $2468, and $1371 for peak energy, nonpeak energy, and demand charges. The total monthly electricity cost of $4604 for the modified facility represents a 16.5% reduction in overall cost.

Battery Basic Principles

Batteries use a reversible chemical reaction to convert electrical energy into chemical energy for storage and back into electrical energy for consumption. This reaction is not perfectly reversible, however, which leads to degradation of system performance over the course of its life cycle. The exact nature of this irreversibility varies with battery chemistry, but the general concept can easily be illustrated with the example of a lead acid battery.

In a lead acid battery, there are two electrode plates (one positive and one negative) flooded with sulfuric acid as an electrolyte. As shown in Figure 4(a), in the fully discharged state, both electrode plates consist of lead sulfate ($PbSO_4$), while the electrolyte is diluted into nearly-pure water. During the charging process [Figure 4(b)], the negative electrode plate consists of pure lead, the positive electrode consists of lead oxide (PbO_2), and the electrolyte is sulfuric acid[3].

(a) (b)

Figure 4. (a) Lead acid battery in fully discharged state; (b) fully charged state[3]

During each discharge portion of the charge/discharge cycle, the electrode plates react with sulfuric acid to produce lead sulfate. However, in the process, a small portion of the lead sulfate tends to crystallize into tree-shaped dendrites of metallic lead[3], these crystalline dendrites being less prone to losing electrons and recombining with the electrolyte. As these dendrites grow, there is progressively less electrolyte material available for the reaction, which reduces the storage capacity. In addition, if the dendrites grow long enough to connect the positive and negative electrolytes, then the cell can be shorted out and permanently disabled. More advanced lead acid batteries use a glass or carbon matrix to limit dendrite growth, which increases their cycle life.

Battery Types and Descriptions

The five commercially-available battery technologies best suited to a small-scale (50-250 kW, 2-8 hour) stationary energy storage system are: lead acid, lithium ion, nickel metal hydride, flow, and sodium sulfur batteries. Each technology has its advantages and disadvantage, which will be described below. Specifications provided for each battery technology are based on an average of a selection of commercial products; cost figures are based on rough quotes obtained from manufacturers and distributors, where available. Spec sheets from products used to generate these averages are provided in the Appendix.

It is important to note that the price quotes are based on the price of the battery only; auxiliary equipment such as charge controllers, thermal management, and inversion/rectification will increase the cost.

Lead Acid

Lead acid batteries are the most common batteries used today. They are inexpensive, robust units, capable of withstanding large swings in temperature and humidity with minimal loss of performance. Because lead acid batteries have been used for a century, there is an established recycling infrastructure, lead acid batteries being almost 100% recyclable[3].

However, lead acid batteries have many disadvantages for commercial electricity storage. Their basic materials (lead and sulfuric acid) are toxic and can be dangerous if mishandled. The batteries have a rather low energy density, which means that systems are large and heavy compared to other technologies. They also cannot be discharged nearly as far as other batteries: only about 50% of the total storage capacity can be utilized without causing significant performance degradation. Finally, basic models have significantly shorter cycle lives than other technologies currently available.

Although lead acid batteries have been in commercial use since the late 1800s, only recently have there been significant advances in the technology. Some of the advanced models currently available have significantly increased cycle life, but their cost is significantly higher as well. In fact, some models of advanced lead acid batteries can withstand upwards of 15,000 cycles, provided that the DOD is kept low (< 10%). The cycle lives provided below assume depths of discharge of 50-60%.

Nickel Metal Hydride

Nickel metal hydride (NiMH) was the third major battery technology to become commercially available. Early cell phones and laptop computers generally used NiMH (or its predecessor, nickel cadmium) batteries. NiMH is another robust storage chemistry, featuring a wide range of operating temperatures and good tolerance to over- and under-charging (a strong possibility in systems where battery storage is coupled with solar PV). It has a better cycle life than lead acid. The main draw of NiMH, however, is the incredibly high sustained charging/discharging rates of 5C (that is, charging from 0% to full in 12 minutes) and the high energy density[8,9,10].

The primary disadvantages of NiMH lie with its storage capabilities. It is well-known for having a memory effect; that is, repeated partial charges can cause the battery to “forget” about the top portion of its capacity. It also features a high rate of self-discharge (about 15% per month at room temperature, and higher at elevated temperatures) and relatively low efficiency[8,9,10].

Lithium Ion

After lead acid, lithium ion is the most prevalent battery type in modern society. Lithium ion batteries can be found in every mobile phone, laptop computer, and hybrid/electric vehicle. Lithium ion batteries come in a variety of chemistries, each with their own advantages and disadvantages. In stationary storage applications, the most common chemistry is lithium iron phosphate ($LiFePO_4$, or “LiFe”), which has better safety characteristics but lower power density than the lithium cobalt oxide ($LiCoO_2$) typically used in mobile applications.

LiFe batteries have numerous advantages for stationary storage systems. They have long cycle lives of 5000+ cycles, high energy and current density, high efficiency, high depth of discharge, low self-discharge, and no memory effect. However, they tend to be quite expensive (though the price is dropping rapidly), and their temperature sensitivity often requires thermal management that can be moderately expensive to run; additionally, they’re currently not recyclable, and proven reserves of lithium are somewhat limited, which means that in the long-term there may be supply issues[11].

Table 1 - Battery Average Specifications

	PbA (basic)	PbA (advanced)	NiMH*	Li-ion	Flow	NaS	NaNiCl
Power Mass Density	180 W/kg		250-1000 W/kg[10]	1800 W/kg	N/A	150 W/kg[4]	140 W/kg
Energy Mass Density	30-40 Wh/kg		30-80 Wh/kg	160 Wh/kg	500 Wh/kg	150-760 Wh/kg[5]	280 Wh/kg
Energy Volume Density	60-70 Wh/L		140-300 Wh/L	270 Wh/L	50-167 Wh/L[6]	151 Wh/L[5]	Up to 290 Wh/L[7]
DOD limit	50%	60%	90%	80%	100%	80-100%	80%
Efficiency	91%	91%	65%	93%	71%	87-92%	~90%
Cycle life(cycles)	1200	2700	3000	6675	15000	2500 at 100% DOD, 4500 at 80% DOD	>3000 at 80% DOD
Upfront Cost ($/kWh)***	$126	$431	$250	$650	$500	>$400**	>$400**

* Unlike other battery chemistries, specifications presented here are approximate figures obtained from online sources instead of spec sheets from specific products.
**Sodium sulfur and sodium nickel chloride battery costs provided are estimated based on qualitative descriptions found in online sources.
***Upfront costs listed here are based on the cost of batteries only. Actual installation costs are likely 50-100% higher after accounting for power conversion, charge control, and thermal management systems as well as labor and EPC costs. Also, costs are approximate based on estimates provided by manufacturers and distributors at EES-NA 2017; actual costs should be negotiated by TECO and will likely be different.

Flow

Flow batteries are the newest chemistry on the market. A number of chemistries fall under the banner of flow battery, such as the vanadium redox, iron redox, zinc bromine, and zinc iron batteries. In each case, the battery consists of two tanks of liquid electrolytes, which are pumped to a membrane where a chemical reaction stores or releases electrical energy[12].

The primary advantage of the flow battery is its very high cycle life, which leads to a low cycle cost over the lifespan of the product despite the relatively high upfront cost and relatively low storage efficiency. While flow batteries do have more moving parts than other chemistries, the battery materials themselves degrade less over time, so overall maintenance costs are likely to be lower than other battery types.

The other main advantage of flow batteries is their high degree of customizability. Energy capacity can be increased by using larger electrolyte tanks, while power capacity can be increased by adding more membrane stacks and increasing fluid flow rates; these two capacities can be sized independently to meet project requirements ranging from 30 minutes to 8 hours of storage.

The primary disadvantage of flow batteries, however, is the low energy density. For example, the ViZn GS-200 zinc/iron redox battery requires ten 40-foot shipping containers (ignoring spacing between containers, this is a total volume of 27,000 ft^3, or roughly the size of a 2000 sq. ft. single-story house with vaulted ceilings and an attic) for 1 MW / 3 MWh of storage capacity. Assuming that volume is directly proportional to capacity, then a 250 kW / 750 kWh unit would occupy a volume of approximately 6750 ft^3, approximately the size of a studio apartment.

Due to the novel nature of the flow battery, there are generally only a handful of products within each chemistry type. Thus, the values in Table 1 are based on a mix of products from several flow chemistries: iron redox, zinc bromine, and zinc iron.

Sodium Batteries

Sodium batteries, such as sodium sulfur and sodium nickel chloride, are unique in that they operate at high temperatures of approximately 300 °C. They use abundant materials, which may give them a lower installation cost than other batteries (note: at the time of writing, no cost estimates could be obtained from manufacturers for these batteries). Because they operate at high temperatures, there is no need for thermal management systems.

Sodium Sulfur (NaS)

Sodium Sulfur batteries are primarily manufactured by NGK in Japan. Approximately 35 MW of battery capacity was installed in partnership with TEPCO; however, a battery fire in 2011 led to a temporary cessation of manufacturing. Other challenges associated with NaS batteries include their low tolerance to moisture and the increased maintenance requirements due to the possibility of cell leaks.

Sodium Nickel Chloride (NaNiCl)

Sodium nickel chloride batteries have many of the same advantages as NaS (specifically the high temperature and abundant raw materials); however, like NaS, they also are quite limited in terms of choice of manufacturers. The primary difference between NaNiCl and NaS is that a NaNiCl system operates at a slightly lower temperature, which reduces the amountof thermal loss due to elevated operating temperatures. It should also be noted that the FIAMM SoNick (the main NaNiCl on the market) claims that optimal performance is achieved at discharge rates of 1/12 C, or full discharge in 12 hours.

Cost Calculations

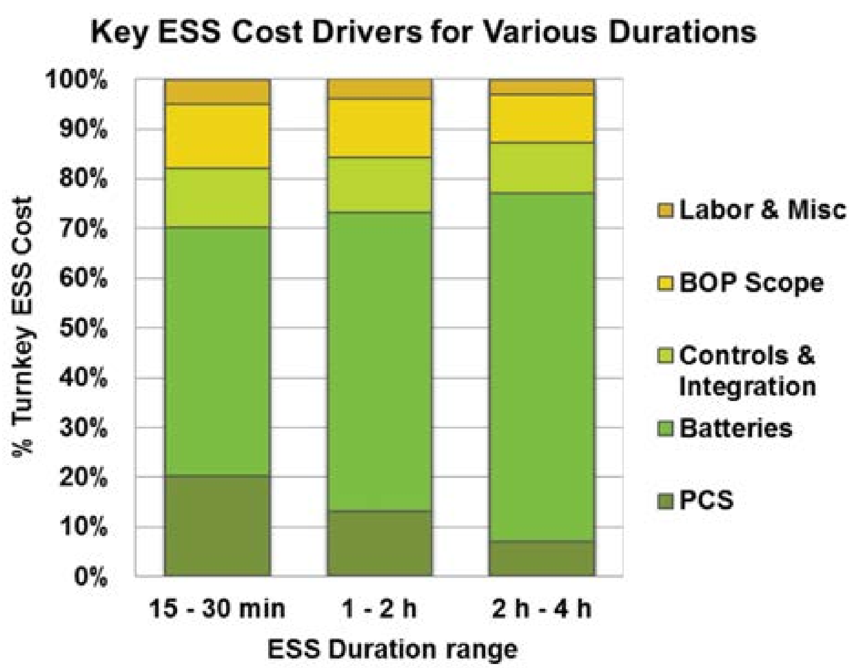

Figure 5. CapEx cost drivers for Energy Storage Systems (ESS) for various storage durations[13]

Installation Cost

Installation costs were calculated under the assumption that 500 kWh of useable capacity (that is, 500 kWh could be discharged per cycle after accounting for efficiency losses and depth of discharge limitations). Based on Figure 5 for 2 hours of storage duration, costs were calculated with the assumption that 70% of the project cost was due to the battery itself, while the other 30% was for auxiliary systems, permitting fees, and EPC fees. Figure 6 shows the installation costs for a variety of battery chemistries. Costs were calculated as follows:

$$\text{Installation cost } = \frac{500\ kWh}{(\max DOD) * (Efficiency)} * (cost\ per\ kWh)$$

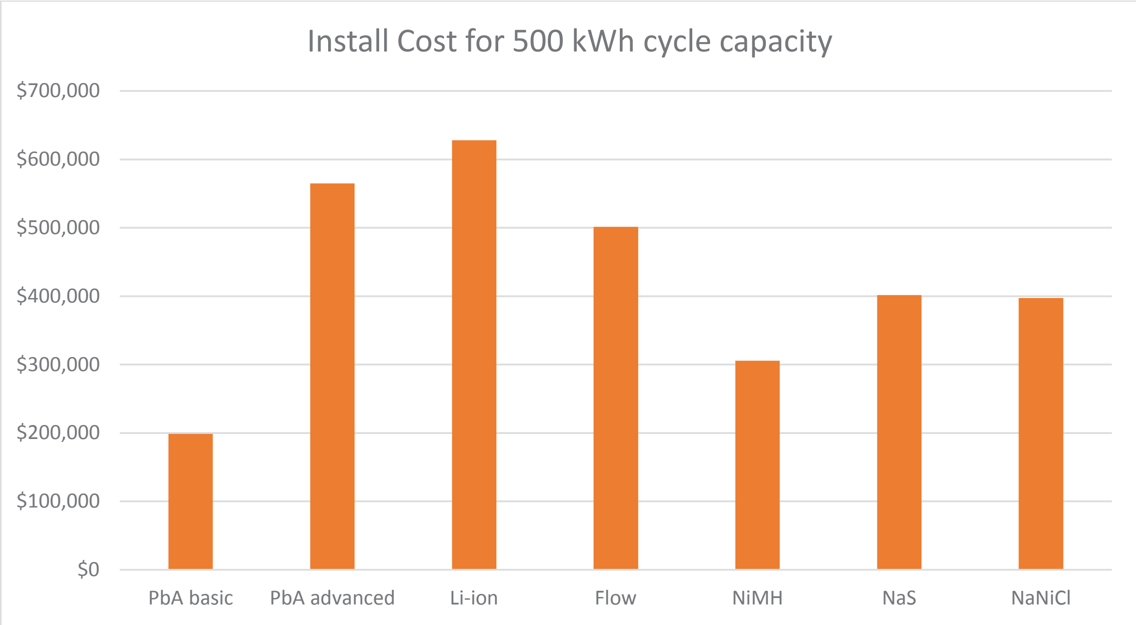

Figure 6. Installation cost for various battery chemistries, 500 kWh of initial daily cycle capacity

Levelized Cost

Based on Figure 5 for 2 hours of storage, levelized costs of storage (LCOS) were also calculated under the assumption that 70% of project cost was due to the battery while 30% was due to auxiliary systems, permitting, and EPC fees. A discount rate of 10% was assumed, while it was assumed that energy would be purchased from the grid during off-peak hours at a rate of $0.05/kWh. One cycle was defined as starting from 0% DOD (i.e. full charge), discharging to the chemistry's maximum DOD (e.g. 50% for basic lead acid or 80% for lithium ion), then recharging to full charge. It was assumed that the system would run at one cycle per day until the battery reached its maximum cycle life. To account for capacity degradation throughout the cycle life, the degradation was assumed to be linear from 100% of initial capacity at start of life to 80% of initial capacity at end of life; storage capacity was reduced to 90% of initial capacity to account for this degradation. Maintenance and thermal management costs were not accounted for due to incomplete availability of data.

Figure 7 shows the levelized cost of storage for a variety of battery chemistries. Costs were calculated as follows:

$$Annual\ Energy\ Consumption = (Storage\ Capacity\ in\ kWh) * (DOD) * \left(365\,\frac{cycles}{year}\right) * (90\%\ Degradation\ Factor)$$

$$Annual\ Energy\ Delivered = (Annual\ Energy\ Consumption) * (Storage\ Efficiency)$$

$$Annual\ Energy\ Cost = (Annual\ Energy\ Consumption) * \$0.05/kWh$$

$$Discounted\ Annual\ Cost = \frac{Annual\ Energy\ Cost}{(1+0.1)^{year}}$$

$$Levelized\ Cost\ of\ Storage = \frac{Upfront\ Cost + \sum_{year=1}^{\max cycle\ life}(Discounted\ Annual\ Cost)}{\sum Annual\ Energy\ Delivered}$$

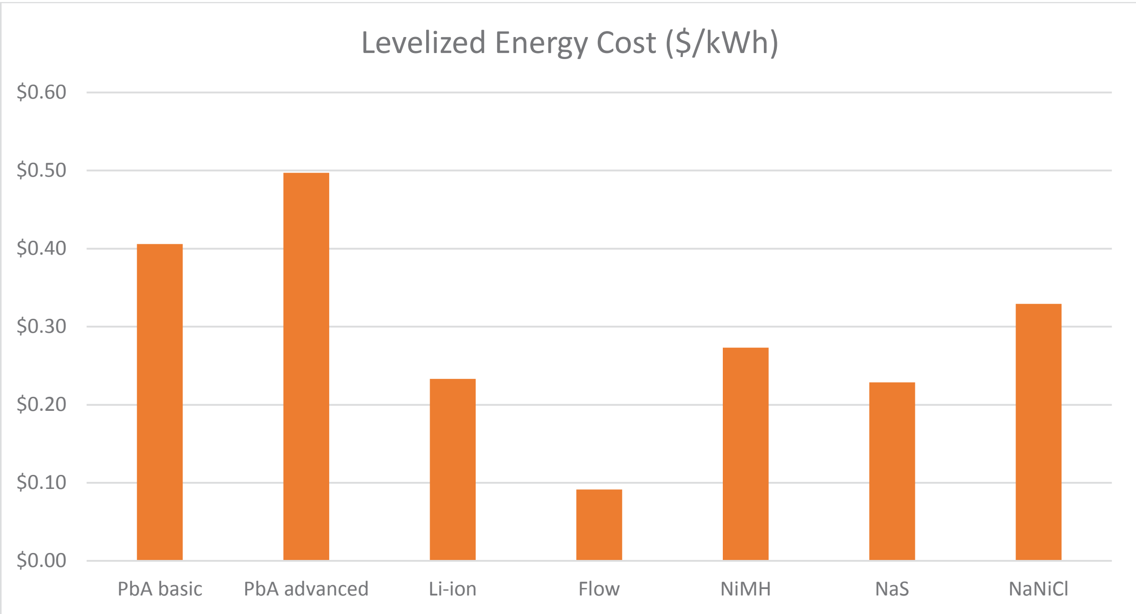

Figure 7. Levelized energy cost for various battery chemistries over their cycle life

Note that the cost of storage above includes the cost of electricity purchases. The added cost of using the battery system over simply purchasing electricity from the utility would be the above figures minus $0.05/kWh.

Levelized Cost for Fixed System Life (with Replacement)

It is useful to consider the effect of battery replacement on the overall LCOS. The following subsections demonstrate the overall LCOS for battery storage systems with fixed system lifetimes of 20, 10, and 5 years. When a given battery technology reaches its maximum cycle life before the end of the project life, it is assumed to be replaced; for simplicity of calculation, this replacement is assumed to be instantaneous with no effect on annual cycling. Replacement costs are based on the cost of the batteries only, with the assumption that each technology will reduce in price at a rate of 10% per year.

Figures 8, 9, and 10 show the LCOS for 20, 10, and 5-year project lives, respectively. Note how the LCOS increases as the project lifespan decreases; this effect is particularly pronounced for lithium ion and flow batteries, largely because the shorter project lifespans are considered to end long before the battery reaches its end of life.

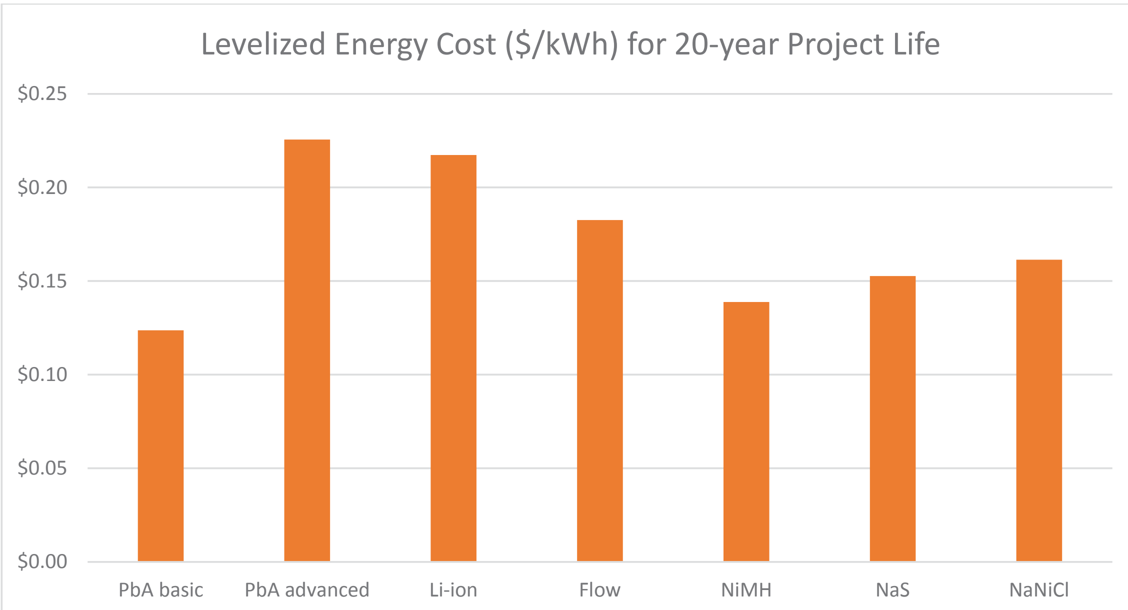

Figure 8. Levelized energy cost for 20-year battery storage project, with battery replacement as needed

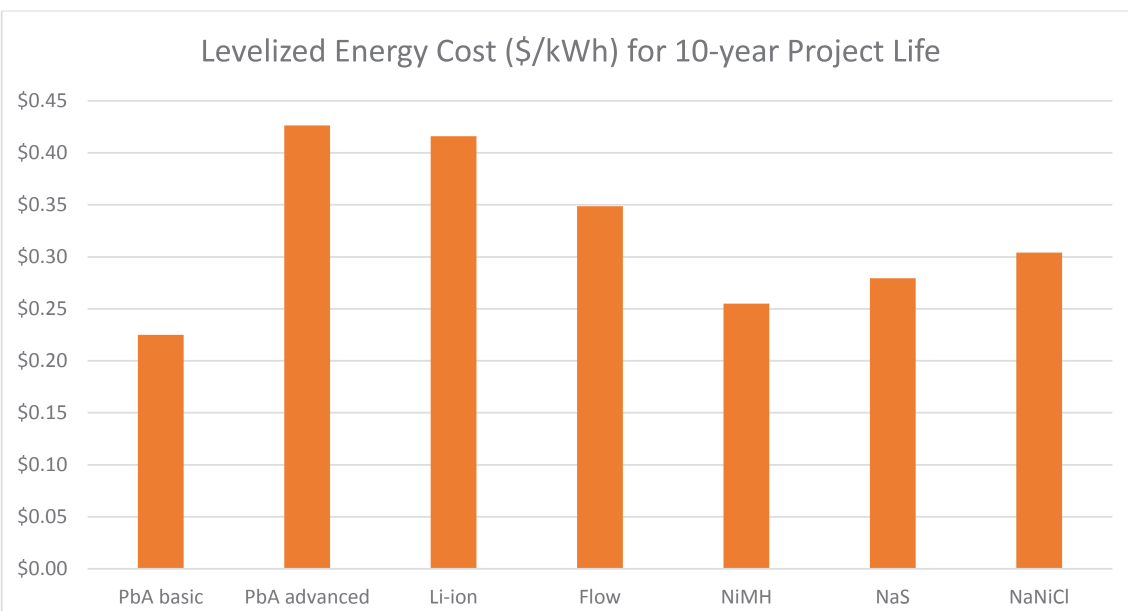

Figure 9. Levelized energy cost for 10-year battery storage project, with battery replacement as needed

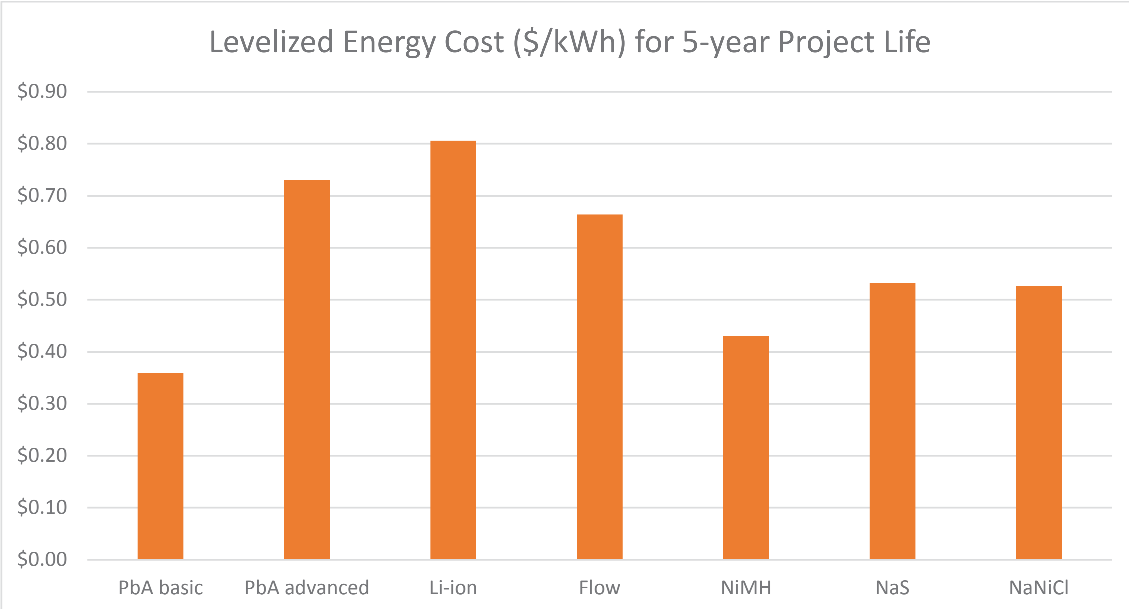

Figure 10. Levelized energy cost for 5-year battery storage project, with battery replacement as needed

Summary and Recommendations

Depending on the intended application, a variety of battery chemistries may be appropriate. Table 2 summarizes the key characteristics of each battery type, with consideration to the power and energy capacities, installation cost, safety, and lifespan of each product, ranked on a 1-5 scale with 5 being the best.

These general recommendations were developed based on basic characteristics of various battery chemistries and on economic calculations based on vendor cost estimates. Battery specs were obtained primarily from data sheets of commercially available products, but in some cases approximate specifications were obtained from online sources such as Wikipedia and Battery University. Calculations were performed to estimate the installation cost of a battery energy storage project with 500 kWh of daily cycling capacity, after accounting for efficiency losses and depth of discharge limitations; and to estimate the levelized cost of storage for a battery project, both over a single cycle life and over fixed project duration (with battery replacement as necessary).

It is very important to remember that battery selection is driven by the specific building, load profile, and application for which it will be used. Some battery chemistries are well suited for long-duration storage but have low energy density and large volumes, others perform well when high discharge rates are required but store relatively little energy, while others offer a compromise between these two extremes. Depending on the exact project requirements, a battery can be selected according to the following general recommendations:

For cases where the absolute lowest cycle cost over a 20-year lifespan is required, regardless of physical size, then flow batteries are the best option. If physical space is constrained, then the lowest cycle cost comes from lithium ion. If extremely high charging/discharging rates are required (e.g. for frequency regulation applications), then NiMH performs best, with advanced lead acid being a decent alternative. Finally, if a storage system is required for a short duration but upfront cost is the primary constraint, then basic lead acid batteries make the most sense.

Table 2 – Battery characteristics summary

Chemistry	Energy Density	Power Density	Installation Cost	Safety	Lifespan	Notes
Basic Lead Acid	2	5	5	4	1	Cheap to install but short lifespan gives high cycle cost
Advanced Lead Acid	2	5	3	4	3	Very high lifespan with low-DOD cycles Medium lifespan with 50%-DOD cycles
Nickel Metal Hydride	4	5	4	5	3	Well suited to projects requiring very high charge/discharge rates
Lithium Ion ($LiFePO_4$)	5	4	3	5	4	Other chemistries with different performance characteristics
Flow	2	2	5	5	5	Variety of chemistries Highly customizable
Sodium Sulfur	4	3	5	4	3	High maintenance costs due to cell leakage; Few manufacturers
Sodium Nickel Chloride	4	3	5	4	3	Few manufacturers

References

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Appendix – Battery Spec Sheets

$100–125/kWh

GS

AGM DEEP CYCLE BATTERY

For Energy Storage Applications

SLX250-12

GS BATTERY (U.S.A.) INC. ENERGY STORAGE SOLUTIONS

The GS Battery SLX250-12 is part of GS Battery's complete line of rechargeable batteries and energy storage systems. These industry leading solutions include batteries in a variety of voltages including 2 volt, 4 volt, and 12 volt models to suit every energy storage application.

In addition, GS Battery's energy storage solutions include a variety of battery chemistries including deep cycle Lead-Acid, advanced Lead-Carbon, robust and reliable Nickel-Cadmium and versatile Lithium-Ion. Energy storage solutions from GS Battery are designed and manufactured according to the most rigorous Japanese quality control standards to deliver extraordinary performance and exceptional long service life.

CYCLE LIFE

The GS Battery SLX250-12 is designed for the high cycle life requirements of energy storage systems. This battery is rated at **1500 cycles at 50% Depth of Discharge (DOD).**

CHEMISTRY

The GS Battery SLX250-12 is Valve Regulated Lead Acid (VRLA) battery and features Absorbed Glass Mat (AGM) technology. These long-life, lead-acid batteries provide extraordinary **versatility, reliability and performance at a value price.**

COMPLIANCE

The GS Battery SLX250-12 is a **UL recognized** systems component and is classified as a "Non-Spillable Battery" for transport. (Complies with DOT HMR49, Non-Hazardous Materials.)

MAINTENANCE FREE

The GS Battery SLX250-12 is **virtually maintenance free** and never require watering. These batteries minimize energy storage system maintenance expenses and increase system value.

SAFETY

The GS Battery SLX250-12 is an **inherently safe energy storage** technology. These batteries are non-spillable, do not generate hazardous gasses with normal use and are constructed from flame retardant ABS (UL94 V-0).

ENVIRONMENTALLY FRIENDLY

The GS Battery SLX250-12 is an environmentally friendly energy storage technology. **96% of lead acid batteries are recycled.** A typical lead-acid battery contains 60-80% recycled lead and plastic.

WARRANTY

The GS Battery SLX250-12 is designed to deliver superior performance and long life in the field and carries a **1-year warranty**.

Pb

ABOUT GS BATTERY (U.S.A.) INC.

GS BATTERY (U.S.A.) INC. is a global leader in energy storage. Our batteries are manufactured to the highest standards and deliver high quality, long life and superior performance in a wide variety of mission critical applications. GS Battery's products deliver reliable battery power for Telecommunications, Energy Storage, Renewable Energy, Uninterruptible Power Supply (UPS), Emergency Lighting, Power Sports, and Automotive industries.

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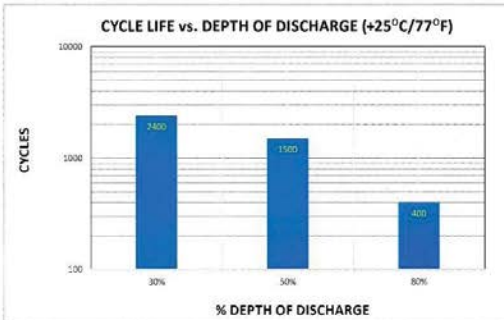
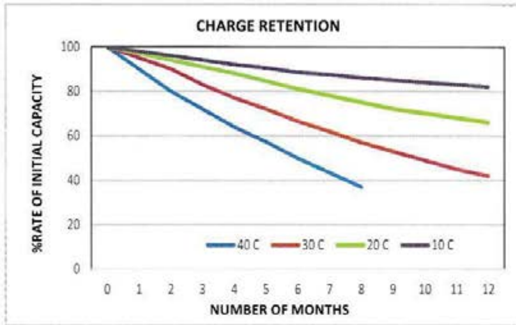
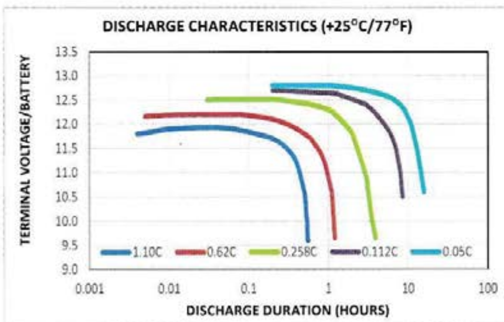
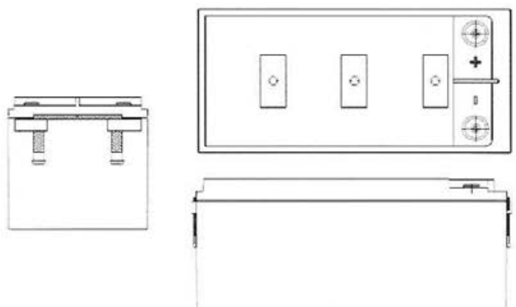
AGM DEEP CYCLE BATTERY

SLX250-12









Battery Characteristics			
Terminal Type	Battery Type	Battery Capacity (20 HR)	Battery Voltage
Bolt (M8)	VRLA AGM	250Ah	12 Volts

Physical Characteristics (±3mm)						
	Length	Width	Case Height	Overall Height		Weight
Inches	20.47	9.57	9.06	9.06	Pounds	165.35
mm	520	243	230	230	kg	75

Capacity @ 25°C (77°F) to 10.5 Volts per Battery (1.75VPC)										
	30 Min Rate	45 Min Rate	1 Hour Rate	2 Hour Rate	3 Hour Rate	4 Hour Rate	5 Hour Rate	8 Hour Rate	10 Hour Rate	20 Hour Rate
W	2819	2088	1676	1019	728	574	478	328	271	146
A	249	182	145	86.3	61.8	48.7	40.6	28	23.2	12.5

500-200-005 ver. 1.0 12-2016

Dealer Information

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GS BATTERY (U.S.A.) INC.
1150 Northmeadow Parkway, Suite 110
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T 800-472-2879

www.gsbattery.com

GS YUASA Group Company

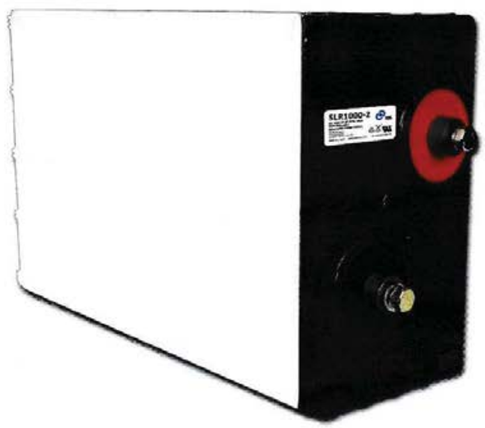
$12000 for 48 kwh

GS

ADVANCED LEAD DEEP CYCLE BATTERY

For Energy Storage Applications

SLR1000-2



CYCLE LIFE

The GS Battery SLR1000-2 is designed for the high cycle life requirements of energy storage systems. This battery is rated at **5000 cycles at 70% Depth of Discharge (DOD).**

CHEMISTRY

The GS Battery SLR1000-2 is a Valve Regulated Lead Acid (VRLA) battery and features Absorbed Glass Mat (AGM) technology. These long-life, lead-acid batteries provide extraordinary **versatility, reliability and performance at a value price.**

COMPLIANCE

The GS Battery SLR1000-2 is a **UL recognized** systems component and is classified as a "Non-Spillable Battery" for transport. (Complies with DOT HMR49, Non-Hazardous Materials.)

MAINTENANCE FREE

The GS Battery SLR1000-2 is **virtually maintenance free** and never requires watering. These batteries minimize energy storage system maintenance expenses and increase system value.

SAFETY

The GS Battery SLR1000-2 is an **inherently safe energy storage** technology. These batteries are non-spillable, do not generate hazardous gasses with normal use and are constructed from flame retardant ABS (UL94 V-0).

ENVIRONMENTALLY FRIENDLY

The GS Battery SLR1000-2 is an environmentally friendly energy storage technology. **96% of lead acid batteries are recycled.** A typical lead-acid battery contains 60-80% recycled lead and plastic.

WARRANTY

The GS Battery SLR1000-2 is designed to deliver superior performance and long life in the field and carries a **10-year limited warranty**.

Pb

GS BATTERY (U.S.A.) INC.
ENERGY STORAGE SOLUTIONS

The GS Battery SLR1000-2 is part of GS Battery's complete line of rechargeable batteries and energy storage systems. These industry leading solutions include batteries in a variety of voltages including 2 volt, 4 volt, and 12 volt models to suit every energy storage application.

In addition, GS Battery's energy storage solutions include a variety of battery chemistries including deep cycle Lead-Acid, advanced Lead-Carbon, robust and reliable Nickel-Cadmium and versatile Lithium-Ion. Energy storage solutions from GS Battery are designed and manufactured according to the most rigorous Japanese quality control standards to deliver extraordinary performance and exceptional long service life.

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GS YUASA Group Company

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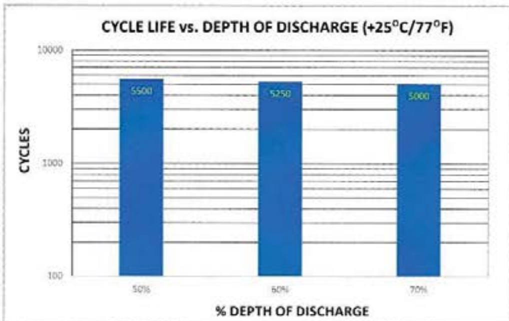
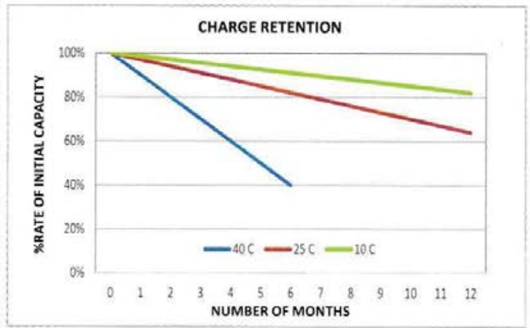
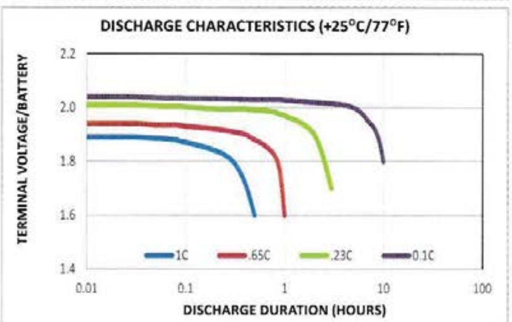
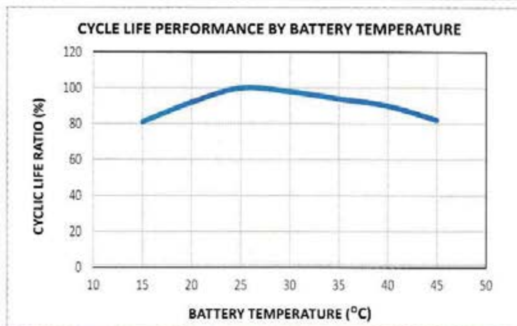
ADVANCED LEAD DEEP CYCLE BATTERY
SLR1000-2



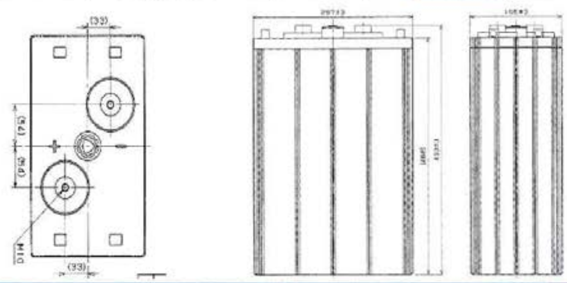






Battery Characteristics			
Terminal Type	Battery Type	Battery Capacity (10 HR)	Battery Voltage
Bolt (M8)	Advanced VRLA AGM	1000Ah	2 Volts

Physical Characteristics (±3mm)						
	Length	Width	Case Height	Overall Height		Weight
Inches	11.30	6.50	18.43	19.41	Pounds	147.71
mm	287	165	468	493	kg	67



10 YEAR WARRANTY

Dealer Information

500-200-003 ver. 2.0 2-2017

GS BATTERY (U.S.A.) INC.
1150 Northmeadow Parkway, Suite 110
Roswell, GA 30076
T 800-472-2879

www.gsbattery.com

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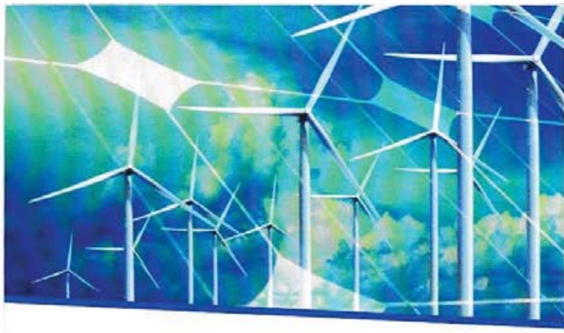


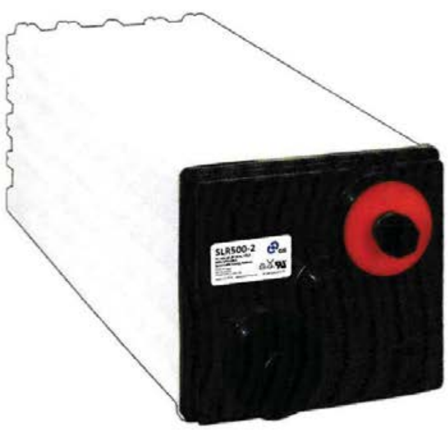
GS

$0.40/wh
$400/kwh

ADVANCED LEAD DEEP CYCLE BATTERY

For Energy Storage Applications

SLR500-2



CYCLE LIFE

The GS Battery SLR500-2 is designed for the high cycle life requirements of energy storage systems. This battery is rated at **5000 cycles at 70% Depth of Discharge (DOD).**

CHEMISTRY

The GS Battery SLR500-2 is a Valve Regulated Lead Acid (VRLA) battery and features Absorbed Glass Mat (AGM) technology. These long-life, lead-acid batteries provide extraordinary **versatility, reliability and performance at a value price.**

COMPLIANCE

The GS Battery SLR500-2 is a **UL recognized** systems component and is classified as a "Non-Spillable Battery" for transport. (Complies with DOT HMR49, Non-Hazardous Materials.)

MAINTENANCE FREE

The GS Battery SLR500-2 is **virtually maintenance free** and never requires watering. These batteries minimize energy storage system maintenance expenses and increase system value.

SAFETY

The GS Battery SLR500-2 is an **inherently safe energy storage** technology. These batteries are non-spillable, do not generate hazardous gasses with normal use and are constructed from flame retardant ABS (UL94 V-0).

ENVIRONMENTALLY FRIENDLY

The GS Battery SLR500-2 is an environmentally friendly energy storage technology. **96% of lead acid batteries are recycled.** A typical lead-acid battery contains 60-80% recycled lead and plastic.

WARRANTY

The GS Battery SLR500-2 is designed to deliver superior performance and long life in the field and carries a **10-year limited warranty**.

Pb

GS BATTERY (U.S.A.) INC.
ENERGY STORAGE SOLUTIONS

The GS Battery SLR500-2 is part of GS Battery's complete line of rechargeable batteries and energy storage systems. These industry leading solutions include batteries in a variety of voltages including 2 volt, 4 volt, and 12 volt models to suit every energy storage application.

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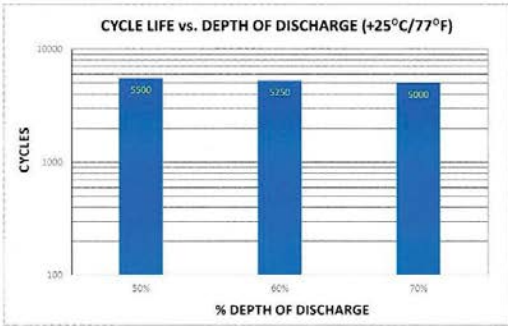
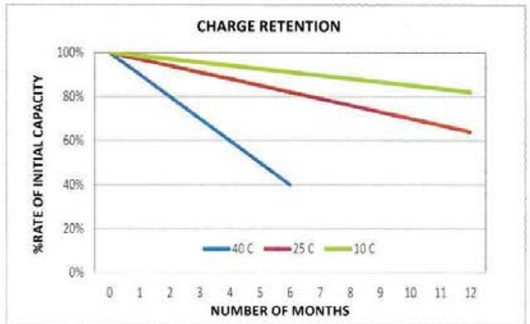
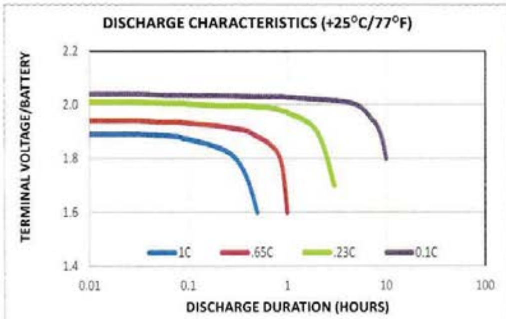
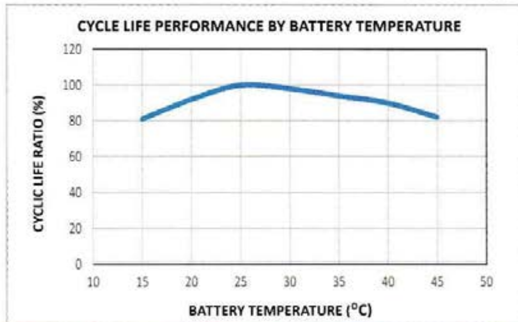


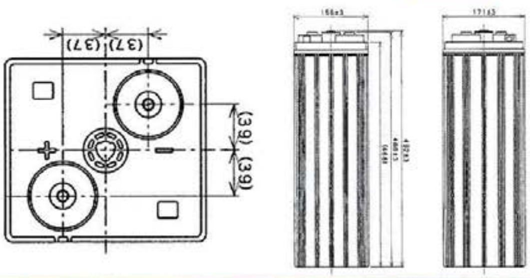






Battery Characteristics			
Terminal Type	Battery Type	Battery Capacity (10 HR)	Battery Voltage
Bolt (M8)	Advanced VRLA AGM	500Ah	2 Volts

Physical Characteristics (±3mm)						
	Length	Width	Case Height	Overall Height		Weight
Inches	6.1	6.7	19.4	19.4	Pounds	75
mm	156	171	492	492	kg	34



10 YEAR WARRANTY

500-200-019 ver. 1.04-2017

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Plug n play
20kW / 28kWh

Flexible Power and Energy Configurations

Sandia tested 20K cycles

UltraFLEX

PRODUCT FACT SHEET

UltraFlex 48 V Plug 'n' Play Energy Storage

With the introduction of the UltraFlex 48 V, Ecoult is making its proven UltraBattery® technology available for commercial and residential applications.

With 17 kWh of usable storage at 60% range of charge, and 20 kW of peak power, the high-cycling, energy-efficient UltraFlex 48 V is safe and simple to deploy, operate and maintain, making it the plug 'n' play energy storage device of choice for a range of applications and environments, including:

- Residential
- Small and medium commercial
- Agriculture
- Distributed infrastructure such as mobile telecoms and utilities
- Rugged and remote locations.

Integrated Battery Solution

The UltraFlex 48 V offers both high power and energy. Each UltraFlex unit comprises:

- 16 x UltraBattery 12 V monoblocs with integrated Monitors
- System Monitoring and Control
- Over-current protection on each string.

Deka UltraBattery

Flexible Applications

Renewables Integration

+ **Smoothing:** Smoothing of renewable energy power sources
+ **Feed-in management and ramp-rate control:** Distributed management of renewable energy sources feeding into the electricity grid

Diesel and Off-Grid

+ **Hybrid energy systems:** Downsizing of diesel/fossil-fuel generators and reduction of generator use, greatly lowering costs and fuel consumption and reducing CO_2 and other emissions
+ **Remote area power supply:** Reliable off-grid renewable power solutions

Energy Shifting/Cost Control

+ **Peak lopping/peak demand management:** Shifting of energy availability to cover demand peaks
+ **Energy arbitrage:** Storage of off-peak energy for use during peak charge times

Revenue Generation

+ **Frequency regulation:** Provision of distributed grid ancillary services or demand response

Any other partial-state-of-charge (PSoC) use

Where batteries may need to charge and discharge rapidly and frequently.

Power and Energy Data

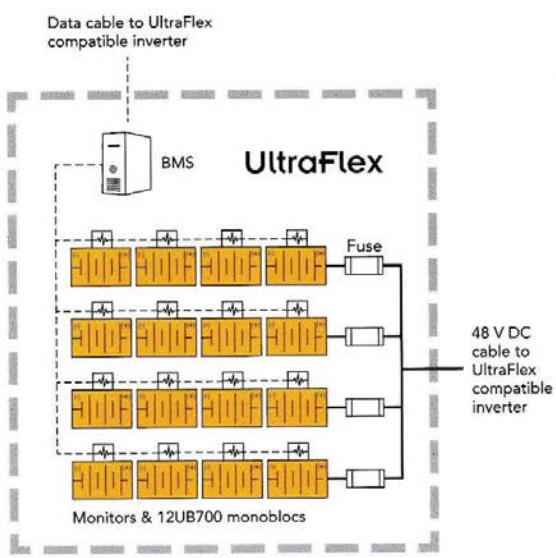
		UltraFlex 4 x 48 V
Continuous power rating*	**1-hour rate**	20.0 kW
	10-hour rate	2.8 kW
Capacity for regular cycling	**Nominal capacity (100%)**	28.2 kWh
	Usable capacity (60% range of charge)	16.9 kWh
Capacity for emergency reserve events	**Usable capacity (90% range of charge at 10-hour rate)**	25.4 kWh

*Charge rate tapered to a voltage limit at the top of the range of charge.

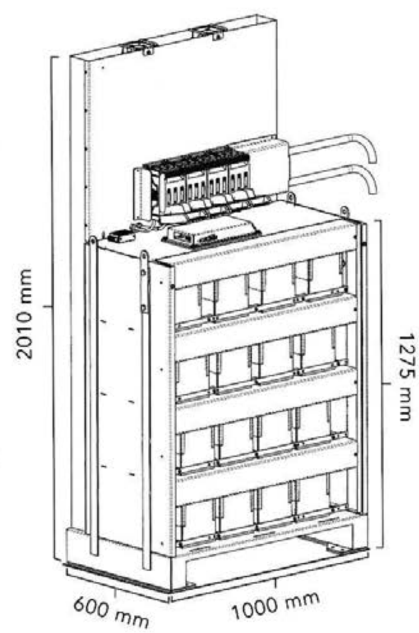
Cabinet Specifications

Nominal Voltage	48 V
Assembly Weight	1190 kg
Indoor UltraFlex Dimensions (W x D x H)	1 x 0.6 x 2 m

Data subject to change without notice. Based on ambient temperature of 25° C.



Single line diagram of UltraFlex (included components are shown within dotted grey line)



UltraFlex system dimensions

System Features

Key Features	Benefits
Modular Design 1, 2, 3 & 4 x 48 V string configurations possible, with up to 16 x 12 V monoblocs per cabinet	Flexible sizing for different power and energy requirements
Plug 'n' Play Solution Available pre-installed or pre-wired for integration on-site, depending on site accessibility	Reduced on-site labour and accelerate installation time
Small Footprint Offers 20 kW power at 1-hour discharge rate with a 1 m x 0.6 m footprint	Fewer batteries required, so space on-site is optimized
Passive Thermal Design Maximizes battery life by channeling airflow to promote operation within optimum temperature bands	Maximizes your business case and return on investment by reducing diverging effects of temperature on UltraBattery cells
UltraBattery Monitoring Provides access to state of charge and other vital information to assist with operating the system within its optimal performance range	Enables management of UltraBattery system to achieve greatest longevity, and monitoring of each individual monobloc remotely to diagnose issues before going to site
Over-current Protection Protects the system from excessive current and faults	Maximizes safety and longevity with application-specific rated breakers or switch fuses; breakers can also be tripped by the battery control system to ensure the batteries operate within performance limits

System Specifications

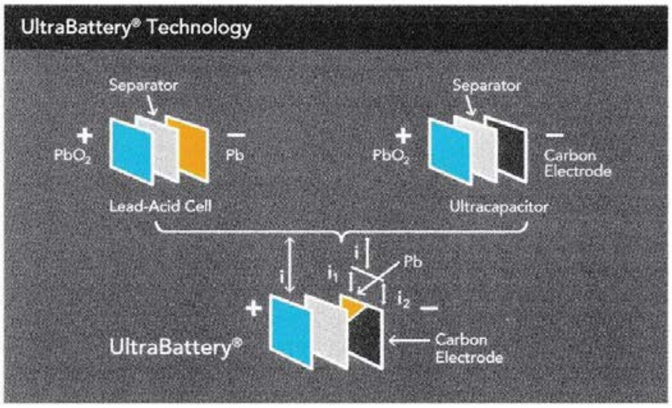
Operating Temperature	10° C – 50° C*
Watt-hour Roundtrip Efficiency	Greater than 91% DC–DC for rates below 0.4 C1 (8 kW)
Battery Monitoring System (BMS) Communications Interface	Modbus via ethernet or RS485
User Interface	Web-based HMI
Over-current Protection	Fuses or optional circuit breakers per string
Recyclability	Recovery of 95%+ of battery components for production of new batteries in a true closed-loop manufacturing process

* See Ecoult Use Rules for detailed temperature allowances

Behind the Scenes

UltraBattery Technology in Partial State of Charge Use

UltraBattery is a new dimension in lead-acid technology: a hybrid, long-life lead-acid energy storage device containing both an ultracapacitor and a battery in a common electrolyte.



UltraBattery is a hybrid, long-life lead-acid energy storage device. It combines the fast charging rates and longevity of ultracapacitor technology with the energy storage potential of lead-acid battery technology in a hybrid device with a single common electrolyte.

UltraBattery is highly efficient in continuous partial-state-of-charge (PSoC) operation: neither totally full nor totally empty.

Every UltraBattery is fully monitored, with browser-based reporting.

Conventional valve-regulated lead-acid (VRLA) batteries, when used for renewable support, are typically operated in a top-of-range cycling pattern and can prematurely fail if operated in the PSoC range for extended periods. UltraBattery technology was created to exploit the performance benefits of the PSoC band.

During lead-acid battery operation, lead sulphate crystals grow on the negative electrode during discharge and fully dissolve at full charge. At PSoC some crystals can become permanent, increasing the battery's internal resistance and decreasing its power, capacity and efficiency. UltraBattery chemistry inhibits the sulfation, allowing the battery to operate with high efficiency at PSoC.

The outcome: UltraBattery processes more energy in PSoC applications.

UltraBattery is a game changer in the lead-acid family. Lead-acid batteries are the world's most ubiquitous chemical storage chemistry, favored for their reliable performance in demanding conditions and their ability to deliver high power and energy.

Processes developed over the past century support the recycling of old lead-acid batteries into new ones, making their production the world's most sustainable industry.

With UltraBattery, lead-acid becomes a fully monitored, fast-cycling, partial-charge technology suited to almost any energy-storage application.

To find out more about UltraFlex including its availability, contact Ecoult

UltraFlex was developed with the support of funding received from Australian Renewable Energy Agency (ARENA) under its Emerging Renewables Program.

03.2017

T +61 2 9241 3001 E info@ecoult.com Ecoult www.ecoult.com www.ultrabattery.com

Specifications

Nominal voltage(V)		36
Rated Capacity(Ah) (*1)		150
Energy capacity(kWh)		5.4
Maximum output(kW) (*2)	**0.1sec**	161
	10sec	96
Outline dimensions(mm) L x W x H(*3)		1375×223×345
Volume(L)		106
Weight(kg)		240
Energy density per unit volume(Wh/L)		51
Energy density per unit weight(Wh/kg)		23

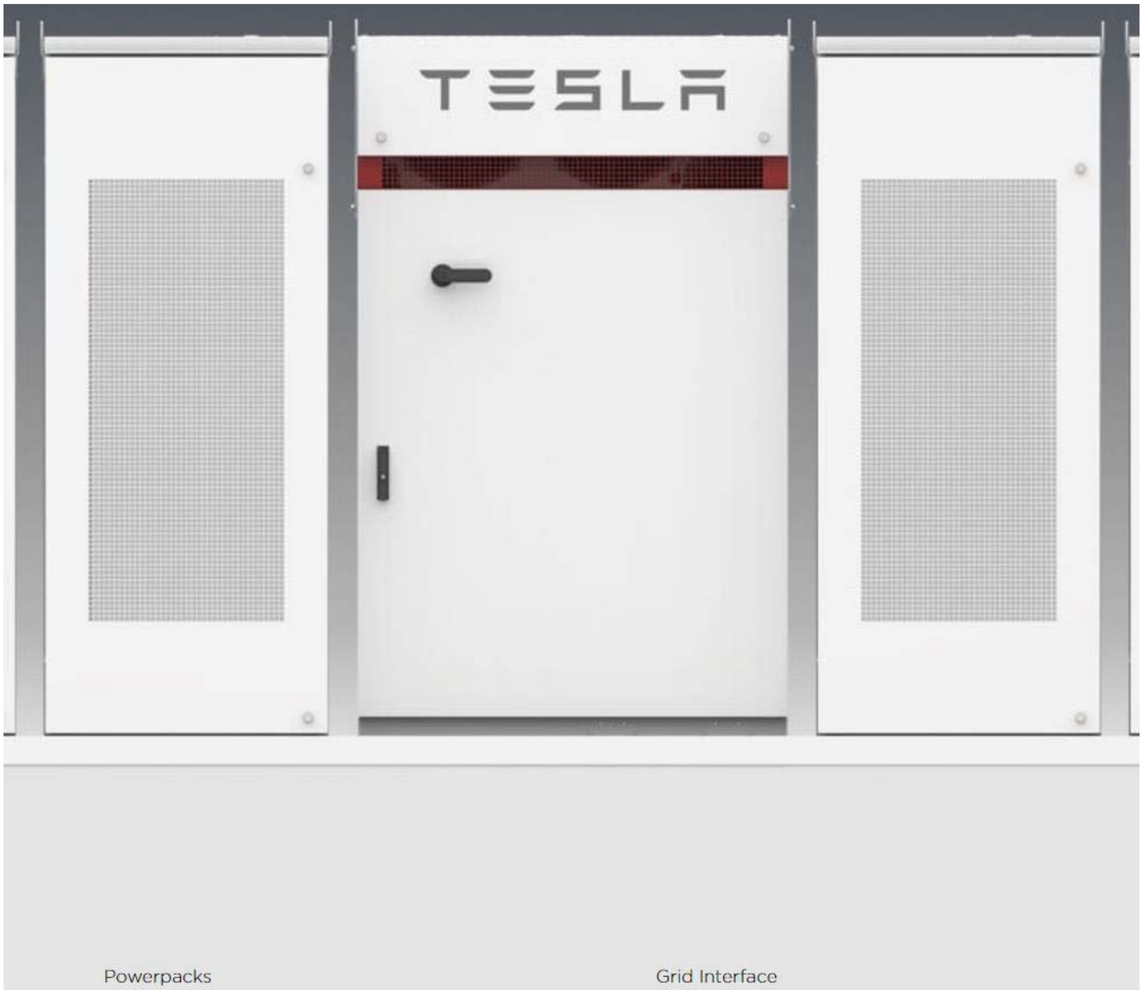
* Specifications may change without notice.

*1 Recommended capacity will depend on operating conditions.

*2 Calculated from results of an I-V test of 0.1 sec discharge(0.6V/cell)

*3 Mounting hardware not included.

Battery Energy Storage System
About GIGACELL
Features
Structure
Specifications
Characteristics
Applications
Brochures -GIGACELL-
Movie Gallery
Frequently Asked Questions


TESLA
Powerpacks
Grid Interface

Powerpacks

Powerpacks house the world's most sophisticated batteries. Each Powerpack is a DC energy storage device containing 16 individual battery pods, a thermal control system and hundreds of sensors that monitor and report on cell level performance.

Grid Interface

- Bi-Directional Inverter
- Powerpack Controller
- Software

Learn More

Overall System Specs

AC Voltage	380 to 480V, 3 phases
Communications	Modbus TCP/IP; DNP3
Power	50kW (AC) per Powerpack
Scalable Inverter Power	from 50kVA to 625kVA (at 480V)
Depth of Discharge	100%
Dimensions	**Powerpack** Length: 1,308 mm (51.5") Width: 822 mm (32.4") Height: 2,185 mm (86") Weight: 1622 kg (3575 lbs) **Industrial Inverter** Length: 1,014 mm (39.9") Width: 1254 mm (49.4") Height: 2192 mm (86.3") Weight: 1200 kg (2650 lbs)

Energy Capacity	210 kWh (AC) per Powerpack
Operating Temperature	-22°F to 122°F / -30°C to 50°C
Enclosures	Pods: IP67 Powerpack: IP35/NEMA 3R Inverter: IP66/NEMA 4
System Efficiency (AC) *	88% round-trip (2 hour system) 89% round-trip (4 hour system)
Certifications	Nationally accredited certifications to international safety, EMC, utility and environmental legislation.

* Net Energy delivered at 25°C (77°F) ambient temperature including thermal control

$0.60/Wh
$600/kWh

GS YUASA

LIM50EN SERIES
Lithium-Ion Battery

RELIABILITY AND HIGH PERFORMANCE VERSATILE LITHIUM-ION
MODULES FOR THE DEMANDS OF RENEWABLE ENERGY STORAGE PROJECTS

ABOUT THE LIM50EN SERIES

The LIM50EN SERIES from GS Yuasa is a premium rechargeable Lithium-Ion battery module. These modules are manufactured in Japan using the highest quality components and under rigorous Japanese quality control standards. These long service life, high cycle life batteries are designed to deliver excellent performance in high-power applications where high charge and discharge rates are required.

The LIM50EN SERIES battery module is ideally engineered for the requirements of a wide variety of industrial energy storage applications including; Renewable Energy, Smart Grid Energy Storage and Automated Guided Vehicles (AGV). The high performance LIM50EN SERIES from GS Yuasa is an excellent choice for any energy storage application requiring extremely reliable performance and high power delivery capability.

HIGH CYCLE LIFE
Engineered to deliver high cycle life and high power. These batteries are rated for 10,000 cycles @50% DOD, 6,700 cycles @ 80% DOD.

EXCELLENT HIGH CURRENT CHARGE/ DISCHARGE CAPABILITY
Designed for high specific power density and peak charge and discharge rates up to 6C.

PARTIAL STATE OF CHARGE PERFORMANCE
Not effected by partial state of charge (PSOC) operation. The formation of sulfate crystals that causes early failure in other battery chemistries is not a factor in this battery.

RAPID CHARGING
Engineered to accept a charge extremely rapidly. These batteries can charge to 70% of rated capacity in 30 minutes.

HIGH EFFICIENCY
Very low energy conversion losses and delivers greater than 95% round trip efficiency during each charge and discharge cycle.

INTEGRATED BATTERY MANAGEMENT SYSTEM (BMS)
Includes an integrated BMS which actively balances cells and monitors cell voltage, temperature, state of charge (SOC), over-current, over-charge and provides fault detection via CANbus or RS485.

ABOUT GS BATTERY (U.S.A.) INC.
GS BATTERY (U.S.A.) INC. is a global leader in energy storage. Our batteries are manufactured to the highest standards and deliver high quality, long life and superior performance in a wide variety of mission critical applications. GS Battery's products deliver reliable battery power for Telecommunications, Energy Storage, Renewable Energy, Uninterruptible Power Supply (UPS), Emergency Lighting, Power Sports, and Automotive industries.

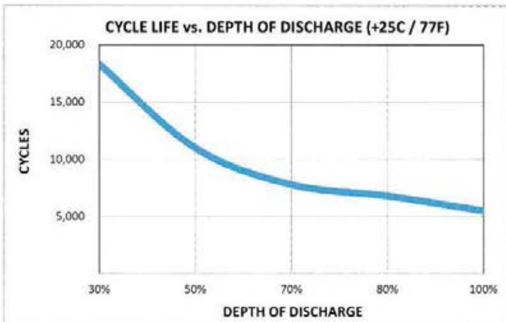
GS YUASA Group Company

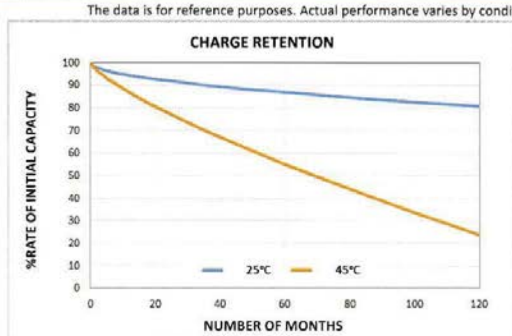
FIND OUT MORE

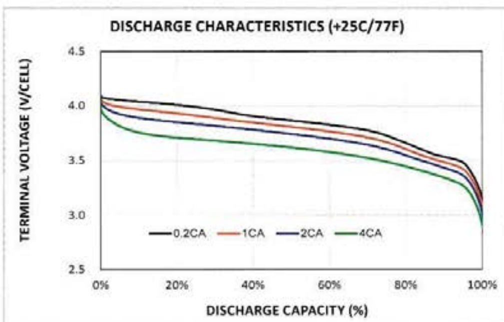
GS YUASA

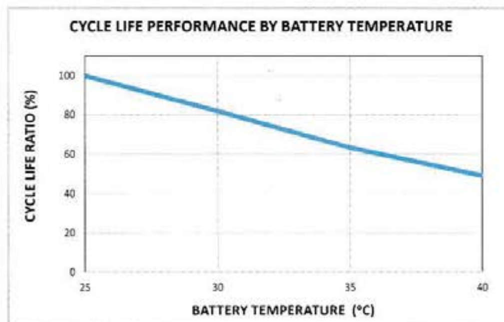
LIM50EN SERIES
Lithium-Ion Battery

The data is for reference purposes. Actual performance varies by condition.



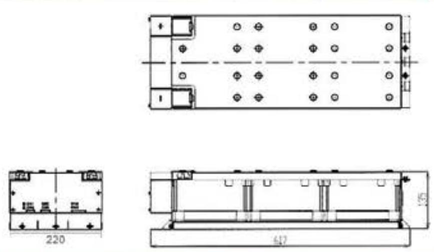


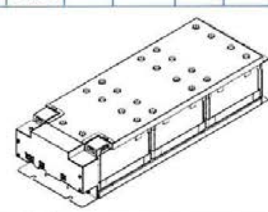




SPECIFICATIONS

MODEL NUMBER	NOMINAL VOLTAGE	RATED CAPACITY	DIMENSIONS						BATTERY WEIGHT	
			L		W		TH			
			mm	in.	mm	in.	mm	in.	kg	lbs.
LIM50EN-8S2-F2-K	29.6	47.5	440	17.32	219	8.62	128	5.04	18.0	39.68
LIM50EN-12S2-F2-K	44.4		617	24.29					27.0	59.52





Dealer Information

500-200-017 ver.2.0 3-2017

GS BATTERY (U.S.A.) INC.
1150 Northmeadow Parkway, Suite 110
Roswell, GA 30076
T 800-472-2879
www.gsbattery.com

GS YUASA Group Company

SIMPLIPHI YOUR POWER WITH AccESS to a fully integrated energy storage and management solution

- AccESS power security with safe, reliable, non-hazardous and efficient energy storage
- AccESS any power generation source with intelligent management
- AccESS your own power when and where you need it - inside or outside your home or business

Manufactured in the United States

STANDARD FEATURES
Pre-programmed ESS for backup power, peak-shaving, and self-consumption of solar PV
Internal transfer switch automatically disconnects from the grid during power outages and provides standby power for critical circuits
Outdoor rated enclosure can be free-standing, or pad-mounted
Advanced LFP batteries with a 10,000 cycle / 10-year warranty
98% round trip efficiency
Remote monitoring by web browser or mobile device app
No thermal regulation, cooling, or risk of fire
Extended operating temperature

OPTIONAL FEATURES
Solar MPPT for DC-coupled or off-grid installations
Automatic Generator control for additional standby power
Wireless gateway for cell modem or WiFi connection

SimpliPhi Power designs and manufactures efficient, non-toxic and enduring energy storage and management systems that utilize lithium ferro phosphate (LFP). Based in California, SimpliPhi combines non-hazardous LFP chemistry with its proprietary cell and battery architecture, power electronics, battery management system (BMS) and assembly methods to create safe, reliable, durable and highly scalable on-demand power solutions. Available for the residential, commercial, military and emergency response markets, SimpliPhi Power storage solutions have been rigorously tested and passed operational performance requirements by the U.S. Army and Marine Corp. Integral to all SimpliPhi Power solutions is a proprietary management system that further optimizes the life-cycle, round-trip efficiency rate, performance and durability of its batteries. SimpliPhi Power storage system components are UL certified and the PHI 3.4 kWh 24V and 48V 60 Amp batteries are ETL Certified, UL 1973 Standard.

Power. On Your Terms.™

simpliphi

420 Bryant Circle | Ojai, CA 93023, USA | +1 (805) 640-6700 | SimpliPhiPower.com

SIMPLIPHI YOUR POWER WITH AccESS to a fully integrated energy storage and management solution

APPLICATIONS

SIA (Standard Interconnection Agreement) customers: ESS allows for solar PV power to be self-consumed, curtailing PV production to prevent the export of power to the grid. Compatible with both string inverters and micro-inverters.

NEM (Net Energy Metering) customers: add standby power and peak-shaving to a new or existing net-metered solar array

Off-grid customers: ESS with 4.8 kW Solar MPPT combines power generation and energy management in a single package

SPECIFICATIONS	AccESS I	AccESS II
General		
Size	H 72 x D 16 x W 28 in (w/feet) (H 183 x D 40.7 x W 71.2 cm)	H 72 x D 16 x W 28 in (w/feet) (H 183 x D 40.7 x W 71.2 cm)
Weight	10.2 kWh - 701.3 lb / 318.10 kg	6.8 kWh - 701.3 lb / 318.1 kg
Environment	NEMA 3R Outdoor rated	NEMA 3R Outdoor rated
Operating Temperature	-4 to 122 °F | -20 to 50 °C	-4 to 122 °F | -20 to 50 °C
Mounting	Free-standing or pad-mounted	Free-standing or pad-mounted
Inverter		
Schneider Electric	Conext XW+ 6848 NA	Conext XW+ 6848 NA
Application	On / Off Grid	On / Off Grid
AC Connections	1 Grid Port, 1 Generator Port	1 Grid Port, 1 Generator Port
AC Output	30 A, 120/240 V AC, 60 Hz	30 A, 120/240 V AC, 60 Hz
Rated / Peak Power	6.8 / 8.5 kW (10.2 kWh Model)	5.5 / 7 kW (6.8 kWh Model)
Max Charge Rate	60 A AC, 7.2 kW	60 A AC, 7.2 kW
CEC Weighted Efficiency	92.50%	92.50%
Battery		
SimpliPhi Power	PHI 3.4 kWh 48VDC 60 Amp (x3)	PHI 3.4 kWh 48VDC 60 Amp (x2)
UL Rating	ETL Certified UL 1973 Standard	ETL Certified UL 1973 Standard
Capacity	10.2 kWh	6.8 kWh
Max Depth-Of-Discharge	100%	100%
Round Trip Efficiency	98%	98%
Cycle Life	10,000 @ 80% DoD	10,000
Warranty Period	10 years	10 years
Solar (select models)		
Schneider Electric Charge Controller	Conext MPPT 80 600	Conext MPPT 80 600
Output Power, Max	4.8 kW	4.8 kW
Charge Current, Max	80 A DC	80 A DC
PV Array Voltage, Operating	195 to 550 V DC	195 to 550 V DC
PV Array Voltage, Max Open Circuit	600 V DC	600 V DC
Options		
Schneider Electric	Conext AGS	Conext AGS
Wireless Gateway	Conext ComBox	Conext ComBox

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simpliphi POWER

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FEATURES AND BENEFITS – LITHIUM

BENEFIT	FEATURE
SAFETY	Inherently safe chemistry. PCB/BMS provides extra protection.
DROP-IN REPLACEMENT	Available in standard industry sizes.
LIGHTWEIGHT	50-60% less weight than lead-acid equivalent.
LONGEST LIFE	Up to 10X longer cycle life than lead-acid equivalent.
MORE USABLE CAPACITY	25-50% more capacity than lead-acid equivalent.
CONSTANT POWER	Full power available throughout discharge. Voltage does not drop like lead-acid.
TEMPERATURE TOLERANT	2.5X more efficient operation at low temperatures. Safely operational up to 149°F (65°C).
CHARGING – FAST & SAFE	Highly efficient charging. Can fully charge in 1-3 hours. Built-in overcharge protection.
PSOC TOLERANT	No damage from partial state of charge operation or storage.
LONG SHELF LIFE	Low self-discharge so battery maintains state of charge.
MAINTENANCE-FREE	Plug, play and charge. No watering.
NON-HAZARDOUS	No gasses emitted.
INSTALLATION FLEXIBILITY	Can be installed upright or on its side.
CUSTOMIZABLE	Easy to customize for your size and power needs.

LITHIUM PRODUCT SPECIFICATIONS

Part Number	BCI Group Size	Capacity @ 25°C (77°F)		Energy (Wh)	Current Capability		Dimensions inches (mm)			Weight lbs (kg)	Terminal Type
		AH	Min @ 25A		Continuous (A)	Peak (A)	Length	Width	Height		
12V - STANDARD											
RB5	NA	5	12	64	5	10	5.9 (151)	2.6 (65)	3.9 (99)	2.0 (0.9)	F2
RB10	NA	10	24	128	10	20	5.9 (151)	3.9 (98)	4.0 (101)	3.6 (1.65)	F2
RB20	NA	20	48	256	20	40	7.1 (181)	3.0 (76)	6.7 (169)	5.6 (2.55)	M6
RB35	U1	35	84	448	35	70	7.8 (195)	5.2 (131)	6.7 (171)	11 (4.8)	M8
RB40	NA	40	96	512	40	80	7.8 (197)	6.5 (166)	6.8 (173)	12 (5.4)	M8
RB50	NA	50	120	640	50	100	7.8 (197)	6.5 (166)	6.8 (173)	15 (6.7)	M8
RB75	24	75	180	960	75	150	10.2 (260)	6.6 (168)	8.6 (218)	24 (10.7)	M8
RB80	27	80	192	1024	80	160	12.0 (305)	6.6 (168)	8.6 (219)	25 (11.3)	M8
RB80-D	DIN	80	192	1024	80	160	13.2 (335)	6.9 (174)	7.5 (191)	25 (11.3)	M8
RB100	31	100	240	1280	100	200	13.0 (329)	6.8 (172)	8.8 (223)	30 (13.5)	M8
RB100-D	DIN	100	240	1280	100	200	13.2 (335)	6.9 (174)	7.5 (191)	30 (13.7)	M8
RB200	8D	200	480	2560	100	200	20.5 (520)	10.5 (267)	9.0 (228)	61 (27.7)	M8
RB300	8D	300	720	3840	100	200	20.5 (520)	10.5 (267)	9.0 (228)	83 (37.5)	M8
12V - X-SERIES (High continuous and peak performance)											
RB20-X	NA	20	48	256	50	90	7.1 (181)	3.0 (76)	6.7 (169)	5.6 (2.55)	FLAG TERMINAL
RB35-X	U1	35	84	448	70	100	7.8 (195)	5.2 (131)	6.7 (171)	11 (4.8)	M8
RB60-X	24	60	144	768	100	200	10.2 (260)	6.6 (168)	8.6 (218)	20 (8.9)	M8
12V - HP-SERIES (High peak performance)											
RB100-HP	31	100	240	1280	100	800	13.0 (329)	6.8 (172)	8.8 (223)	30 (13.5)	M8
RB100-DHP	DIN	100	240	1280	100	800	13.2 (335)	6.9 (174)	7.5 (191)	30 (13.7)	M8
RB100-DHP	DIN	300	720	3840	100	800	20.5 (520)	10.5 (267)	9.0 (228)	83 (37.5)	M8
RB100-LT (Low temperature operation)											
RB100-LT	31	100	240	1280	100	200	13.0 (329)	6.8 (172)	8.8 (223)	30 (13.5)	M8
24V - STANDARD											
RB24V50	31	50	120	1280	50	100	13.0 (329)	6.8 (172)	8.8 (223)	29 (13.2)	M8
RB24V100	NA	100	240	2560	100	200	20.5 (520)	10.5 (267)	9.0 (228)	61 (27.7)	M8
48V - STANDARD											
RB48V100	NA	100	240	5120	100	200	22.8 (578)	16.1 (410)	7.8 (197)	154 (70)	M10M
RB48V200	NA	200	480	10240	200	250	34.1 (867)	14.1 (358)	15.5 (393)	265 (120)	M10M
RB48V300	NA	300	720	15360	100	200	29.1 (740)	19.9 (506)	16.1 (408)	359 (163)	M10M

INTRODUCING THE **GRIDBANK GB35 & GB50**

THE FIRST NON-FLAMMABLE LI-ION ESS FOR C&I APPLICATIONS

The **GB35/GB50** mini Alevo ESS GridBanks™ are the most advanced Energy Storage Systems for the Commercial and Industrial Markets, offering the highest level of Safety, Robustness, Reliability and the lowest levelized cost of storage (LCOS). At the heart of the 35 and 50 kWh systems is Alevolyte™ - Alevo's patented proprietary inorganic electrolyte. Alevolyte's properties make Alevo batteries non-flammable and capable of extreme long life (50,000+ cycles), while facilitating the **GB35/GB50** to continue to provide their nameplate high power output (70 & 100 kW respectively).

The **GB35/GB50** are workhorses that are best used to insure reliability for must-run critical loads – hospitals, data centers, sensitive machinery, continuous manufacturing processes, hotels, island resorts, mines and microgrids. The **GB35/GB50** are perfect for DC fast charging stations for EVs due to their high power and non-flammability.

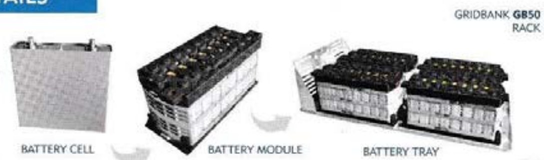
Alevo can provide a custom needs assessment and develop an energy storage solution that best suits your needs. Get the conversation started at **www.alevo.com/gridbank/RFP**.

COMMERCIAL & INDUSTRIAL
Peak Shaving
(Demand Charge Mitigation)
Renewables Integration
Backup Power

UTILITIES
Substation Backup Power
Voltage Support
T&D Deferral

ENERGY STORAGE SYSTEM DETAILS

ALEVOLYTE – INORGANIC ELECTROLYTE INSIDE – At the heart of each ESS is Alevo's inorganic electrolyte which cannot burn or explode. See for yourself at **www.alevo.com/demo**.



- Multiple ESS can be stacked to meet capacity needs
- Can be configured to meet various voltage needs
- Compatible with domestic and international voltage
- Battery management system included

GRIDBANK GB35

35 kWh / 70 kW	
8 Cells per Module	4 Modules per Tray
0.616 kWh per Module	2.5 kWh per Tray
2 Trays per Shelf	7 Shelves

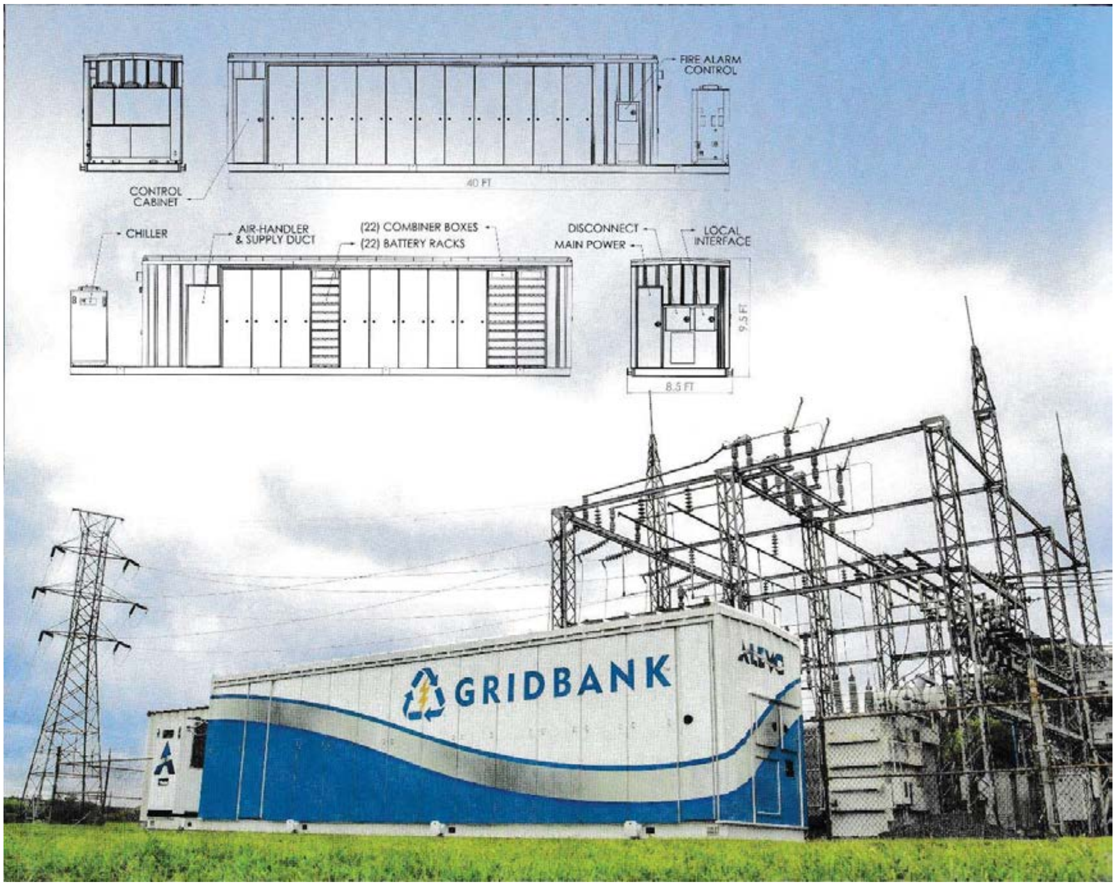
GRIDBANK GB50

50 kWh / 100 kW	
8 Cells per Module	4 Modules per Tray
0.616 kWh per Module	2.5 kWh per Tray
2 Trays per Shelf	10 Shelves

TECHNICAL SPECIFICATIONS

External Ambient Temperature Range	-20°C - 45°C (-4°F - 113°F)
Internal Relative Humidity	20% - 80%
Internal Storage Temperature Range	10°C - 30°C (50°F - 86°F)
Extended Storage Temperature Range	10°C - 50°C (50°F - 122°F)
Dimensions	84" x 35.5" x 35.5" (**GB35**) 108" x 35.5" x 35.5" (**GB50**)
Electrical Rating	Rack DC Power: 800 – 1150 VDC 2C Charge – 89 A average - 30 mins 4C Discharge – 178 A average - 15 mins

ALEVO
REDEFINING ENERGY
www.alevo.com


FIRE ALARM CONTROL
CONTROL CABINET
40 FT
CHILLER
AIR-HANDLER & SUPPLY DUCT
(22) COMBINER BOXES
(22) BATTERY RACKS
DISCONNECT
MAIN POWER
LOCAL INTERFACE
9.5 FT
8.5 FT
GRIDBANK

THE ALEVO GRIDBANK STORAGE SYSTEM

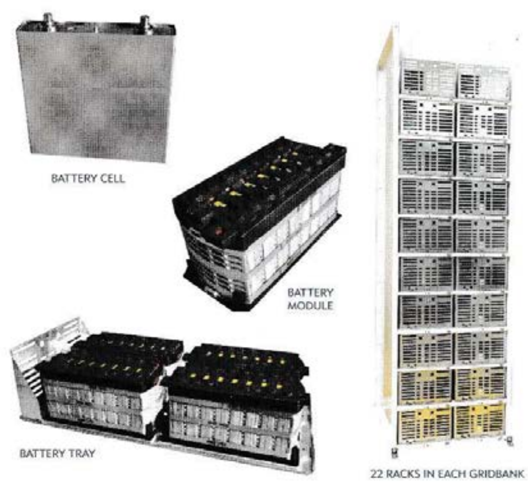
The GridBank is a fully integrated and vertically engineered storage system. Alevo's GridBank storage system contains 22 separate rack doors and is designed to be easily maintained with direct access to individual battery racks. By accessing isolated racks from outside the container, servicing a GridBank by qualified technicians is possible without turning off the entire system, ensuring more uptime and increased operator safety.

When fully loaded, each GridBank storage system contains 2 MW / 1MWh. GridBanks are a scalable solution which can also be installed without an enclosure using specialized racks that can be housed in existing structures or custom builds.

Designed & Engineered for Maximum Uptime

EACH 2MW GRIDBANK CONTAINS:

14,080 Battery Cells	8 Cells per Module
1,760 Battery Modules	4 Modules per Tray
440 Battery Trays	2 Trays per Shelf
220 Shelves	10 Shelves per Rack
22 Racks per GridBank	TOTALING: 2 MW / 1 MWh



GRIDSTAR™ LITHIUM-ION ENERGY STORAGE SYSTEM

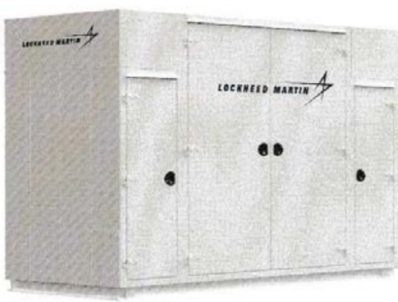
Turn-key energy storage for commercial, industrial, and utility applications

- Demand Charge Reduction
- Renewables Integration
- Transmission and Distribution Investment Deferral
- Frequency and Voltage Regulation
- Microgrid Support

Complete solution. Compact package.

Offering you:

- Ease of installation and compact footprint
- Flexibility – modular in 100-375 kW_{AC} and 200-600 kWh_{AC} increments
- Scalability – simple to scale up to MW-class applications
- AC-coupling of multiple energy storage units
- Full Lockheed Martin warranty



Contact Information:
storage@lmcoenergy.com, (617) 374-3797 x234
www.lockheedmartin.com/energystorage

GridStar™ Li-Ion Energy Storage Unit Specifications

System Description	Turn-key outdoor-rated energy storage system including AC/DC protection, power conversion, energy storage, thermal management, and controls
Maximum AC Power	100 kW to 375 kW configurations
Maximum Energy Capacity	200 to 600 kWh AC; beginning of life
Round Trip Efficiency	>90%
Footprint	5' D x 12' L x 8' H
Weight	<17,000 lbs (7,711 kg)
Storage Type	Lithium-ion
Power Interface	480VAC, 3-phase 3-wire standard (4-wire optional)
Control Interface	RS-485 / Modbus, Ethernet / Modbus TCP
Control	Compatible with Lockheed Martin or 3rd party provided
Warranty	3-year standard, 10-yr option available
Ambient Operating Temp	-22° to 122°F (-30 to 50°C)
Enclosure	NEMA 4X

Certifications

System	UL 9540 design
Inverter	UL1741, IEEE 1547
Battery Cell	UL 1642

Note: Product specifications are subject to change without notice.

LOCKHEED MARTIN

Trinabess
Battery Energy Storage Systems

TrinaCommercial

Trina Energy Storage Solutions for Commercial Installations.

Key Features

Safety

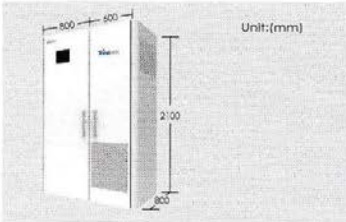
- Passes strict safety regulation(UL, CE, RoHS)
- Anti-islanding protection
- 10-year warranty

Multi-function

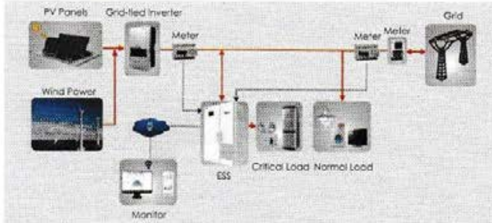
- Reduces electricity bills by reducing contracted power
- Acts as a valuable asset for Energy Arbitrage
- Frequency regulation

Trinabess
Battery Energy Storage Systems

Dimension



On Grid Mode



Specifications

Battery Inverter (PCS)			
AC Side (Output)			
Rated Output Power	50kW	100kW	150kW
Output Voltage		480Vac(423~528Vac)	
Output Frequency		60Hz(59.5~60.5Hz)	
Rated Output Current	60A	120A	180A
Max. Output Current	66A	132A	198A
Out Put PF		0.8 leading to 0.8 lagging	
DC Side (Battery Input)			
Operation Voltage Range		520~900Vdc	
Rated Charging Current	77A	154A	231A
Max. Charging Current	100A	200A	300A
Rated Discharging Current	77A	154A	231A
Max. Discharging Current	100A	200A	300A
PCS Other Parameters			
IP Protection Class		IP 21	
Noise		< 55dB	
Dimension(W*H*D)		800*2160*800mm	
Weight	450KG	550KG	780KG
Cooling		Forced Air Cooling	
Certificate		UL 1741, IEEE 1547, UL 9540	
Battery Packs			
Battery Capacity	50kWh, 100kWh, 150kWh	100kWh, 200kWh, 300kWh	200kWh, 300kWh, 400kWh
Nominal Voltage	772.5V	772.5V	772.5V
DOD		90%	
Cycle Life		>8000	
Dimension(W*H*D)		600*2160*800mm	
Communication		Ethernet, CAN 2.0, RS485	
Certificate		UL 1642, UL 1973	
IP Protection Class		IP 21	
System			
Warranty		5 years product, 10 years battery performance	
Operating Temperature Range		0 ~ 45℃ (-10~0℃ with derating)	

CAUTION: READ SAFETY AND INSTALLATION INSTRUCTIONS BEFORE USING THE PRODUCT.

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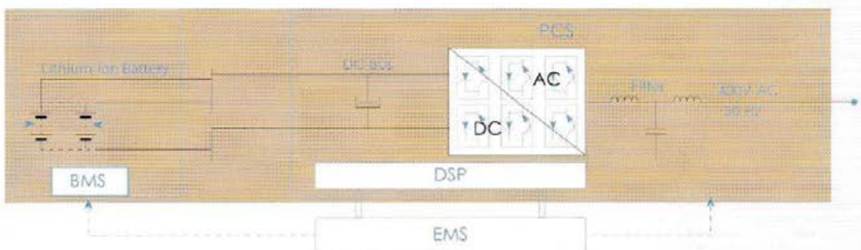
Trinabess
Battery Energy Storage Systems

SYSTEM DIAGRAM

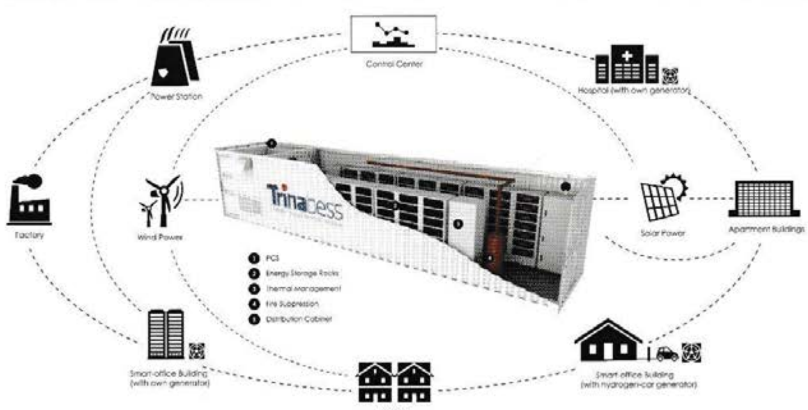


TECHNICAL DATA

Model	TrinaMega
Energy Storage	**2 MWh / Container**
Power Rating (kW)	500 / 2,000
AC Voltage (V)	400
Grid Frequency (Hz)	50/60
THD	< 3%
Operating Temperature Range (℃)	-20~50
Protection Level	IP54
Dimension(mm)	12,192*2,438*2,896 (40' HQ)

500kWh~2MWh	15Minutes~4+ Hours	~88%	Fast Sub-second
Capacity Scalability	Duration	System Efficiency (AC~AC)	Response Time

APPLICATION



CAUTION: READ SAFETY AND INSTALLATION INSTRUCTIONS BEFORE USING THE PRODUCT.

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~$200K / unit

ESS INC ENERGY STORAGE SYSTEMS

50kW/400kWh Energy Warehouse™

THE MOST SUSTAINABLE LONG-DURATION STORAGE CAPACITY AT THE LOWEST LCOS

ENERGY STORAGE FOR CRITICAL PROJECTS

Utilizing earth-abundant iron, salt and water for its electrolyte, and simple materials for battery components, the Iron Flow Battery (IFB) from ESS Inc. is a durable, environmentally-safe, long-duration storage solution that is ideally suited for:

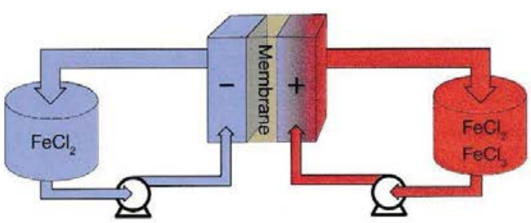
- time-shifting renewable energy on a daily basis,
- managing a facility's demand or TOU charges, and
- smoothing the intermittency of renewables on a constrained grid.

The IFB has a lifespan that exceeds 20,000 cycles, has low maintenance requirements, and an energy capacity of over 6 hours. It matches well with the 25-year life span of solar and wind projects, supporting those applications' low levelized cost of energy (LCOE) requirements.

Concurrent with serving these applications, the IFB's inherent quick-response power electronics can perform ancillary services such as voltage and frequency support on microgrids and utility-scale applications.

TECHNOLOGY

All-iron redox (reduction-oxidation) flow battery technology by ESS is based on the elegant simplicity of the electrochemical ferrous/iron plating reaction on the negative side and the ferrous/ferric redox reaction on the battery's positive side.



Negative side — plating side   Positive side — redox side

ALL-IRON FLOW BATTERY

Each ESS Iron Flow Battery system is built in a 40' long by 9'6" high customized shipping container housing. Separate containers can be stacked to conserve space.

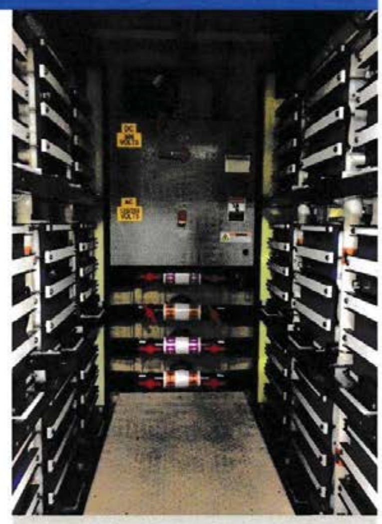
FEATURES AND BENEFITS

- Cost-effective, made of Earth's basic elements
- Environmentally safe, non-toxic electrolyte
  - Non-flammable - No corrosive acids
  - No hazardous materials - No noxious fumes
- Long-duration storage (over 6 hours) smoothes renewables output, and reduces demand charges.
- Provides flexibility for power and energy use cases
- Long life, >20,000 cycles, low maintenance
- Transports preassembled anywhere worldwide
  -The electrolyte can be hydrated onsite

50kW/400kWh All-Iron Flow Battery – Delivering 8+ hours of flexible energy storage

SPECIFICATIONS

FEATURE	DATA	Notes
Electrical		
Power	50 kW (AC)	
Energy Capacity	400 kWh	100% available
AC Interface	480 VAC, 3-phase	
Communications	Remote Monitoring 3rd Party Data/control	Proprietary interface Modbus interface
Mechanical		
Enclosed ISO Container Dimensions	40'L x 8'W x 9' 6"H	Turnkey AC system
Weight (Dry)	12,700 kg	
Weight (Wet)	33,200 kg	
Environmental		
Battery	Recyclable components	
Electrolyte	$FeCl_2$, KCl, H_2O	Non-flammable, non-corrosive
Operating Temperature	-5°C to +50°C	Can extend range with active temperature control
Warranty	Comprehensive 20-Year	With continuous extended Service Agreement
Certification	NRTL Field Certification UL	Meets AHJ requirements Pending
Performance		
Cycle Life	>20,000 cycles	To 100% DOD
AC/AC Peak Roundtrip Efficiency	>70%	80% DOD cycles
Response Time	Full power in <1 sec.	From standby, inverter limited



Each Iron Flow Battery and its AC electronic components are housed in a shipping container for transportability and protection from the elements.

For more information, contact:

ESS INC ENERGY STORAGE SYSTEMS

ESS, Inc.
SW Upper Boones Ferry Rd.
Portland, Oregon 97224

Tel: (855) 423-9920
Email: info@essinc.com

www.essinc.com

ViZn ENERGY

GS200 PRODUCT SHEET

Engineered for Safety. Non-toxic, non-explosive, non-flammable, the GS200 Energy Storage System is self-contained, modular storage system delivering the most cost effective and safest energy storage on the market. The Zinc/Iron redox flow incorporates the most efficient and worry free non-acid chemistry available today. The flexible GS200 modules can be interconnected for higher power and energy requirements.

- High power, short duration: Quick response and millisecond (ms) switching between charge and discharge cycles make the GS200 suitable for rapid response applications such as frequency and voltage regulations requiring high power.
- High capacity, long duration: High endurance redox design provides flexible State-of-Charge (SOC) output even during the most punishing duty cycles without SOC limits or capacity fade. Greater than eight hours discharge at nominal rated power output, and 2.4 hours continuous discharge at maximum rated power output.
- State of Charge access: The GS-200 process allows for 100% dynamic range of the SoC. This access to full capacity of the battery without damage gives the GS200 significantly more useable output than competitive batteries.
- Heavy-duty cycle: ViZn's flow battery can cycle at high frequency and at high power several times per day without the ill effects of overheating which enables it to support simultaneous revenue grade applications without reducing the battery life.
- Safety: ViZn flow batteries are manufactured with non-toxic, non-explosive and non-flammable materials. The batteries do not pose a risk to people, communities or the environment.
- Value: The unique combination of long cycle life, plus high power and high capacity in the ViZn flow battery offers the best value for utility, micro-grids and commercial & industrial applications

Battery stacks
Designed using abundant, inexpensive materials

Low cost alkaline chemistry
Inherently safe, non-toxic, non-flammable, non-explosive

High quality seamless tanks
Rotomolded high strength polypropylene

Rapid ROI
Low O&M,
20-year life, multi-use

ViZn ENERGY

GS200 SPECIFICATION


GS200 1 MW 1.0 MW/3.0 MWh (5 units)

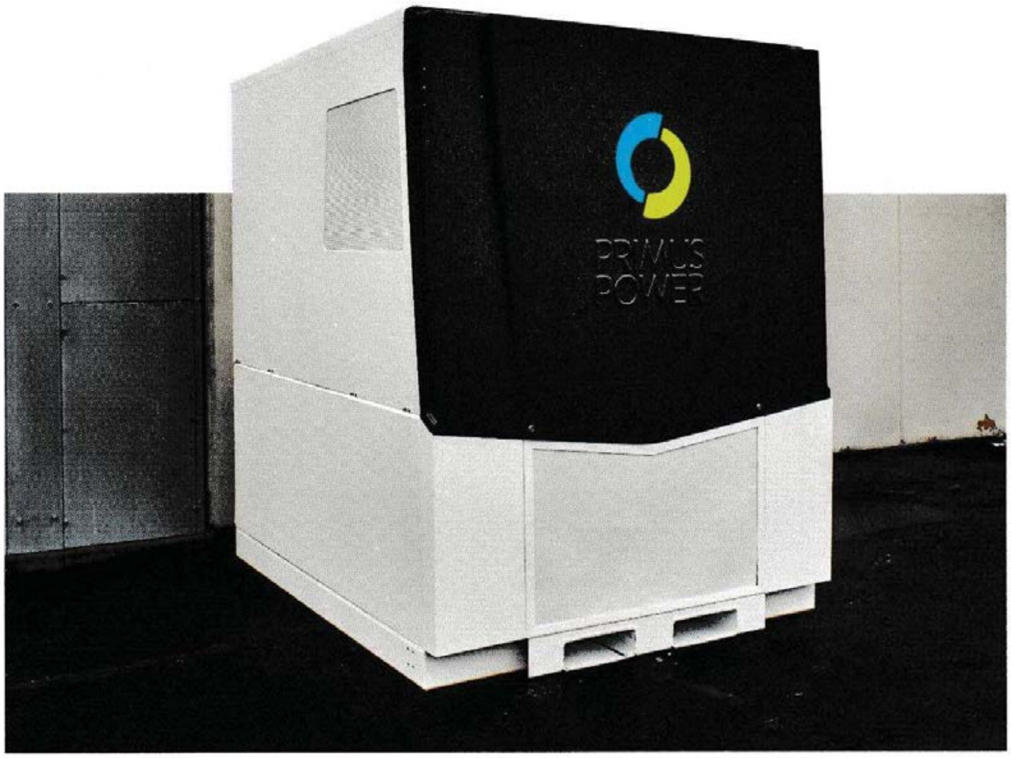

GS200 1.4 MW/4.2 MWh (7 units)

GS200 (MW)	Nominal Power (kW)	Maximum Power (kW)	Maximum Energy (kWh)	Minimum DC Voltage	Maximum DC Voltage	Hours @ Maximum Power	Hours @ Nominal Power
1.0	340	1,000	3,000	400	625	2.4	8.8
1.2	400	1,200	3,600	480	750	2.4	8.8
1.4	470	1,400	4,200	560	875	2.4	8.8

ESU ELECTRICAL (TYPICAL 1 MW INSTALLATION)	
Life-time	10,000 cycles @ 100% DOD - 20 years
Maximum power	1,000 kW
Energy	3,000 kWh
Duration at maximum power	2.4 hours
Nominal power	340 kW
Duration at nominal power	8.8 hours
Charge to Discharge switching time	<25 ms
DC voltage range (nominal min/max)	400/625 VDC
DC current range (nominal min/max)	470/700 A
Max DC current	2,400 A
ESU efficiency - AC/AC	74% at nominal power
ESU efficiency - DC/DC	90% at nominal power
Auxiliary power required	480 VAC, 60 Hz, 3 Phase

ESU MECHANICAL AND OPERATING	
Communication	USB, 485, Modbus Ethernet
External operating temperature	-10° C to 45° C (14° F to 113° F)
Internal ambient temperature	10° C to 50° C (50° F to 122° F)
ESU weight power module	18,900 lbs (8,573 kg)
ESU weight energy chemistry module dry/wet	5,000 lbs/120,000 lbs (2.270 kg/54,431 kg)
Safety/Regulatory	Compliant with UL, CSA and CE requirements

PRIMUS POWER
Carbon Free Cloud™



ENERGYPOD® 2

LONG DURATION ENERGY STORAGE

Multi-hour duration, full power

Multi-decade life

No electrode stack replacement

No fire risk

ENERGYPOD® 2

Key Applications

- Peak shaving
- Bulk energy shifting
- Renewables integration
- Smart grid support
- Islanding/black start

Options

- Cold weather package
- Hot weather package
- Black start
- Hybrid flex flow
- Primus Energy Management System (PEMS)
- Multiple front cover color options

All options packaged within EnergyPod enclosure

TECHNOLOGY

Battery type	Zinc bromide flow battery
Electrodes	Titanium
Cell architecture	No separator/membrane
Flow architecture	Single tank, single pump, single flow loop

PERFORMANCE

Rated power	25 kW
Rated discharge energy *At rated power*	125 kWh
EnergyPod efficiency *Roundtrip DC incl. auxiliaries at 25°C ambient*	70%
Depth of discharge	100%

PHYSICAL

Dimensions	1.8 x 2.1 x 2.2 m
Mass	4,200 kg
Handling/transport	Forklift, pallet jack, crane, standard ISO shipping container

COMMUNICATIONS

Supported protocols	TCP/IP, Modbus over TCP/IP or RS485, DNP3, SCADA, Open ADR, CAN Open and OPC Server

ENVIRONMENTAL

Ambient temperature *With base package*	-5°C to 40°C
Ambient temperature *With optional cold and hot weather packages*	-30°C to 50°C
Humidity	Non-condensing
Enclosure	IP54/NEMA 3S
Seismic	IEEE 693

STANDARDS

Designed to comply with: UL 9540, UL1973, NFPA 70, IEEE 693

PRIMUS POWER
Carbon Free Cloud™

Specifications are subject to change without notice.

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www.primuspower.com

Primus EnergyPods use non-flammable zinc bromide electrolyte with safety risks lower than most other batteries

National Fire Protection Association Hazard Ratings
0 = lowest hazard level
4 = highest hazard level

	Health		Flammability		Instability		Specific Hazard	
Primus EnergyPod	3	Can cause permanent injury	0	Will not burn	0	Stable	COR	Corrosive
Li Ion	3	Can cause permanent injury	2	Flash point 38°C to 93°C	2	Violent chemical change at high T or P	W	Reacts violently with water
Vanadium flow	3	Can cause permanent injury	0	Will not burn	2	Violent chemical change at high T or P	COR	Corrosive
Sodium sulfur	3	Can cause permanent injury	0	Will not burn	2	Violent chemical change at high T or P	W	Reacts violently with water
Lead acid	3	Can cause permanent injury	2	Flash point 38°C to 93°C	1	Can become unstable at high T or P	COR	Corrosive

National Fire Protection Association standard 704 diamond shown. Primus Power safety rating analysis performed by Hazard Solutions, Inc. Spring 2015

PRIMUS POWER