Apollo Sunguard

Effects of Sun Shading on Electric Vehicle Battery Temperature and Energy Consumption

November 2012

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Acronyms

°C	Degrees Celsius
°F	Degrees Fahrenheit
A	Amp
AC	Alternating Current
Avg	Average
BMS	Battery Management System
CAN	Controller Area Network
DC	Direct Current
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
Hz	Hertz
kW	Kilowatts (power)
kWh	Kilowatt-hours (energy)
m	Minutes
s	Seconds
SOC	State of Charge
V	Volt
W	Watts (power)
Wh	Watt-hours (energy)

1 EXECUTIVE SUMMARY

This study was initiated on behalf of Apollo Sunguard Systems, Inc. to verify the effects of the X12 model sunshade on electric vehicle (EV) charging, cabin cooling, and battery temperature. The study was conducted on September 30th, 2012 with ambient temperatures reaching a high of 111 °F. The subject of the test was the Apollo Sunguard X12 sunshade featuring black polyethylene Rachel Knitted Mesh fabric with 96% ultra violet block and 95% shade factor. Other equipment used for this undertaking included two identical white Nissan Leaf SL model EVs equipped with data loggers and charged using Blink AC Level 2 wall-mount electric vehicle supply equipment (EVSE) units. For the study, one EV was fully charged while covered by the shade while a second EV was fully charged while exposed to direct sunlight; the total energy input for the vehicles was then compared. Following this initial test, the climate controls for both EVs were set to maximum cooling and measurements were made to compare the total energy output and time to bring the vehicle cabin temperature to a fixed value.

The results of this study reveal that the parking shade kept the EV battery 5.4 °F (3 °C) cooler – when compared to the unshaded EV – throughout the course of both charging and vehicle cabin cooling events. Furthermore, battery signals from the vehicle CAN show the battery temperature of the unshaded EV exceeded ambient temperatures after five hours of charging, whereas the shaded EV's battery temperature remained below ambient temperatures throughout the charging event.

The two vehicles were prepared for the charge event in the same manner, but it is very difficult to achieve identical beginning states of charge (SOCs). The beginning SOCs for the unshaded and shaded EVs were 16.5% and 14.6%, respectively. In order to obtain a comparison of equal charge events, the portion of the charge data that brought the shaded EV to 16.5% was truncated. This is considered justifiable because despite the fact that the algorithm used to calculate SOC is unknown, the difference in battery voltages throughout both charge events were within 0.25% on average. The charge event was considered complete when the CAN battery current reached zero. The ending SOCs for the unshaded and shaded EVs were 95.0% and 95.1%, respectively. The data beyond 95% for both EVs are truncated using the same rationale as before. Using the two like charge event data, the shaded EV required 14 minutes less to completely charge the battery and the charge event consumed 7.7% less energy versus the EV exposed to direct sunlight.

For the cabin cooling event, the shaded EV required 15 minutes less cabin cooling time and 26.5% less energy to reach 70 °F. For higher cabin temperatures, the cooling efficiency for the shaded EV was significantly greater.

2 INTRODUCTION

This report examines the effects of sun shading on Electric Vehicle (EV) battery temperature and energy consumption during charging and cooling events. The report begins with a review of the methodology used for data collection during tests conducted on the Apollo Sunguard X12 sunshade, and covers a series of three separate tests conducted during the study period examining the effects of the sunshade on battery temperature, charging energy input and time, and vehicle cabin cooling energy output and time. The study results reflect a net time and energy savings associated with the use of the sunshade for both charging and cooling when compared to an EV exposed to direct sunlight.

3 OBJECTIVES

The following are the objectives of the Effects of Sun Shading on EV Battery Temperature and Energy Consumption study:

- Collect and record the traction battery temperature over time for shaded versus unshaded EVs.
- Quantify energy input and charging time required for shaded versus unshaded EVs during a battery charging event based upon real-world conditions.
- Quantify energy output, cabin temperature, and cooling time required for shaded versus unshaded EVs during a vehicle cabin cooling event based upon real-world conditions.

4 METHODOLOGY

Tests conducted for the Effects of Sun Shading on EV Battery Temperature and Energy Consumption study were carried out at the ECOtality North America vehicle testing facilities in Phoenix, Arizona. The tests were carried out on September 30th, 2012 between 11:00 am and 7:00 pm. The test date was selected to ensure ambient temperatures would be in excess of 90 °F with minimal cloud coverage.

Data collected for the tests were obtained using the X-12 model parking semi-cantilever shade fabric manufactured by Apollo Sunguard Systems, Inc. According to specifications provided to ECOtality by Apollo Sunguard Systems, the shade fabric used is a black panel polyethylene Rachel Knitted Mesh with 96% ultraviolet block, 95% shade factor. The shade fabric was mounted on a temporary canopy frame structure and cast shadows of approximately 9' by 20' depending upon the time of day and angle of the sun. Figure 1 below provides a graphical representation of the orientation of the X-12 parking shade (the grayed area) and the test vehicles.

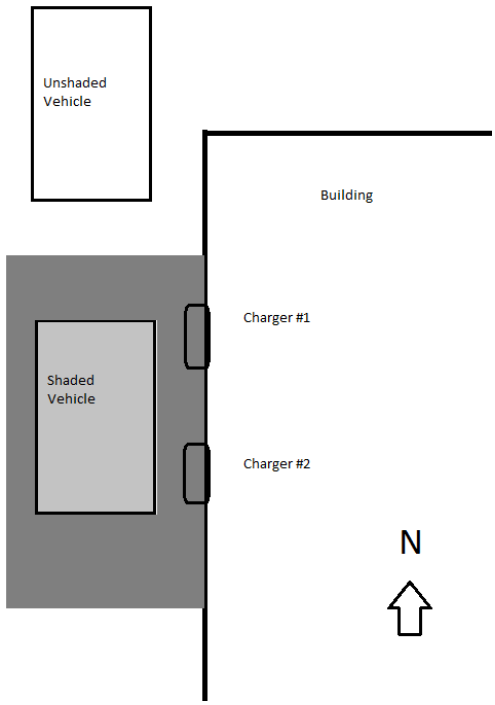

Figure 1: Vehicle shade testing diagram

This study was conducted using two identical, white 2012 Nissan Leaf SL model EVs. The Nissan Leaf EVs feature a battery pack with a rated capacity of 24 kWh. Prior to the study, the EVs were driven on a prescribed test route until the vehicle batteries were depleted to "turtle mode". The vehicles were then parked overnight and through the morning in an unshaded area to receive a direct solar thermal load soak. Upon completion of the preliminary thermal load soak, the vehicles were then parked adjacent to each other, facing south in such a way as to allow one vehicle to be shaded 100% during the test period while the other vehicle was exposed to direct sunlight.

Each vehicle was equipped with a wireless ISAAC data logger connected to the vehicle Controller Area Network (CAN) bus to collect real-time data over the test period at a sampling rate of 1 Hz. To conserve file size, raw 1 Hz data was sampled at one minute intervals. Four thermocouples were also placed at the top and bottom of each EV battery pack, at the front bumper of the vehicle to collect ambient temperature, and in the vehicle cabin to collect cabin temperatures. Measurements of the battery current and voltage were also taken to derive the battery power and energy input/output in accordance with Watt's Law. Table 1 below displays the resolution and accuracy information for the data loggers:

Table 1: ISAAC Data Logger specifications

Measurement	Resolution	Accuracy
Time	0.1 Seconds	± 0.1%
Temperature	2 °F (1 °C)	± 2 °F (± 1 °C)
Battery Current	0.5 Amps	± 1 A
Battery Voltage	0.5 Volts	± 1 V

The EVs were charged using wall-mount AC Level 2 Blink electric vehicle supply equipment (EVSE) units rated at 240 V/30 A (7.2 kW).[1] The pass through power from the Blink EVSE is limited to only 3.3 kW by the Leaf on-board charger, which converts electricity from alternating current (AC) to direct current (DC) for delivery to the EV battery. The vehicle charging event lasted approximately six hours and was followed immediately by the vehicle cabin cooling event, which consisted of setting vehicle climate controls to the maximum cooling settings and measuring the elapsed time and energy output required to reach a constant 65 °F internal temperature.

[1] The Blink units are depicted as Charger #1 and Charger #2 in Figure 1.

5 FINDINGS

The following section includes details on each test conducted.

5.1 Battery Temperature

Ambient temperatures during the study period ranged from a low of 91 °F to a high of 111 °F in direct sunlight and a low of 86 °F to a high of 106 °F in the shade – a difference of 5 °F over the range of values. However, a more significant measurement of temperatures insofar as EVs are concerned is the temperature of the battery pack. Table 2 provides a snapshot of shaded versus unshaded battery temperatures during the charging and cooling events.

Table 2: Shaded versus unshaded battery temperatures

Battery Temp		Shaded		Unshaded	
		°F	**°C**	**°F**	**°C**
Charging	Max	100.40	38.00	105.80	41.00
	Avg	92.59	33.66	95.66	35.36
	Min	87.80	31.00	89.60	32.00
Cooling	Max	100.40	38.00	105.80	41.00
	Avg	100.40	38.00	105.74	40.97
	Min	100.40	38.00	104.00	40.00

During the charging event, the maximum battery temperature in the shade reached 100 °F (38 °C) versus a maximum battery temperature of 105.8 °F (41 °C) in direct sunlight – a difference of 5.4 °F (3 °C) over the range of values. During the cooling event, the shaded battery temperature held at a constant 100 °F (38 °C) while the unshaded battery varied between 104 °F (40 °C) and 105.8 °F (41 °C) – a similar difference of up to 5.4 °F (3 °C) during the cooling test. While it is suspected that decreased battery temperatures for EVs will extend the useable life of the battery, quantifying this battery life improvement is beyond the scope of this study.

Figure 2 below is a graphical representation of the ambient temperature (in degrees Celsius) over time in comparison to the shaded and unshaded battery temperatures during the charging event. The temperature differential between shaded and unshaded batteries was 1 °C (a difference of 3%) at the start of the test and grew to 3 °C (7.5%) by the end of the test period. It should be noted that the battery temperature measurements in the graph rise in a step-wise manner due to limitations in the resolution of the data loggers and the signals received from the Battery Management System (BMS). Were a resolution beyond 1 °C available, the graph would likely show a rise in battery temperatures resembling something curvilinear as opposed to step-wise.

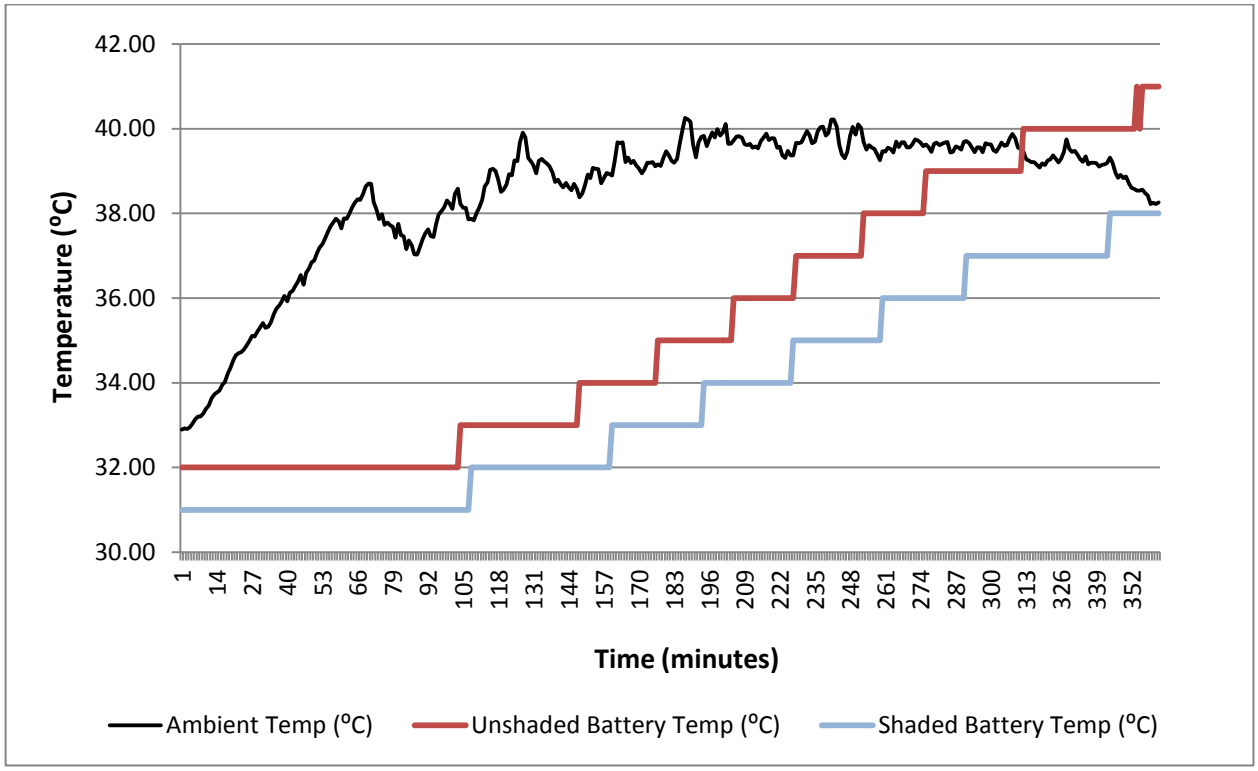

Figure 2: Ambient and vehicle battery temperatures over time

Another important finding from the data presented in Figure 2 is that the battery temperature of the unshaded EV actually exceeded the ambient temperature at approximately 310 minutes (5 hours) into the charge event, while the battery temperature for the shaded EV remained below the ambient temperature over the entire test period.

5.2 Energy Input During Charging Events

When considering changes in total energy, it is important to establish a baseline so that all measurements of energy changes are made relative to a set value. For this test, the battery SOC is used for baseline purposes. The battery SOC is a percentage measurement of total energy available in the battery pack. The unshaded EV started the charging test at an SOC of 16.5% while the shaded EV started the test at an SOC of 14.6%. The charge event is considered complete when the battery current on the CAN bus reaches 0 A. The unshaded EV battery was brought to a total SOC of 95.0%, while the shaded EV battery was brought to a total SOC of 95.1%. The lower beginning SOC and higher ending SOC for the shaded EV means that more energy was added to the shaded EV to fully charge the battery. To adjust for this difference so that a comparison between the two charge events can be made, the initial and ending portions of the shaded EV energy consumption during the charge

test are removed so that both EVs are evaluated from an initial SOC of 16.6%; the result will be referred to as adjusted energy input.[2]

The total adjusted charge time for the shaded EV was five hours and 45 minutes while the unshaded EV charged for an additional 14 minutes, for a total of five hours and 59 minutes. The energy transfer rate from charger to battery reached a maximum of 3.514 kW at four hours and 45 minutes and 3.344 kW at five hours and 24 minutes for the unshaded and shaded EVs, respectively, while the average energy transfer rate was 3.2 kW and 3.1 kW for the unshaded and shaded EVs, respectively. The cumulative adjusted energy input for shaded and unshaded EVs is presented in Figure 3 below.

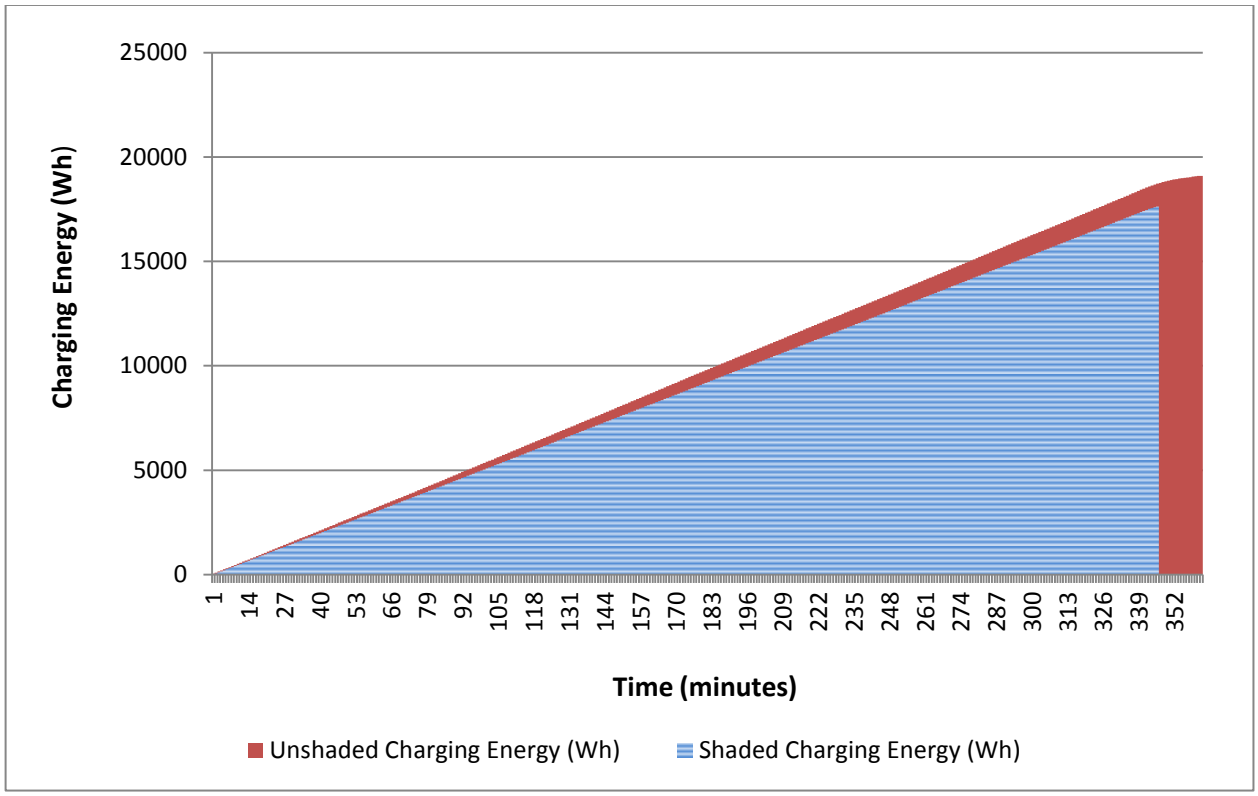

Figure 3: Shaded versus unshaded EV charging energy input

Charging energy input for the shaded EV is reflected in the blue triangle, while the red area shows energy input for the unshaded EV. The total energy input to the unshaded EV was 19.1 kWh while the total adjusted energy input supplied to the shaded EV was only 17.7 kWh – a 7.7% energy savings for the charging event.

[2] The non-adjusted data is available in Appendix A of this report. The shaded energy input values excluded for a baseline SOC of 16.6% are grayed out in the column on the right. The voltages of the two EV batteries were compared against the SOC values throughout the two charge events and were seen to be less than 0.25% on average. The algorithm for the battery SOC calculation is unknown; however, the assumption is made that the truncation of the data is justified because of the voltage match.

Charging time and adjusted energy input data by 10% SOC increments for the shaded and unshaded EVs are presented in Table 3 below. The maximum energy savings for the shaded versus unshaded vehicle occurred at the 20% SOC interval where the shaded EV was found to charge five minutes more quickly and requires 26% less energy. The efficiency gains for the shaded EV decrease to a minimum 5.77% difference versus the unshaded EV at 60% SOC – note that this time value occurs very near the peak in ambient temperatures from Figure 2.

Table 3: Time and energy input to battery by SOC

	Shaded		Unshaded		Time Savings	Energy Savings
SOC	**Minutes**	**Wh**	**Minutes**	**Wh**	**Minutes**	**%**
20%	19	966	24	1308	5	26.15%
30%	65	3298	69	3712	4	11.15%
40%	90	4572	95	5129	5	10.86%
50%	126	6414	129	6984	3	8.16%
60%	175	8919	174	9465	-1	5.77%
70%	224	11433	224	12169	0	6.05%
80%	273	13955	276	14989	3	6.90%
90%	320	16378	323	17550	3	6.68%
95%	345	17626	361	19096	16	7.70%

5.3 Energy Output During Cabin Cooling Events

The cabin temperature of the EV at the start of the cooling test was 106 °F in the shaded EV and 121.86 °F in the unshaded EV. The total cooling time to reduce the shaded EV cabin to a temperature of 70 °F was 24 minutes versus 39 minutes for the unshaded EV. Table 4 displays data on the total cooling time (in minutes and seconds) and energy output (in Wh) required to bring the cabin temperatures of the shaded and unshaded EVs below the temperatures listed on the left:

Table 4: Total Time and Energy Output by Cabin Temperature

Cabin Temperature	Shaded		Unshaded		Time Savings	Energy Savings
(°F)	**mm:ss**	**Wh**	**mm:ss**	**Wh**	**mm:ss**	
121.86°	N/A	N/A	0	0	0	0
Below 110°	0:00	0	00:58	28.4	0:58	100.0%
Below 100°	0:55	26.5	03:06	92.4	2:11	71.3%
Below 90°	2:30	83.3	10:30	315.7	8:00	73.6%
Below 80°	8:46	311.0	22:26	682.5	13:40	54.4%
Below 70°	24:15	864.9	39:20	1177.0	15:05	26.5%
65°	44:58	1461.54	61:03	1643.6	16:05	11.1%

The unshaded EV required 1,177 Wh of energy output to cool the vehicle cabin to 70 °F, while the shaded EV required only 865 Wh – an energy savings of 26.5%. A graphical presentation of the energy output versus cabin temperature in the EVs is presented in Figure 4 below.

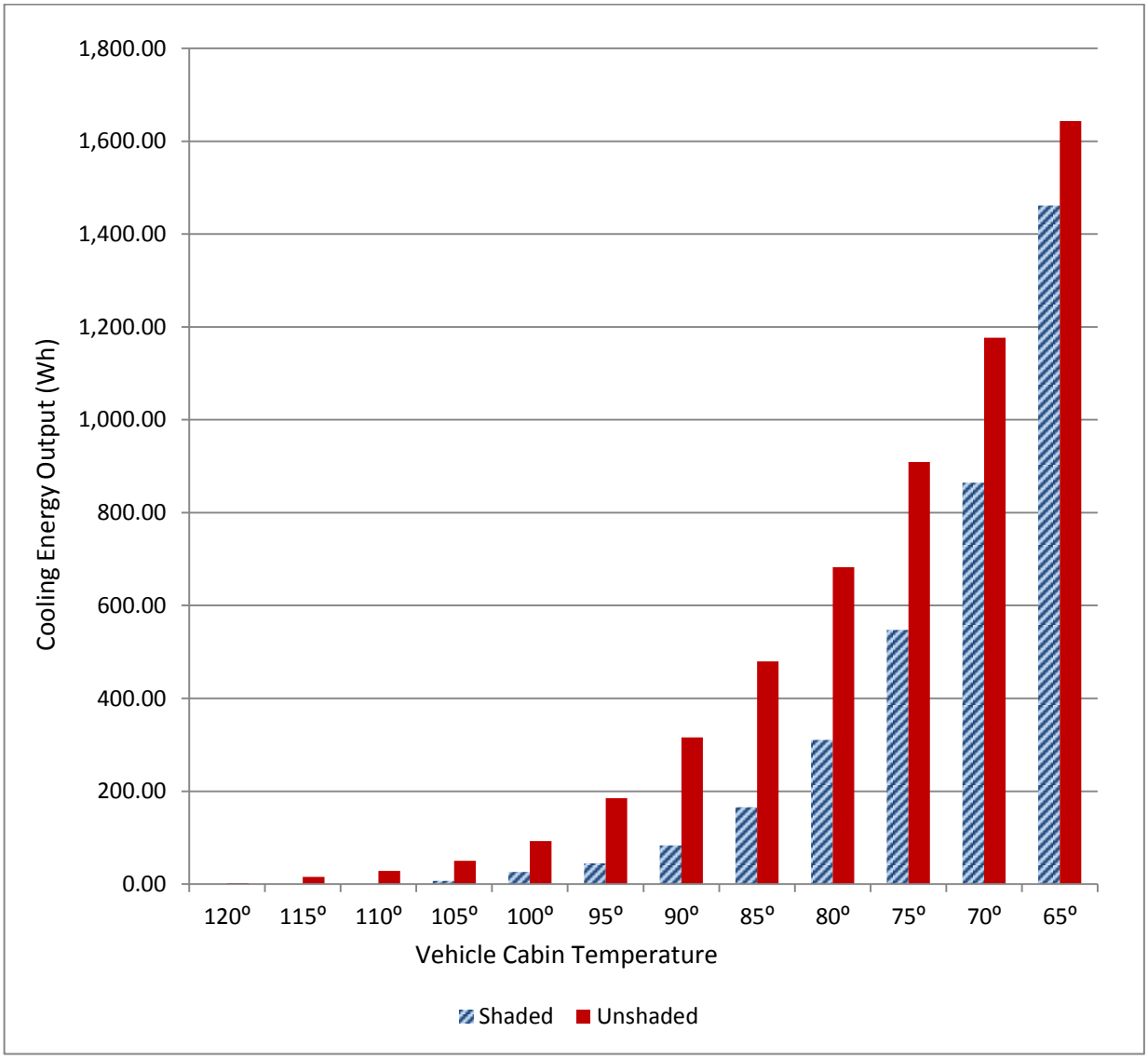

Figure 4: Cooling energy output versus vehicle cabin temperature

The data reflects the "law of diminishing returns" of the shade on internal vehicle temperature as the efficiency gains of the sunshade are reduced as the cabin temperature approaches 65 °F, requiring greater amounts of energy output from the EV battery for each incremental degree of cooling.

6 CONCLUSION

The total charge event time for the shaded EV was 14 minutes less than the unshaded EV, and required 7.7% less energy input to fully charge the battery. For shorter charging periods, the shaded EV required up to 26.15% less energy than the EV exposed to direct sunlight. During the cabin cooling event, the shaded EV required 15 minutes less of cooling time for the vehicle cabin to reach 70 °F, and needed 26.52% less energy output from the battery. For higher cabin temperatures, the shaded EV required up to 73.62% less energy output for cabin cooling than the EV exposed to direct sunlight. This latter result is subject to the "law of diminishing returns" as the net efficeincy realized from the shade is reduced with each incremental degree of cooling. The X-12 model Apollo Sunguard Systems sunshade reduced battery temperatures by 5.4 °F (3 °C) for both the charging and cooling events. While it is suspected that decreased battery temperatures for EVs will extend the useable life of the battery, quantifying this battery life improvement is beyond the scope of this study.

APPENDIX A: CHARGING DATA

	Unshaded					Shaded				
Time (m)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)
0	16.5	176.00	0	NULL	32.96	14.6	12.0	0	NULL	30.05
1	16.6	3004.75	43.23	32	32.90	14.7	2800.00	40.73	31	30.06
2	16.8	3013.25	95.35	32	32.93	14.9	2632.50	87.02	31	30.37
3	17	3195.00	148.14	32	32.91	15.0	3168.00	134.50	31	30.25
4	17.2	3199.50	200.67	32	32.95	15.2	3172.50	186.27	31	30.27
5	17.4	3204.00	251.87	32	33.04	15.4	3181.50	237.80	31	30.74
6	17.5	3213.00	304.65	32	33.14	15.6	3013.25	289.29	31	30.54
7	17.7	3213.00	357.41	32	33.21	15.7	3195.00	340.30	31	31.42
8	17.9	3217.50	410.38	32	33.21	15.9	3021.75	391.54	31	31.27
9	18.1	3043.00	462.29	32	33.28	16.1	3204.00	442.42	31	30.97
10	18.3	3222.00	515.35	32	33.38	16.3	3030.25	493.57	31	30.94
11	18.4	3226.50	568.09	32	33.47	16.4	3030.25	543.33	31	31.17
12	18.6	3047.25	620.52	32	33.63	16.6	3213.00	594.45	31	31.62
13	18.8	3226.50	672.80	32	33.72	16.8	3217.50	645.18	31	32.68
14	19	3231.00	724.94	32	33.77	17.0	3038.75	695.93	31	31.92
15	19.2	3231.00	778.69	32	33.82	17.1	3043.00	745.75	31	31.52
16	19.3	3231.00	832.15	32	33.95	17.3	3043.00	796.72	31	31.53
17	19.3	3235.50	885.46	32	34.02	17.3	3047.25	848.50	31	32.25
18	19.3	3055.75	938.48	32	34.22	17.3	3047.25	899.84	31	32.35
19	19.3	3055.75	990.31	32	34.35	17.5	2868.00	950.52	31	32.86
20	19.3	3235.50	1043.39	32	34.52	17.7	3047.25	1002.41	31	33.99

	Unshaded					Shaded				
Time (m)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)
21	19.3	3235.50	1096.37	32	34.64	17.9	3051.50	1054.17	31	33.02
22	19.3	3060.00	1149.30	32	34.70	18.1	3051.50	1105.08	31	33.36
23	19.6	3240.00	1202.25	32	34.72	18.3	2692.50	1155.68	31	33.95
24	19.8	3240.00	1254.42	32	34.79	18.6	3051.50	1205.86	31	33.58
25	20	3244.50	1308.35	32	34.88	18.8	3055.75	1256.53	31	33.40
26	20.2	3064.25	1362.17	32	34.98	19.0	3055.75	1307.36	31	33.66
27	20.5	3244.50	1416.35	32	35.11	19.2	3055.75	1358.35	31	33.71
28	20.7	3249.00	1469.87	32	35.09	19.4	2880.00	1408.64	31	33.71
29	20.9	3249.00	1522.46	32	35.21	19.6	2880.00	1459.44	31	33.57
30	21.2	3068.50	1575.96	32	35.31	19.8	3060.00	1510.19	31	33.66
31	21.4	3253.50	1629.72	32	35.41	20.1	3064.25	1560.93	31	34.36
32	21.6	3253.50	1683.64	32	35.30	20.3	3064.25	1611.40	31	34.66
33	21.8	3253.50	1737.61	32	35.33	20.5	3064.25	1662.42	31	35.16
34	22.1	3258.00	1790.18	32	35.43	20.7	3068.50	1713.56	31	34.70
35	22.3	3258.00	1843.90	32	35.62	20.9	3068.50	1764.80	31	34.54
36	22.5	3258.00	1897.25	32	35.75	21.1	3068.50	1815.79	31	34.46
37	22.7	3258.00	1950.89	32	35.83	21.4	3072.75	1865.93	31	34.71
38	23	3081.25	2004.30	32	35.92	21.6	3072.75	1916.94	31	34.96
39	23.2	3262.50	2056.91	32	36.05	21.8	3072.75	1967.70	31	35.00
40	23.4	3262.50	2111.08	32	35.92	22.0	2892.00	2018.48	31	35.49
41	23.6	3267.00	2164.95	32	36.13	22.2	3077.00	2068.31	31	35.27
42	23.9	3085.50	2219.13	32	36.17	22.4	3077.00	2119.14	31	35.17
43	24.1	3267.00	2273.23	32	36.29	22.6	3077.00	2169.77	31	35.28
44	24.3	3271.50	2326.83	32	36.40	22.8	3077.00	2220.40	31	35.18
45	24.5	3271.50	2379.68	32	36.54	23.1	3077.00	2270.83	31	35.34

	Unshaded					Shaded				
Time (m)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)
46	24.8	3271.50	2434.01	32	36.32	23.3	3081.25	2321.27	31	36.03
47	25	3276.00	2488.06	32	36.60	23.5	3081.25	2372.72	31	36.31
48	25.2	3094.00	2541.95	32	36.70	23.7	3085.50	2423.65	31	36.54
49	25.4	3276.00	2595.64	32	36.85	23.9	3085.50	2474.52	31	36.20
50	25.6	3094.00	2648.37	32	36.89	24.1	3085.50	2524.68	31	36.39
51	25.9	3280.50	2701.67	32	37.07	24.3	3089.75	2575.69	31	36.17
52	26.1	3280.50	2755.03	32	37.20	24.5	3089.75	2626.27	31	36.16
53	26.3	3285.00	2808.87	32	37.28	24.7	3094.00	2676.62	31	36.28
54	26.5	3102.50	2863.17	32	37.41	25.0	3094.00	2727.12	31	36.35
55	26.8	3289.50	2917.42	32	37.57	25.2	3098.25	2776.93	31	36.60
56	27	3106.75	2969.66	32	37.70	25.4	3098.25	2828.16	31	36.75
57	27.2	3106.75	3022.35	32	37.79	25.6	3098.25	2879.34	31	36.65
58	27.4	3111.00	3075.68	32	37.87	25.8	3102.50	2930.03	31	36.67
59	27.7	3294.00	3129.81	32	37.81	26.0	3102.50	2980.22	31	36.82
60	27.9	3294.00	3183.80	32	37.65	26.2	3106.75	3029.98	31	36.99
61	28.1	3115.25	3237.60	32	37.88	26.4	3106.75	3080.49	31	37.01
62	28.3	3298.50	3290.39	32	37.87	26.6	3111.00	3131.06	31	37.60
63	28.6	3119.50	3344.35	32	37.99	26.9	3111.00	3181.22	31	37.49
64	28.8	3303.00	3398.43	32	38.14	27.1	3111.00	3232.00	31	37.43
65	29	3123.75	3451.56	32	38.25	27.3	3115.25	3281.74	31	37.73
66	29.2	2940.00	3503.72	32	38.33	27.5	3115.25	3332.49	31	37.38
67	29.4	3128.00	3556.02	32	38.32	27.7	3115.25	3383.24	31	37.36
68	29.6	3312.00	3607.29	32	38.46	27.9	3115.25	3433.48	31	37.92
69	29.9	3128.00	3659.37	32	38.64	28.1	2936.00	3483.65	31	38.40
70	30.1	3128.00	3711.96	32	38.71	28.3	3119.50	3533.91	31	38.58

	Unshaded					Shaded				
Time (m)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)
71	30.3	3316.50	3765.99	32	38.70	28.5	3123.75	3585.16	31	38.58
72	30.5	3316.50	3820.75	32	38.27	28.8	3123.75	3636.81	31	38.33
73	30.8	3321.00	3875.38	32	38.08	29.0	3128.00	3688.20	31	38.12
74	31	3136.50	3928.01	32	37.86	29.3	3128.00	3739.62	31	37.57
75	31.4	3321.00	3982.23	32	37.98	29.5	3132.25	3790.28	31	38.09
76	31.7	3325.50	4036.67	32	37.73	29.8	3132.25	3841.25	31	37.26
77	32	3140.75	4090.65	32	37.78	30.1	3132.25	3892.07	31	37.99
78	32.3	3145.00	4144.80	32	37.72	30.5	3136.50	3943.04	31	38.27
79	32.7	3330.00	4199.37	32	37.69	30.9	3136.50	3993.98	31	38.52
80	33.1	3145.00	4254.00	32	37.43	31.3	3136.50	4044.12	31	37.71
81	33.4	3334.50	4307.30	32	37.75	31.7	3140.75	4095.13	31	38.61
82	33.8	3149.25	4362.21	32	37.49	32.1	2956.00	4145.93	31	38.20
83	34.1	3334.50	4417.01	32	37.46	32.4	2960.00	4196.44	31	38.41
84	34.5	3153.50	4471.66	32	37.16	32.7	2775.00	4246.43	31	38.43
85	35	3339.00	4526.38	32	37.36	33.0	2775.00	4296.38	31	37.85
86	35.4	3157.75	4581.53	32	37.25	33.4	2960.00	4345.94	31	38.10
87	35.9	2786.25	4636.27	32	37.04	33.7	3149.25	4397.50	31	37.58
88	36.3	3343.50	4690.19	32	37.03	34.1	2964.00	4448.75	31	38.38
89	36.8	3343.50	4745.35	32	37.20	34.5	2778.75	4500.00	31	38.68
90	37.2	3162.00	4800.39	32	37.39	34.9	2968.00	4551.07	31	38.11
91	37.7	3162.00	4855.16	32	37.53	35.3	2968.00	4601.77	31	38.36
92	38.1	3352.50	4910.09	32	37.63	35.8	2972.00	4653.23	31	38.11
93	38.5	3352.50	4965.18	32	37.47	36.2	2972.00	4704.68	31	37.77
94	39	2793.75	5018.99	32	37.45	36.6	2972.00	4755.81	31	38.71
95	39.4	3352.50	5073.83	32	37.74	37.0	2976.00	4807.88	31	38.64

	Unshaded					Shaded				
Time (m)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)
96	39.9	3352.50	5129.15	32	37.97	37.4	2604.00	4858.25	31	38.64
97	40.3	3357.00	5184.32	32	38.05	37.9	2980.00	4909.30	31	38.74
98	40.8	3170.50	5239.60	32	38.14	38.3	2980.00	4960.82	31	39.23
99	41.2	3170.50	5294.57	32	38.30	38.7	2980.00	5012.40	31	39.20
100	41.7	3174.75	5348.66	32	38.24	39.1	3166.25	5063.78	31	39.37
101	42.1	3174.75	5401.36	32	38.11	39.5	3170.50	5115.34	31	39.29
102	42.5	3174.75	5453.03	32	38.46	39.9	2984.00	5166.00	31	39.86
103	42.9	3174.75	5506.41	32	38.58	40.4	3170.50	5217.86	31	40.15
104	43.2	3366.00	5560.86	33	38.22	40.8	3170.50	5269.51	31	39.54
105	43.6	3366.00	5616.39	33	38.13	41.2	3170.50	5321.32	31	39.32
106	43.9	3366.00	5671.92	33	38.13	41.6	3174.75	5372.97	31	38.78
107	44.2	3366.00	5727.39	33	37.86	42.0	3174.75	5424.58	31	37.89
108	44.4	3183.25	5782.72	33	37.87	42.5	2988.00	5474.75	32	38.06
109	44.7	3370.50	5836.02	33	37.83	42.7	3174.75	5525.22	32	38.40
110	45	3370.50	5891.10	33	38.02	43.0	2988.00	5575.88	32	38.21
111	45.3	3370.50	5946.49	33	38.14	43.4	2992.00	5626.58	32	38.52
112	45.6	3375.00	6001.64	33	38.32	43.8	3179.00	5677.48	32	39.50
113	46	3370.50	6056.99	33	38.64	44.0	2992.00	5728.59	32	39.92
114	46.3	3375.00	6112.61	33	38.74	44.2	2992.00	5778.77	32	40.26
115	46.5	3187.50	6168.19	33	39.03	44.5	3183.25	5830.22	32	40.39
116	46.7	3187.50	6223.86	33	39.05	44.8	2996.00	5881.38	32	40.64
117	47	3379.50	6277.62	33	39.00	45.1	2996.00	5932.82	32	40.67
118	47.2	3191.75	6332.30	33	38.80	45.3	2996.00	5983.90	32	39.99
119	47.5	3191.75	6385.91	33	38.51	45.5	2808.75	6034.87	32	38.89
120	47.7	3191.75	6439.52	33	38.56	45.8	3183.25	6085.55	32	39.21

	Unshaded					Shaded				
Time (m)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)
121	47.9	3379.50	6493.55	33	38.68	46.1	3000.00	6136.64	32	39.22
122	48.1	3191.75	6547.42	33	38.93	46.3	3000.00	6187.47	32	39.64
123	48.4	3384.00	6602.02	33	38.90	46.6	3000.00	6238.56	32	39.81
124	48.6	2820.00	6656.11	33	39.25	46.9	3000.00	6289.45	32	40.52
125	48.9	3384.00	6710.32	33	39.24	47.1	3000.00	6340.54	32	41.02
126	49.1	3384.00	6765.10	33	39.68	47.3	3000.00	6390.59	32	41.04
127	49.3	3196.00	6819.78	33	39.91	47.6	3000.00	6441.69	32	41.22
128	49.5	3196.00	6874.40	33	39.80	47.8	3191.75	6492.64	32	41.28
129	49.8	3384.00	6929.44	33	39.31	48.0	3191.75	6544.27	32	39.96
130	50	3196.00	6984.28	33	39.24	48.2	3191.75	6595.43	32	39.90
131	50.2	3384.00	7039.06	33	39.14	48.4	3004.00	6646.64	32	40.17
132	50.4	3196.00	7093.79	33	38.95	48.6	3191.75	6697.34	32	38.96
133	50.6	3384.00	7146.74	33	39.24	48.8	3191.75	6749.07	32	39.93
134	50.9	3388.50	7201.55	33	39.29	49.0	3191.75	6800.72	32	40.38
135	51.1	3200.25	7255.41	33	39.23	49.2	3196.00	6853.09	32	40.46
136	51.3	3200.25	7309.16	33	39.18	49.4	3196.00	6905.05	32	38.74
137	51.5	3200.25	7362.86	33	39.11	49.7	3196.00	6957.17	32	38.71
138	51.7	3200.25	7416.78	33	38.96	49.9	3196.00	7008.29	32	39.08
139	51.9	3200.25	7470.27	33	38.74	50.1	3196.00	7060.62	32	39.63
140	52.2	3200.25	7524.83	33	38.80	50.3	3200.25	7112.76	32	39.42
141	52.4	3393.00	7578.49	33	38.69	50.5	3012.00	7164.21	32	38.97
142	52.6	3393.00	7634.31	33	38.61	50.7	3200.25	7215.87	32	38.29
143	52.8	3393.00	7690.23	33	38.72	50.9	3200.25	7267.27	32	39.47
144	53.1	3204.50	7745.99	33	38.62	51.1	2823.75	7317.94	32	39.76
145	53.3	3393.00	7801.97	33	38.55	51.3	3200.25	7368.82	32	39.68

	Unshaded					Shaded				
Time (m)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)
146	53.5	3397.50	7857.91	33	38.70	51.5	3200.25	7420.23	32	39.55
147	53.7	3397.50	7913.63	33	38.58	51.7	3012.00	7471.43	32	39.03
148	54	3208.75	7968.68	34	38.38	51.9	3204.50	7523.09	32	38.49
149	54.2	3397.50	8024.15	34	38.47	52.2	3204.50	7574.51	32	38.79
150	54.4	3397.50	8077.37	34	38.66	52.4	3204.50	7626.40	32	39.60
151	54.6	3397.50	8133.21	34	38.92	52.6	3016.00	7676.72	32	39.33
152	54.8	3208.75	8189.00	34	38.83	52.8	3016.00	7727.98	32	40.15
153	55.1	3397.50	8244.47	34	39.08	53.0	3204.50	7779.56	32	39.18
154	55.3	3402.00	8299.90	34	39.05	53.2	3020.00	7830.86	32	39.48
155	55.5	3402.00	8354.92	34	39.05	53.4	2831.25	7882.56	32	40.10
156	55.7	3213.00	8410.10	34	38.71	53.6	3020.00	7933.99	32	38.71
157	56	3217.25	8465.31	34	38.83	53.8	3020.00	7985.59	32	39.03
158	56.2	3217.25	8520.55	34	38.96	54.0	2831.25	8036.18	32	38.58
159	56.4	3406.50	8573.69	34	38.93	54.2	3024.00	8087.68	32	38.83
160	56.6	3406.50	8629.10	34	38.89	54.4	3024.00	8138.70	33	39.68
161	56.8	3217.25	8683.83	34	39.23	54.6	3024.00	8189.94	33	39.74
162	57.1	3406.50	8739.19	34	39.68	54.8	3024.00	8241.91	33	39.65
163	57.3	3217.25	8795.06	34	39.66	55.0	3024.00	8293.05	33	39.50
164	57.5	3411.00	8851.11	34	39.68	55.3	3024.00	8343.24	33	39.21
165	57.7	3221.50	8906.85	34	39.21	55.5	3024.00	8394.27	33	38.73
166	58	3411.00	8962.97	34	39.32	55.7	3024.00	8444.67	33	39.46
167	58.2	3411.00	9018.82	34	39.19	55.9	3024.00	8495.12	33	39.75
168	58.4	3411.00	9072.40	34	39.24	56.1	3024.00	8546.01	33	38.83
169	58.6	3221.50	9128.57	34	39.13	56.3	2838.75	8596.26	33	39.10
170	58.8	3411.00	9184.58	34	39.06	56.5	3028.00	8646.52	33	39.21

	Unshaded					Shaded				
Time (m)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)
171	59.1	3411.00	9240.69	34	38.95	56.7	2838.75	8695.83	33	39.48
172	59.3	3415.50	9296.95	34	39.04	56.9	3028.00	8746.35	33	38.90
173	59.5	3225.75	9353.35	34	39.20	57.1	3217.25	8796.93	33	39.76
174	59.7	3415.50	9409.54	34	39.20	57.3	3032.00	8847.39	33	39.21
175	60	3415.50	9465.46	34	39.21	57.5	3032.00	8898.02	33	39.11
176	60.2	3415.50	9521.70	34	39.11	57.7	3032.00	8949.24	33	38.92
177	60.4	3225.75	9577.41	35	39.16	57.9	3221.50	9001.25	33	39.33
178	60.6	3230.00	9629.88	35	39.12	58.1	3221.50	9052.15	33	39.29
179	60.8	3230.00	9683.50	35	39.30	58.3	3225.75	9103.45	33	40.30
180	61.1	3230.00	9737.01	35	39.47	58.5	3036.00	9154.79	33	40.65
181	61.3	3230.00	9790.63	35	39.38	58.7	3036.00	9206.07	33	39.87
182	61.5	3230.00	9843.94	35	39.24	59.0	3036.00	9257.20	33	40.11
183	61.7	3234.25	9897.30	35	39.20	59.2	3036.00	9308.06	33	39.31
184	61.9	3234.25	9951.04	35	39.29	59.4	3230.00	9359.36	33	38.83
185	62.1	3234.25	10004.57	35	39.63	59.6	3040.00	9409.70	33	39.46
186	62.4	3234.25	10058.31	35	39.98	59.8	3040.00	9461.84	33	40.49
187	62.6	2663.50	10111.69	35	40.26	60.0	3040.00	9513.46	33	41.02
188	62.8	3234.25	10164.07	35	40.23	60.2	3040.00	9565.34	33	41.27
189	63	3238.50	10218.71	35	40.17	60.4	3230.00	9617.38	33	40.15
190	63.2	3238.50	10273.96	35	39.64	60.6	3230.00	9669.42	33	39.70
191	63.4	3238.50	10328.41	35	39.33	60.8	3234.25	9721.53	33	39.93
192	63.6	3429.00	10382.97	35	39.68	61.0	3044.00	9772.15	33	40.74
193	63.8	3238.50	10437.05	35	39.81	61.2	3044.00	9823.89	33	40.68
194	63.9	3242.75	10491.16	35	39.83	61.4	3044.00	9876.15	34	40.88
195	64.1	3242.75	10544.94	35	39.59	61.6	3238.50	9928.79	34	39.89

	Unshaded					Shaded				
Time (m)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)
196	64.4	3052.00	10598.35	35	39.76	61.8	3048.00	9980.77	34	40.66
197	64.6	3242.75	10651.92	35	39.92	62.1	3048.00	10032.25	34	40.33
198	64.8	3247.00	10703.84	35	39.80	62.3	3048.00	10083.42	34	40.74
199	65	3438.00	10757.74	35	39.99	62.5	3048.00	10134.70	34	40.30
200	65.2	3247.00	10811.81	35	39.84	62.7	3238.50	10184.81	34	39.89
201	65.4	3247.00	10865.82	35	39.92	62.9	3048.00	10236.58	34	40.57
202	65.6	3247.00	10919.93	35	40.11	63.1	3052.00	10288.23	34	40.37
203	65.9	3442.50	10974.24	35	39.65	63.3	3052.00	10339.42	34	39.78
204	66.1	3251.25	11028.74	35	39.65	63.5	3242.75	10390.34	34	40.06
205	66.3	3251.25	11083.30	36	39.73	63.7	3052.00	10442.05	34	39.71
206	66.5	3251.25	11137.91	36	39.82	63.9	3056.00	10493.26	34	40.16
207	66.6	3060.00	11192.42	36	39.83	64.1	3056.00	10542.91	34	40.05
208	66.8	3251.25	11244.62	36	39.79	64.3	3247.00	10593.63	34	40.63
209	67	3255.50	11299.46	36	39.64	64.5	3056.00	10644.57	34	40.13
210	67.2	3255.50	11354.25	36	39.61	64.7	3060.00	10695.85	34	39.31
211	67.4	3255.50	11408.93	36	39.65	64.9	3251.25	10747.16	34	39.85
212	67.6	3259.75	11463.46	36	39.55	65.1	3060.00	10798.48	34	39.44
213	67.8	3259.75	11517.98	36	39.58	65.3	3060.00	10849.69	34	39.55
214	68.1	3259.75	11572.46	36	39.54	65.5	2868.75	10900.37	34	39.52
215	68.3	3068.00	11627.64	36	39.71	65.7	3060.00	10951.21	34	40.18
216	68.4	3451.50	11682.72	36	39.79	65.9	3060.00	11002.64	34	40.44
217	68.5	3451.50	11737.26	36	39.89	66.1	3060.00	11053.74	34	39.90
218	68.7	3068.00	11791.80	36	39.74	66.3	3255.50	11105.20	34	39.44
219	68.9	3259.75	11844.00	36	39.78	66.5	3064.00	11156.80	34	40.20
220	69.2	3259.75	11899.24	36	39.77	66.7	3064.00	11208.24	34	40.30

	Unshaded					Shaded				
Time (m)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)
221	69.2	3264.00	11953.84	36	39.55	67.0	3064.00	11259.30	34	40.03
222	69.4	3264.00	12007.90	36	39.58	67.2	3064.00	11309.10	34	39.26
223	69.6	3072.00	12061.77	36	39.37	67.4	3259.75	11360.26	34	39.33
224	69.8	3264.00	12115.58	36	39.31	67.6	3068.00	11411.40	34	38.83
225	70	3264.00	12169.29	36	39.48	67.8	2876.25	11462.42	34	39.15
226	70.2	3264.00	12223.21	36	39.37	68.0	3068.00	11513.50	34	39.22
227	70.4	3268.25	12276.84	36	39.37	68.2	3068.00	11564.64	35	39.05
228	70.6	3268.25	12330.08	37	39.67	68.4	3068.00	11615.56	35	39.18
229	70.8	3268.25	12383.38	37	39.66	68.6	3072.00	11666.29	35	39.21
230	71	3268.25	12435.18	37	39.68	68.8	3072.00	11716.37	35	39.18
231	71.1	3268.25	12489.01	37	39.81	69.0	2880.00	11767.94	35	39.37
232	71.2	3268.25	12542.84	37	39.95	69.2	3072.00	11819.84	35	39.74
233	71.4	3272.50	12597.09	37	39.85	69.4	3072.00	11871.62	35	39.43
234	71.6	3272.50	12651.42	37	39.66	69.6	2883.75	11923.51	35	39.51
235	71.8	3272.50	12705.75	37	39.70	69.8	3076.00	11975.41	35	38.95
236	72	3084.00	12760.04	37	39.93	70.0	3268.25	12027.05	35	39.18
237	72.3	3276.75	12813.99	37	40.04	70.2	2691.50	12077.84	35	39.67
238	72.5	3276.75	12867.85	37	40.05	70.4	2883.75	12128.78	35	39.83
239	72.7	3084.00	12921.45	37	39.84	70.6	3080.00	12180.60	35	39.72
240	72.9	3084.00	12974.45	37	39.90	70.8	3080.00	12231.98	35	40.17
241	73	3276.75	13026.44	37	40.22	71.0	3080.00	12283.10	35	40.17
242	73.1	3276.75	13080.33	37	40.22	71.2	3080.00	12333.90	35	40.05
243	73.4	3281.00	13134.41	37	40.05	71.4	2887.50	12384.91	35	39.54
244	73.6	3281.00	13188.72	37	39.62	71.6	3080.00	12435.82	35	39.04
245	73.8	3281.00	13243.13	37	39.40	71.8	3084.00	12485.85	35	38.76

	Unshaded					Shaded				
Time (m)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)
246	73.9	3281.00	13297.28	37	39.30	72.0	3084.00	12537.73	35	38.89
247	74.1	3281.00	13351.37	37	39.46	72.3	3084.00	12590.20	35	38.77
248	74.3	3285.25	13405.56	37	39.84	72.5	3084.00	12642.24	35	39.68
249	74.5	3092.00	13459.77	37	40.05	72.7	3084.00	12693.98	35	39.83
250	74.7	3285.25	13514.21	37	39.86	72.9	3281.00	12745.54	35	39.74
251	74.9	3285.25	13568.53	37	40.11	73.1	3088.00	12797.54	35	40.02
252	75.1	3285.25	13620.33	37	40.02	73.3	3088.00	12848.95	35	40.17
253	75.3	3096.00	13674.78	38	39.69	73.5	3088.00	12898.86	35	39.15
254	75.6	3289.50	13729.46	38	39.51	73.7	3088.00	12950.51	35	38.92
255	75.8	3289.50	13784.23	38	39.61	73.9	3285.25	13002.40	35	38.93
256	76	3483.00	13839.11	38	39.56	74.1	3092.00	13054.10	35	38.83
257	76.2	3483.00	13894.58	38	39.52	74.3	3092.00	13106.06	35	39.07
258	76.2	3289.50	13949.62	38	39.40	74.5	3092.00	13157.91	35	39.44
259	76.2	3289.50	14004.33	38	39.26	74.7	3092.00	13209.51	35	39.36
260	76.5	3289.50	14059.01	38	39.47	74.9	3096.00	13261.20	36	39.21
261	76.7	3100.00	14113.30	38	39.46	75.1	3096.00	13311.82	36	39.07
262	76.9	3100.00	14167.70	38	39.55	75.3	3096.00	13363.74	36	39.21
263	77.1	3100.00	14219.59	38	39.52	75.5	3096.00	13415.72	36	39.46
264	77.3	3487.50	14274.48	38	39.44	75.7	3096.00	13467.80	36	39.78
265	77.5	3293.75	14329.16	38	39.70	75.9	3096.00	13519.78	36	39.32
266	77.7	3100.00	14383.74	38	39.57	76.1	3096.00	13571.70	36	38.69
267	77.9	3293.75	14438.09	38	39.68	76.3	3096.00	13622.93	36	38.83
268	78.2	3293.75	14492.77	38	39.68	76.5	3096.00	13674.31	36	39.32
269	78.4	3492.00	14548.36	38	39.56	76.7	3100.00	13724.43	36	39.40
270	78.6	3298.00	14603.98	38	39.56	76.9	3100.00	13776.04	36	39.67

	Unshaded					Shaded				
Time (m)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)
271	78.8	3298.00	14659.75	38	39.63	77.2	3100.00	13827.23	36	39.49
272	79	3298.00	14715.42	38	39.75	77.4	3100.00	13879.11	36	39.19
273	79.2	3302.25	14770.77	38	39.73	77.6	3298.00	13930.80	36	39.15
274	79.5	2525.25	14824.62	38	39.68	77.8	3104.00	13982.59	36	39.36
275	79.7	3306.50	14878.21	38	39.59	78.0	3104.00	14034.38	36	39.66
276	79.9	3306.50	14933.86	39	39.63	78.2	3298.00	14086.16	36	39.71
277	80.1	3306.50	14989.45	39	39.57	78.4	3108.00	14136.76	36	39.61
278	80.3	3306.50	15044.83	39	39.46	78.6	3108.00	14188.61	36	39.56
279	80.5	3310.75	15100.27	39	39.65	78.8	3302.25	14240.41	36	39.54
280	80.8	3505.50	15156.15	39	39.68	79.0	3112.00	14292.52	36	40.33
281	81	3310.75	15211.93	39	39.61	79.2	3112.00	14344.23	36	39.66
282	81.2	3315.00	15267.38	39	39.65	79.4	3310.75	14395.69	36	39.72
283	81.4	3315.00	15322.90	39	39.68	79.6	3116.00	14447.35	36	40.64
284	81.6	3510.00	15378.26	39	39.69	79.8	3310.75	14498.90	36	39.55
285	81.8	3319.25	15433.73	39	39.44	80.0	3120.00	14549.01	36	40.06
286	82	3514.50	15486.34	39	39.46	80.2	3315.00	14601.50	36	38.68
287	82.3	3319.25	15542.26	39	39.58	80.4	3315.00	14653.93	36	39.19
288	82.5	3323.50	15598.50	39	39.56	80.7	3120.00	14706.15	36	39.31
289	82.7	3323.50	15653.81	39	39.51	81.0	3124.00	14759.14	36	39.94
290	82.9	3323.50	15708.60	39	39.69	81.3	2928.75	14811.51	36	39.20
291	83.2	3323.50	15763.34	39	39.71	81.7	3319.25	14863.36	37	39.30
292	83.4	3128.00	15818.35	39	39.66	81.9	3124.00	14915.16	37	39.76
293	83.6	3323.50	15873.25	39	39.56	82.1	2733.50	14965.54	37	39.50
294	83.8	3323.50	15928.10	39	39.45	82.3	3128.00	15016.26	37	39.21
295	84	3323.50	15982.84	39	39.56	82.6	2932.50	15068.20	37	38.98

	Unshaded					Shaded				
Time (m)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)
296	84.2	3128.00	16037.69	39	39.56	82.9	3128.00	15119.89	37	38.96
297	84.4	2737.00	16090.42	39	39.45	83.1	3128.00	15171.53	37	38.89
298	84.6	3323.50	16144.46	39	39.66	83.3	2932.50	15223.17	37	39.66
299	84.8	3323.50	16199.09	39	39.64	83.5	3128.00	15274.71	37	39.21
300	85.1	3128.00	16252.84	39	39.63	83.7	2932.50	15326.46	37	39.40
301	85.3	3132.00	16305.96	39	39.49	83.9	3128.00	15377.89	37	39.19
302	85.5	3132.00	16359.08	39	39.46	84.1	2932.50	15428.01	37	39.33
303	85.7	3132.00	16412.10	39	39.56	84.3	3128.00	15479.71	37	39.24
304	85.9	3327.75	16465.44	39	39.68	84.5	2932.50	15531.03	37	39.10
305	86.1	3132.00	16518.35	39	39.60	84.7	2932.50	15582.73	37	38.80
306	86.3	3327.75	16571.47	39	39.61	84.9	2932.50	15634.21	37	38.72
307	86.5	3132.00	16624.27	39	39.78	85.1	2932.50	15685.70	37	39.09
308	86.7	3136.00	16677.31	39	39.88	85.3	3128.00	15737.24	37	39.84
309	86.9	3136.00	16728.64	39	39.77	85.5	2936.25	15788.66	37	39.43
310	87.1	3332.00	16783.35	39	39.56	85.7	2936.25	15838.68	37	39.06
311	87.3	3332.00	16837.96	39	39.52	85.9	2936.25	15890.12	37	38.31
312	87.6	3332.00	16892.84	40	39.47	86.1	3132.00	15941.72	37	38.27
313	87.8	3136.00	16947.33	40	39.28	86.3	3132.00	15993.37	37	38.42
314	88	3332.00	17001.89	40	39.25	86.5	2936.25	16044.70	37	38.87
315	88.2	3332.00	17056.70	40	39.21	86.7	3132.00	16096.09	37	38.27
316	88.4	3336.25	17111.70	40	39.21	86.9	3132.00	16147.53	37	38.26
317	88.6	3336.25	17166.92	40	39.15	87.1	3132.00	16199.20	37	38.50
318	88.8	3336.25	17221.71	40	39.08	87.3	3136.00	16249.12	37	38.84
319	89	3336.25	17276.93	40	39.18	87.5	3136.00	16301.22	37	38.75
320	89.3	3336.25	17331.66	40	39.15	87.7	3136.00	16353.27	37	38.83

	Unshaded					Shaded				
Time (m)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)
321	89.5	3140.00	17383.94	40	39.25	87.9	3136.00	16404.99	37	39.05
322	89.7	3144.00	17439.14	40	39.28	88.1	3136.00	16456.88	37	39.20
323	89.9	3336.25	17494.48	40	39.37	88.3	3136.00	16508.76	37	39.28
324	90.1	3340.50	17549.93	40	39.29	88.5	3140.00	16560.66	37	38.85
325	90.3	3340.50	17605.39	40	39.21	88.7	3140.00	16612.53	37	39.52
326	90.5	3144.00	17660.79	40	39.29	88.9	2551.25	16663.61	37	39.05
327	90.8	3340.50	17716.30	40	39.46	89.1	3140.00	16714.69	37	38.89
328	91	3340.50	17771.38	40	39.75	89.3	3140.00	16766.75	37	39.36
329	91.2	3340.50	17826.48	40	39.52	89.5	3140.00	16818.65	37	39.11
330	91.4	3148.00	17881.23	40	39.46	89.7	3140.00	16870.42	37	38.66
331	91.6	3344.75	17935.88	40	39.48	89.9	2947.50	16921.94	37	39.00
332	91.8	3344.75	17988.07	40	39.40	90.1	3144.00	16972.71	37	39.08
333	92	3148.00	18042.45	40	39.28	90.3	3144.00	17023.96	37	39.12
334	92.2	3148.00	18097.22	40	39.22	90.5	3144.00	17075.16	37	39.05
335	92.4	3152.00	18152.06	40	39.35	90.7	3144.00	17125.05	37	38.97
336	92.7	3349.00	18207.32	40	39.16	90.9	3344.75	17176.87	37	39.24
337	92.9	3349.00	18263.03	40	39.20	91.1	3148.00	17228.84	37	39.42
338	93.1	3349.00	18318.30	40	39.20	91.3	3148.00	17281.25	37	38.77
339	93.3	3349.00	18373.46	40	39.19	91.5	2951.25	17333.72	37	39.39
340	93.5	3349.00	18429.11	40	39.11	91.8	3148.00	17385.86	37	38.90
341	93.7	3349.00	18484.27	40	39.15	92.0	3148.00	17438.22	37	38.77
342	93.9	3349.00	18539.07	40	39.16	92.2	3152.00	17490.48	37	38.74
343	94.1	3353.25	18593.90	40	39.19	92.4	3152.00	17540.48	37	39.26
344	94.3	2758.00	18638.65	40	39.32	92.6	3152.00	17592.14	38	40.05
345	94.4	2561.00	18682.36	40	39.20	92.8	3152.00	17643.96	38	39.20

	Unshaded					Shaded				
Time (m)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)	SOC (%)	Power (W)	Energy (Wh)	Battery Temp (°C)	Ambient Temp (°C)
346	94.6	2564.25	18726.20	40	38.96	93.0	3152.00	17695.40	38	38.58
347	94.6	2169.75	18765.20	40	38.84	93.2	3152.00	17747.11	38	38.96
348	94.7	2367.00	18802.68	40	38.91	93.4	3152.00	17798.62	38	39.03
349	94.7	1775.25	18833.69	40	38.83	93.6	3156.00	17850.77	38	38.48
350	94.7	2169.75	18863.70	40	38.87	93.8	2958.75	17902.49	38	39.01
351	94.8	1578.00	18891.86	40	38.71	94.0	2564.25	17953.06	38	38.47
352	94.8	1578.00	18919.08	40	38.61	94.1	3156.00	18004.35	38	38.34
353	94.8	1578.00	18946.20	40	38.58	94.3	2958.75	18055.74	38	38.34
354	94.8	1379.00	18968.12	41	38.54	94.5	2958.75	18106.53	38	38.24
355	94.8	1578.00	18989.09	40	38.54	94.7	1972.50	18144.23	38	38.26
356	94.8	985.00	19004.92	41	38.56	94.9	2564.25	18187.57	38	38.46
357	94.9	986.25	19023.82	41	38.48	95.0	2564.25	18220.50	38	38.14
358	95.0	1183.50	19040.86	41	38.42	95.1	1775.25	18252.77	38	37.83
359	95.0	986.25	19057.90	41	38.22	95.1	1775.25	18276.72	38	37.98
360	95.0	789.00	19074.00	41	38.25	95.1	1578.00	18303.02	38	37.95
361	95.0	1183.50	19090.22	41	38.22	95.1	986.25	18325.10	38	37.98
362	95.0	0.00	19096.41	41	38.26	95.1	0.00	18326.58	38	38.39

APPENDIX B: COOLING DATA

	Unshaded						Shaded					
Time (m)	Battery SOC (%)	Power (W)	Cumulative Energy (Wh)	Cabin Temp (°F)	Battery Temp (°F)	Ambient Temp (°F)	Battery SOC (%)	Power (W)	Cumulative Energy (Wh)	Cabin Temp (°F)	Battery Temp (°F)	Ambient Temp (°F)
0	0.0	0.00	0.00	121.86	NULL	99.46	94.9	983.75	0.27	106.14	NULL	100.40
1	94.8	1768.50	29.37	109.70	105.80	101.10	94.6	2164.25	30.06	98.98	100.40	101.04
2	94.6	1768.50	59.45	103.39	105.80	103.99	94.3	2161.50	65.81	91.84	100.40	102.01
3	94.5	1768.50	89.90	100.21	105.80	106.31	94.1	2161.50	101.94	88.63	100.40	102.53
4	94.3	1962.50	119.76	97.86	105.80	108.51	93.9	2161.50	138.35	86.19	100.40	102.69
5	94.2	1766.25	150.13	96.80	105.80	108.66	93.8	2161.50	174.43	84.42	100.40	103.69
6	94.1	1766.25	181.32	95.15	105.80	109.22	93.6	2158.75	210.97	83.12	100.40	104.18
7	93.9	1766.25	211.03	93.91	105.80	109.11	93.5	2158.75	247.45	81.72	100.40	104.56
8	93.8	1766.25	240.90	93.06	105.80	110.24	93.3	2158.75	283.86	80.81	100.40	105.00
9	93.6	1962.50	270.94	91.66	105.80	111.08	93.1	2158.75	320.11	79.66	100.40	104.77
10	93.5	1766.25	301.19	90.55	105.80	109.74	92.9	2158.75	356.47	78.79	100.40	105.31
11	93.3	1962.50	331.45	89.66	105.80	110.85	92.6	2156.00	392.52	77.86	100.40	105.72
12	93.2	1764.00	361.53	88.27	105.80	110.69	92.4	2156.00	428.73	77.41	100.40	105.01
13	93.0	1960.00	391.43	87.54	105.80	110.06	92.2	2156.00	464.66	76.43	100.40	106.43
14	92.9	1764.00	421.37	86.60	105.80	109.06	92.1	2156.00	500.27	76.04	100.40	106.48
15	92.7	1764.00	451.97	85.78	105.80	110.54	92.0	1960.00	535.82	75.29	100.40	105.94
16	92.6	1764.00	483.22	84.90	105.80	110.39	91.8	1960.00	570.83	74.68	100.40	106.20
17	92.4	1960.00	513.60	84.34	105.80	110.35	91.7	2156.00	606.59	74.13	100.40	106.60
18	92.1	1761.75	543.65	83.49	105.80	109.60	91.5	2153.25	642.61	73.43	100.40	106.63
19	91.9	1957.50	574.34	82.64	105.80	109.42	91.4	2153.25	678.71	72.75	100.40	106.31
20	91.6	1957.50	605.99	81.80	105.80	109.01	91.2	2153.25	714.65	71.95	100.40	106.20
21	91.40	1957.50	637.63	80.88	105.80	109.27	91.10	1957.50	749.84	71.85	100.40	104.72

	Unshaded						Shaded					
Time (m)	Battery SOC (%)	Power (W)	Cumulative Energy (Wh)	Cabin Temp (°F)	Battery Temp (°F)	Ambient Temp (°F)	Battery SOC (%)	Power (W)	Cumulative Energy (Wh)	Cabin Temp (°F)	Battery Temp (°F)	Ambient Temp (°F)
22	91.3	1761.75	669.61	80.39	105.80	108.96	91.0	2153.25	785.02	70.86	100.40	105.68
23	91.1	1761.75	700.44	79.54	105.80	108.63	90.8	2153.25	820.63	70.27	100.40	105.17
24	91.0	1761.75	731.65	78.65	105.80	109.60	90.7	2349.00	856.52	70.42	100.40	106.84
25	90.9	1957.50	763.46	78.25	105.80	109.23	90.5	2153.25	892.41	69.27	100.40	106.10
26	90.8	1761.75	794.99	77.29	105.80	109.00	90.40	2346.00	928.07	69.34	100.40	105.90
27	90.6	1759.50	825.93	77.11	105.80	109.25	90.30	2150.50	963.66	68.54	100.40	105.87
28	90.5	1759.50	856.95	76.32	105.80	109.11	90.10	2150.50	999.34	67.81	100.40	106.71
29	90.4	1759.50	886.34	75.61	105.80	108.88	90.00	1955.00	1032.80	67.82	100.40	106.13
30	90.3	1955.00	915.39	74.89	105.80	108.61	89.90	1564.00	1062.50	67.80	100.40	104.41
31	90.2	1759.50	944.39	74.03	105.80	108.74	89.70	1759.50	1090.36	67.95	100.40	106.09
32	90.1	1564.00	973.33	73.97	105.80	108.06	89.60	1759.50	1117.40	67.67	100.40	105.09
33	89.9	1759.50	1001.95	73.59	105.80	107.63	89.50	1759.50	1144.39	67.48	100.40	105.37
34	89.8	1759.50	1029.97	72.48	105.80	107.04	89.40	1564.00	1171.00	67.26	100.40	104.89
35	89.7	1564.00	1057.94	72.03	105.80	106.77	89.30	1564.00	1197.72	67.38	100.40	104.30
36	89.6	1564.00	1085.04	71.68	105.80	105.71	89.20	1564.00	1224.49	67.24	100.40	104.62
37	89.5	1759.50	1112.36	70.83	105.80	106.62	89.10	1564.00	1250.89	66.77	100.40	104.67
38	89.4	1564.00	1139.78	70.58	105.80	105.80	89.00	1759.50	1277.12	66.56	100.40	104.83
39	89.3	1955.00	1167.80	70.14	105.80	105.15	88.90	1759.50	1303.45	66.11	100.40	104.32
40	89.2	1564.00	1194.09	69.85	105.80	106.33	88.80	1564.00	1329.79	66.41	100.40	104.71
41	89.10	1368.50	1217.11	69.95	105.80	107.11	88.70	1759.50	1356.24	66.30	100.40	104.14
42	89.00	1368.50	1239.86	69.52	105.80	105.47	88.60	1564.00	1382.80	65.68	100.40	103.61
43	88.90	1368.50	1262.51	69.06	105.80	106.22	88.40	1564.00	1409.02	65.65	100.40	103.20
44	88.80	1173.00	1284.94	69.08	105.80	106.07	88.30	1564.00	1435.53	65.42	100.40	103.36
45	88.70	1368.50	1307.58	68.64	105.80	105.07	88.20	1759.50	1462.46	64.97	100.40	103.33
46	88.60	1368.50	1330.28	68.36	105.80	104.47						

	Unshaded						Shaded					
Time (m)	Battery SOC (%)	Power (W)	Energy (Wh)	Cabin Temp (°F)	Battery Temp (°F)	Ambient Temp (°F)	Battery SOC (%)	Power (W)	Energy (Wh)	Cabin Temp (°F)	Battery Temp (°F)	Ambient Temp (°F)
47	88.60	1368.50	1352.71	68.03	105.80	104.97						
48	88.50	1366.75	1375.08	68.17	105.80	103.70						
49	88.40	1173.00	1397.35	67.60	105.80	104.27						
50	88.30	1368.50	1419.77	67.54	105.80	104.29						
51	88.20	1368.50	1442.74	67.41	105.80	103.63						
52	88.10	1562.00	1464.89	66.99	105.80	103.63						
53	88.00	1173.00	1486.17	66.81	105.80	103.78						
54	87.90	1171.50	1507.92	66.62	105.80	103.01						
55	87.90	1171.50	1528.91	66.48	105.80	102.80						
56	87.80	1171.50	1549.03	66.05	105.80	102.87						
57	87.70	976.25	1568.45	65.89	105.80	102.68						
58	87.60	1171.50	1587.81	65.68	105.80	102.57						
59	87.50	976.25	1606.47	65.21	105.80	101.77						
60	87.50	1171.50	1624.42	65.19	105.80	101.92						
61	87.40	976.25	1642.59	65.03	105.80	102.54						
62	87.30	976.25	1660.87	64.90	105.80	102.15						