

Demand Response Advanced Measurement Methodology

Analysis of Open-Source Baseline and Comparison Group Methods to Enable CAISO Demand Response Resource Performance Evaluation

Extended Results Appendix



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Introduction and Important Notes

This document contains many figures that supplement the analysis presented in the main report. For figure descriptions see the text in the report and analogous figure captions. This appendix presents figures by unique combinations of Demand Response Provider (DRP), Load Serving Entity (LSE), solar status, and Sector (Residential or Non-Residential). As with the main body of the report, all programs are anonymized, results are aggregated as appropriate and differential privacy noise is added to all data points. If differential privacy is not explicitly indicated the reader can assume a maximum of 5% noise for any given data point, though often it is far less, especially when large samples were the subject of the analysis. Unless indicated otherwise, savings values are adjusted by the % difference of differences calculation covered in the main body of the report.

This analysis represents a comparison group performance assessment based on the CAISO Tariff. It is not structured as a qualifying capacity methodology that complies with the CPUC Load Impact Protocols.¹ While the methods fully comport with requirements for "ex-post analysis" in the Load Impact Protocols the **results** presented in this report have a few important differences:

1. Open source codebases are available to replicate the methods (and reproduce the results if one has access to the same data).
2. Results for this study reflect the geographic locations where both participant and non-participant program and consumption data were available.
3. The analysis focused on the heatwave events in 2020.

It is also important to note that this study was enabled by the voluntary participation of DRPs and LSEs and Recurve focused analysis on regions where data for both participating and non-participating customers were available. Therefore, results should not necessarily be considered representative of a DRP's entire program. At least one program called events that began or ended partway through an hour. In these cases such hours were treated as event hours without further adjustment. For at least two of the DRPs Recurve observed evidence of incomplete data provided on events that occurred in the measurement baseline period. In such cases savings are likely to be underestimated. Despite these caveats, the main objective of this study has been achieved - to test, refine, and publish detailed comparison group methods that are compliant with the CAISO tariff for performance settlement and immediately available for use.

¹ The CEC (in Docket 21-DR-01) is currently considering updates to the Resource Adequacy Qualifying Capacity of Supply-Side Demand Response in an industry working group forum. The methods presented in this report may also be considered as part of that process.

Summary Results

FLEXmeter Results for Demand Response Provider A, Residential, Non-Solar

DRP	LSE	Date	Event	Avg. Temp (F)	Participants	Avg. Hourly Savings (kW)	Max. DP Noise (kW)	% Savings	Comp Group Savings Adjustment (kW)
A	1	2020-08-14	FALSE	86.1	4,202	0.00	0.0000	0.2%	-0.019
A	1	2020-08-14	TRUE	95.2	4,202	0.15	0.0004	6.5%	0.002
A	1	2020-08-17	FALSE	85.5	4,188	0.03	0.0001	1.6%	0.067
A	1	2020-08-17	TRUE	93.2	4,188	0.21	0.0004	8.5%	0.071
A	1	2020-08-18	FALSE	87.0	4,087	0.01	0.0001	0.9%	0.037
A	1	2020-08-18	TRUE	92.1	4,087	0.24	0.0003	10.2%	0.052
A	1	2020-08-19	FALSE	87.4	4,212	-0.03	0.0000	-1.5%	0.058
A	1	2020-08-19	TRUE	90.1	4,212	0.09	0.0006	4.1%	0.104
A	1	2020-08-20	FALSE	85.6	4,199	-0.07	0.0001	-4.2%	0.074
A	1	2020-08-20	TRUE	88.3	4,199	0.08	0.0006	3.4%	0.192
A	2	2020-08-14	FALSE	84.3	4,228	-0.03	0.0000	-2.8%	-0.064
A	2	2020-08-14	TRUE	96.4	4,228	0.14	0.0002	7.1%	-0.110
A	2	2020-08-18	FALSE	81.6	377	-0.02	0.0002	-1.6%	0.037
A	2	2020-08-18	TRUE	93.2	377	0.28	0.0026	14.8%	-0.133
A	2	2020-08-19	FALSE	76.6	1,268	-0.01	0.0001	-1.1%	0.025
A	2	2020-08-19	TRUE	86.3	1,268	0.14	0.0005	9.5%	0.083
A	2	2020-08-20	FALSE	75.2	3,035	-0.01	0.0000	-0.9%	0.101
A	2	2020-08-20	TRUE	78.0	3,035	0.16	0.0006	10.4%	0.192
A	3	2020-08-14	FALSE	80.1	4,476	-0.02	0.0000	-2.1%	-0.065
A	3	2020-08-14	TRUE	86.0	4,476	0.08	0.0001	4.9%	-0.054
A	3	2020-08-17	FALSE	78.3	4,530	-0.01	0.0000	-0.8%	0.022
A	3	2020-08-17	TRUE	83.1	4,530	0.13	0.0002	7.5%	0.026
A	3	2020-08-18	FALSE	80.6	4,403	-0.01	0.0001	-0.8%	0.016
A	3	2020-08-18	TRUE	84.3	4,403	0.13	0.0002	7.0%	0.191
A	3	2020-08-19	FALSE	81.7	4,568	-0.01	0.0001	-0.8%	0.083
A	3	2020-08-19	TRUE	82.4	4,568	0.14	0.0004	7.6%	0.207
A	3	2020-08-20	FALSE	80.2	4,555	-0.01	0.0000	-0.6%	0.118
A	3	2020-08-20	TRUE	80.0	4,555	0.12	0.0005	7.0%	0.309
A	3	2020-08-14	FALSE	81.4	289	-0.01	0.0015	-0.9%	-0.109

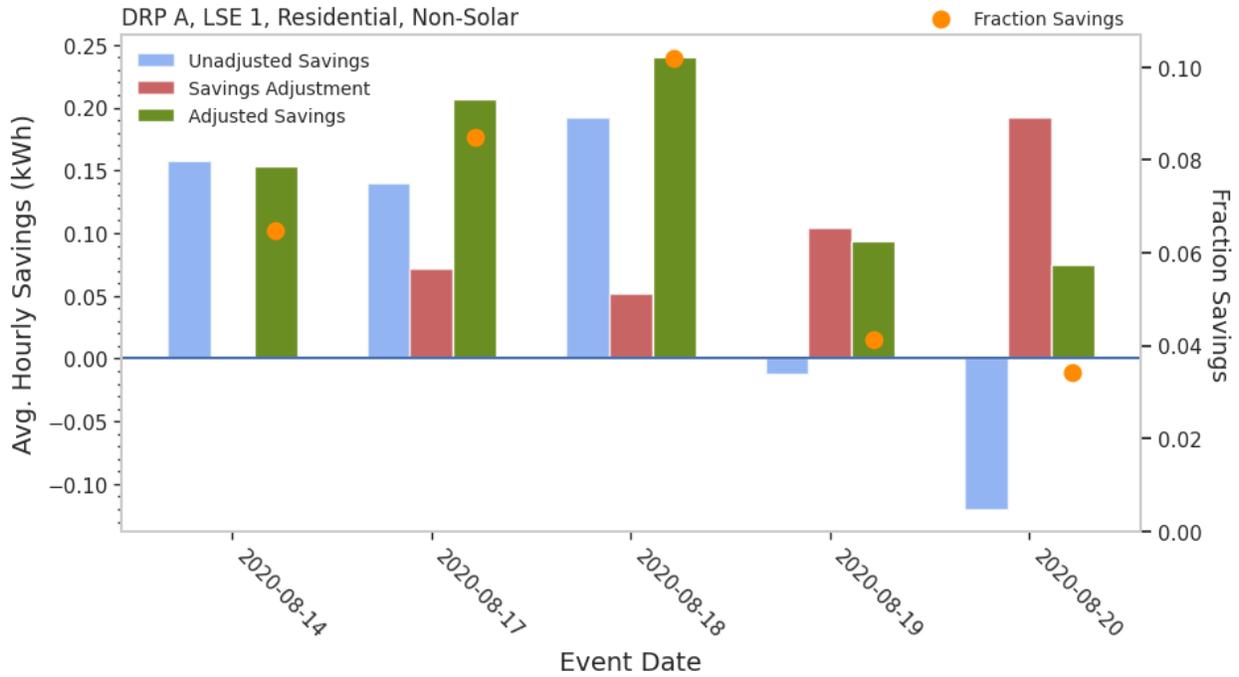


Figure 10: DRP A, LSE 1, Non-Solar. Average participant hourly unadjusted savings (blue bars), the comparison group adjustment (red bars), and the adjusted savings (green bars) for each event. Fractional savings (savings/counterfactual) are shown as orange dots and refer to the right-hand axis.

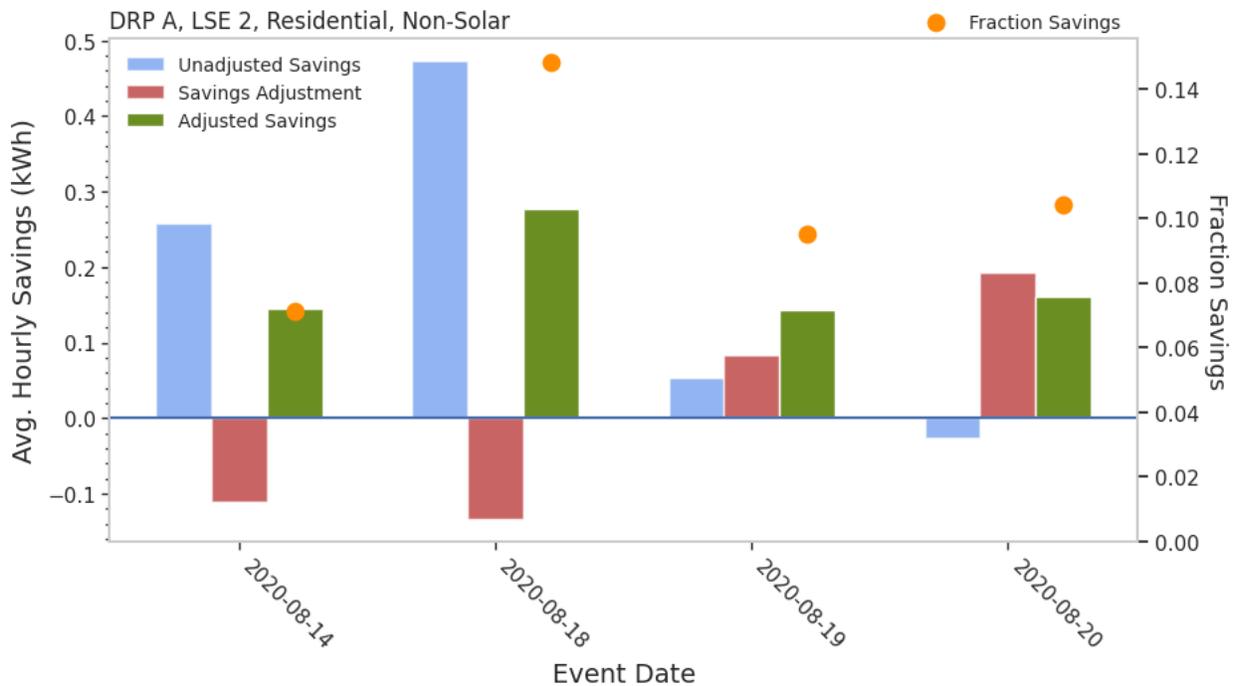


Figure 11: DRP A, LSE 2, Non-Solar. Average participant hourly unadjusted savings (blue bars), the comparison group adjustment (red bars), and the adjusted savings (green bars) for each event. Fractional savings (savings/counterfactual) are shown in orange dots and refer to the right-hand axis.

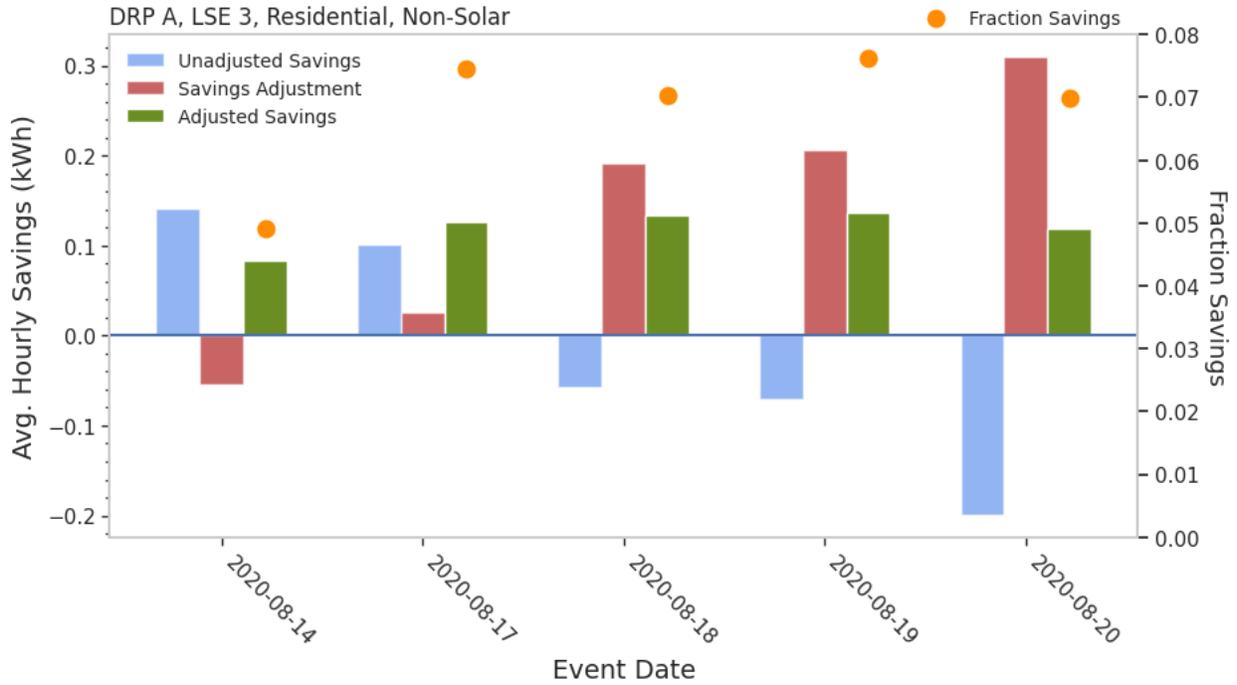


Figure 12: DRP A, LSE 3 Non-Solar. Average participant hourly unadjusted savings (blue bars), the comparison group adjustment (red bars), and the adjusted savings (green bars) for each event. Fractional savings (savings/counterfactual) are shown in orange dots and refer to the right hand axis.

Table 2: FLEXmeter Results for Demand Response Provider A, Residential, Solar

DRP	LSE	Date	Event	Avg. Temp (F)	Participants	Avg. Hourly Savings (kW)	Max. DP Noise (kW)	% Savings	Comp Group Savings Adjustment (kW)
A	2	2020-08-14	FALSE	84.7	187	-0.07	0.0022	-8.2%	-0.063
A	2	2020-08-14	TRUE	97.2	187	0.36	0.0068	13.2%	-0.202
A	2	2020-08-20	FALSE	75.5	138	-0.04	0.0030	-10.5%	0.211
A	2	2020-08-20	TRUE	78.7	138	0.11	0.0087	6.0%	0.246
A	3	2020-08-14	TRUE	88.5	289	0.14	0.0030	5.2%	-0.153
A	3	2020-08-17	FALSE	80.0	300	-0.05	0.0013	-4.3%	0.082
A	3	2020-08-17	TRUE	85.0	300	0.38	0.0057	14.1%	0.092
A	3	2020-08-18	FALSE	81.7	287	0.00	0.0017	-0.2%	0.047
A	3	2020-08-18	TRUE	87.8	287	0.36	0.0064	12.3%	0.277
A	3	2020-08-19	FALSE	82.9	305	-0.03	0.0015	-2.2%	0.101
A	3	2020-08-19	TRUE	84.1	305	0.35	0.0052	11.2%	0.325
A	3	2020-08-20	FALSE	81.3	307	-0.05	0.0013	-4.1%	0.130
A	3	2020-08-20	TRUE	81.8	307	0.24	0.0097	7.9%	0.500

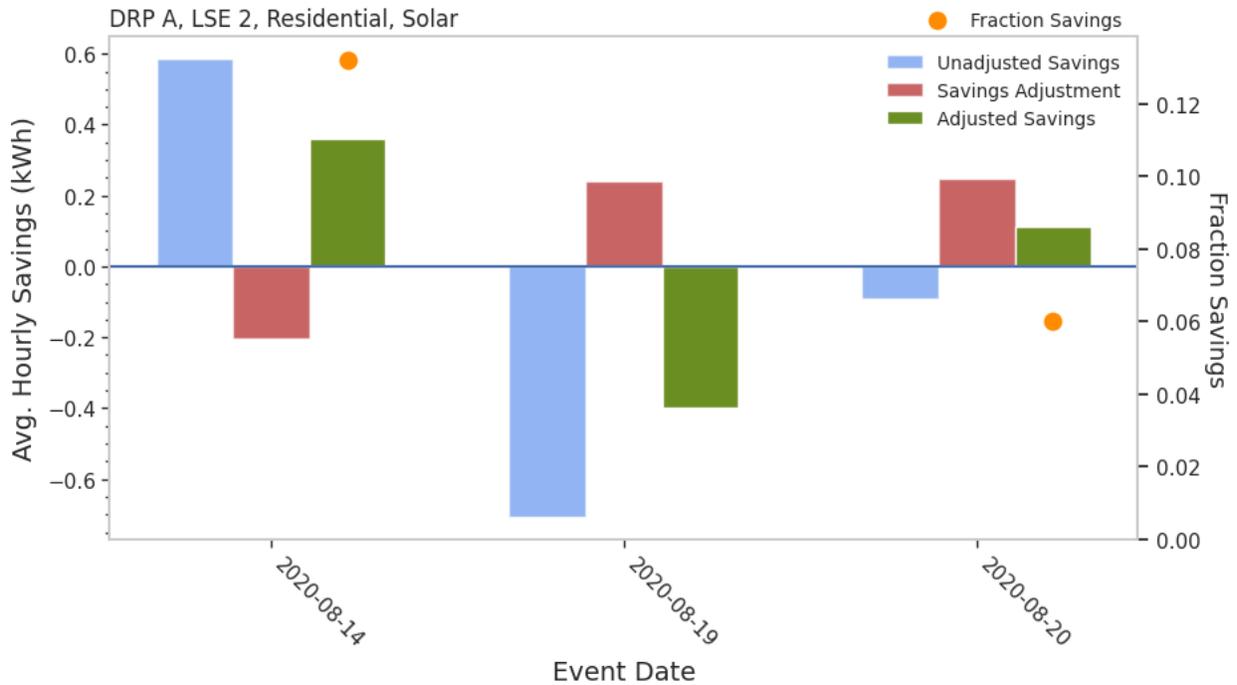


Figure 13: DRP A, LSE 2 Solar. Average participant hourly unadjusted savings (blue bars), the comparison group adjustment (red bars), and the adjusted savings (green bars) for each event. Fractional savings (savings/counterfactual) are shown in orange dots and refer to the right hand axis.

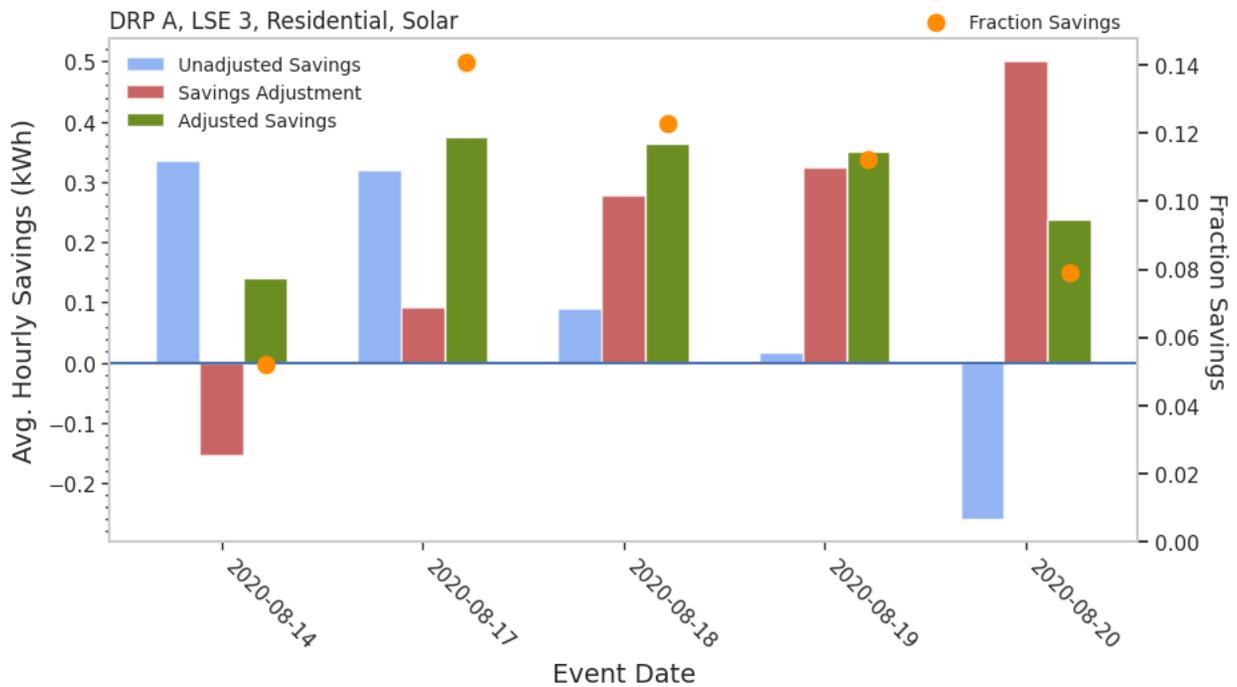


Figure 14: DRP A, LSE 3 Solar. Average participant hourly unadjusted savings (blue bars), the comparison group adjustment (red bars), and the adjusted savings (green bars) for each event. Fractional savings (savings/counterfactual) are shown in orange dots and refer to the right hand axis.

Table 3: FLEXmeter Results for Demand Response Provider B, Residential, Non-Solar

DRP	LSE	Date	Event	Avg. Temp (F)	Participants	Avg. Hourly Savings (kW)	Max. DP Noise (kW)	% Savings	Comp Group Savings Adjustment (kW)
B	2	2020-08-14	FALSE	84.1	1,509	-0.04	0.0002	-2.4%	-0.086
B	2	2020-08-14	TRUE	98.9	1,509	0.72	0.0006	22.5%	-0.133
B	2	2020-08-18	FALSE	83.4	1,532	-0.05	0.0001	-2.4%	0.033
B	2	2020-08-18	TRUE	96.7	1,532	0.89	0.0009	28.5%	-0.039
B	2	2020-08-19	FALSE	82.3	1,531	-0.05	0.0001	-3.1%	-0.022
B	2	2020-08-19	TRUE	93.2	1,531	0.94	0.0008	32.3%	0.148
B	4	2020-08-14	FALSE	83.5	1,235	-0.01	0.0001	-0.6%	-0.096
B	4	2020-08-14	TRUE	95.3	1,235	0.72	0.0003	24.3%	-0.168
B	4	2020-08-18	FALSE	80.0	1,223	-0.02	0.0001	-1.1%	0.034
B	4	2020-08-18	TRUE	91.5	1,223	0.89	0.0002	31.6%	0.036
B	4	2020-08-19	FALSE	77.4	1,222	-0.02	0.0001	-1.5%	0.078
B	4	2020-08-19	TRUE	84.6	1,222	0.65	0.0001	30.0%	-0.004

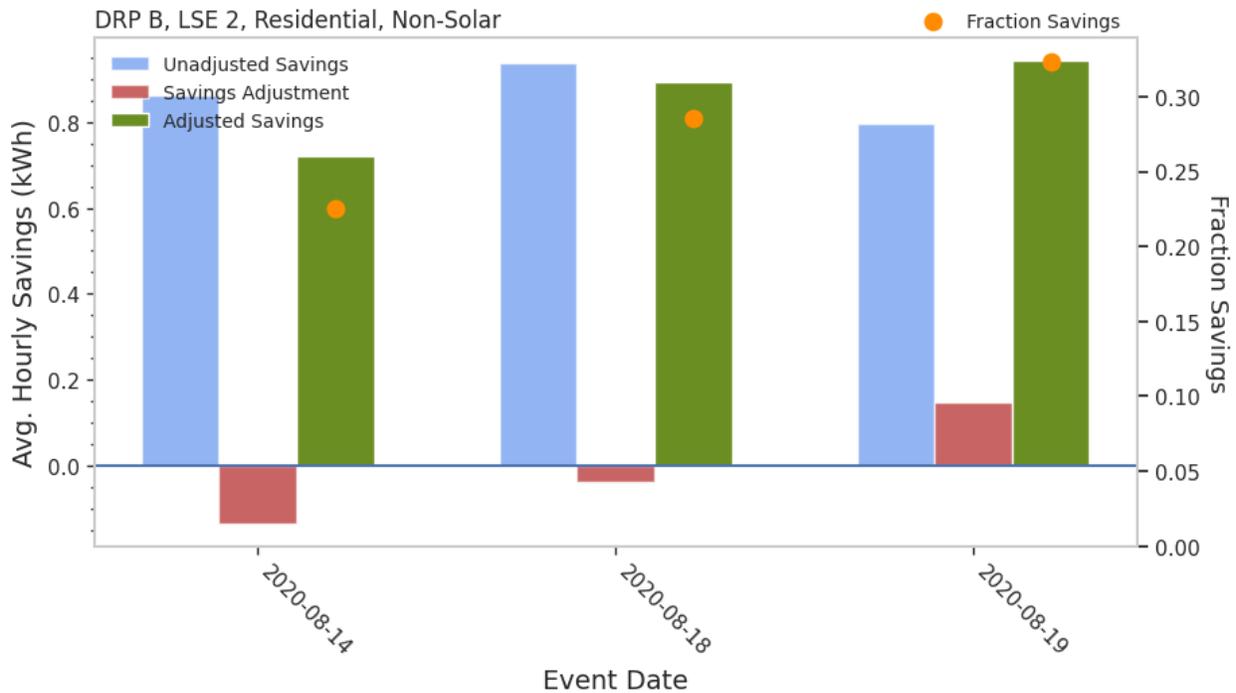


Figure 15: DRP B, LSE 2 Non-Solar. Average participant hourly unadjusted savings (blue bars), the comparison group adjustment (red bars), and the adjusted savings (green bars) for each event. Fractional savings (savings/counterfactual) are shown in orange dots and refer to the right hand axis.

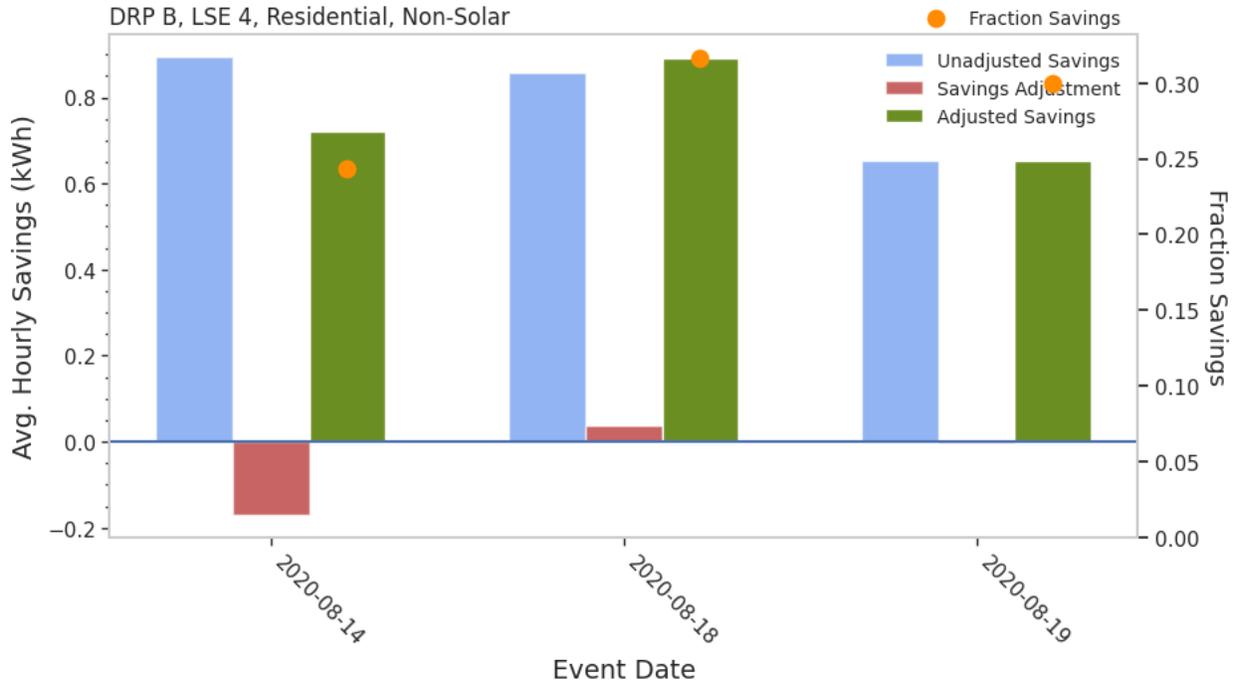


Figure 16: DRP B, LSE 4 Non-Solar. Average participant hourly unadjusted savings (blue bars), the comparison group adjustment (red bars), and the adjusted savings (green bars) for each event. Fractional savings (savings/counterfactual) are shown in orange dots and refer to the right hand axis.

Table 4: FLEXmeter Results for Demand Response Provider C, Non-Residential, Non-Solar

DRP	LSE	Date	Event	Avg. Temp (F)	Participants	Avg. Hourly Savings (kW)	Max. DP Noise (kW)	% Savings	Comp Group Savings Adjustment (kW)
C	1	2020-08-13	FALSE	84.8	87	-1.30	0.1144	-1.0%	-3.427
C	1	2020-08-13	TRUE	93.2	87	53.40	3.1632	39.2%	-9.758
C	1	2020-08-14	FALSE	84.3	138	-0.75	0.1094	-0.6%	-3.482
C	1	2020-08-14	TRUE	92.4	138	24.23	0.7981	18.2%	-8.004
C	1	2020-08-17	FALSE	82.5	138	1.09	0.1430	0.8%	0.981
C	1	2020-08-17	TRUE	89.9	138	41.29	0.7067	30.6%	-6.867
C	1	2020-08-18	FALSE	85.0	138	-0.94	0.1255	-0.7%	1.313
C	1	2020-08-18	TRUE	90.5	138	34.03	0.7269	24.7%	-4.644
C	1	2020-08-19	FALSE	85.6	138	2.14	0.0790	1.6%	0.782
C	1	2020-08-19	TRUE	90.4	138	46.03	0.8010	34.6%	-3.028

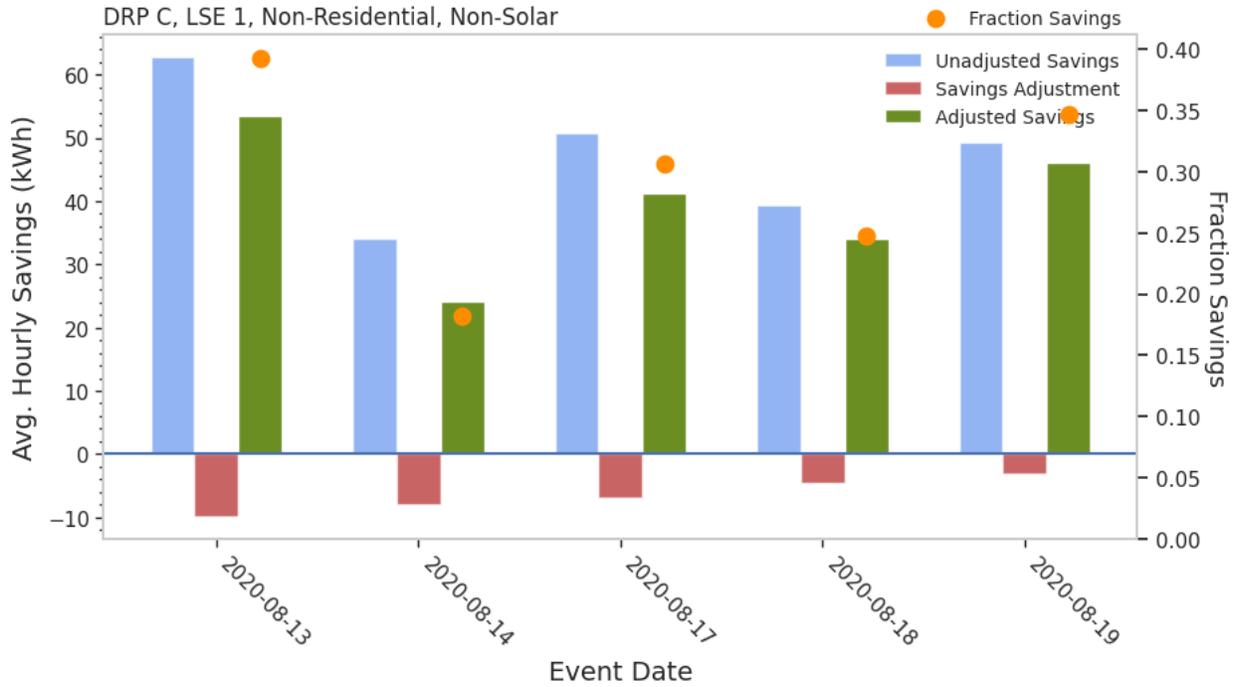


Figure 17: DRP C, LSE 1 Non-Solar. Average participant hourly unadjusted savings (blue bars), the comparison group adjustment (red bars), and the adjusted savings (green bars) for each event. Fractional savings (savings/counterfactual) are shown in orange dots and refer to the right hand axis.

Table 5: FLEXmeter Results for Demand Response Provider D, Residential, Non-Solar

DRP	LSE	Date	Event	Avg. Temp (F)	Participants	Avg. Hourly Savings (kW)	Max. DP Noise (kW)	% Savings	Comp Group Savings Adjustment (kW)
D	1	2020-08-13	FALSE	83.5	5,073	0.06	0.0000	4.0%	-0.118
D	1	2020-08-13	TRUE	88.0	5,073	0.28	0.0002	11.6%	-0.134
D	1	2020-08-14	FALSE	84.9	5,048	-0.01	0.0000	-0.6%	-0.037
D	1	2020-08-14	TRUE	93.4	5,048	0.80	0.0001	26.8%	0.038
D	1	2020-08-15	FALSE	85.5	5,066	-0.10	0.0001	-5.1%	0.051
D	1	2020-08-15	TRUE	96.0	5,066	1.06	0.0001	32.7%	0.083
D	1	2020-08-16	FALSE	85.1	5,064	-0.08	0.0000	-4.2%	0.120
D	1	2020-08-16	TRUE	90.0	5,064	0.43	0.0002	15.2%	0.192
D	1	2020-08-17	FALSE	83.8	5,068	-0.04	0.0000	-2.0%	0.062
D	1	2020-08-17	TRUE	94.7	5,067	0.91	0.0002	29.4%	0.101
D	1	2020-08-18	FALSE	83.6	5,065	-0.09	0.0001	-5.4%	0.027
D	1	2020-08-18	TRUE	97.6	5,065	0.84	0.0002	27.0%	0.017

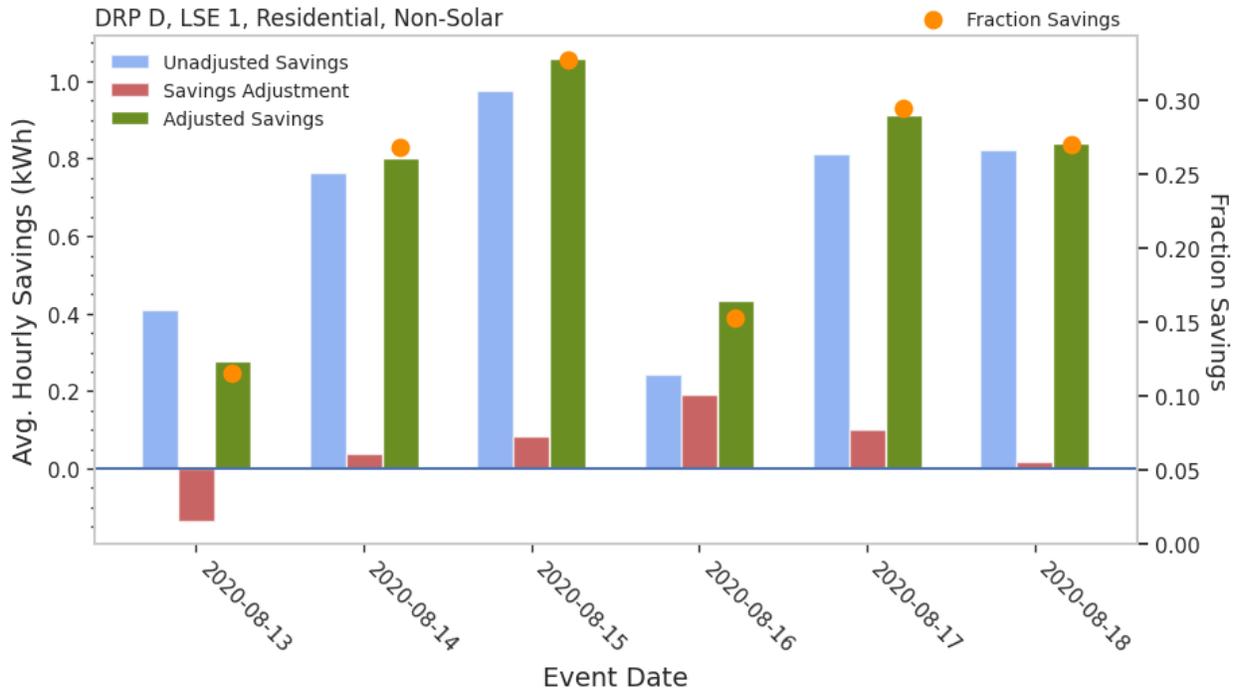


Figure 18: DRP D, LSE 1, Non-Solar, Residential. Average participant hourly unadjusted savings (blue bars), the comparison group adjustment (red bars), and the adjusted savings (green bars) for each event. Fractional savings (savings/counterfactual) are shown in orange dots and refer to the right hand axis.

Table 6: FLEXmeter Results for Demand Response Provider D, Non-Residential, Non-Solar

DRP	LSE	Date	Event	Avg. Temp (F)	Participants	Avg. Hourly Savings (kW)	Max. DP Noise (kW)	% Savings	Comp Group Savings Adjustment (kW)
D	1	2020-08-13	FALSE	81.7	2,749	-0.55	0.0027	-3.2%	-0.800
D	1	2020-08-13	TRUE	84.3	2,748	0.20	0.0214	1.3%	-1.153
D	1	2020-08-14	FALSE	83.3	2,748	-0.85	0.0031	-4.7%	-0.399
D	1	2020-08-14	TRUE	90.3	2,748	1.31	0.0073	7.5%	-0.763
D	1	2020-08-15	FALSE	83.9	2,748	0.23	0.0021	1.7%	-0.165
D	1	2020-08-15	TRUE	93.6	2,748	1.86	0.0089	11.0%	-0.220
D	1	2020-08-16	FALSE	83.5	2,749	0.14	0.0027	1.0%	0.071
D	1	2020-08-16	TRUE	87.6	2,748	0.57	0.0097	4.0%	0.351
D	1	2020-08-17	FALSE	82.0	2,756	-0.57	0.0042	-3.0%	0.366
D	1	2020-08-17	TRUE	92.5	2,756	1.57	0.0076	7.7%	-0.013
D	1	2020-08-18	FALSE	81.9	2,756	-0.04	0.0020	-0.2%	0.264
D	1	2020-08-18	TRUE	95.4	2,756	2.24	0.0079	9.1%	-0.099

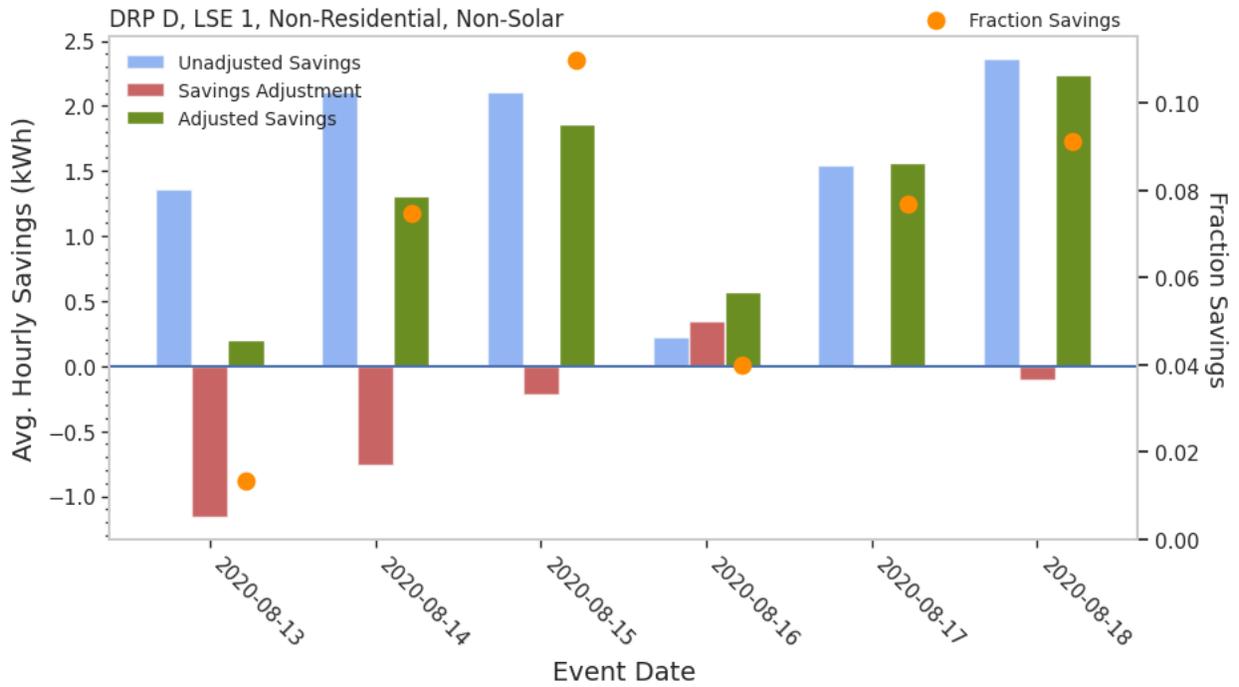
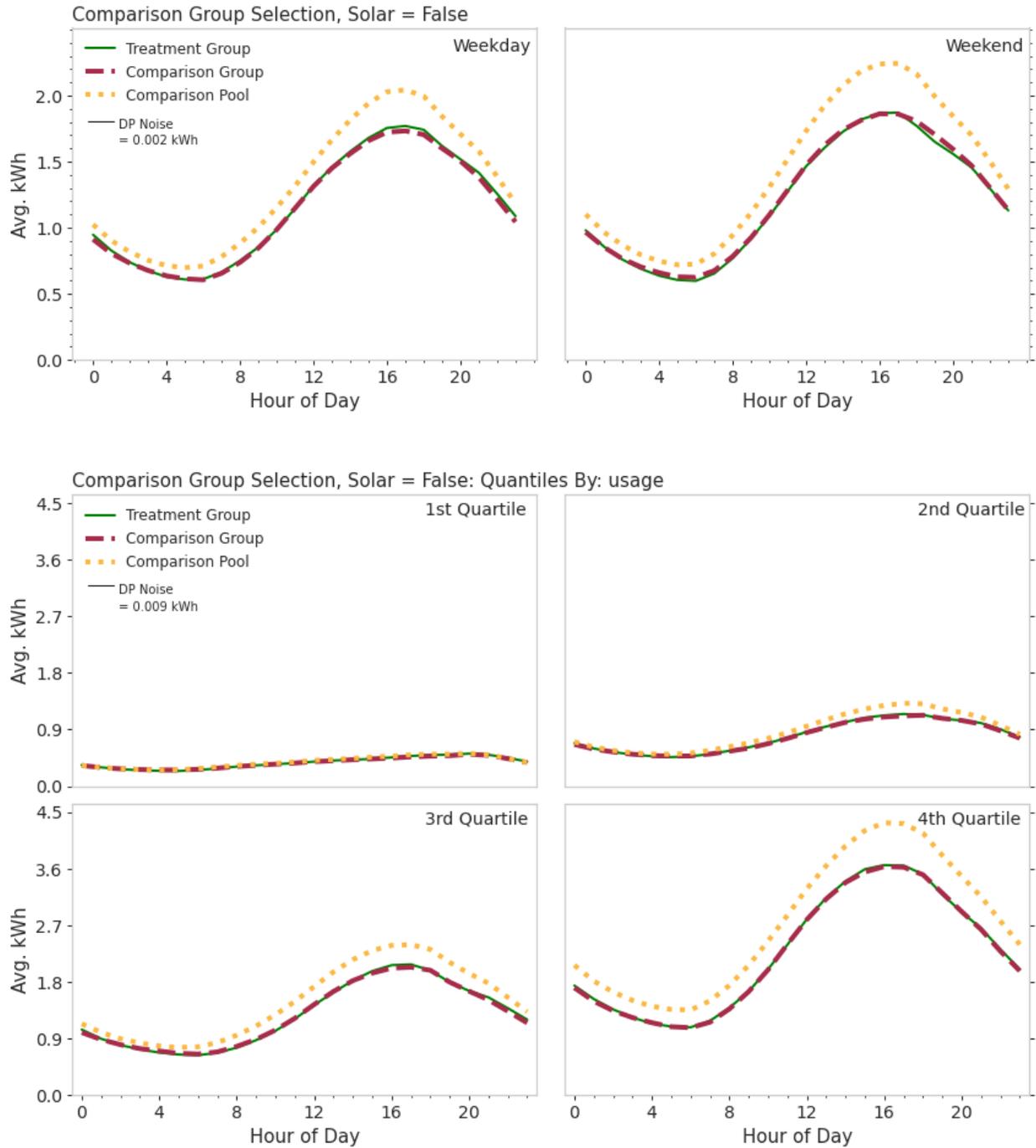
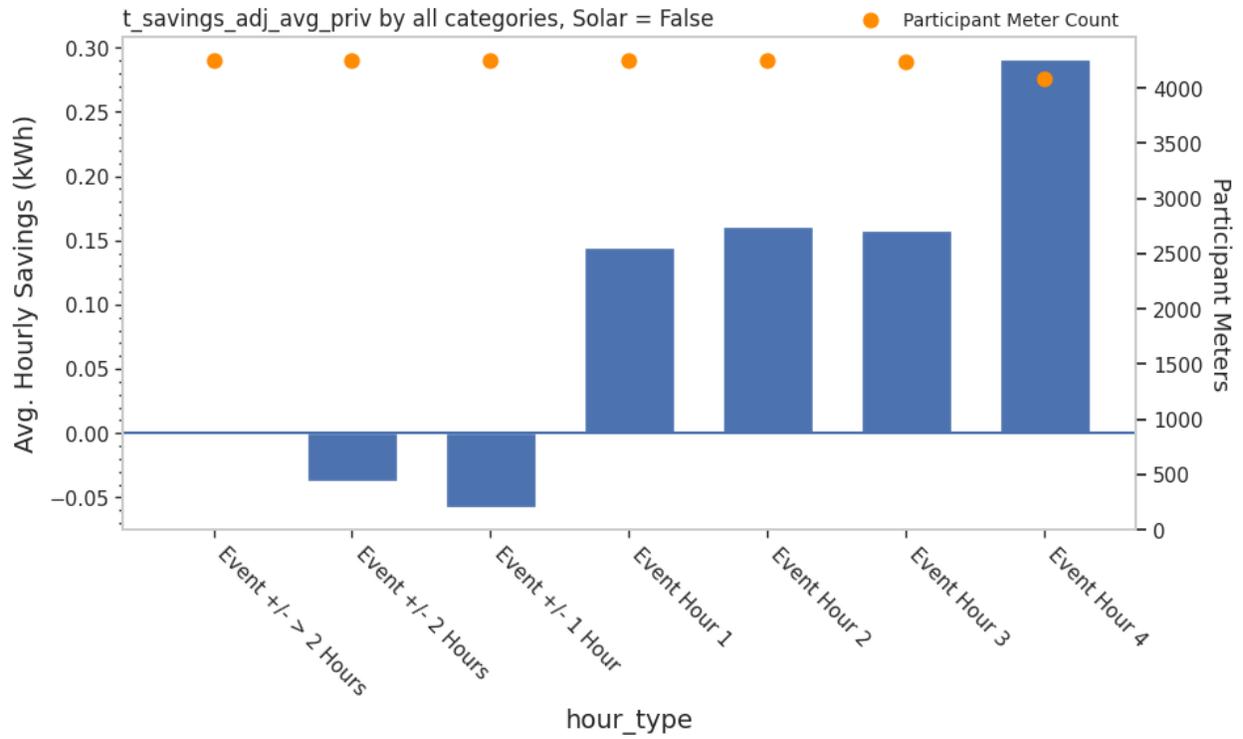
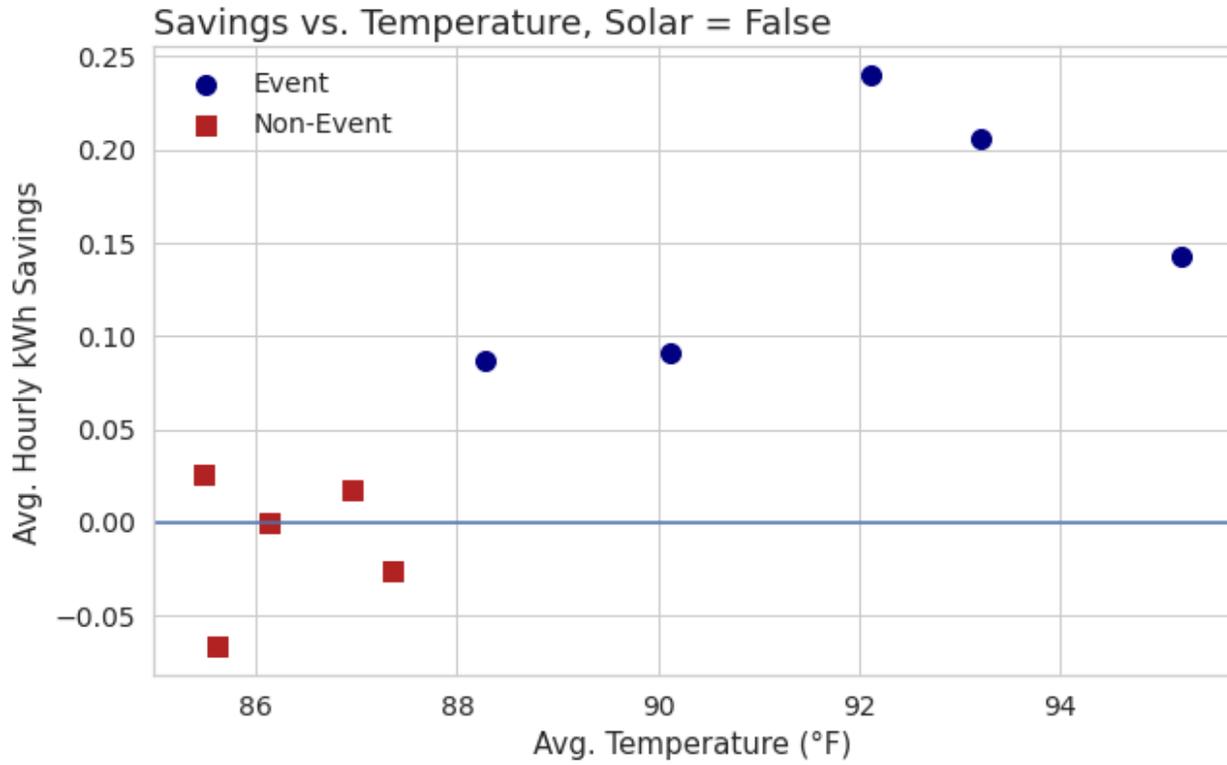
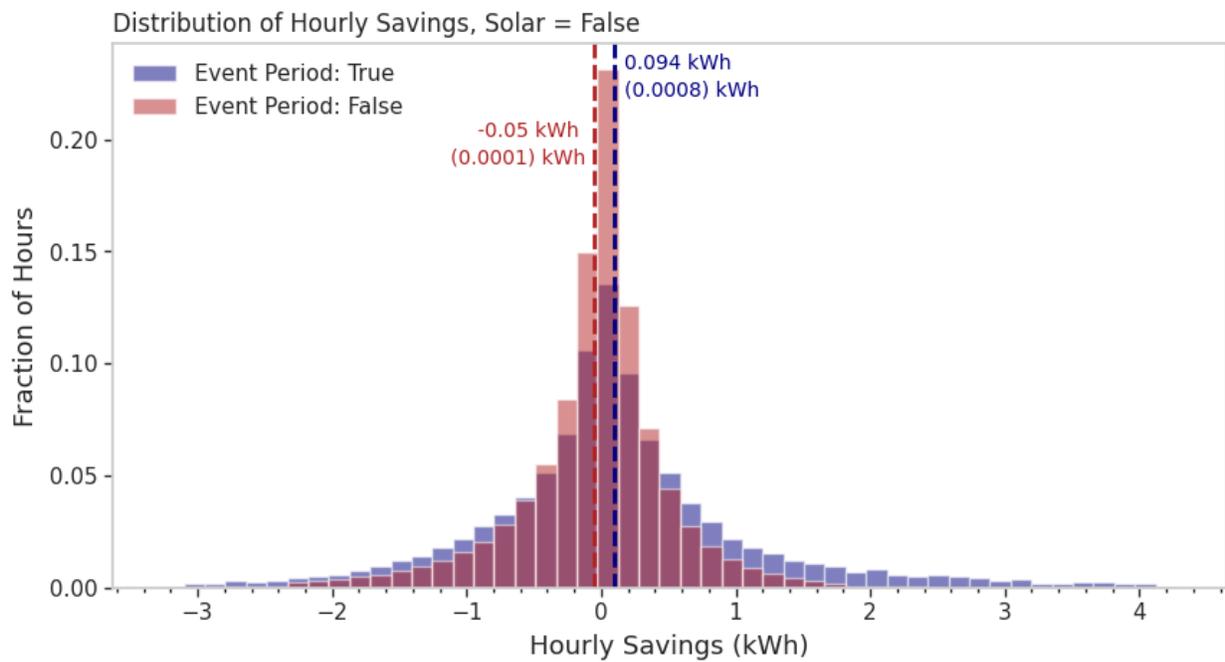
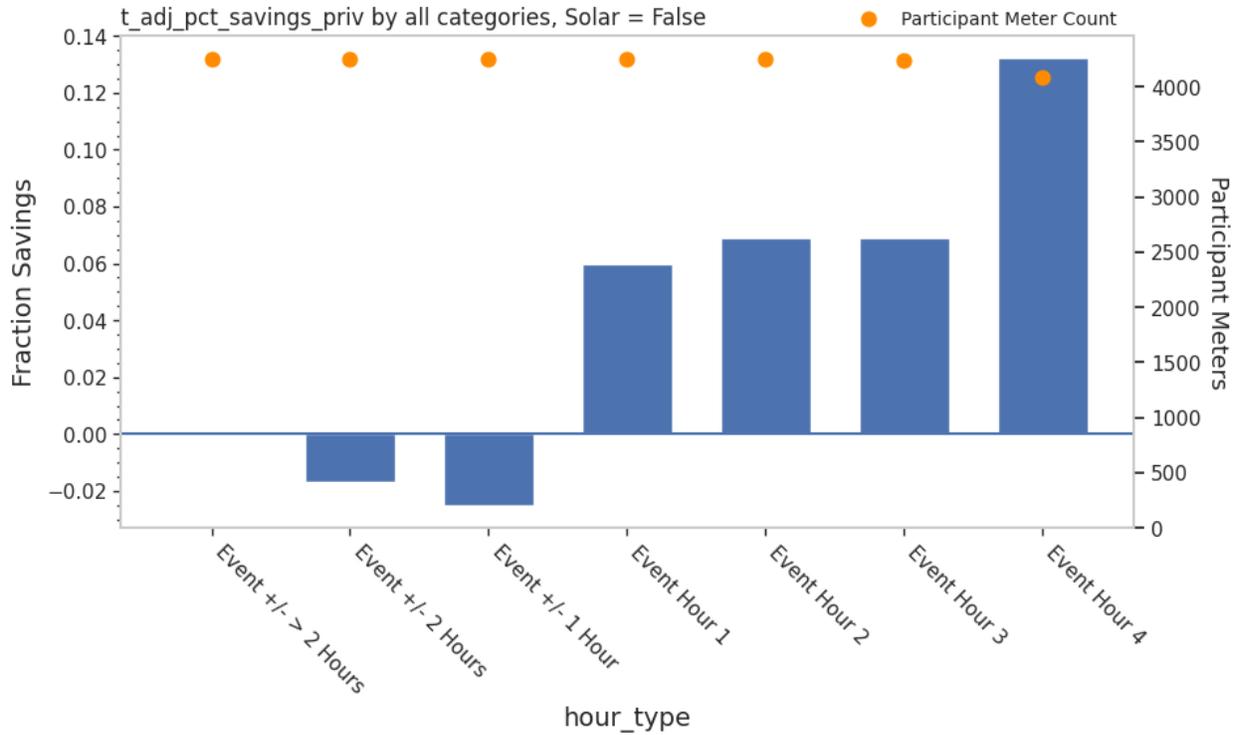


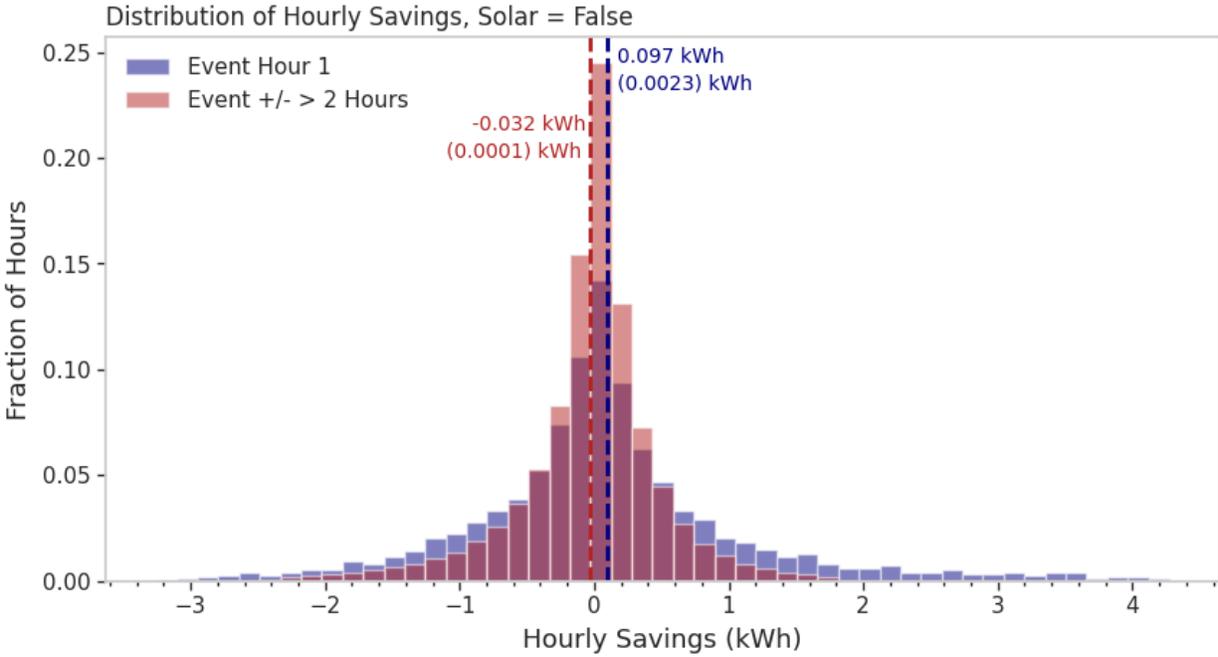
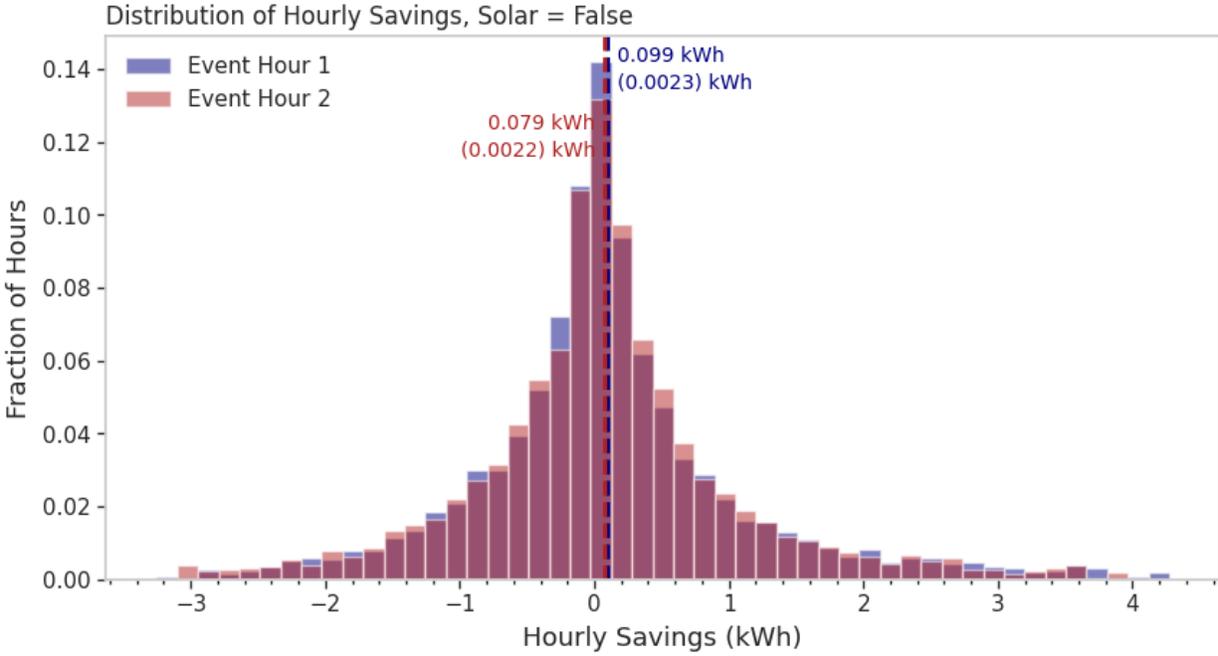
Figure 19: DRP D, LSE 1, Non-Solar, Non-Residential. Average participant hourly unadjusted savings (blue bars), the comparison group adjustment (red bars), and the adjusted savings (green bars) for each event. Fractional savings (savings/counterfactual) are shown in orange dots and refer to the right hand axis.

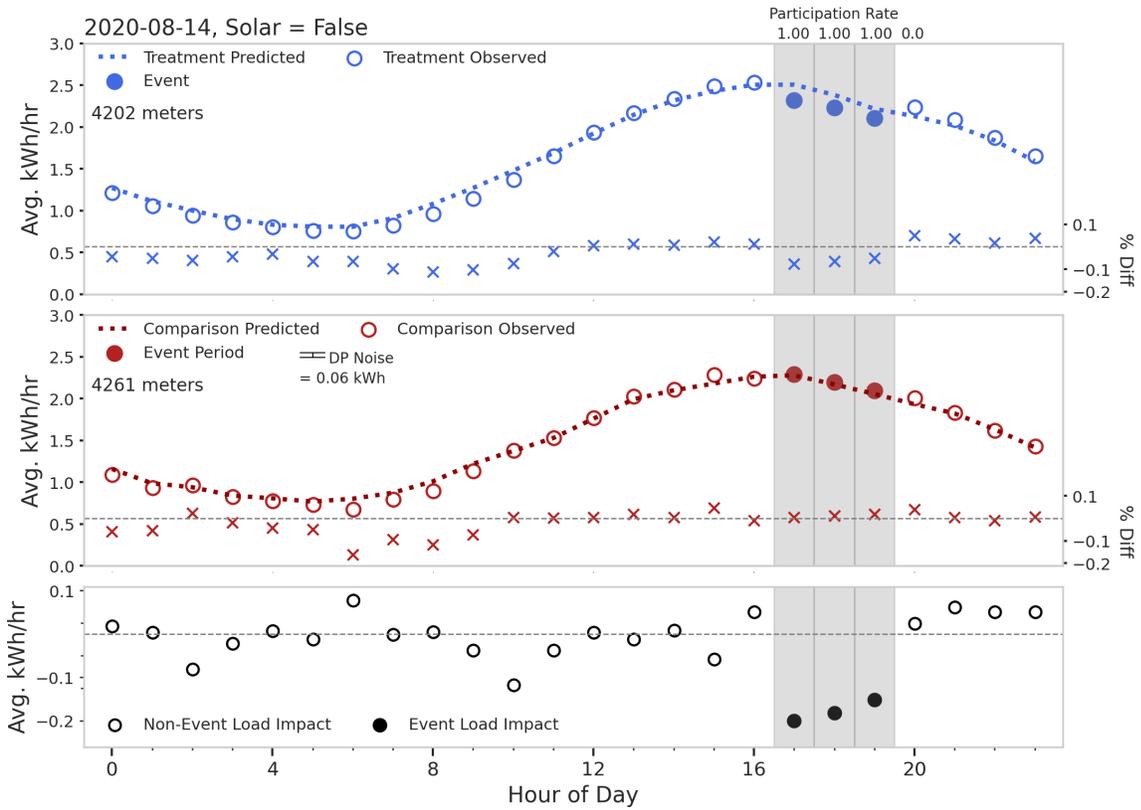
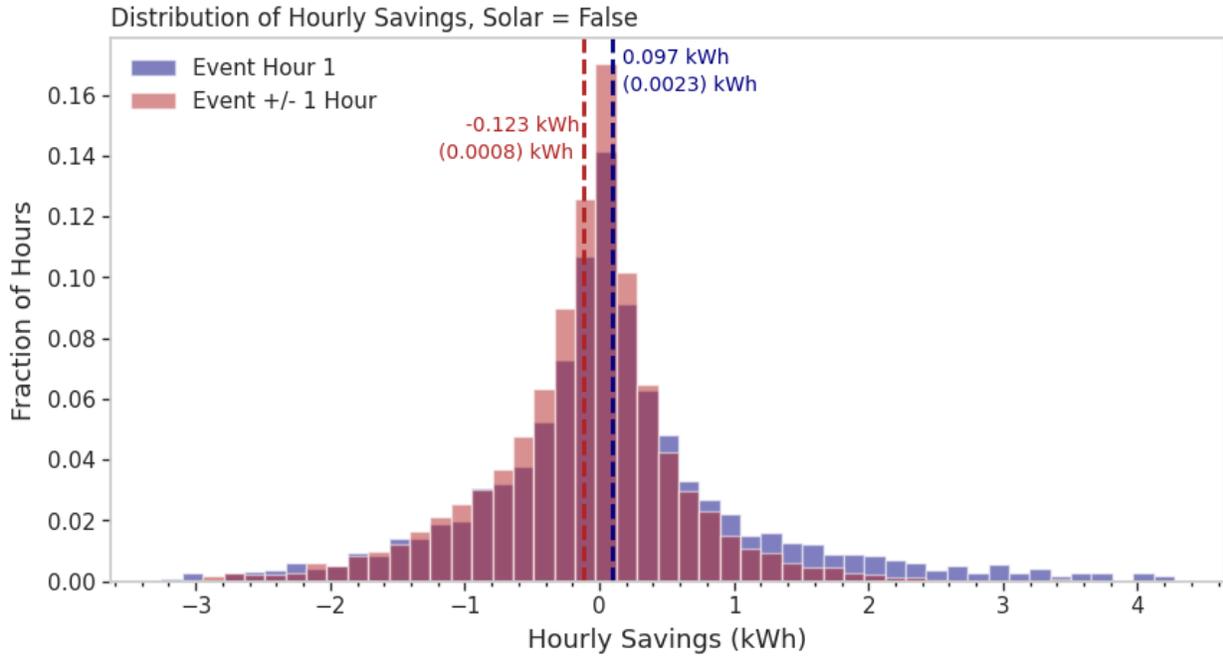
Additional Results: DRP A, LSE 1, Residential

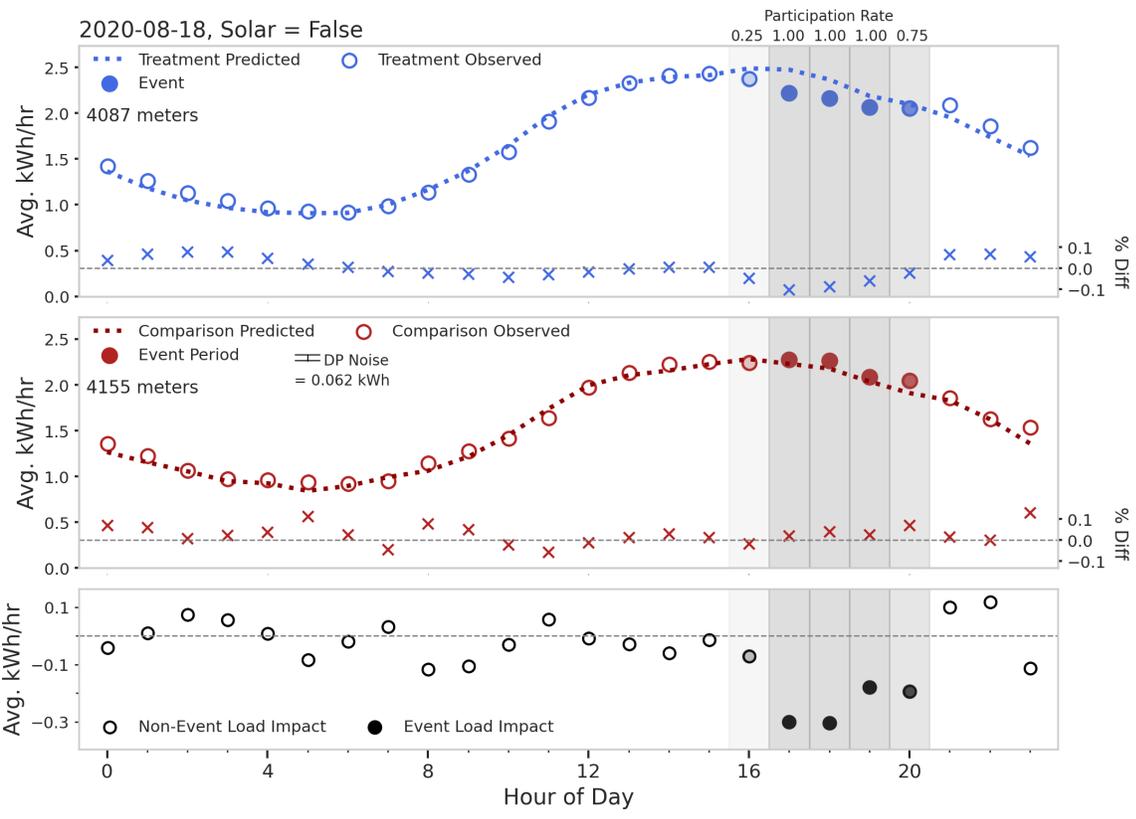
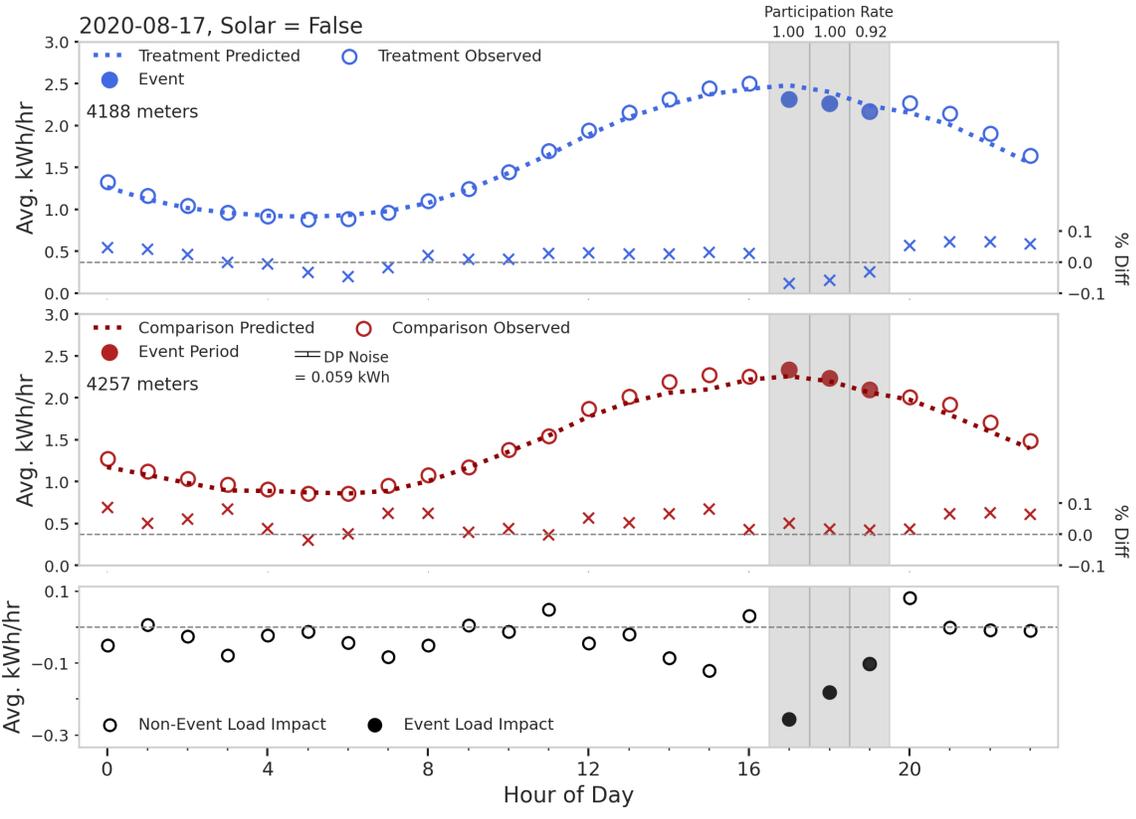


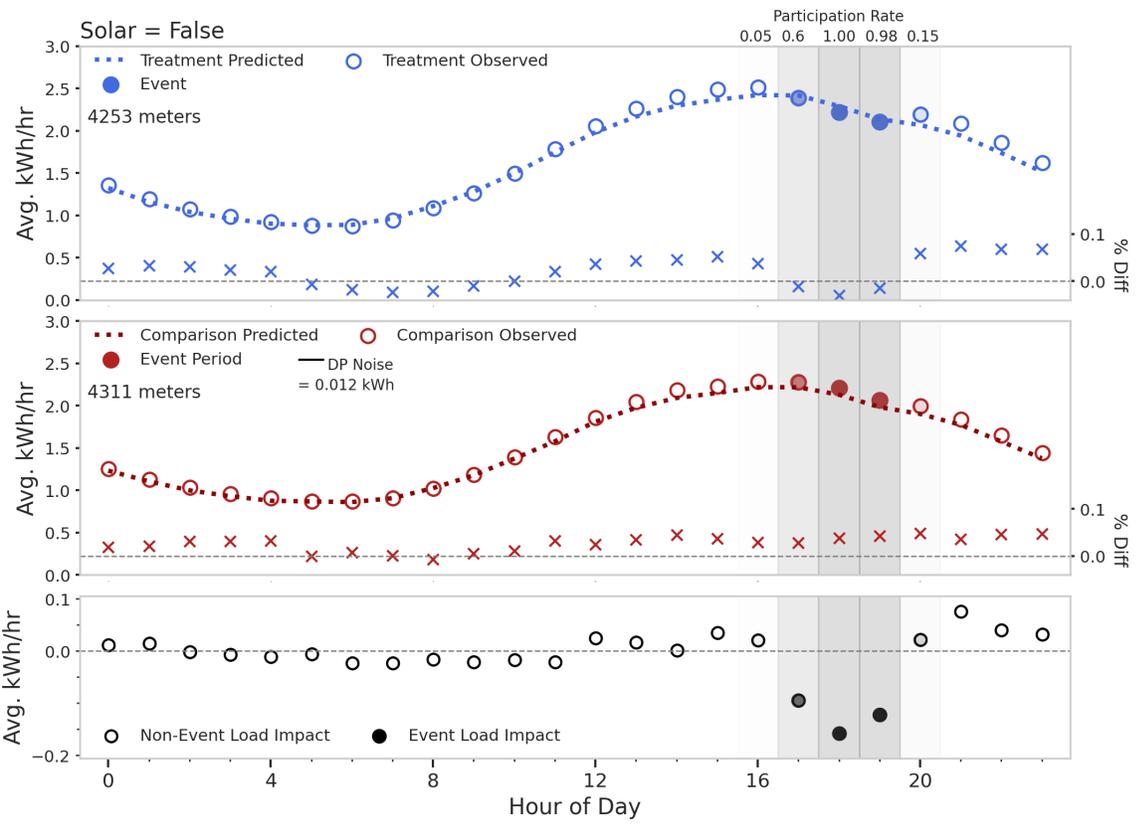
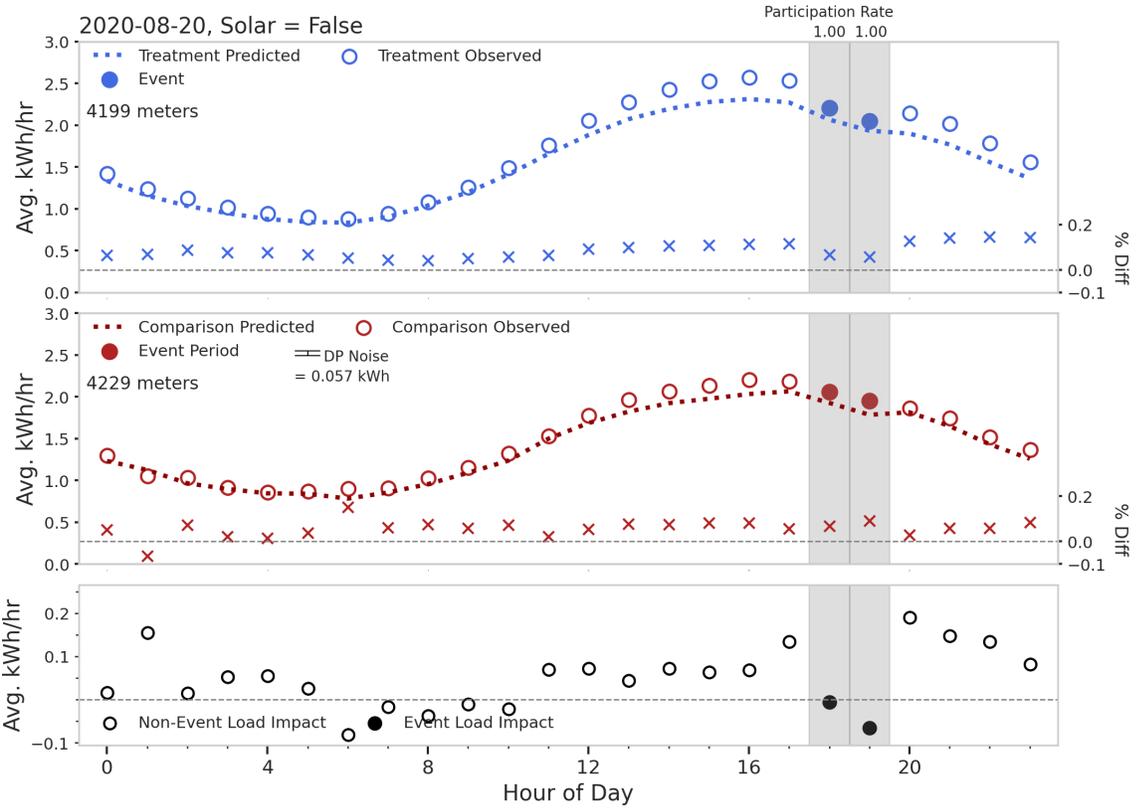




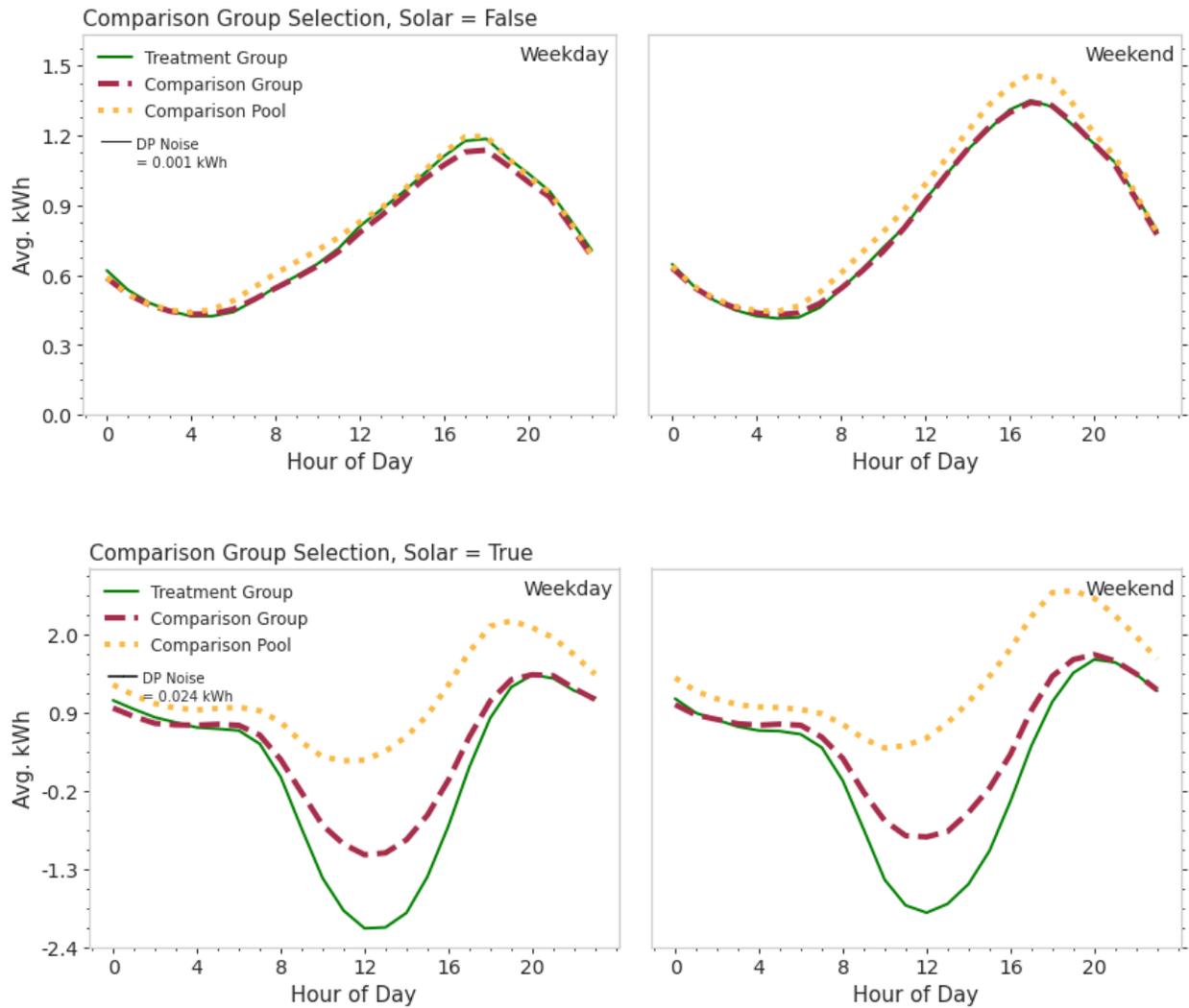




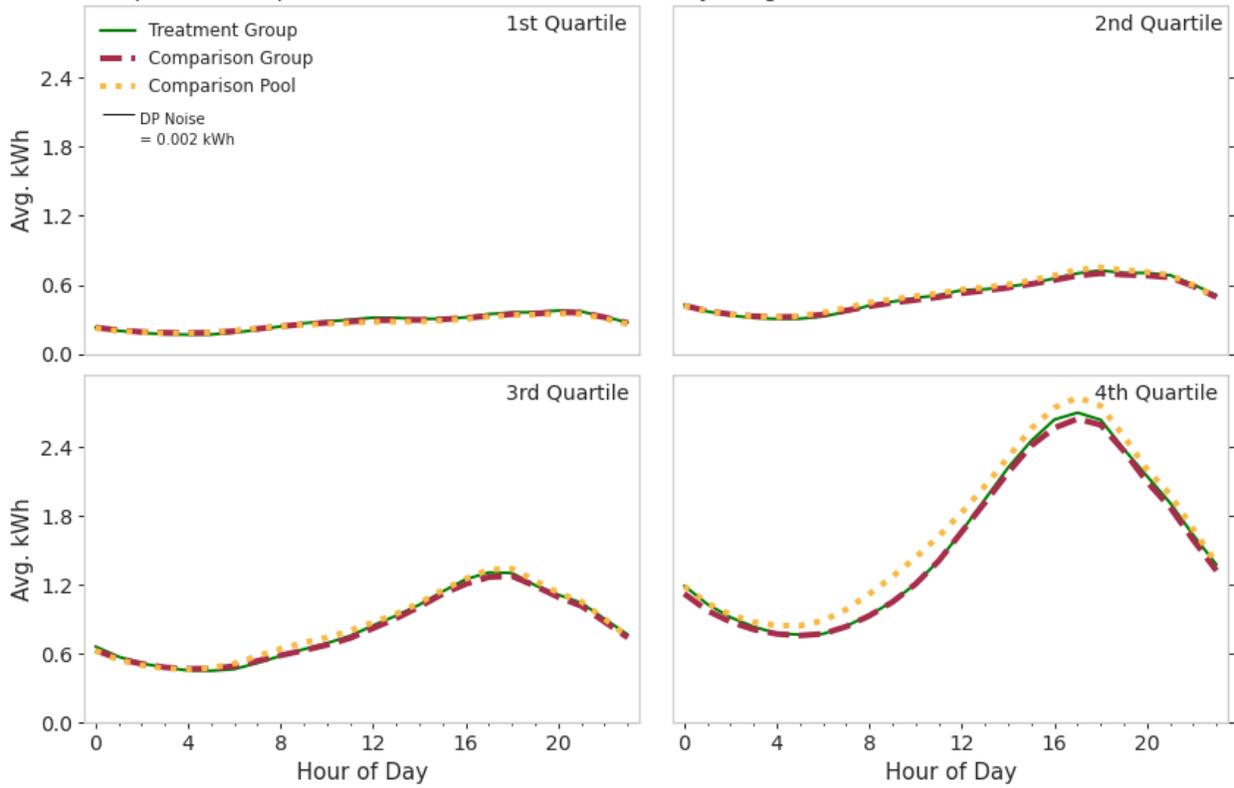




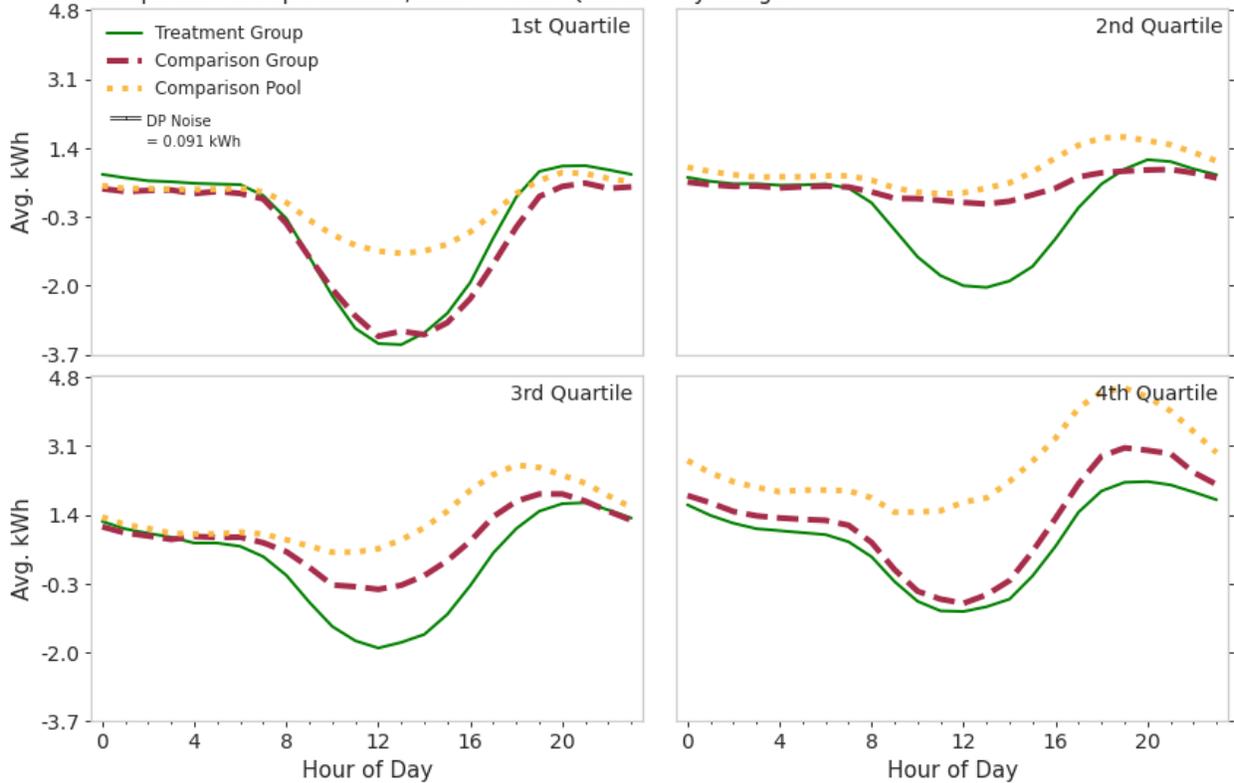
Additional Results: DRP A, LSE 2, Residential



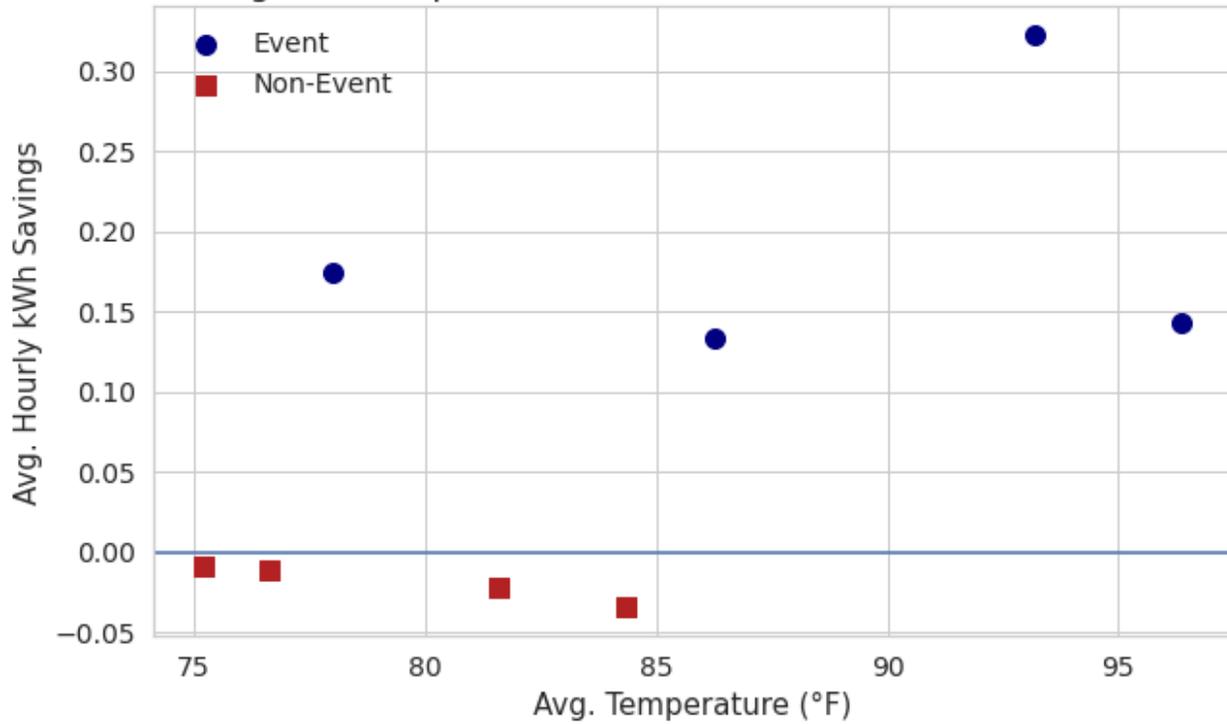
Comparison Group Selection, Solar = False: Quantiles By: usage



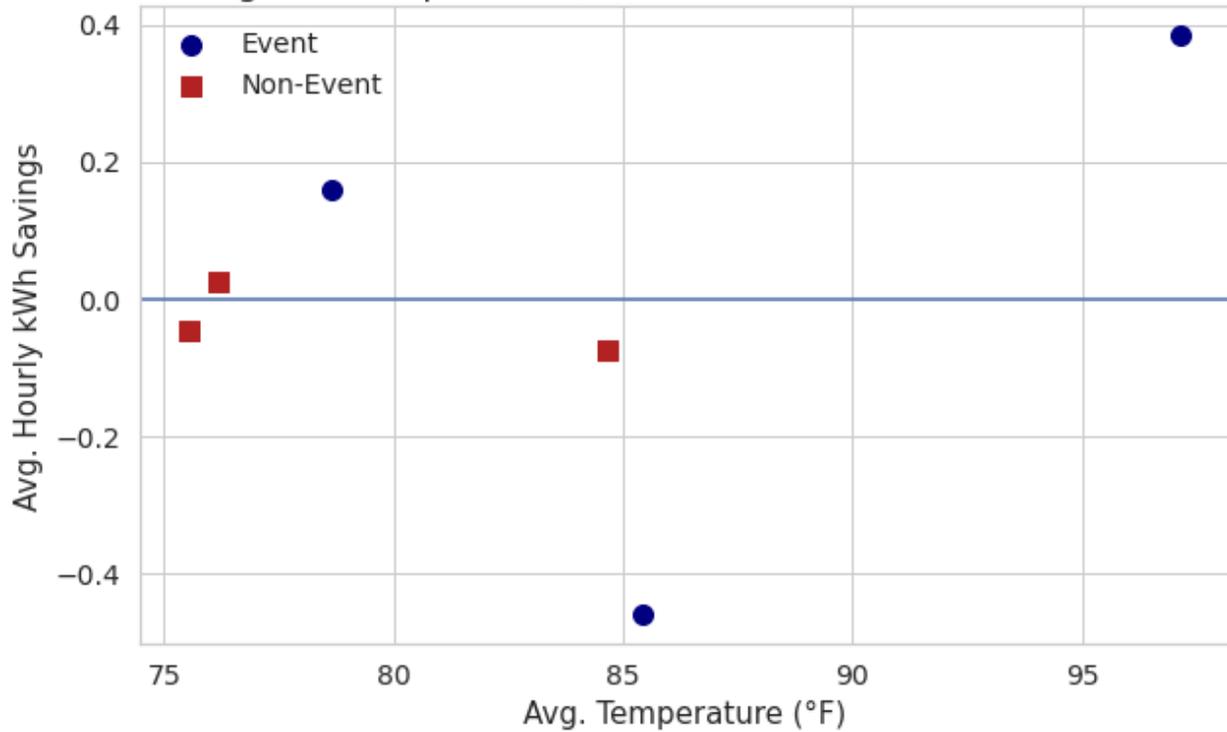
Comparison Group Selection, Solar = True: Quantiles By: usage

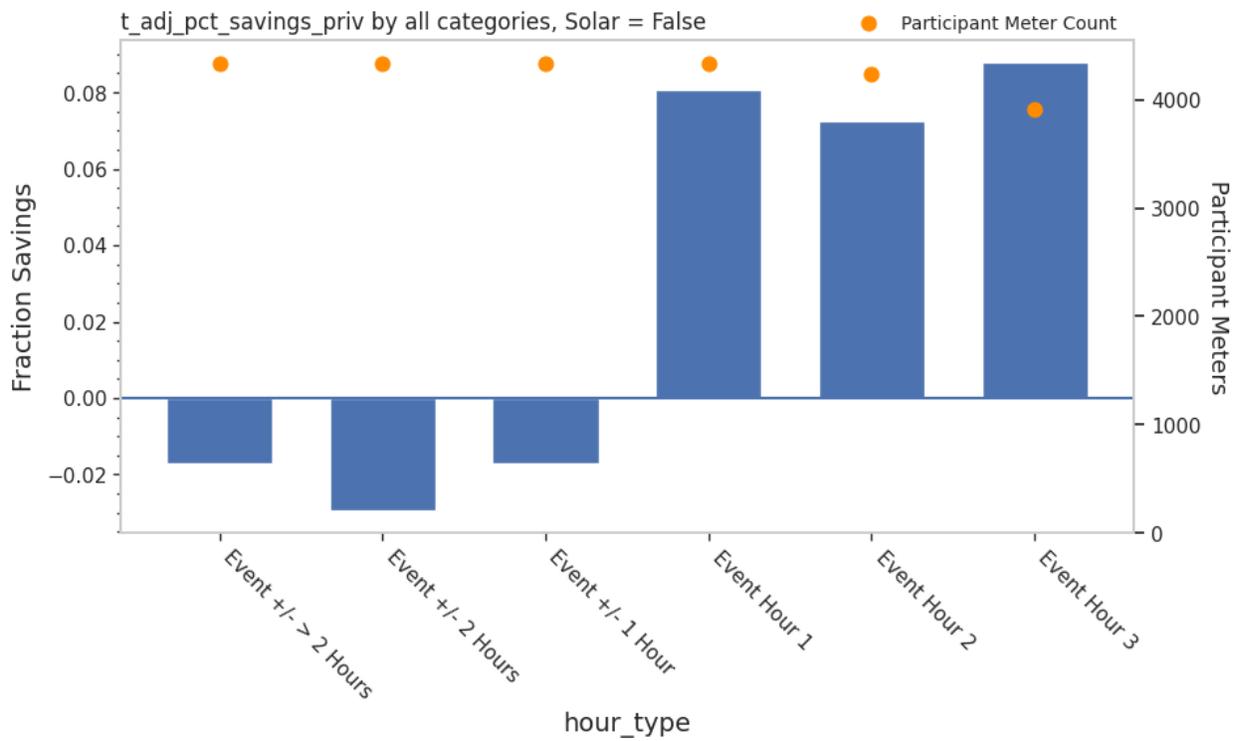
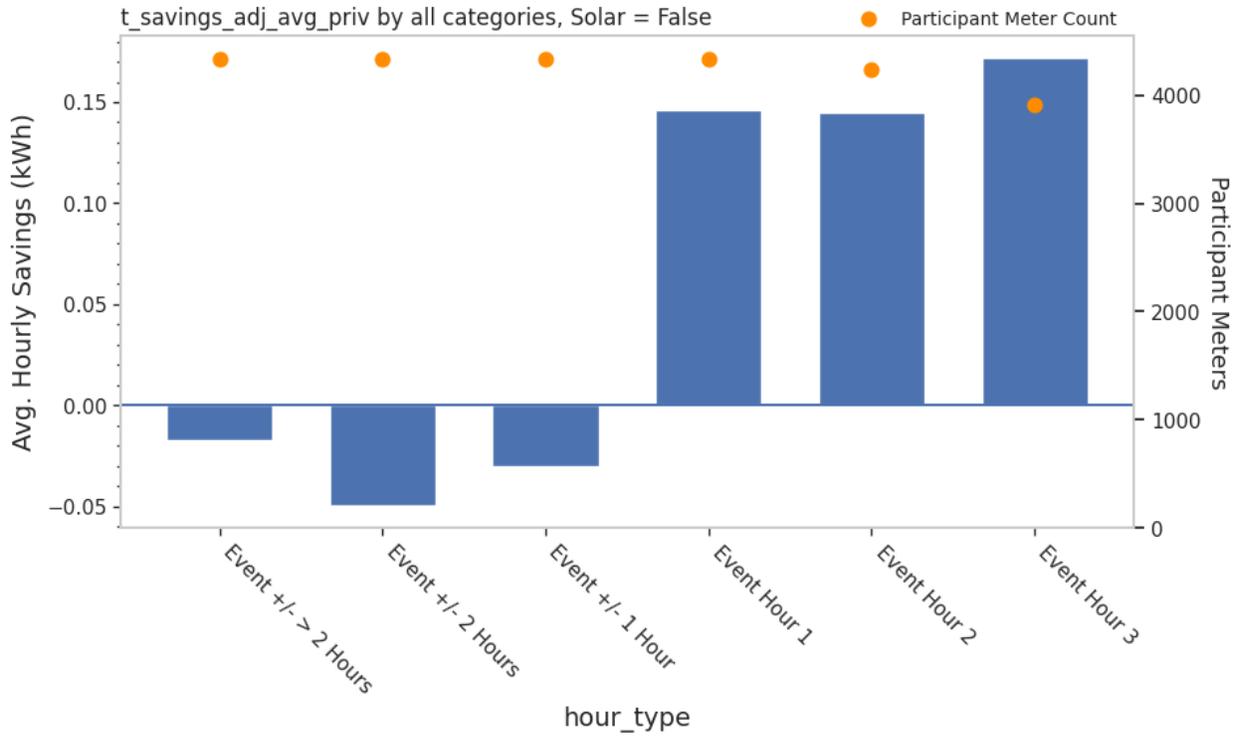


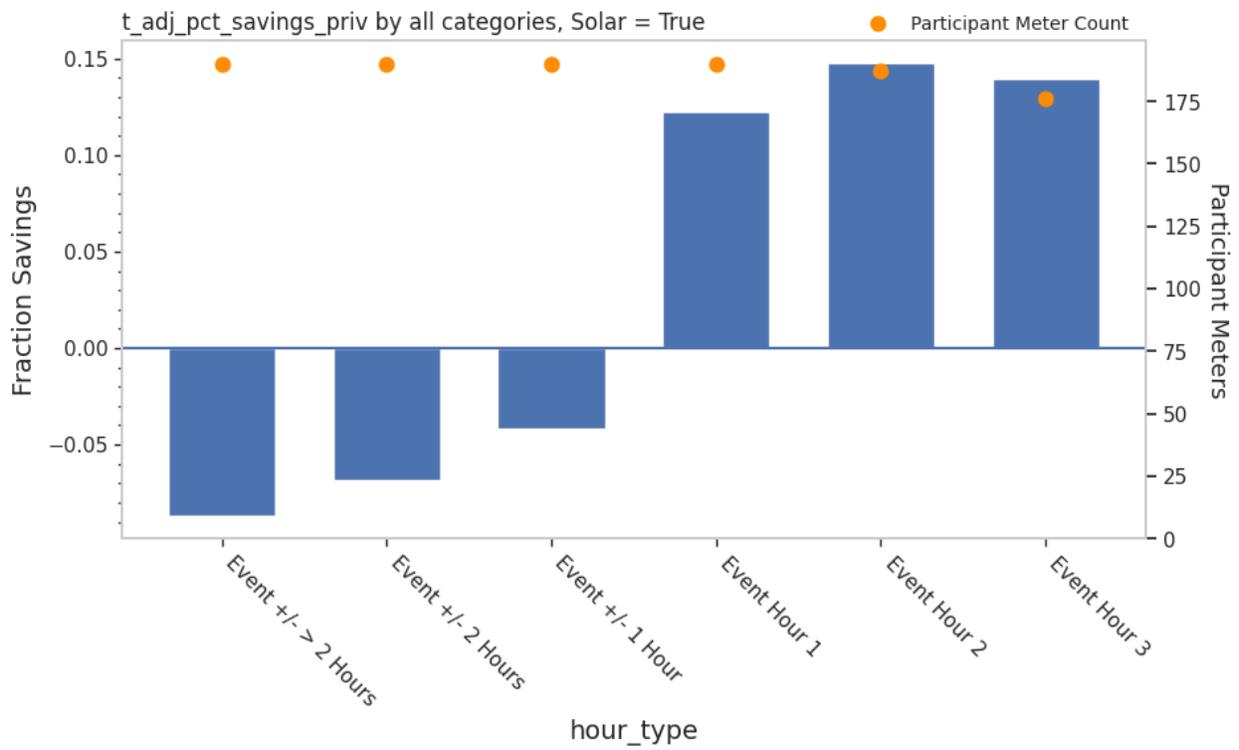
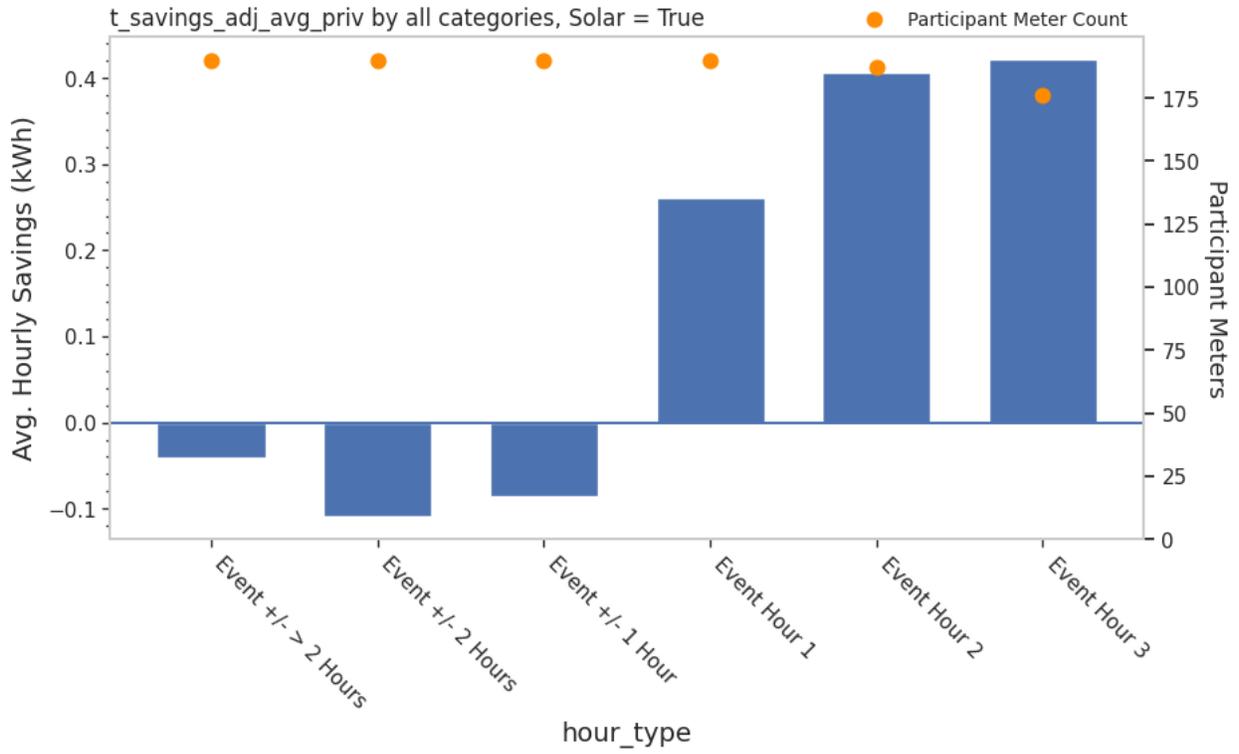
Savings vs. Temperature, Solar = False

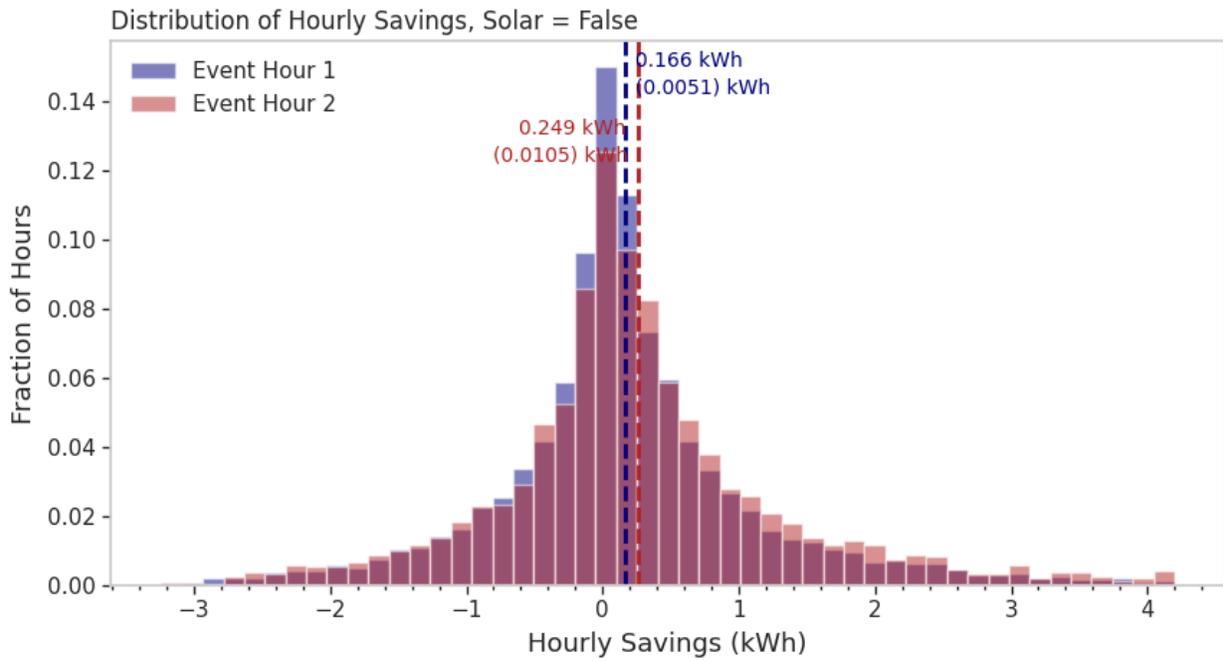
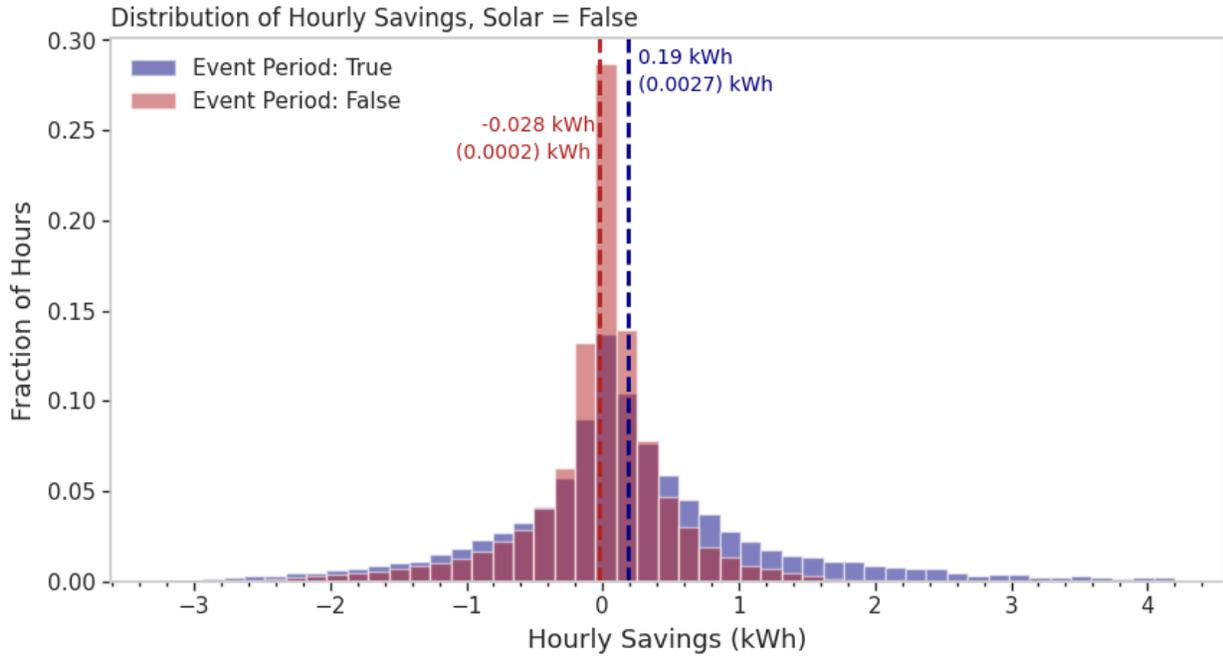


Savings vs. Temperature, Solar = True

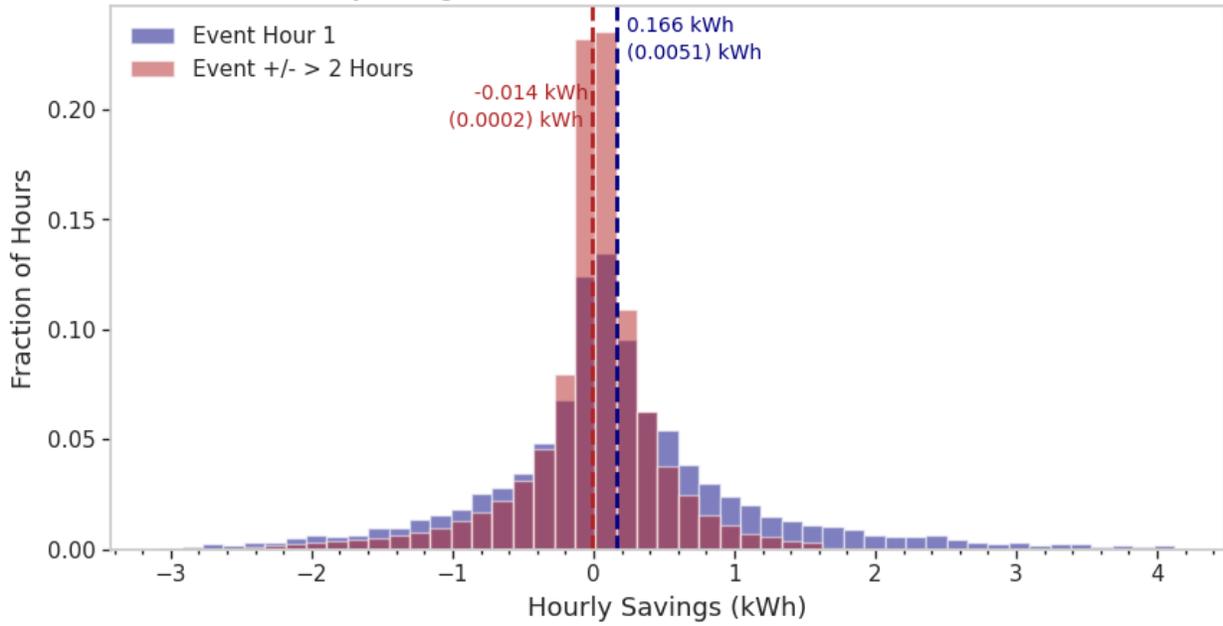




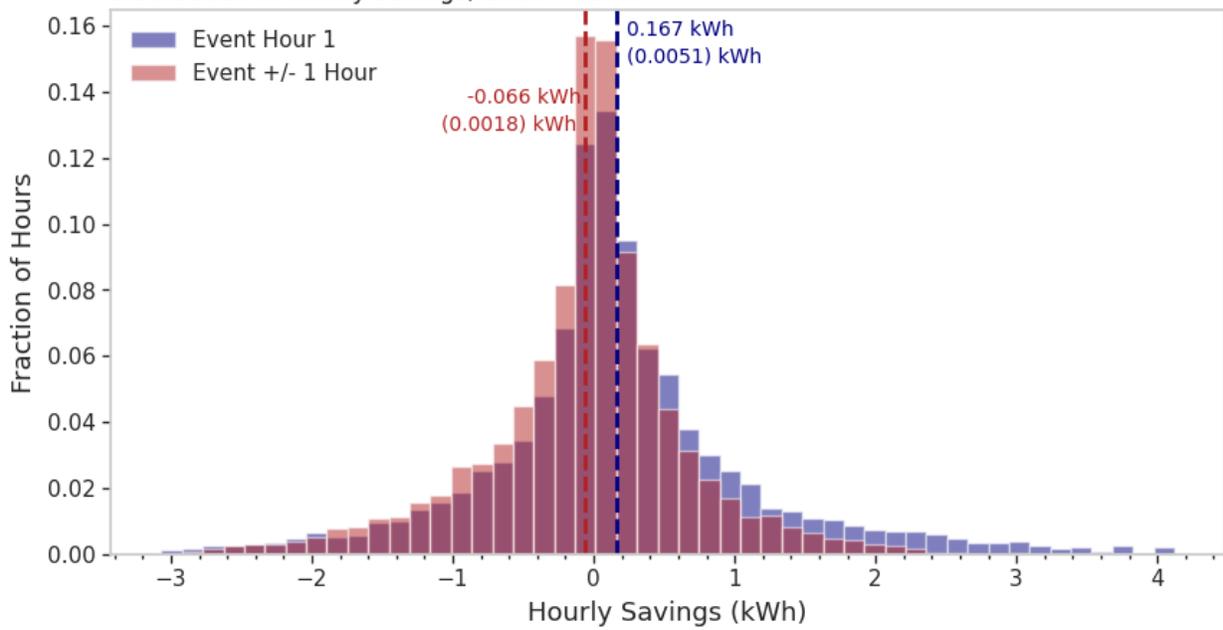


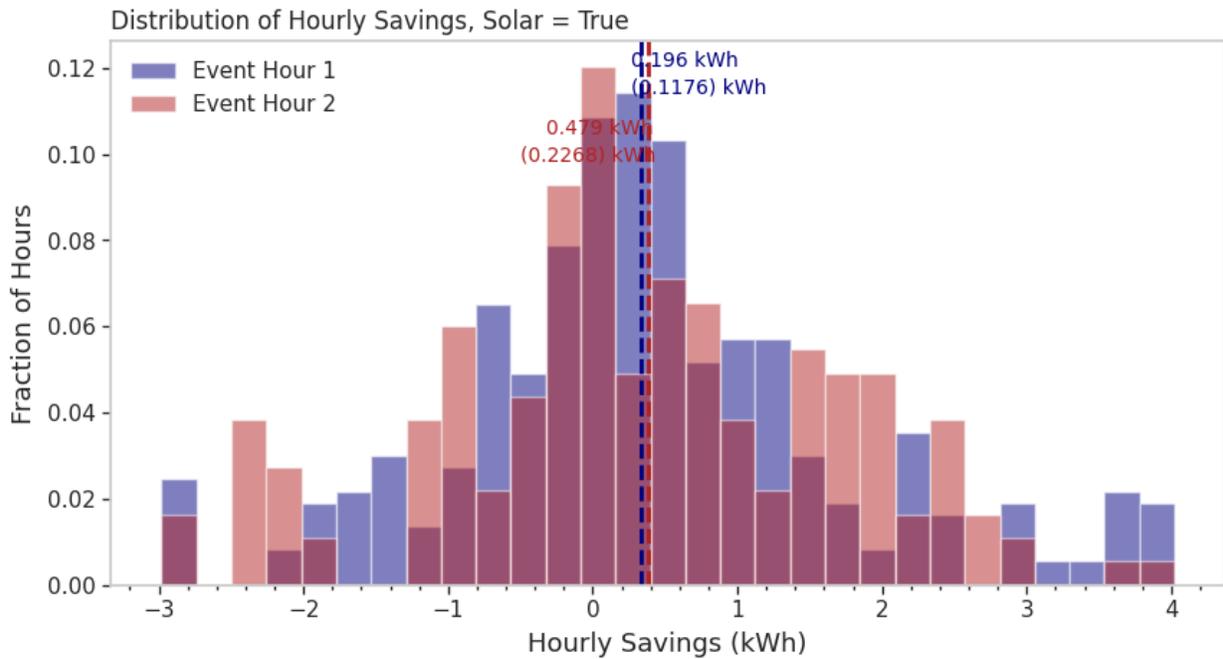
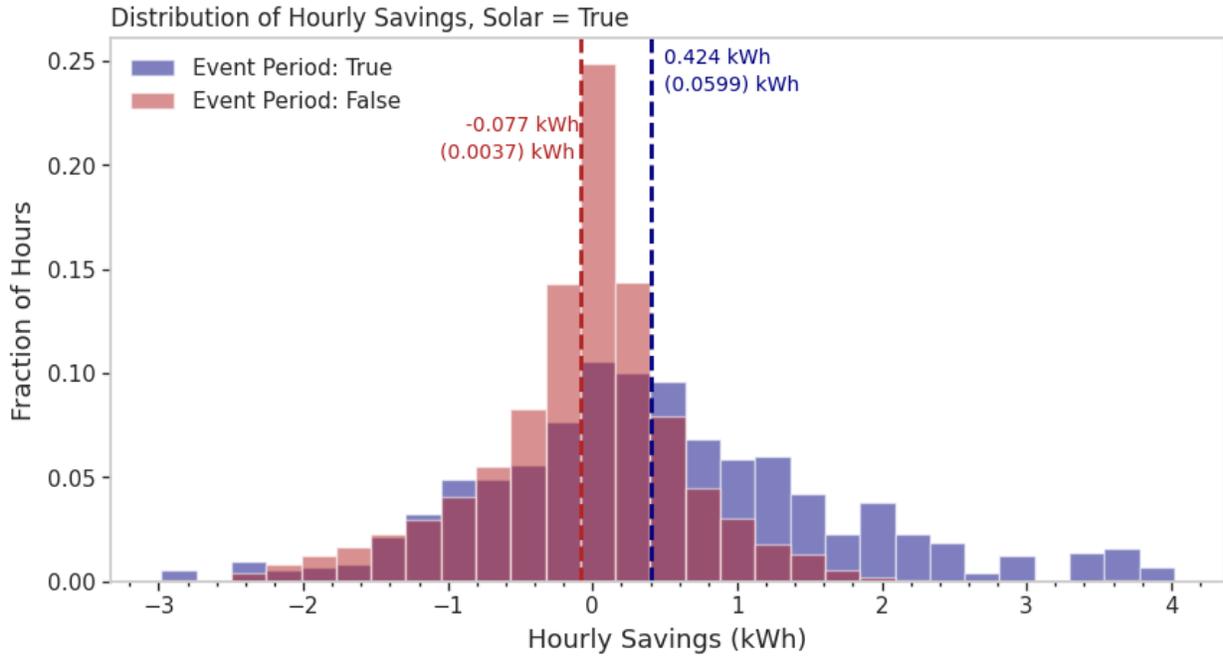


Distribution of Hourly Savings, Solar = False

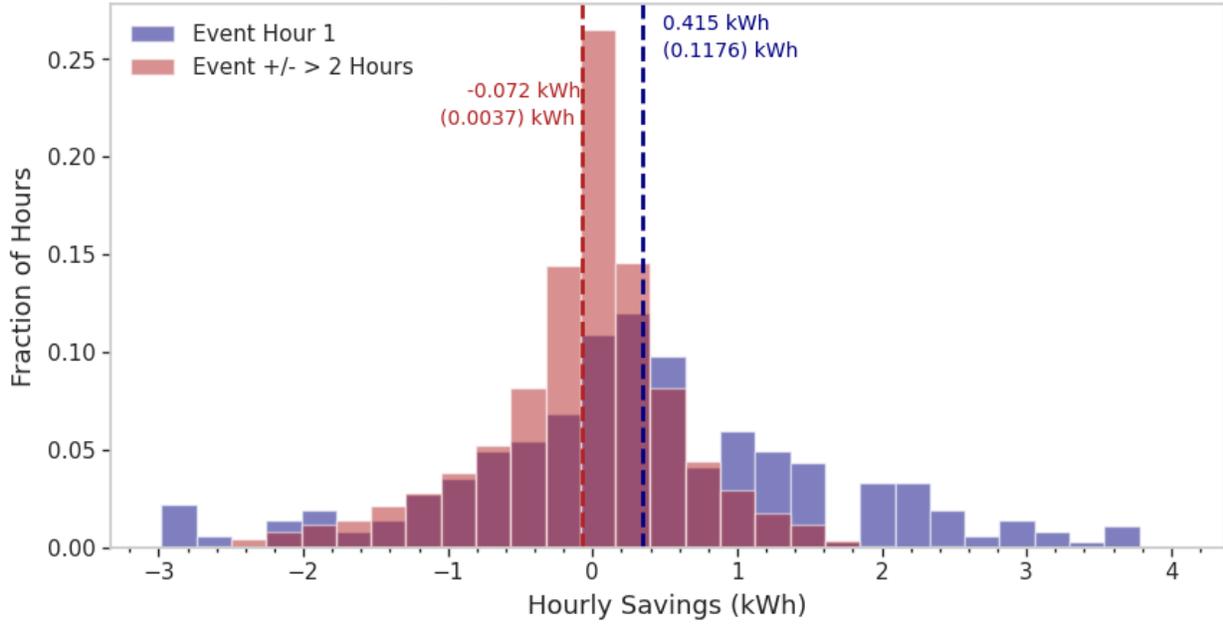


Distribution of Hourly Savings, Solar = False

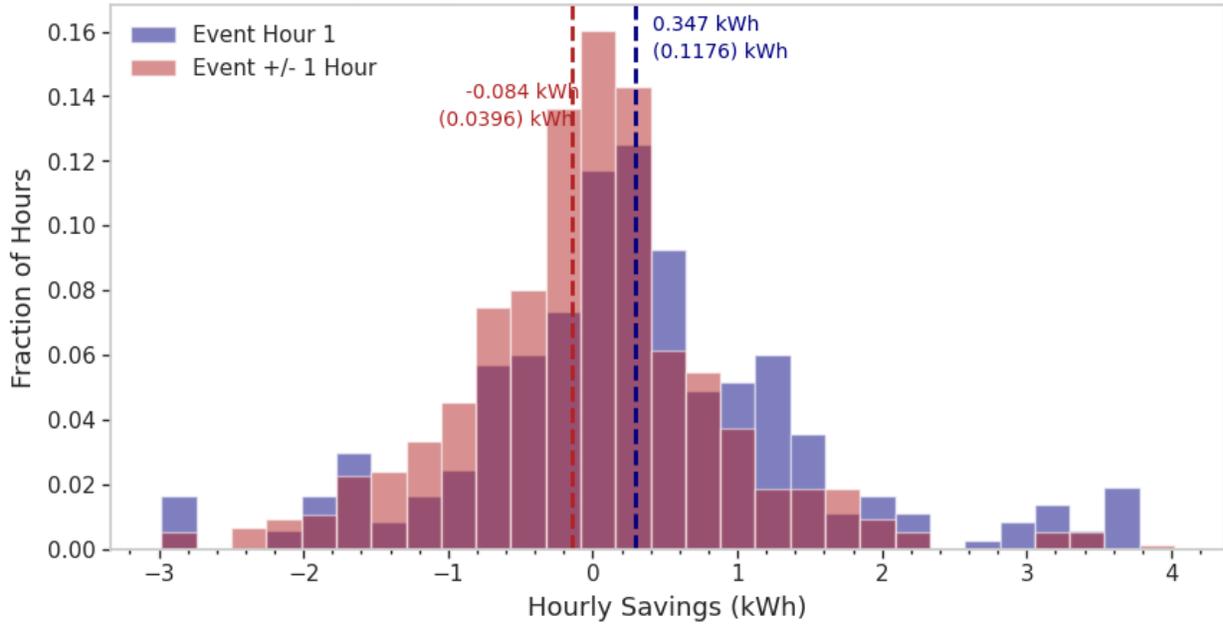


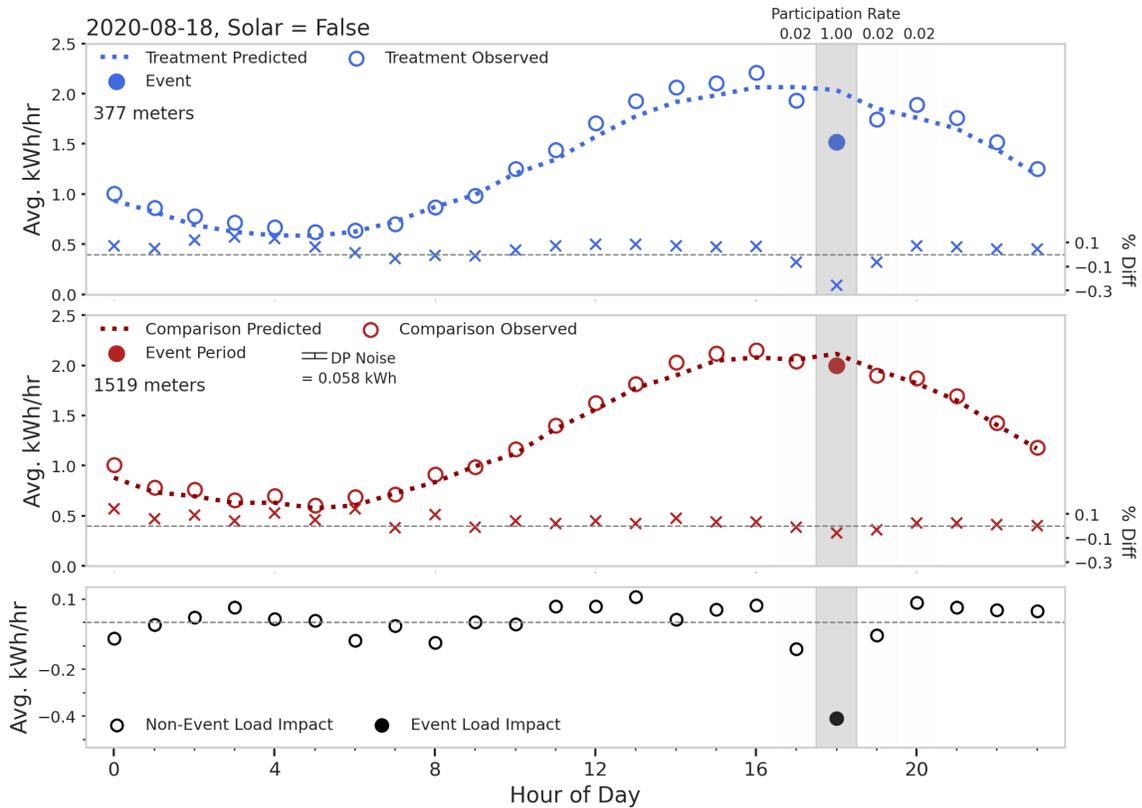
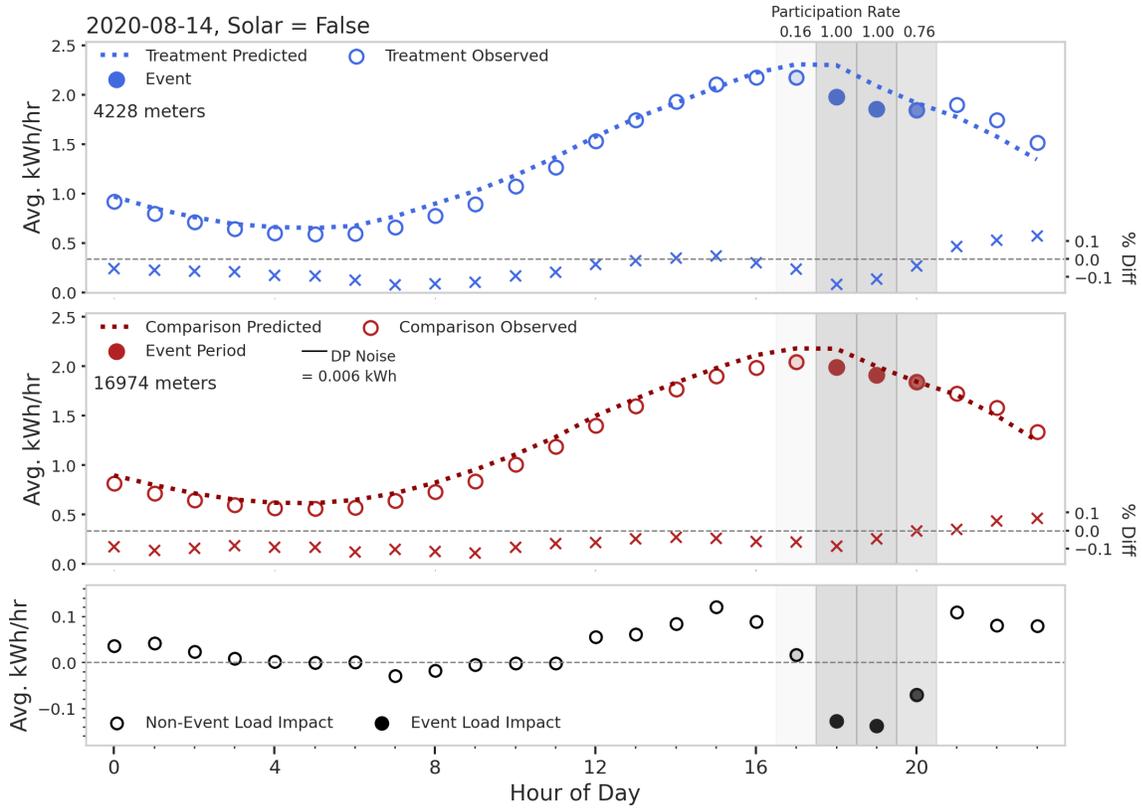


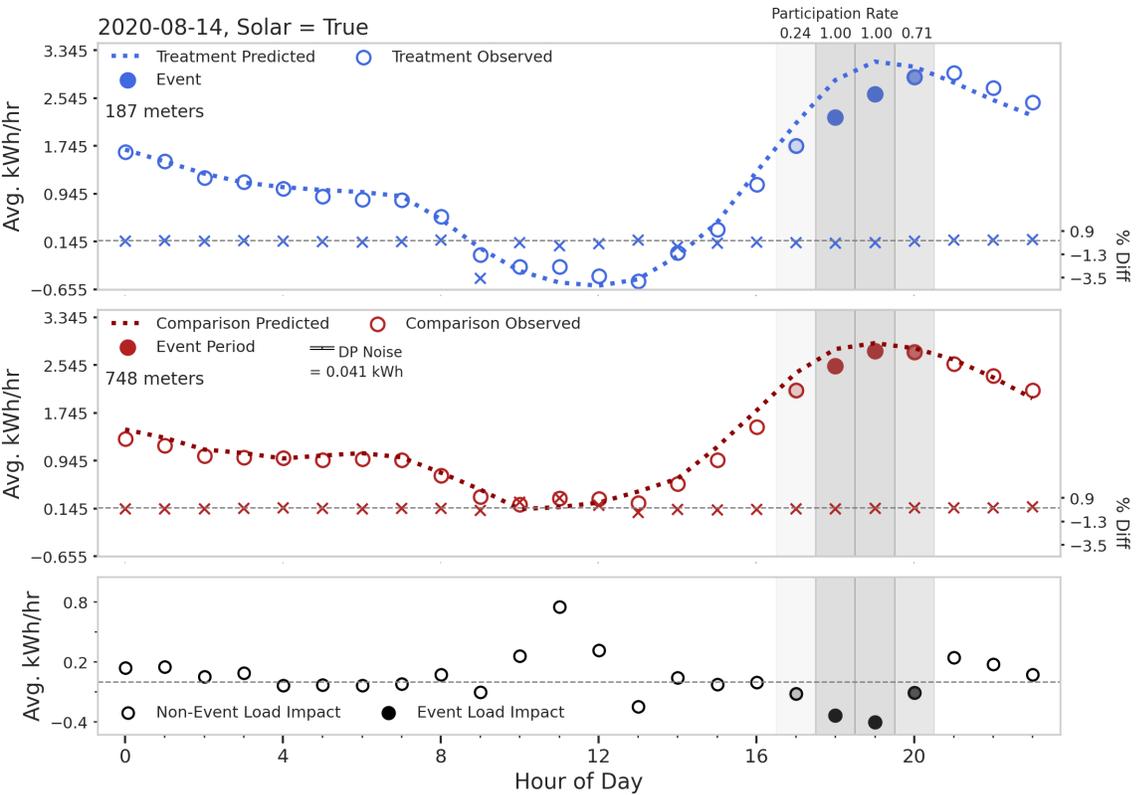
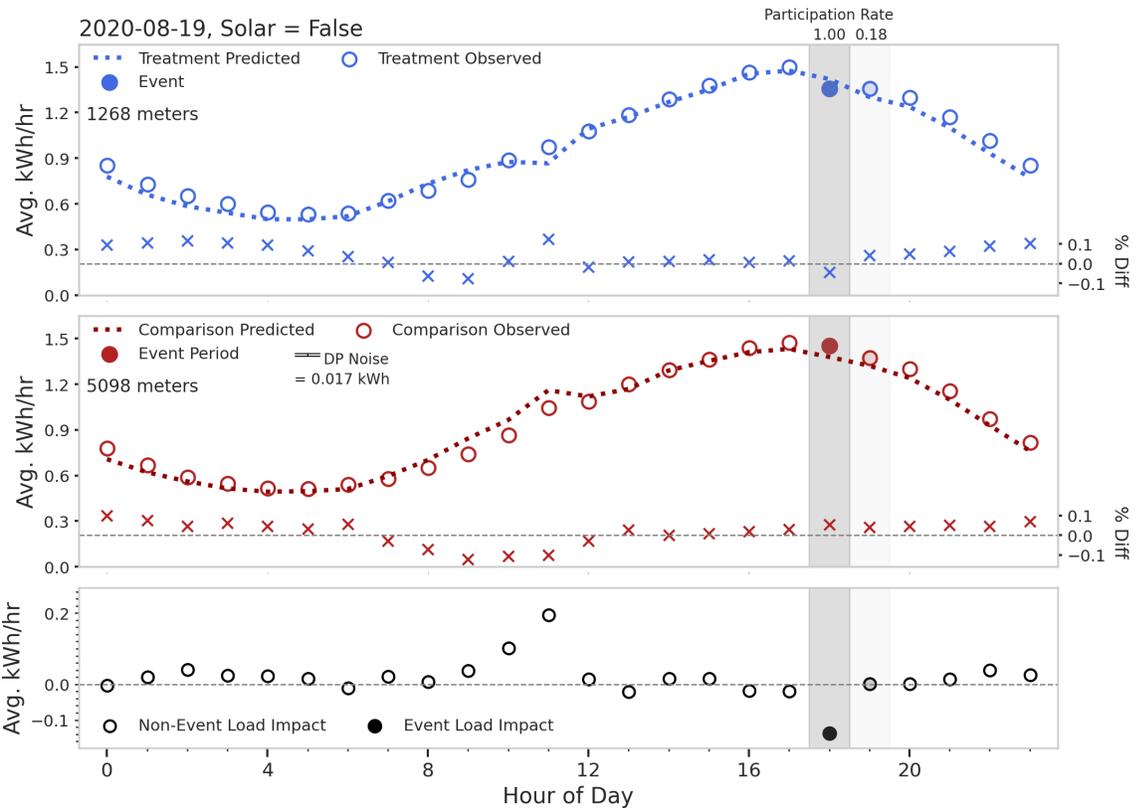
Distribution of Hourly Savings, Solar = True

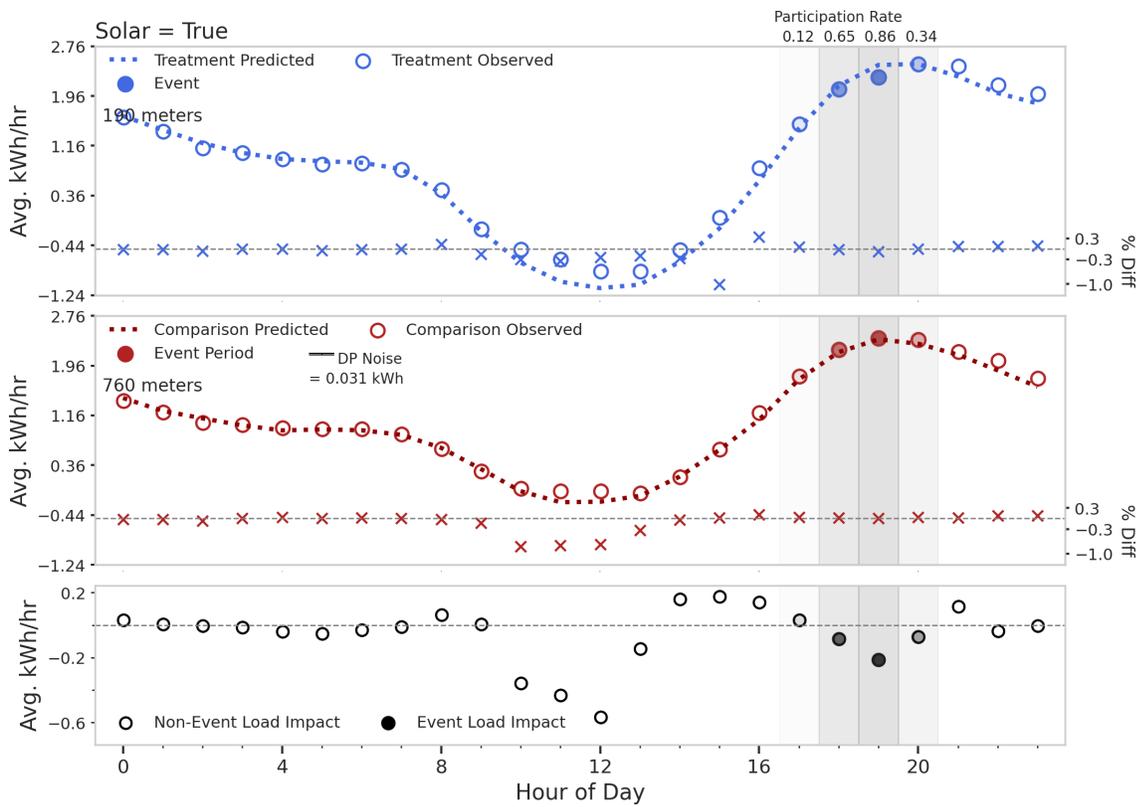
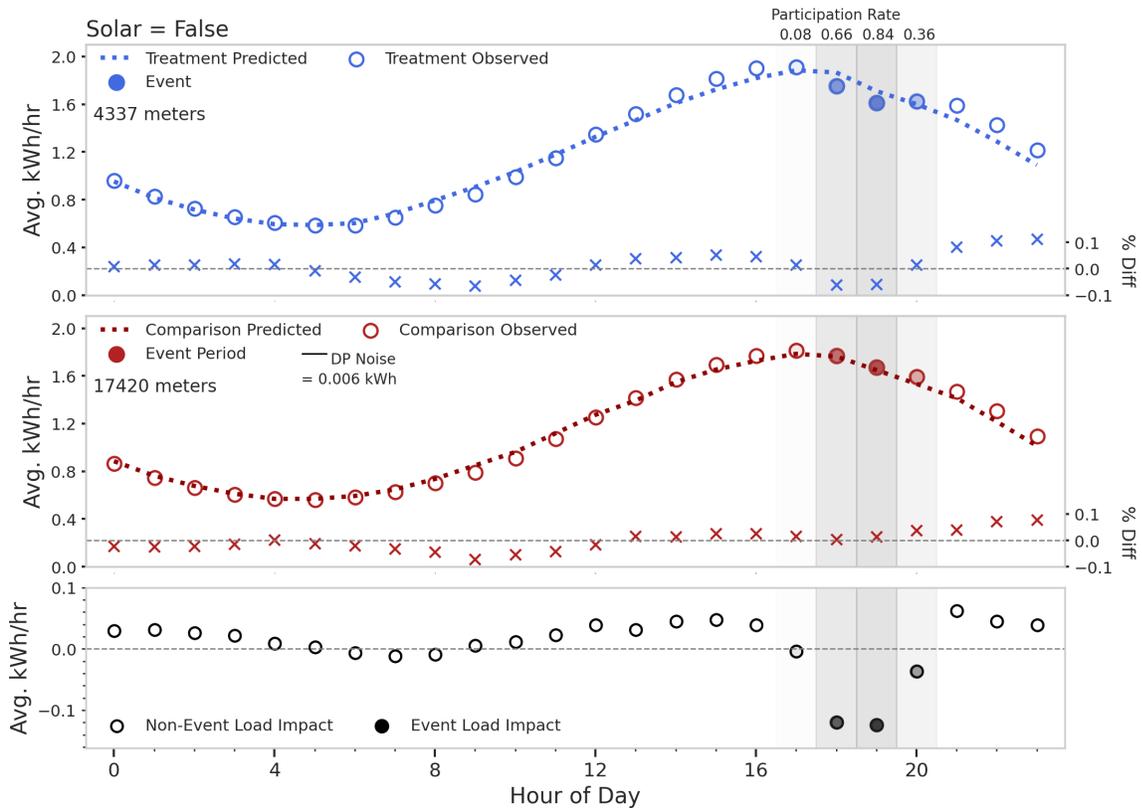


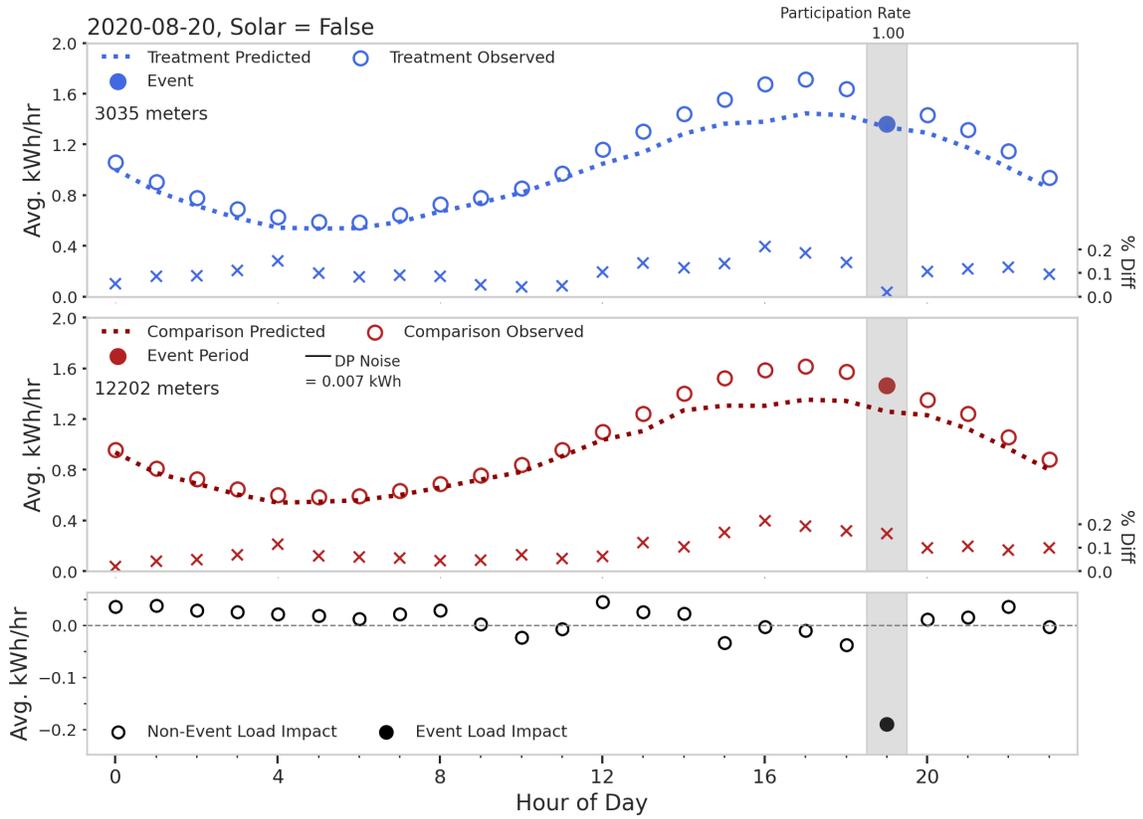
Distribution of Hourly Savings, Solar = True



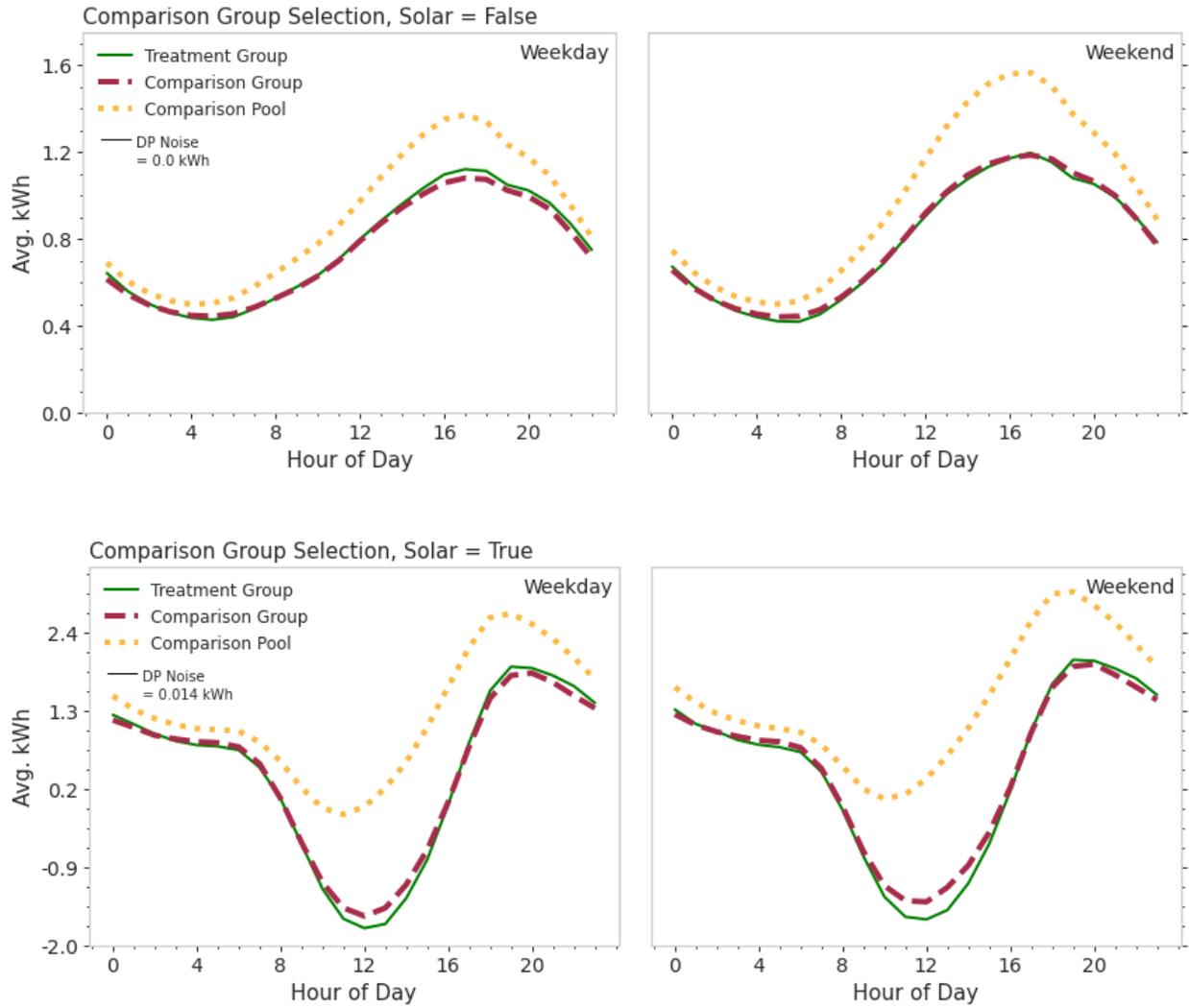




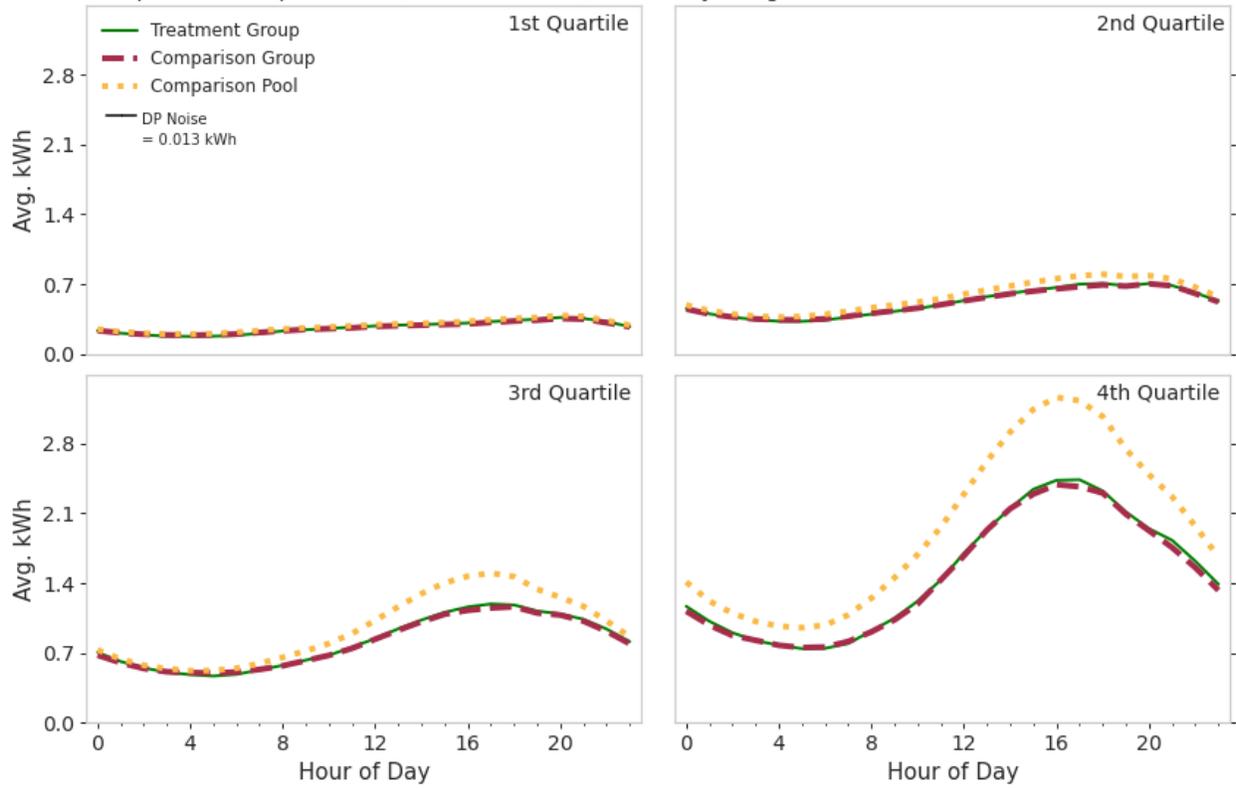




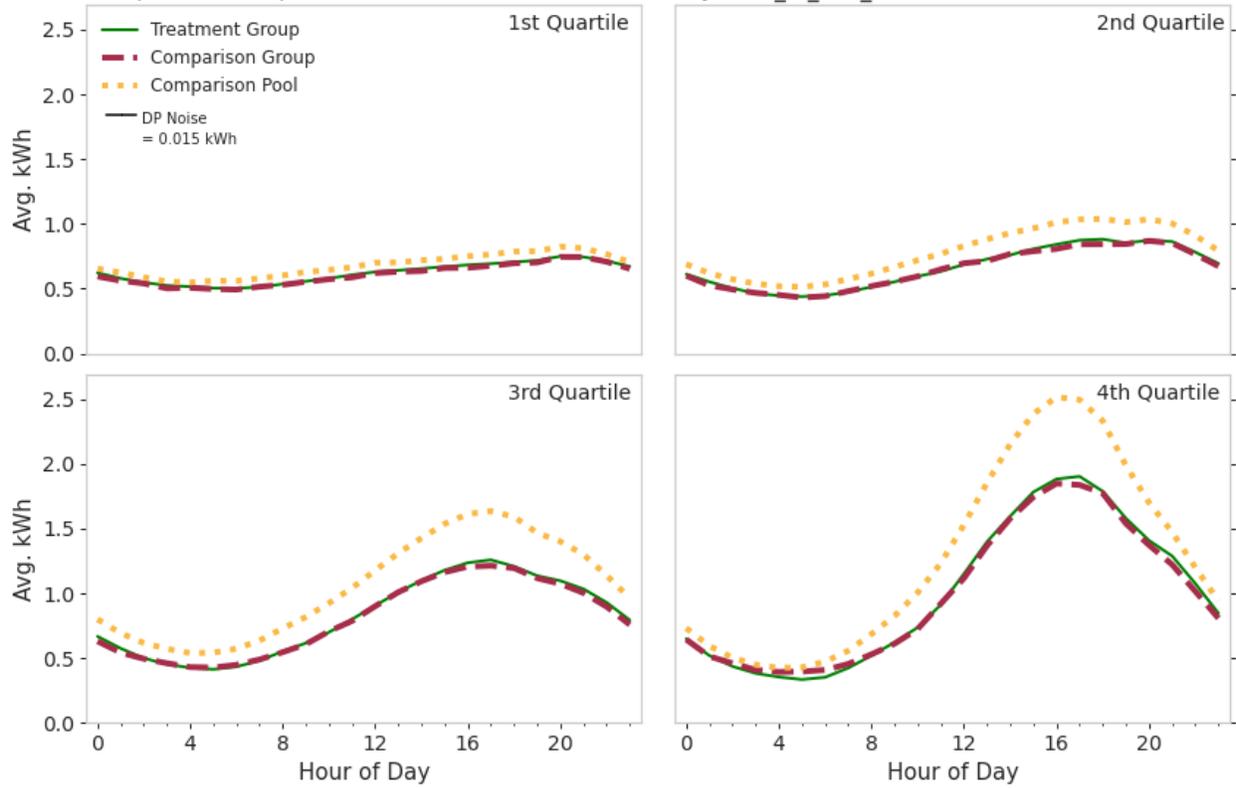
Additional Results: DRP A, LSE 3, Residential

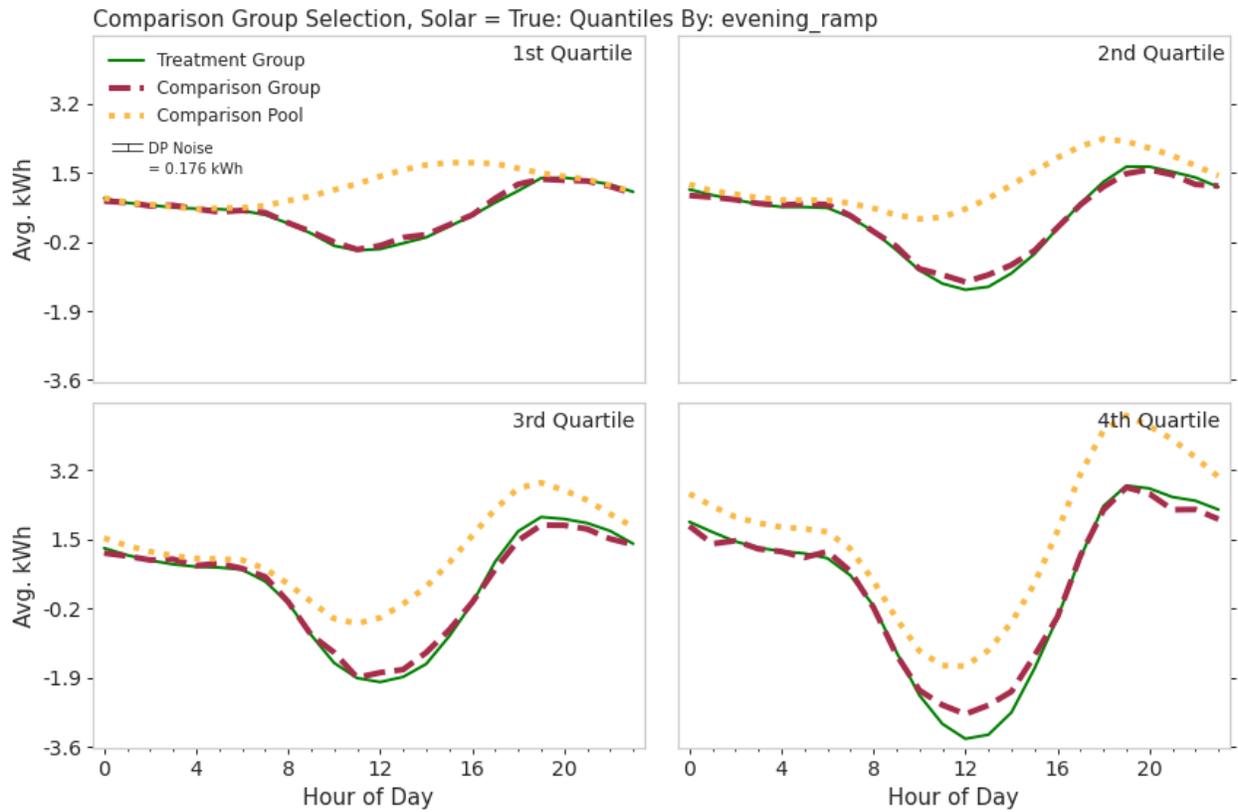
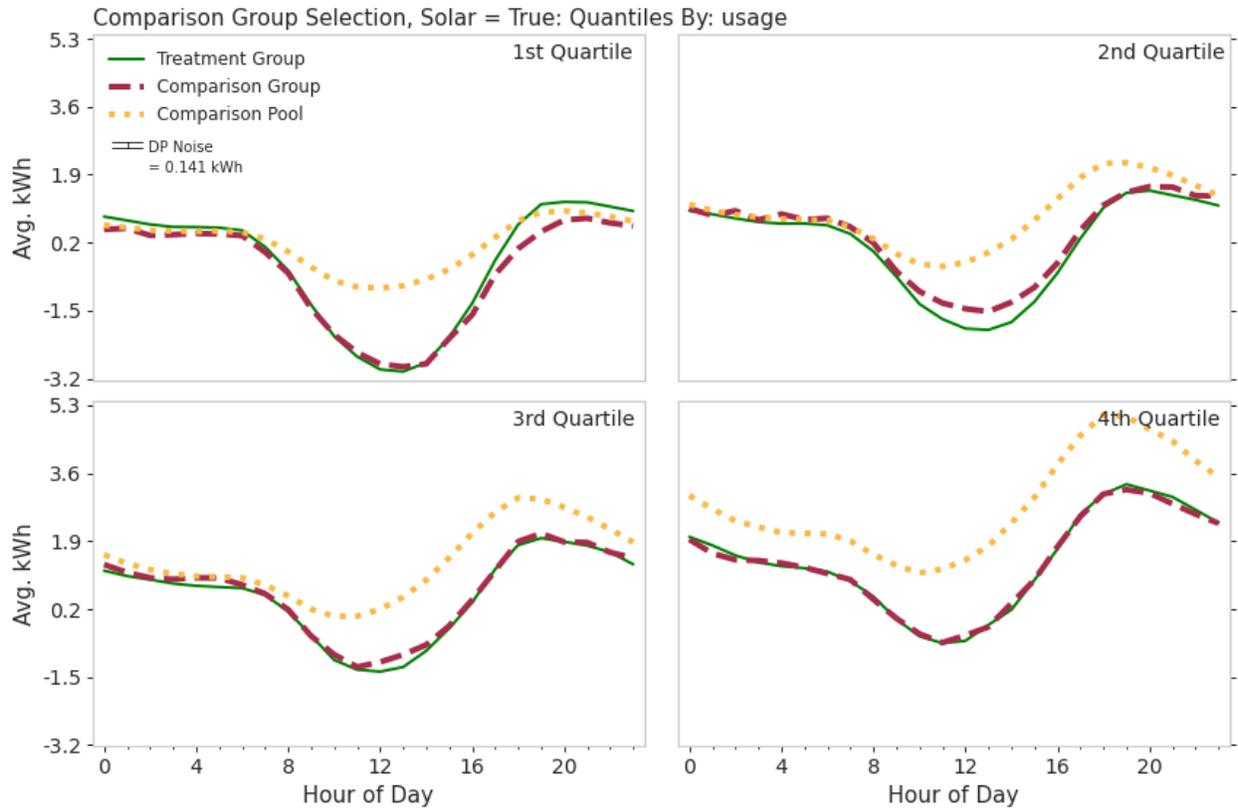


Comparison Group Selection, Solar = False: Quantiles By: usage

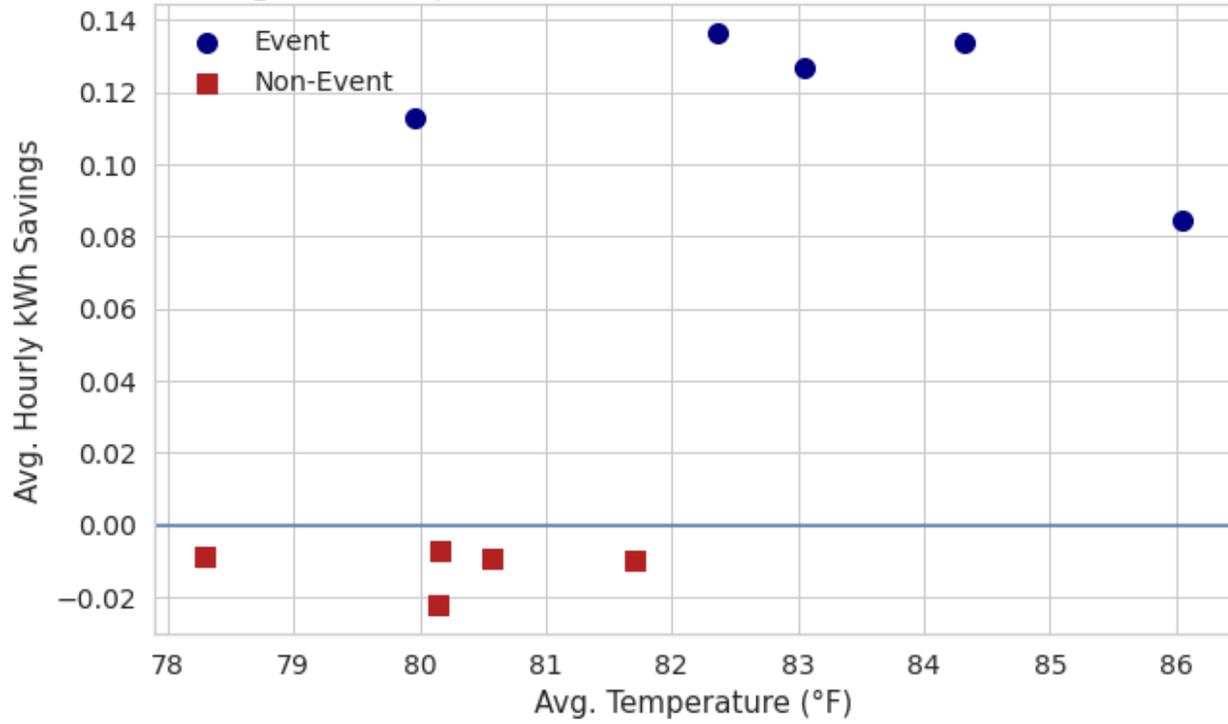


Comparison Group Selection, Solar = False: Quantiles By: max_to_min_ratio

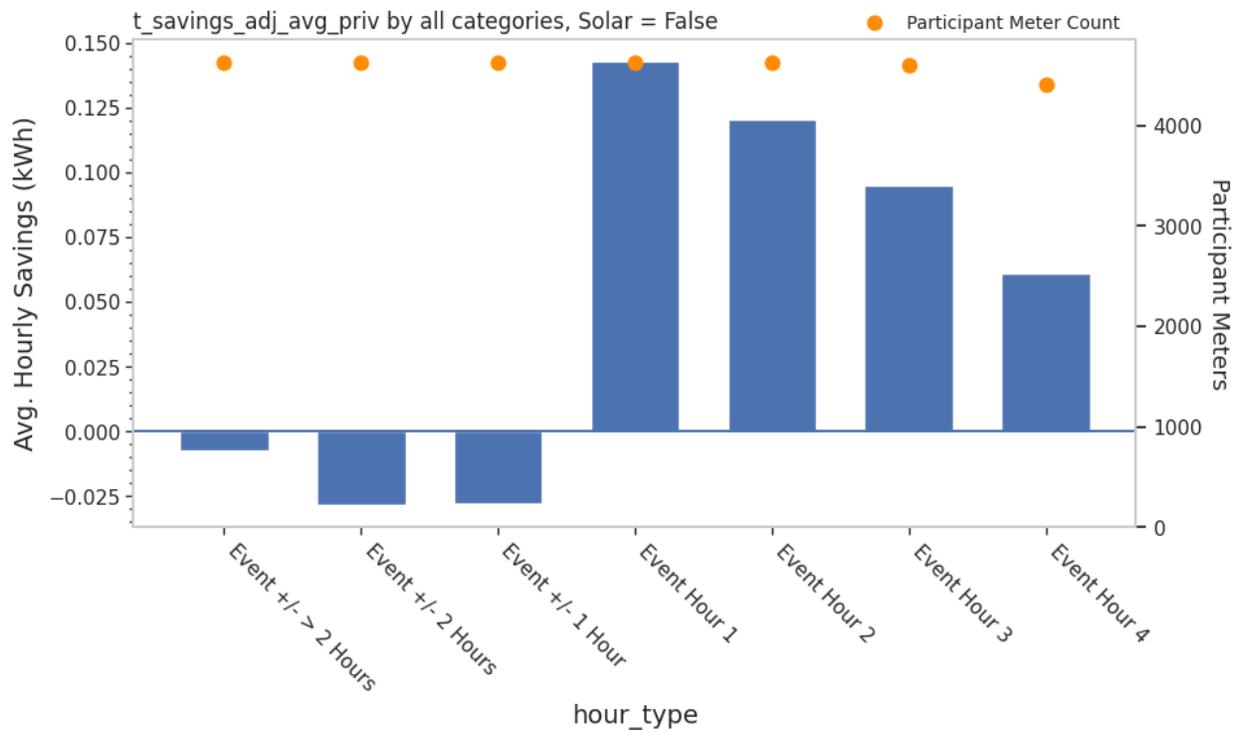
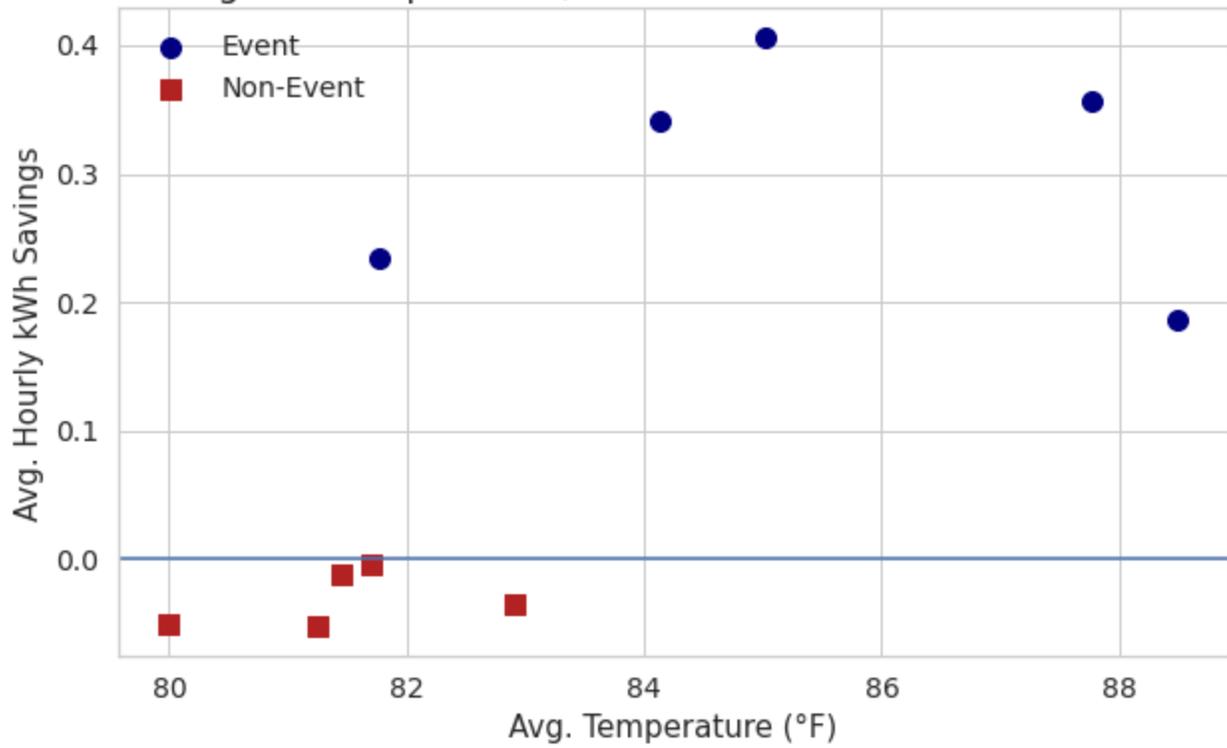


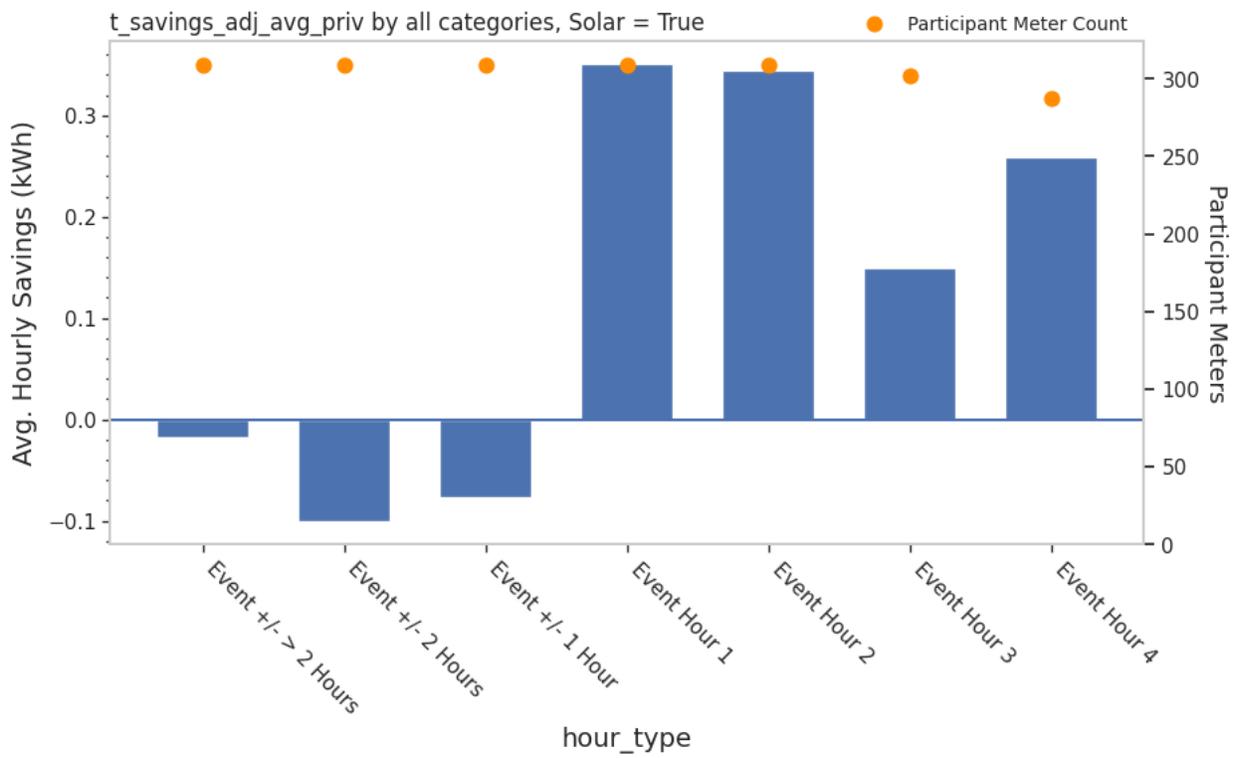
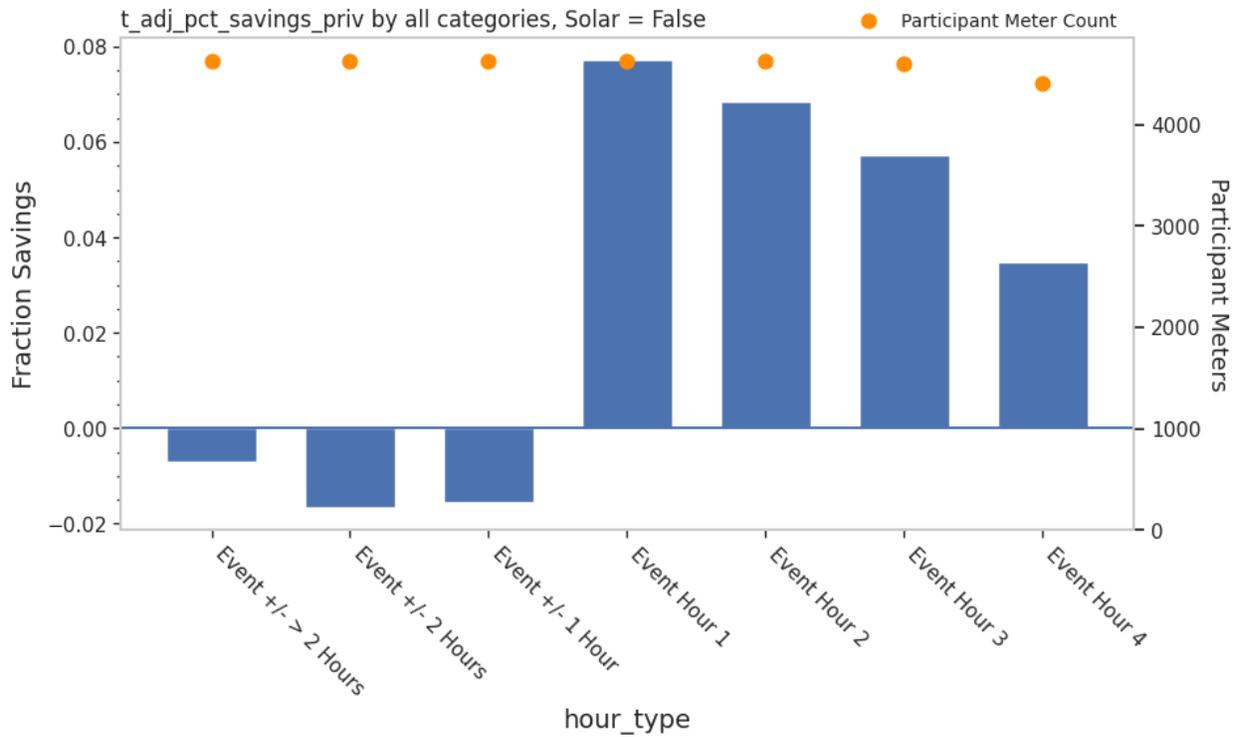


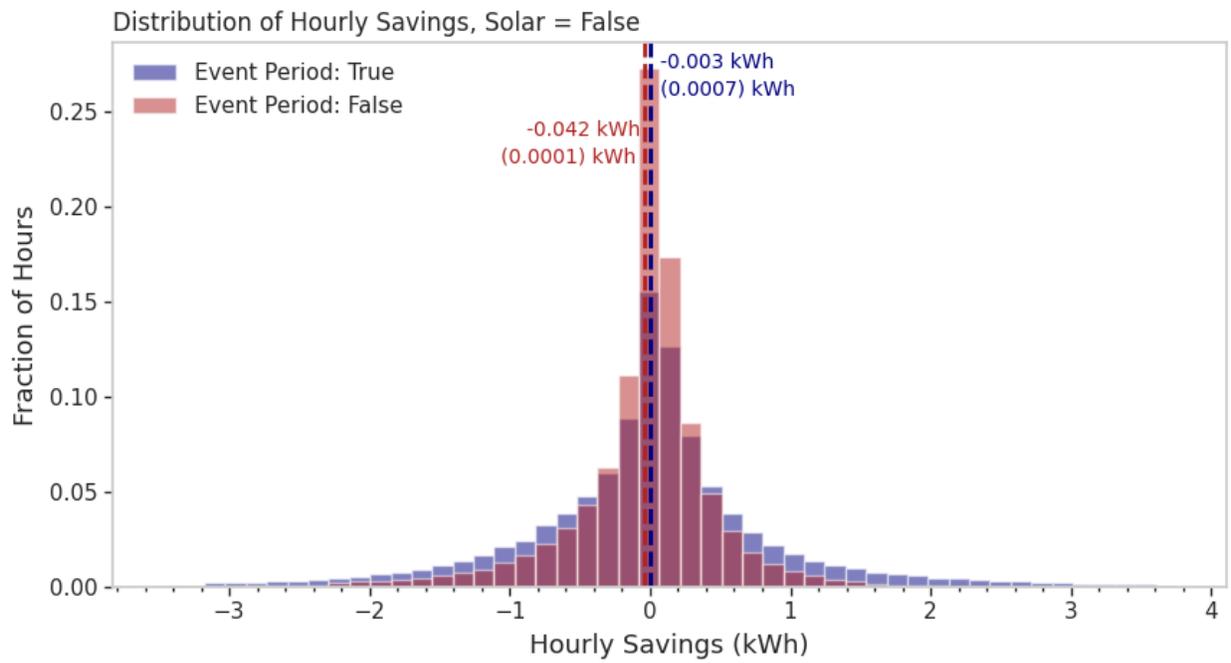
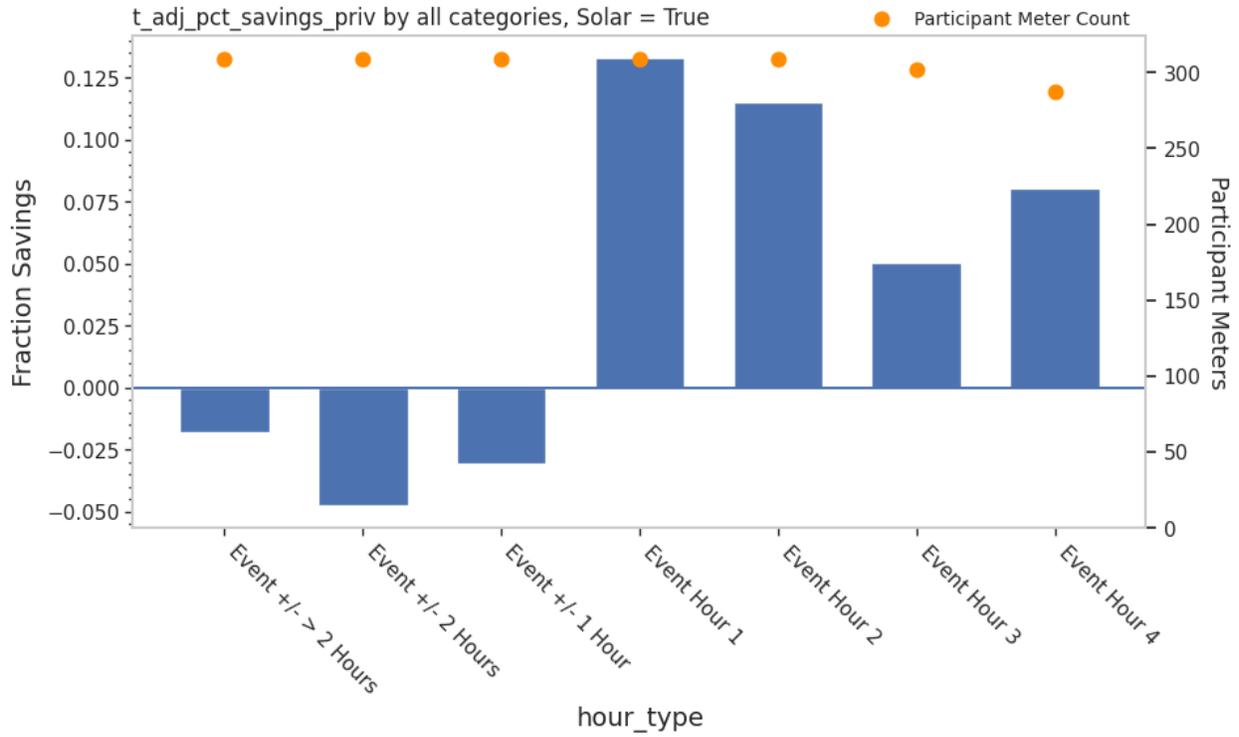
Savings vs. Temperature, Solar = False

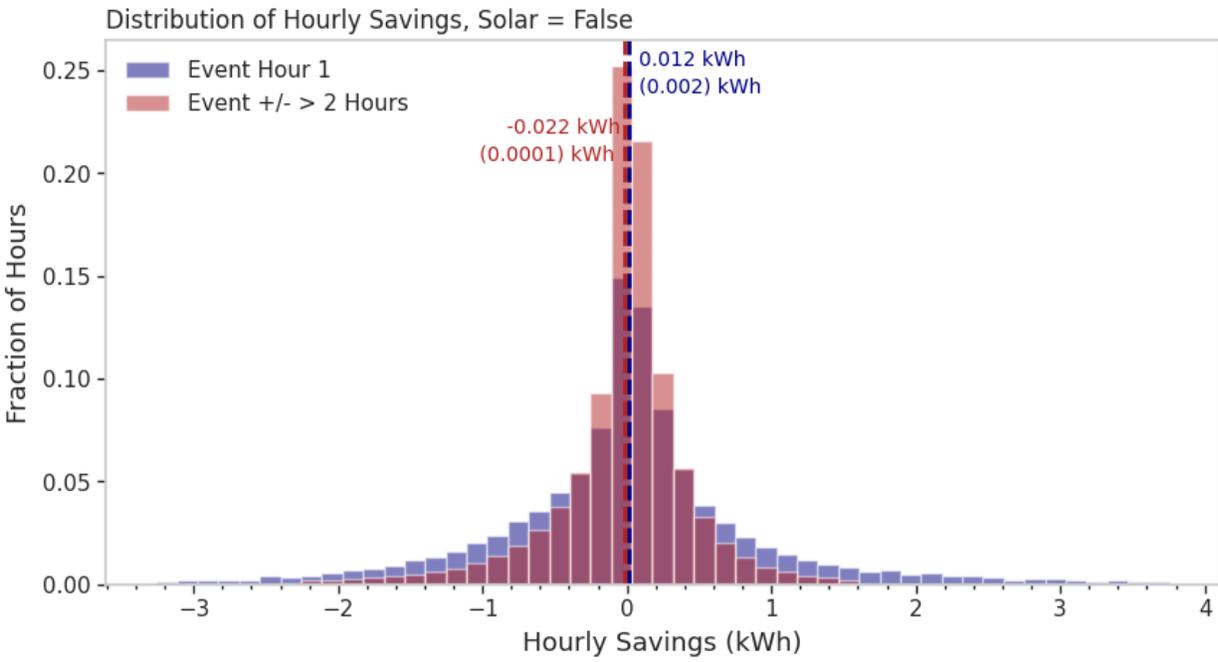
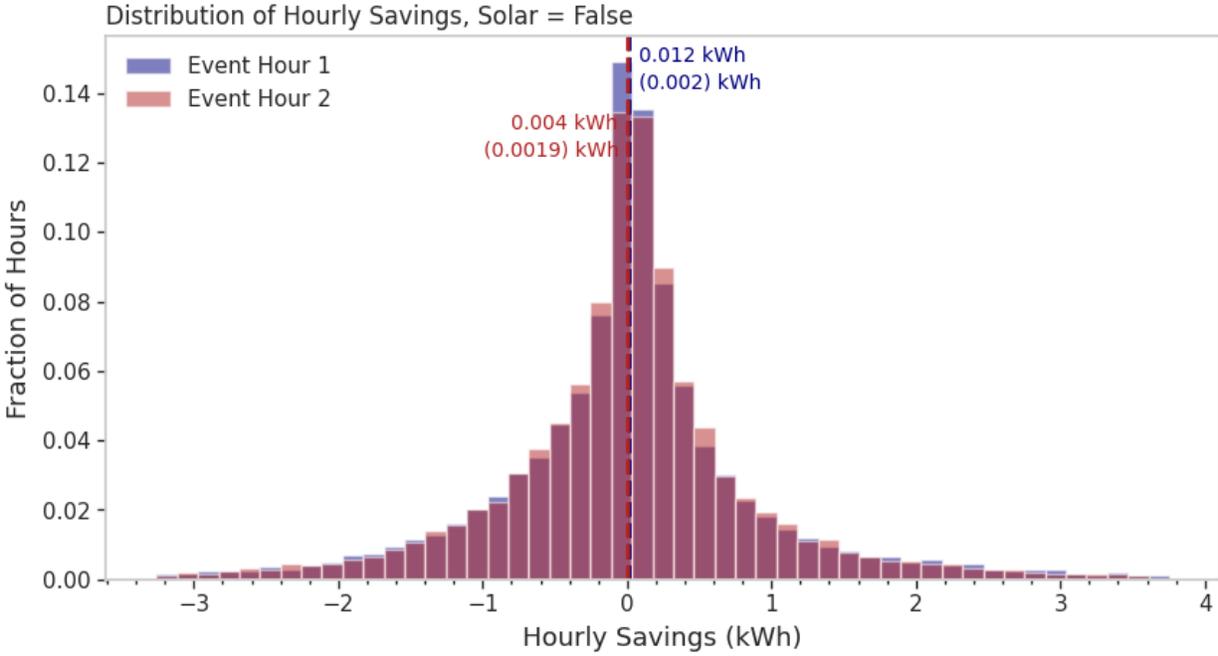


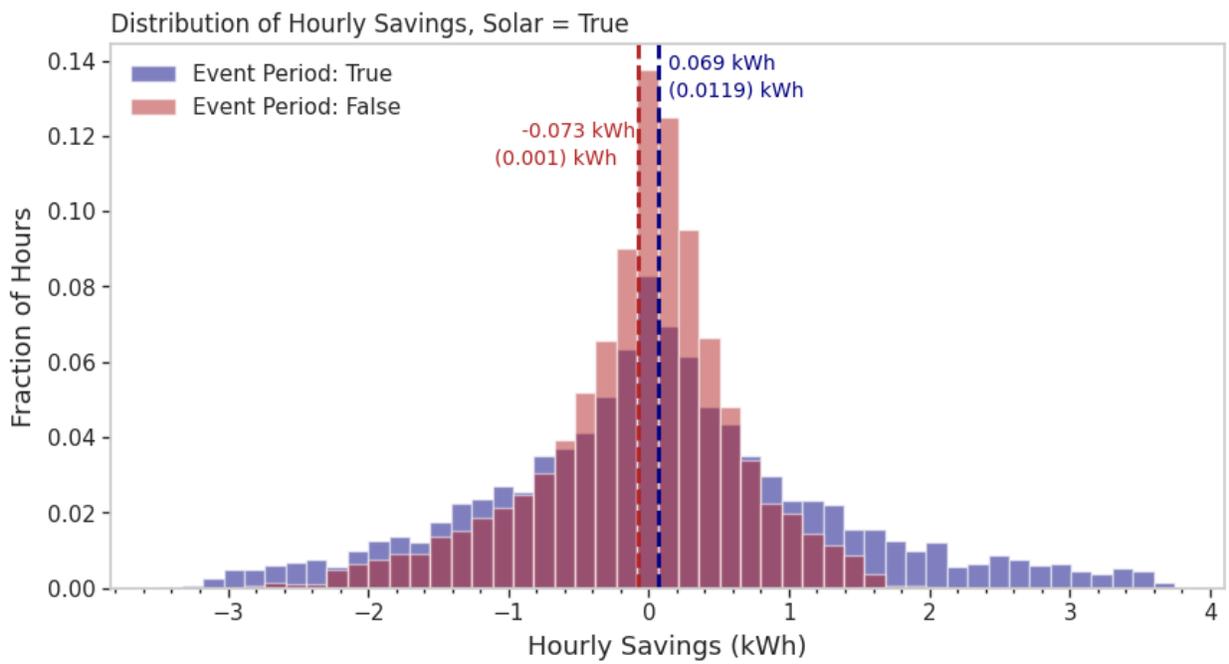
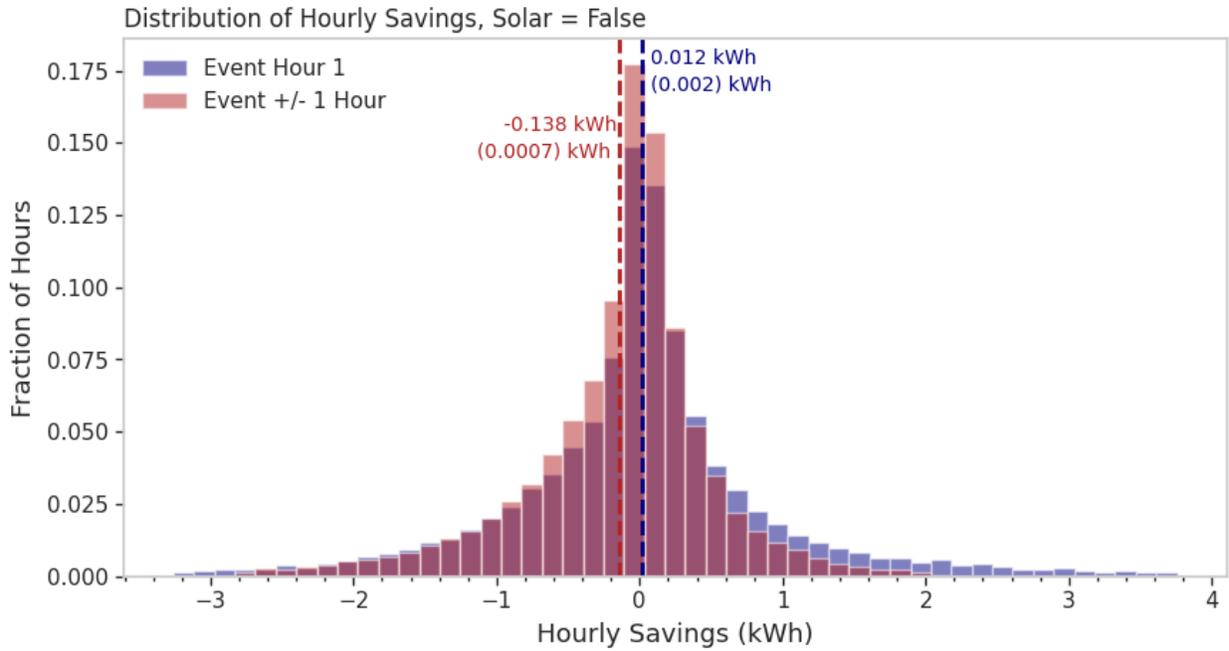
Savings vs. Temperature, Solar = True



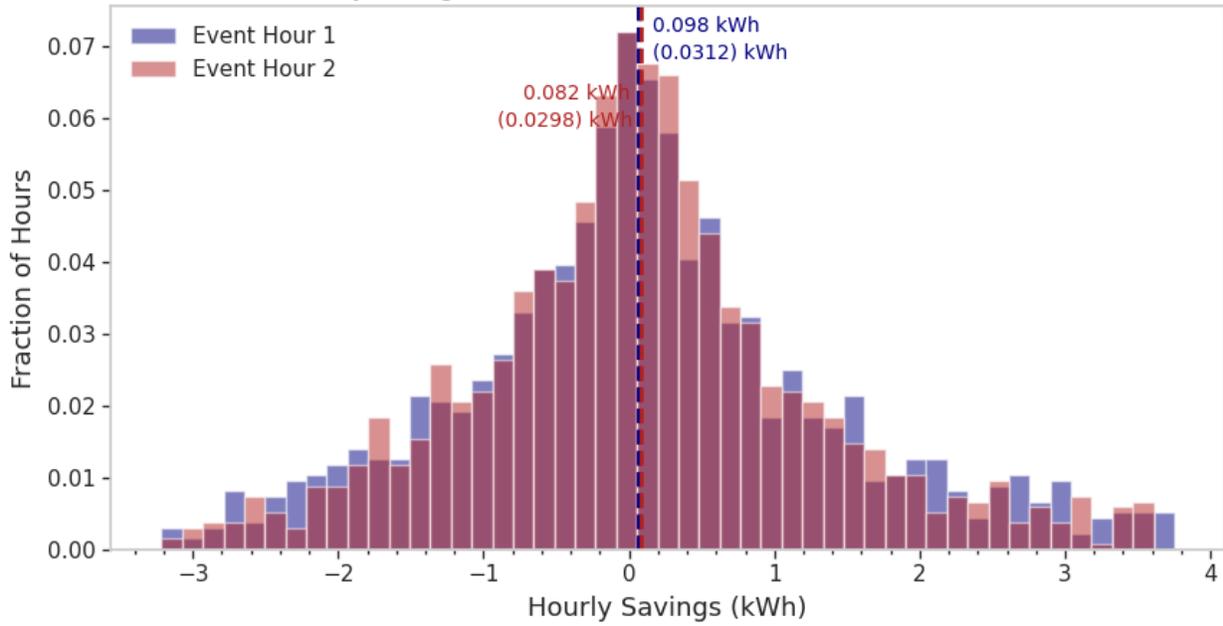




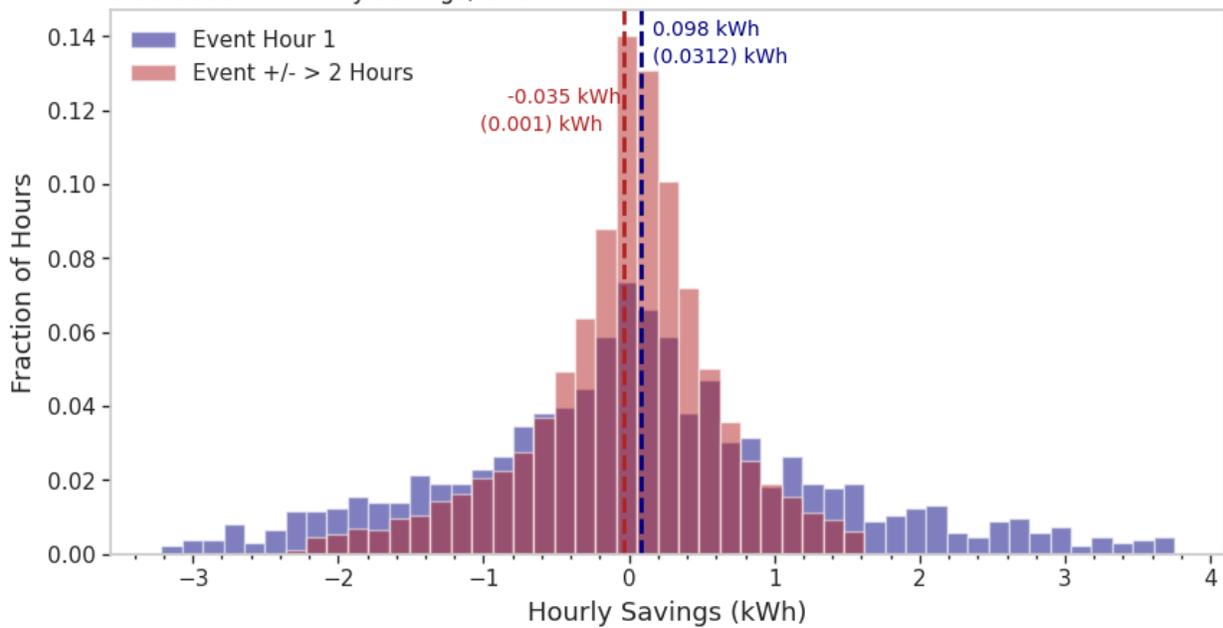


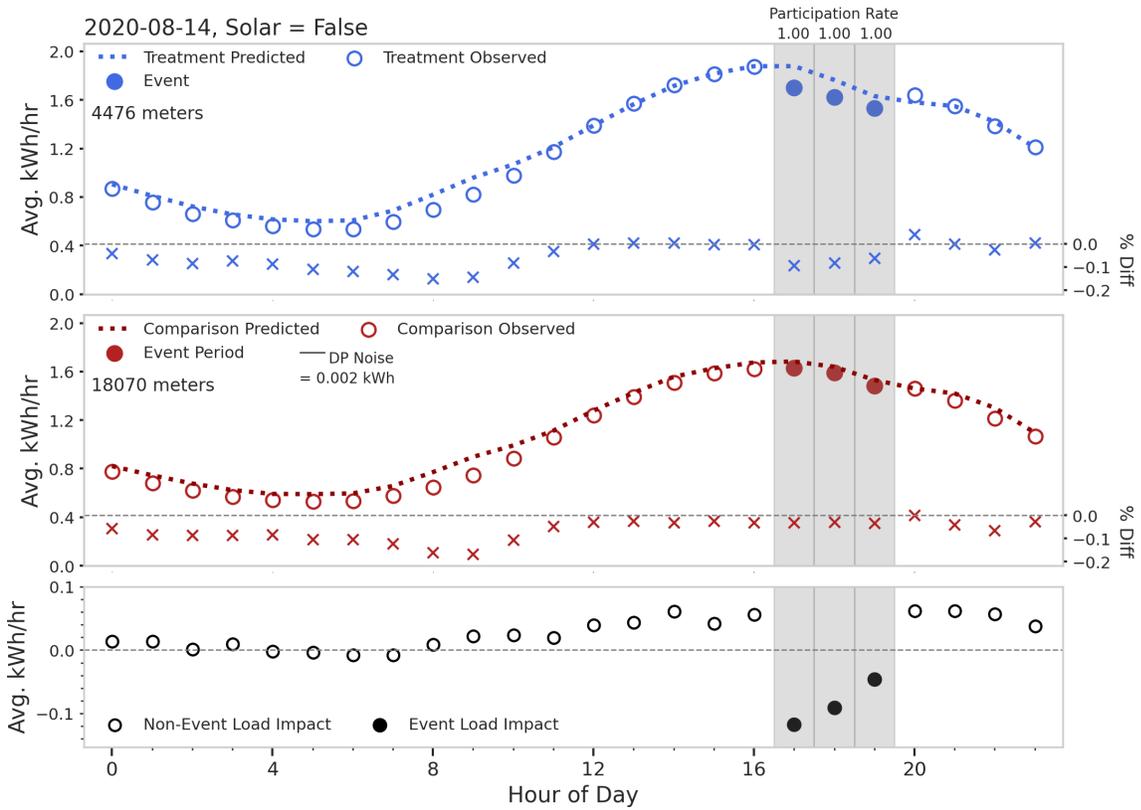
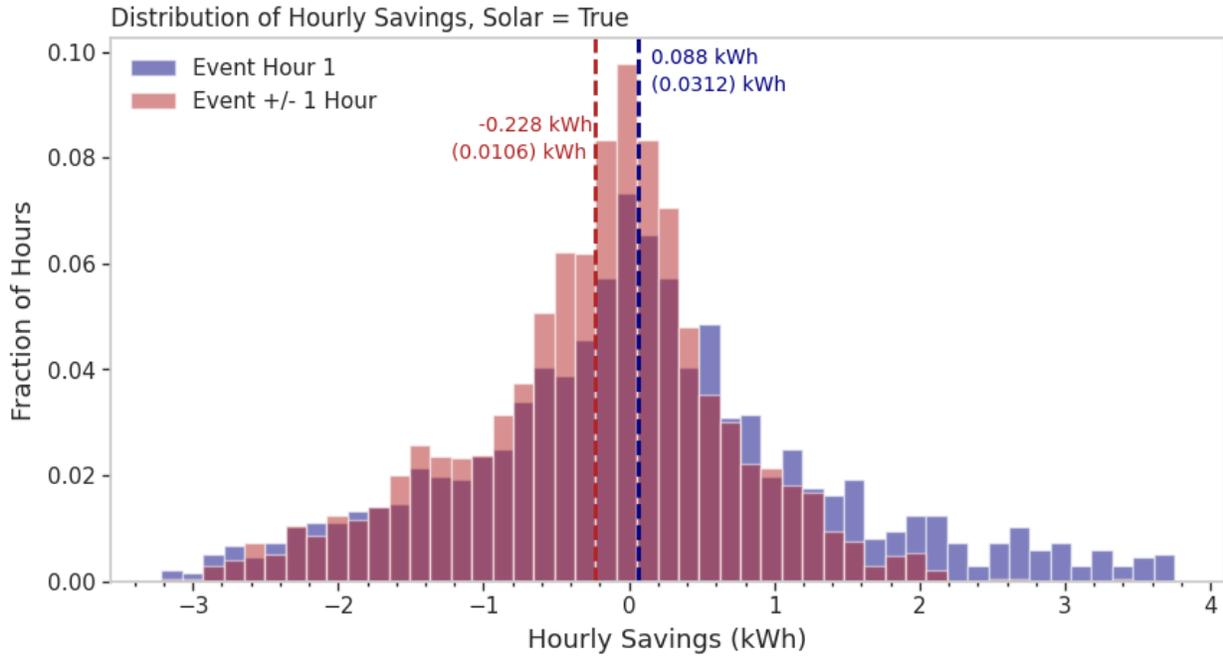


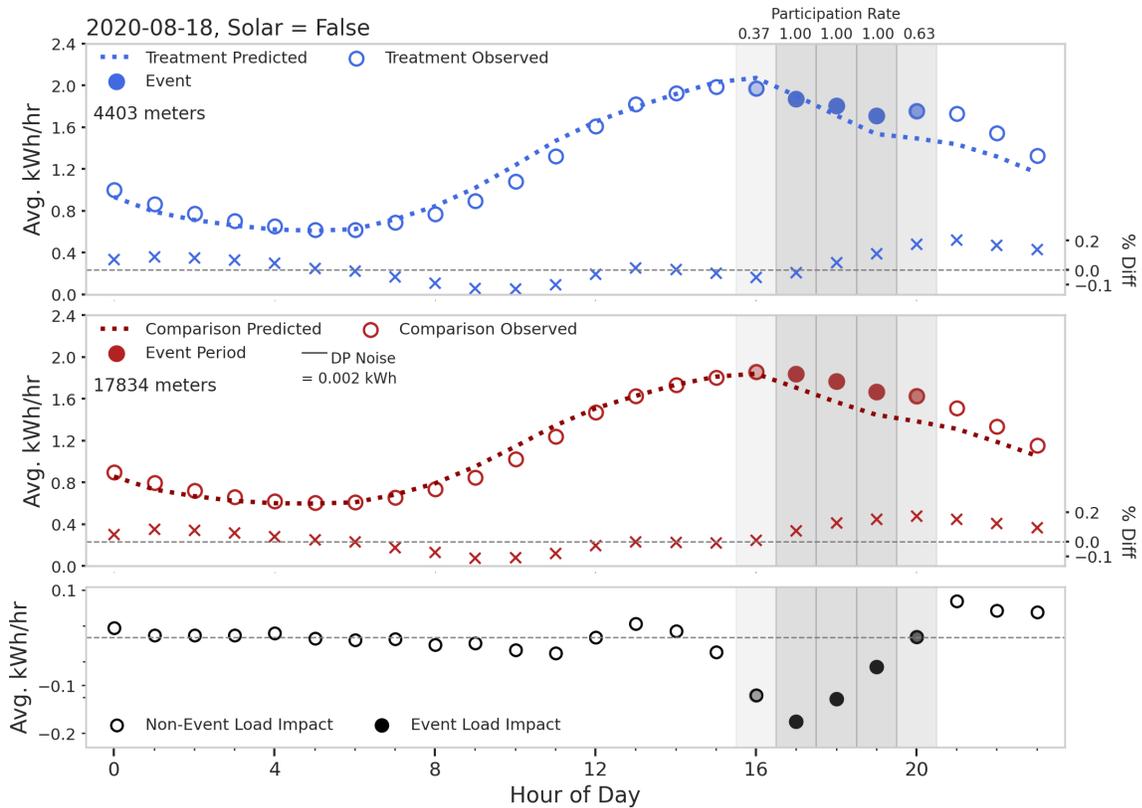
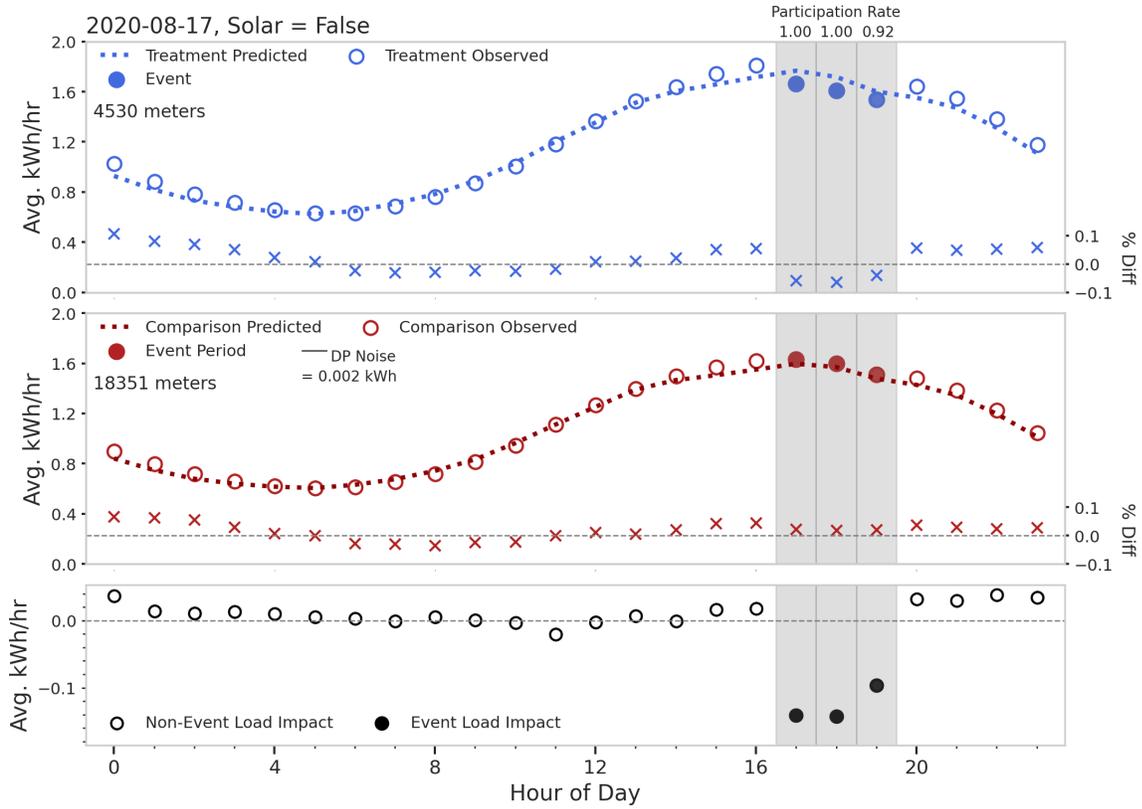
Distribution of Hourly Savings, Solar = True

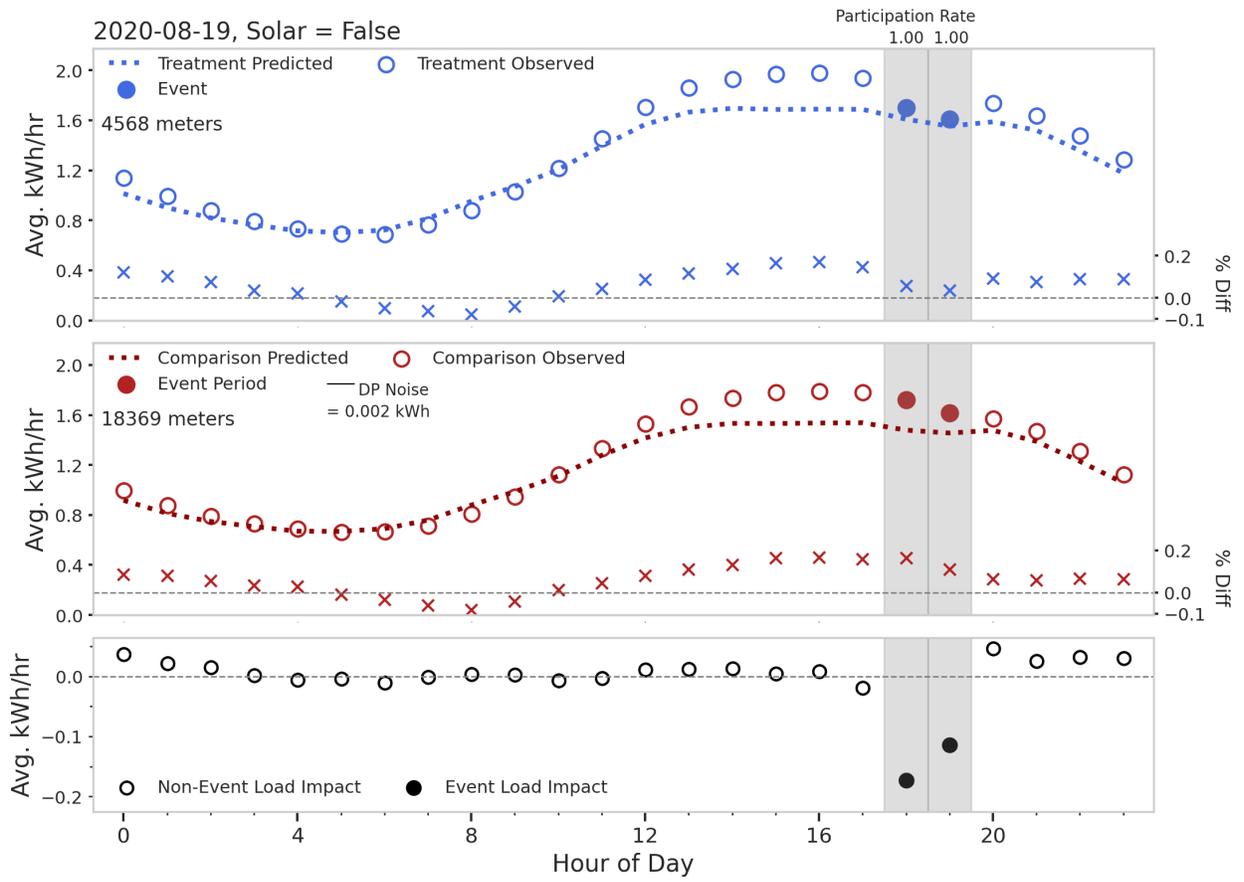


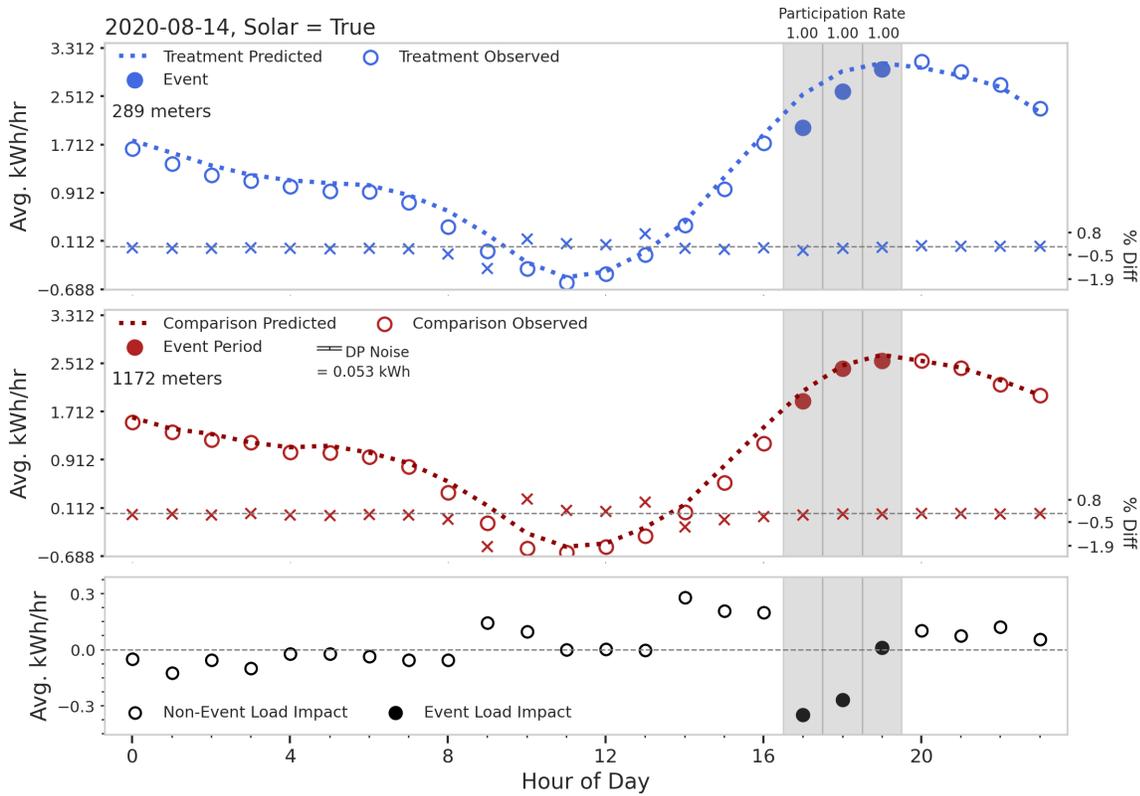
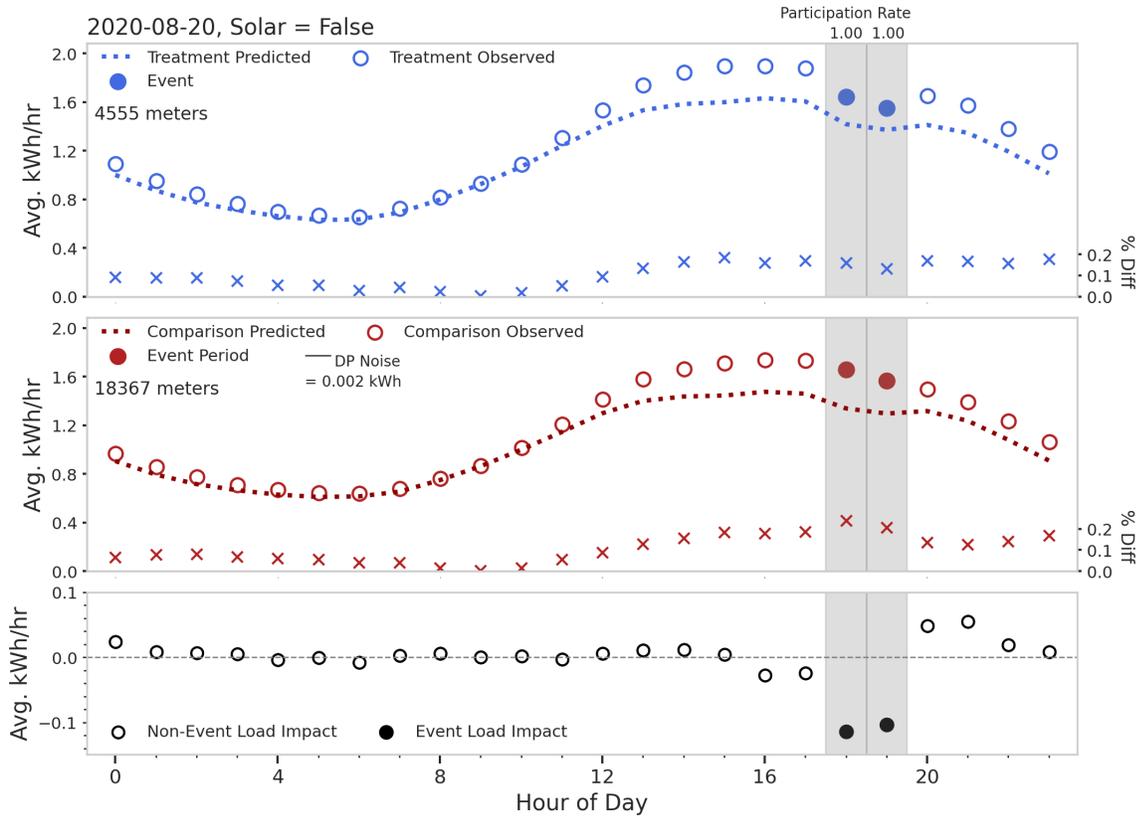
Distribution of Hourly Savings, Solar = True

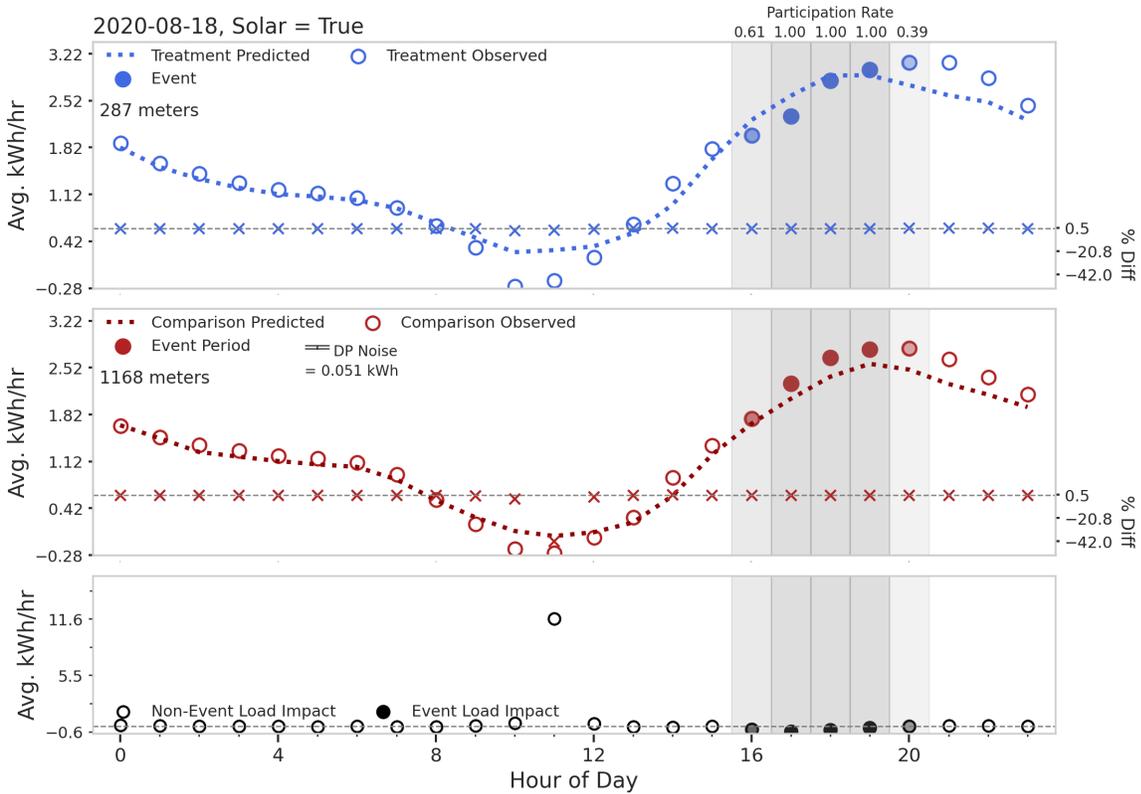
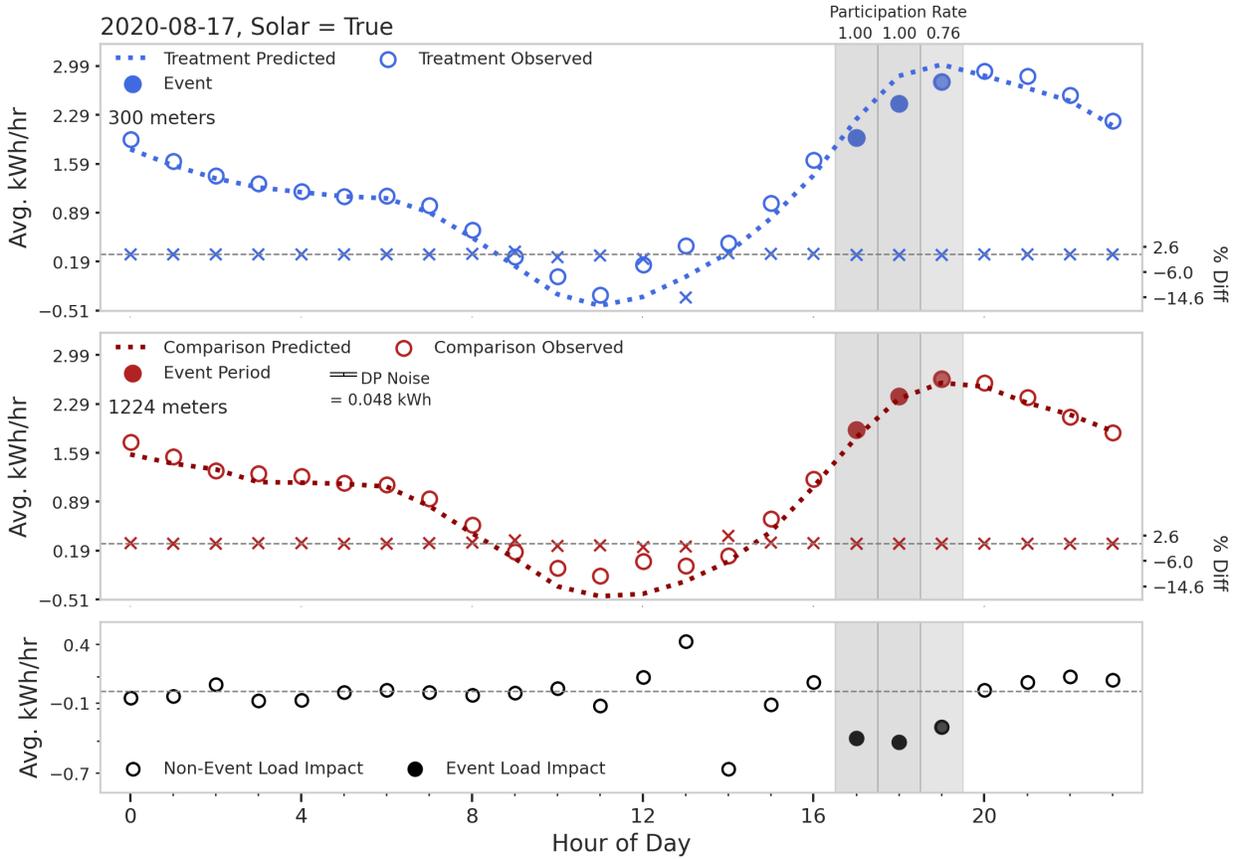


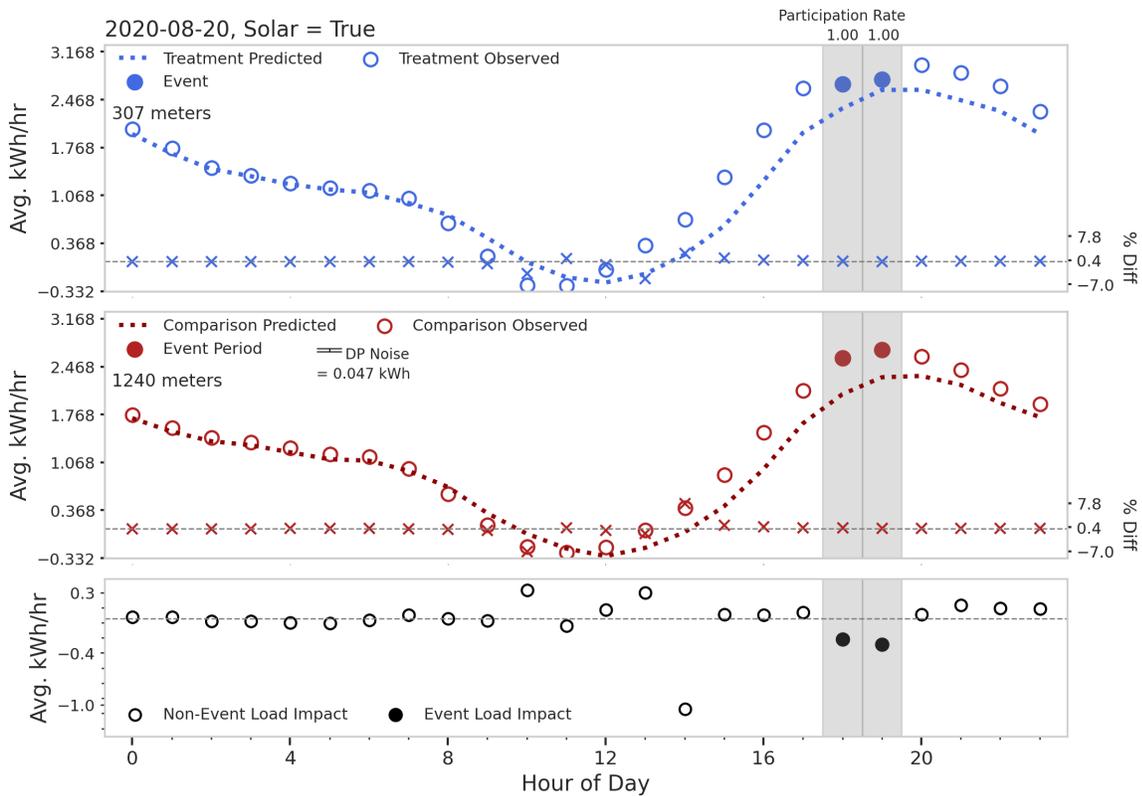
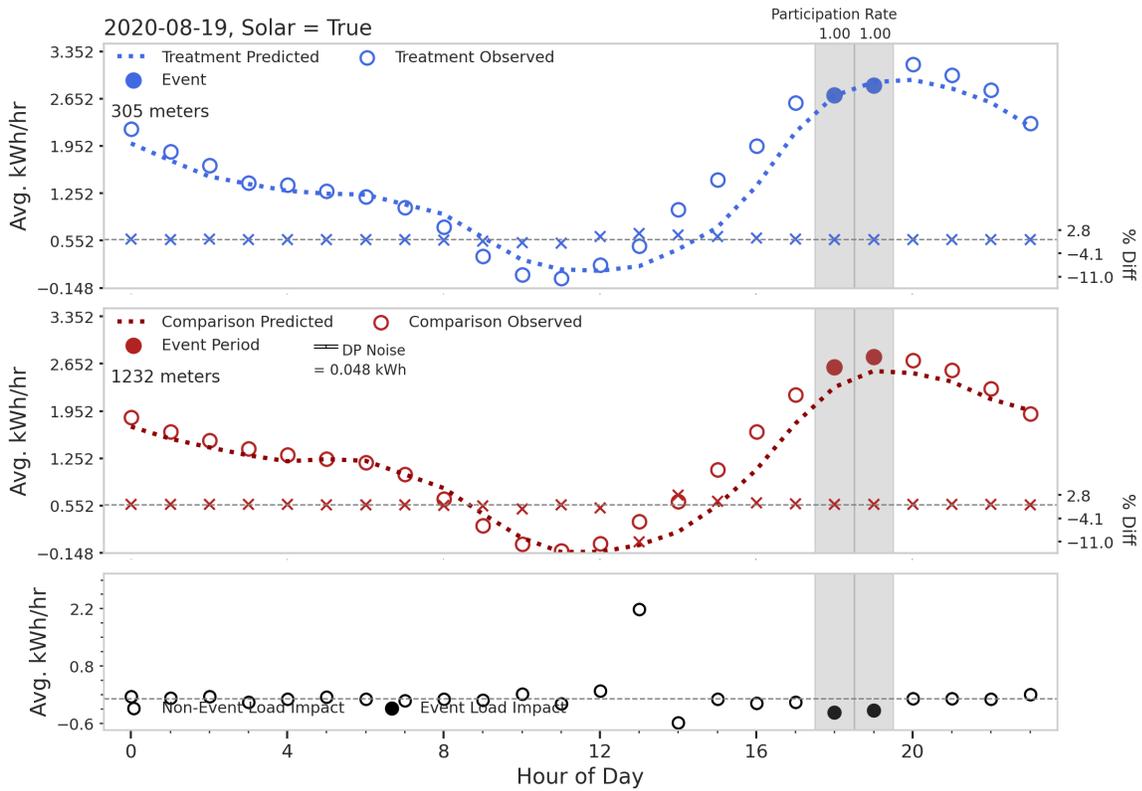


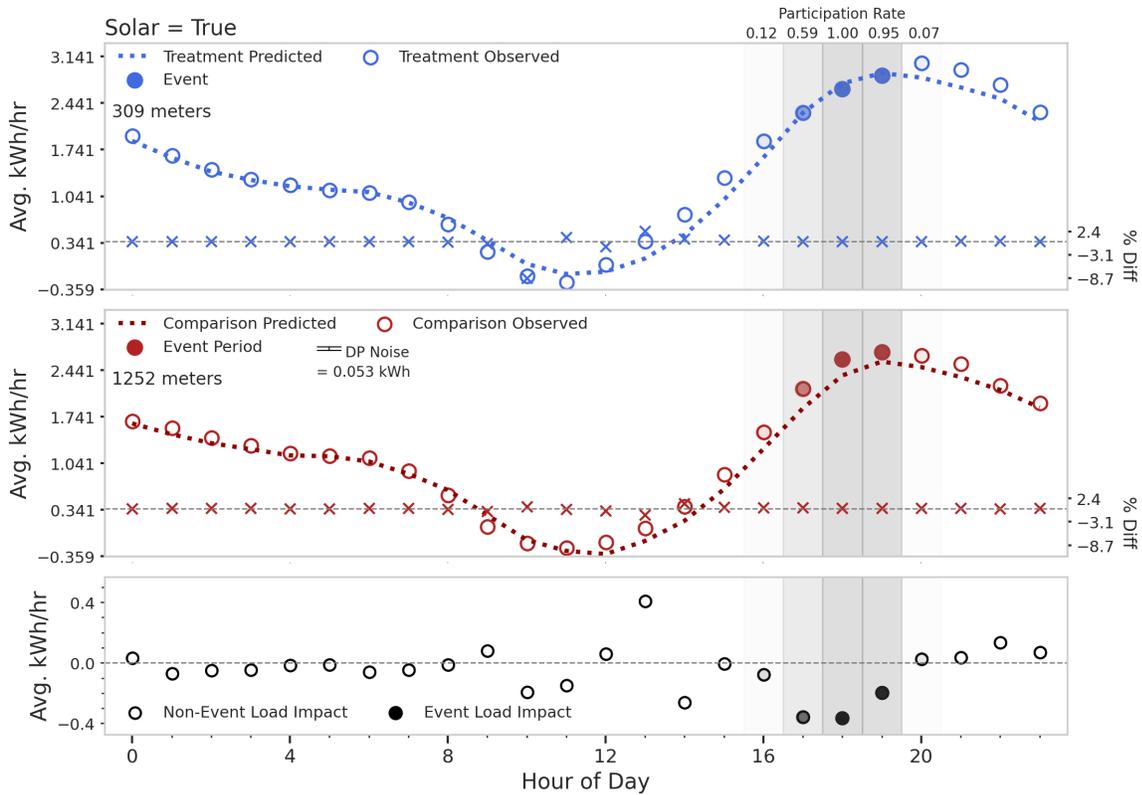
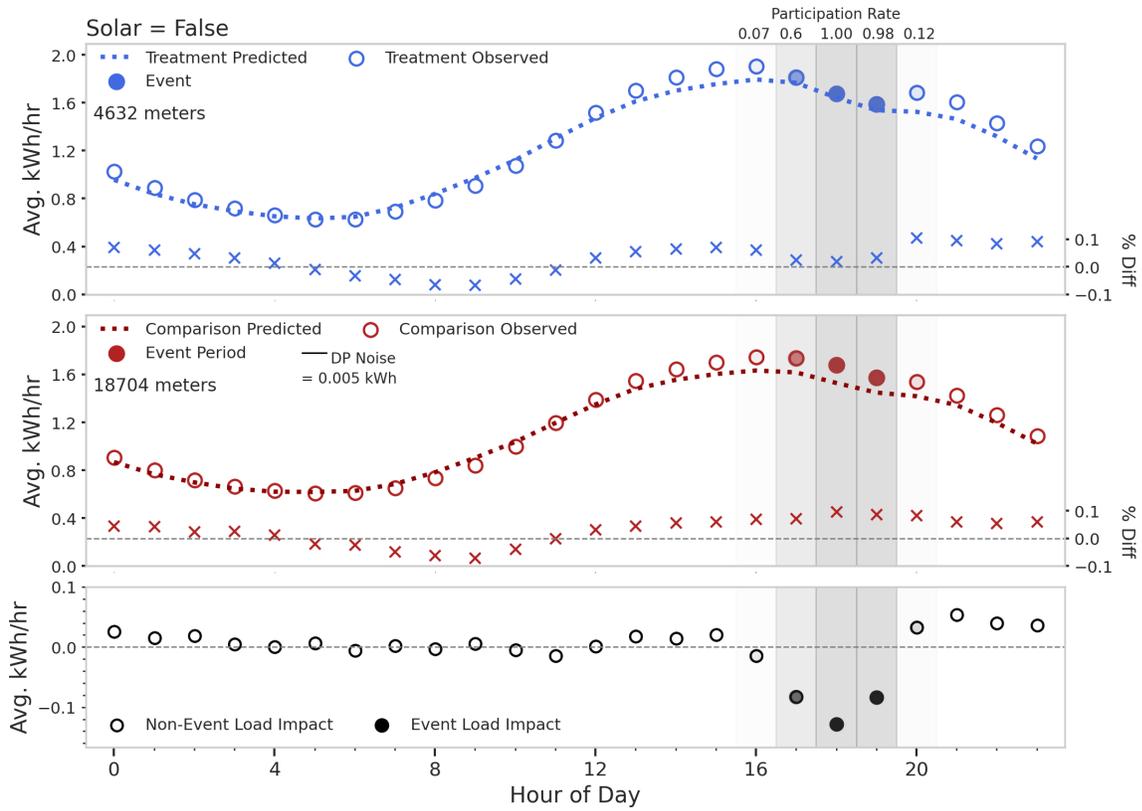




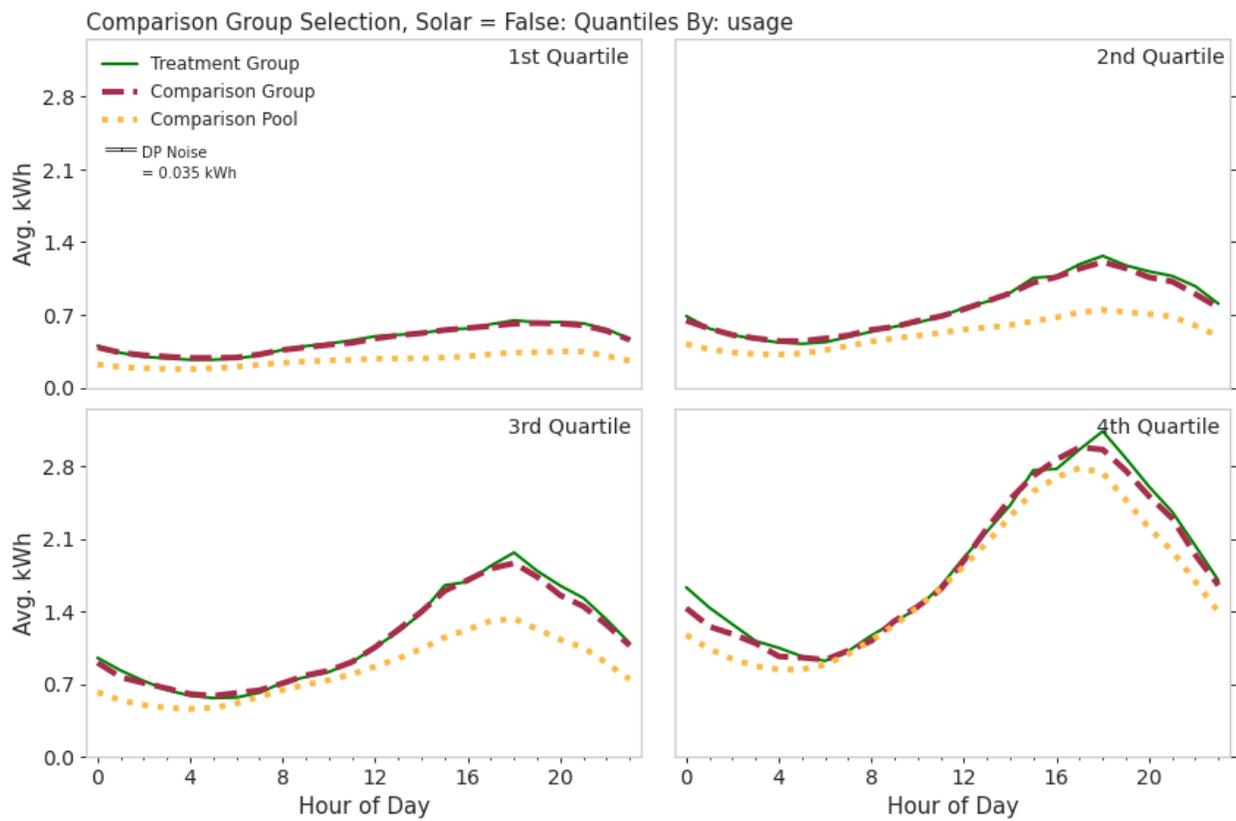
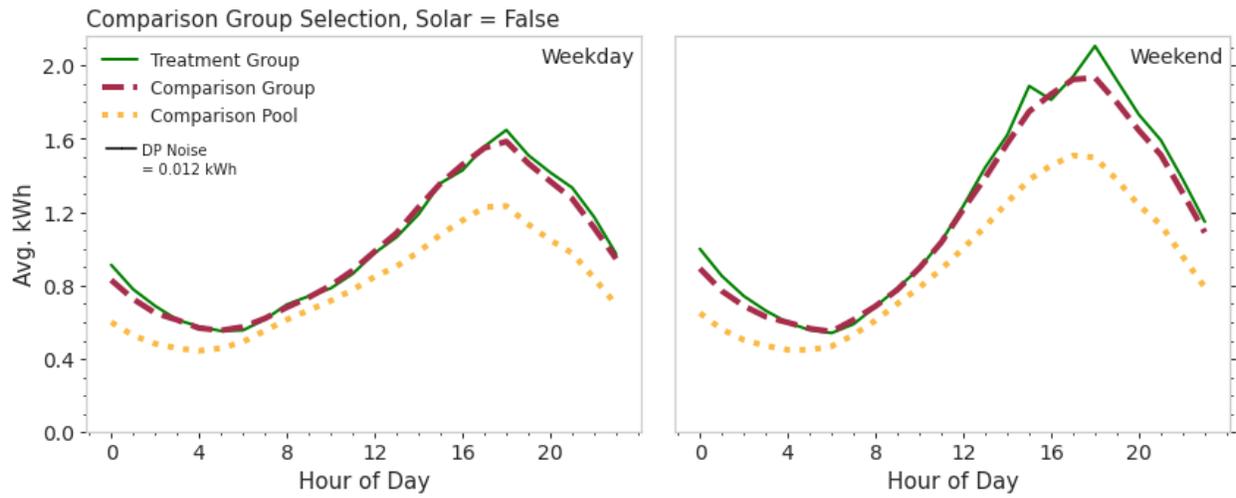




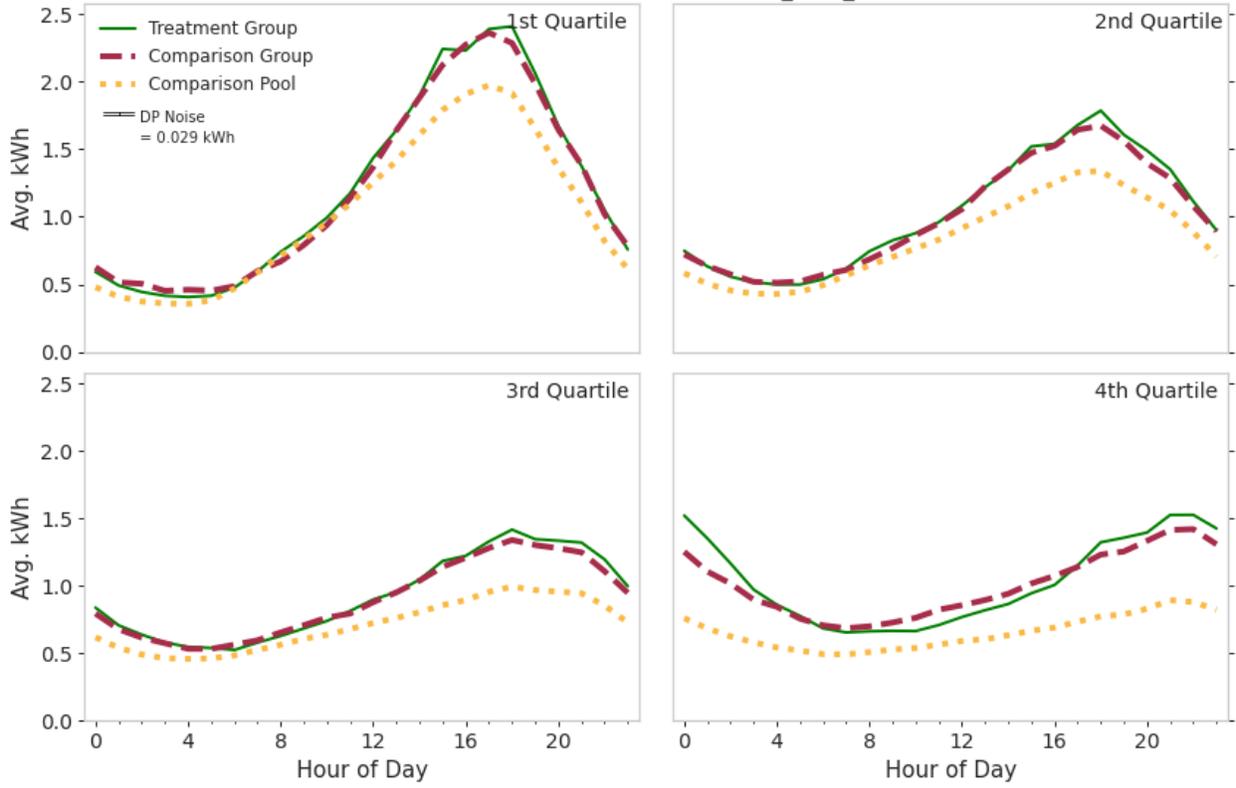




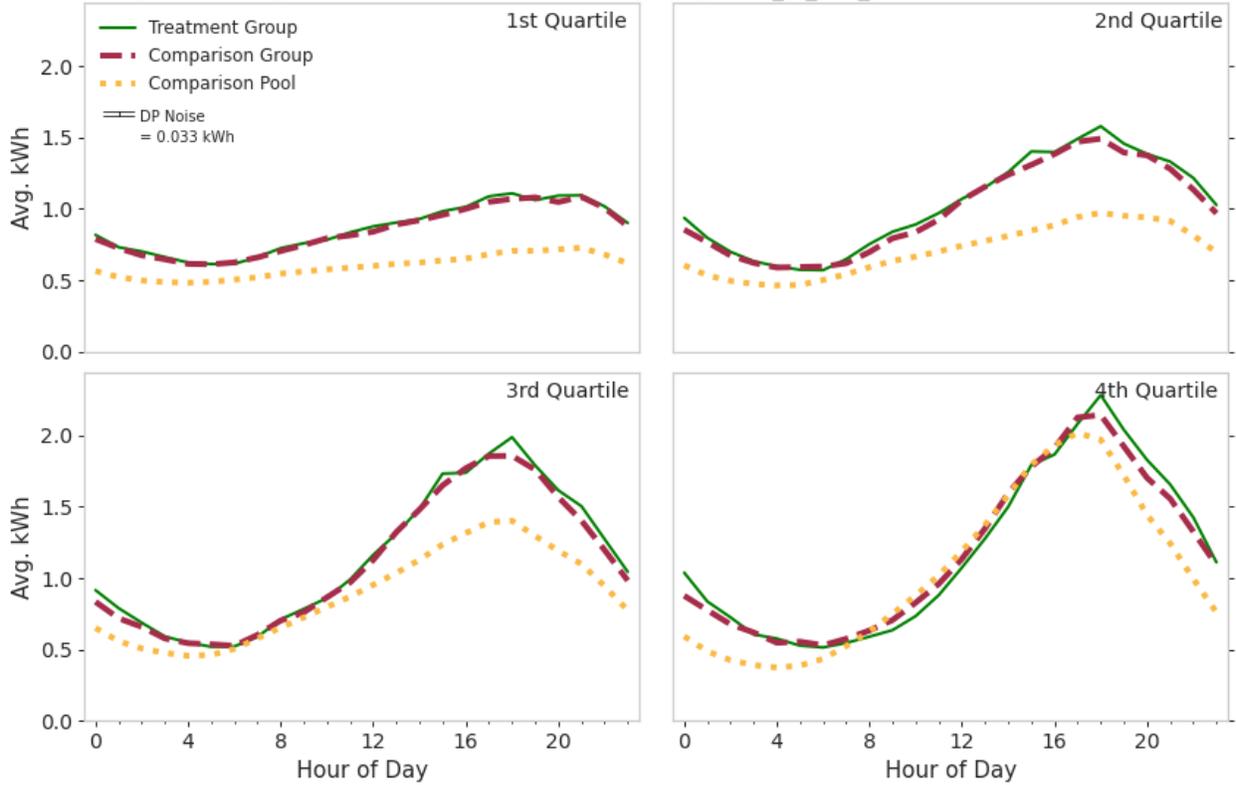
Additional Results: DRP B, LSE 2, Residential



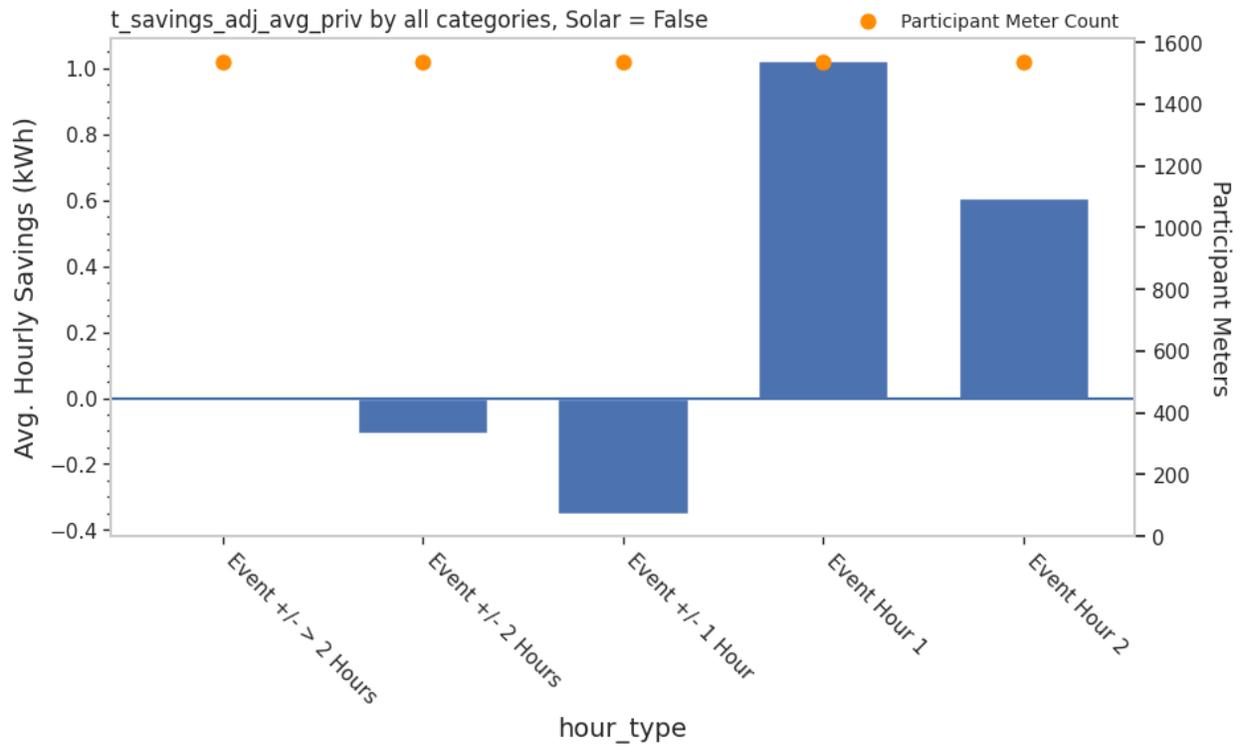
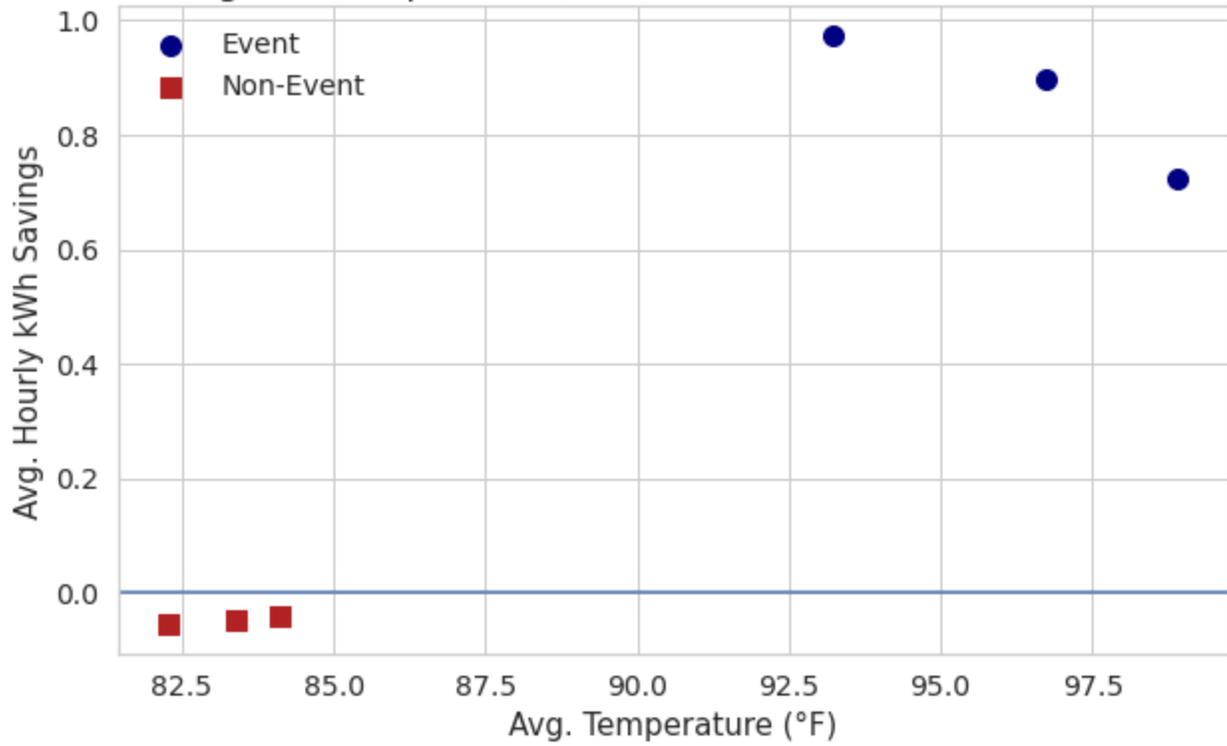
Comparison Group Selection, Solar = False: Quantiles By: night_total_ratio

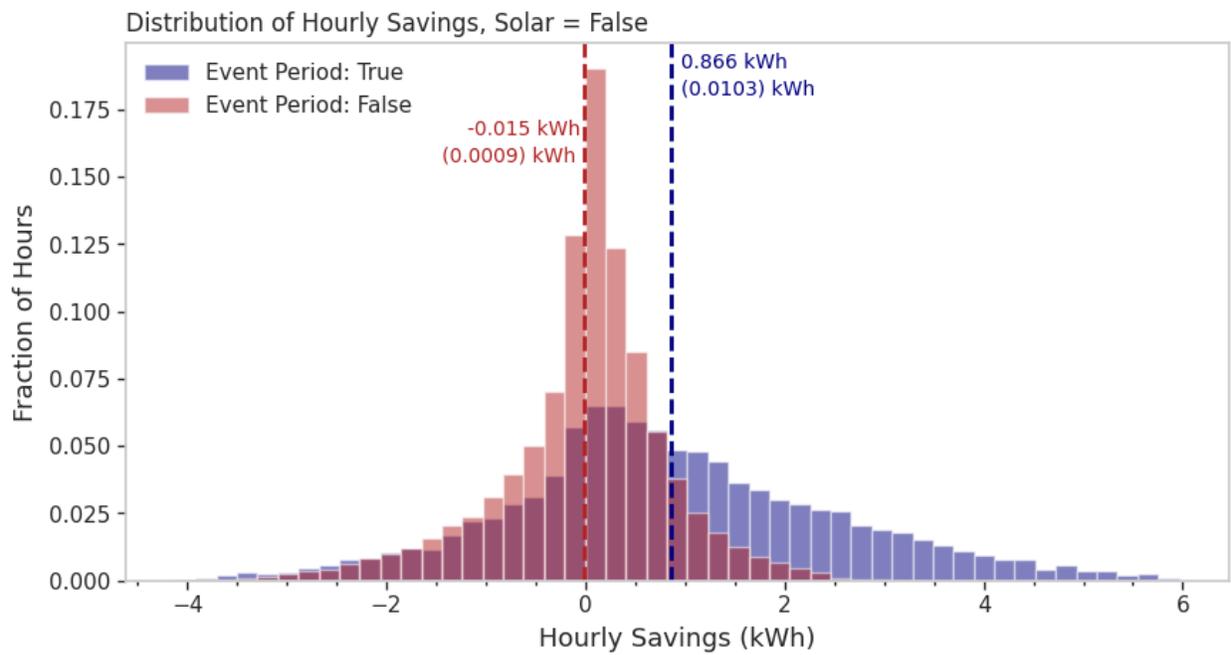
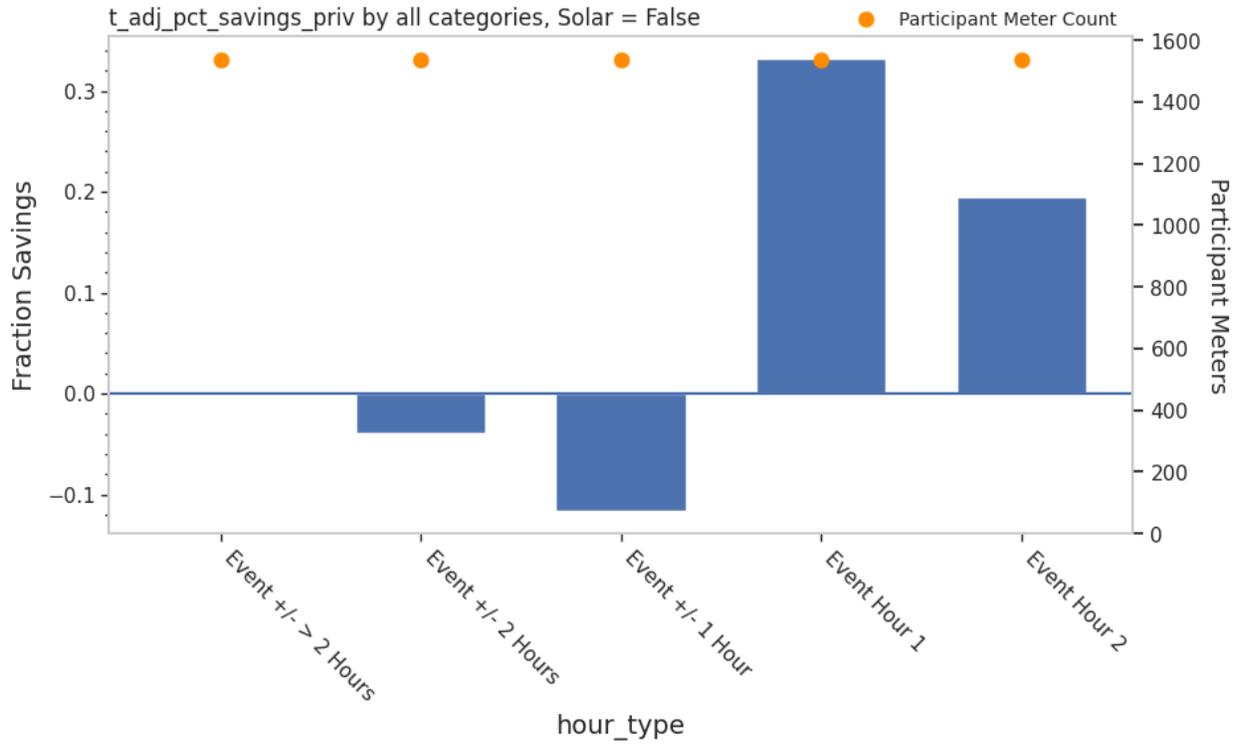


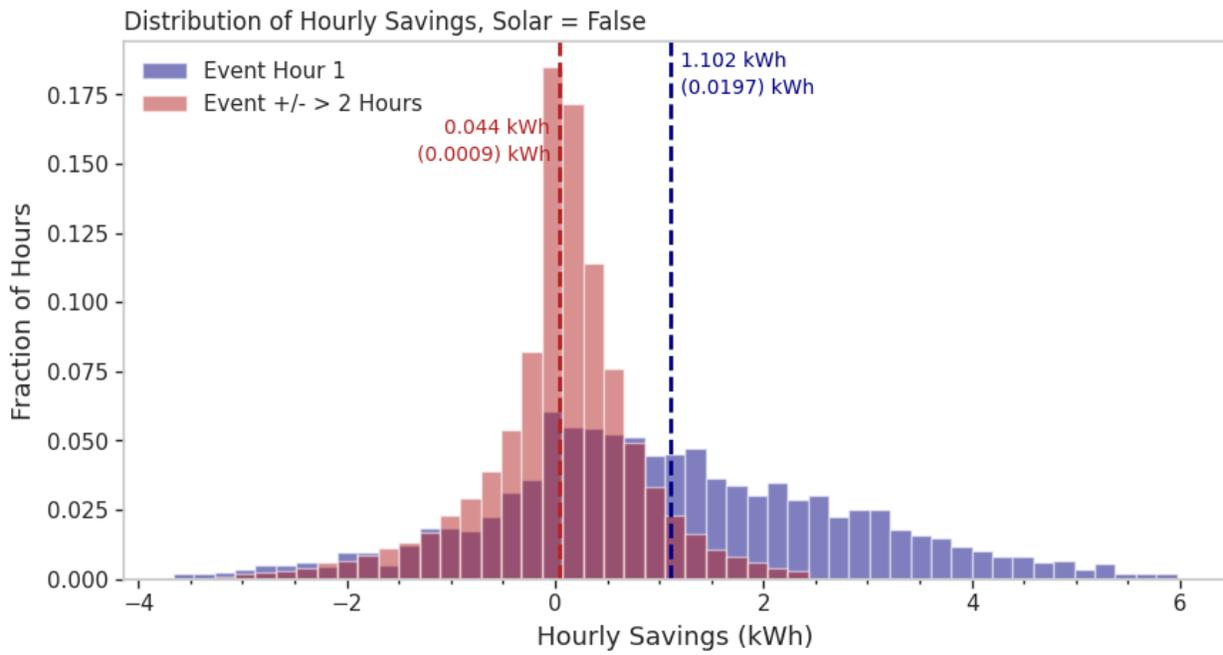
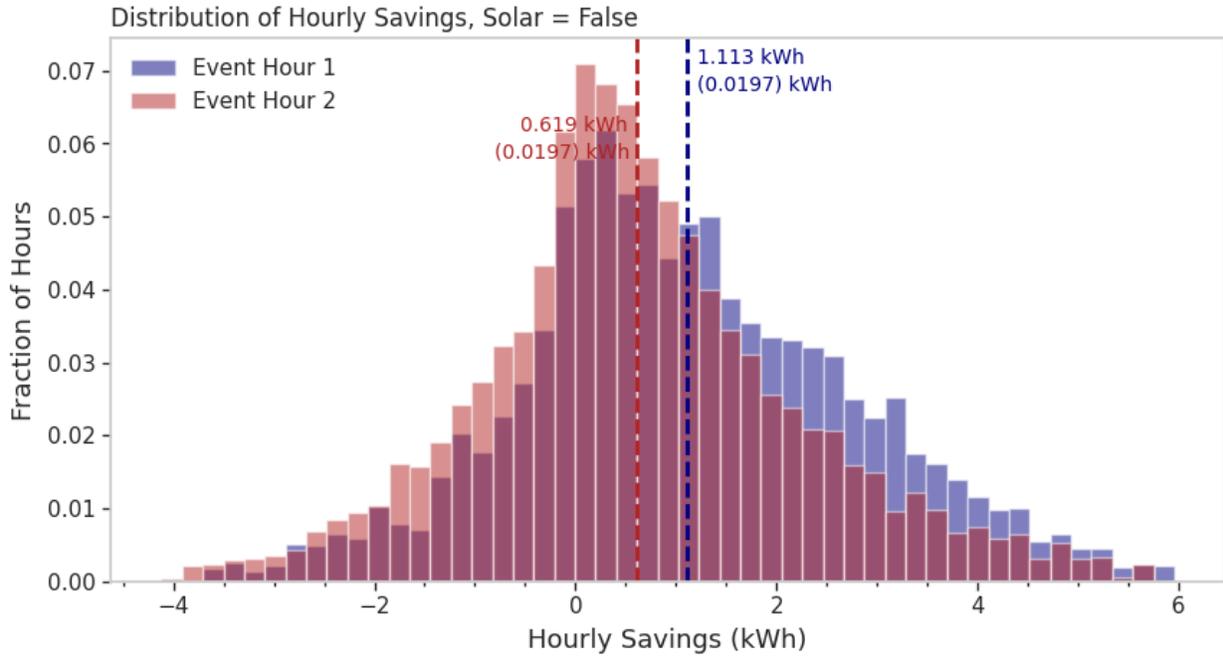
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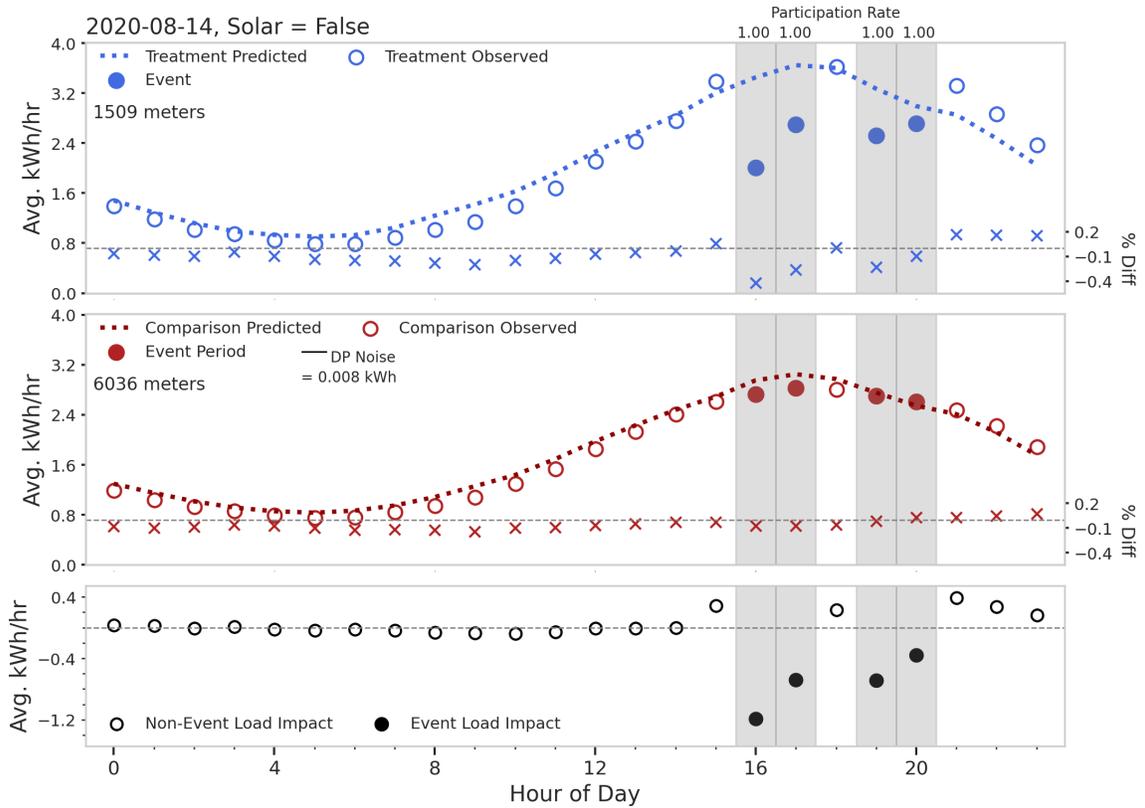
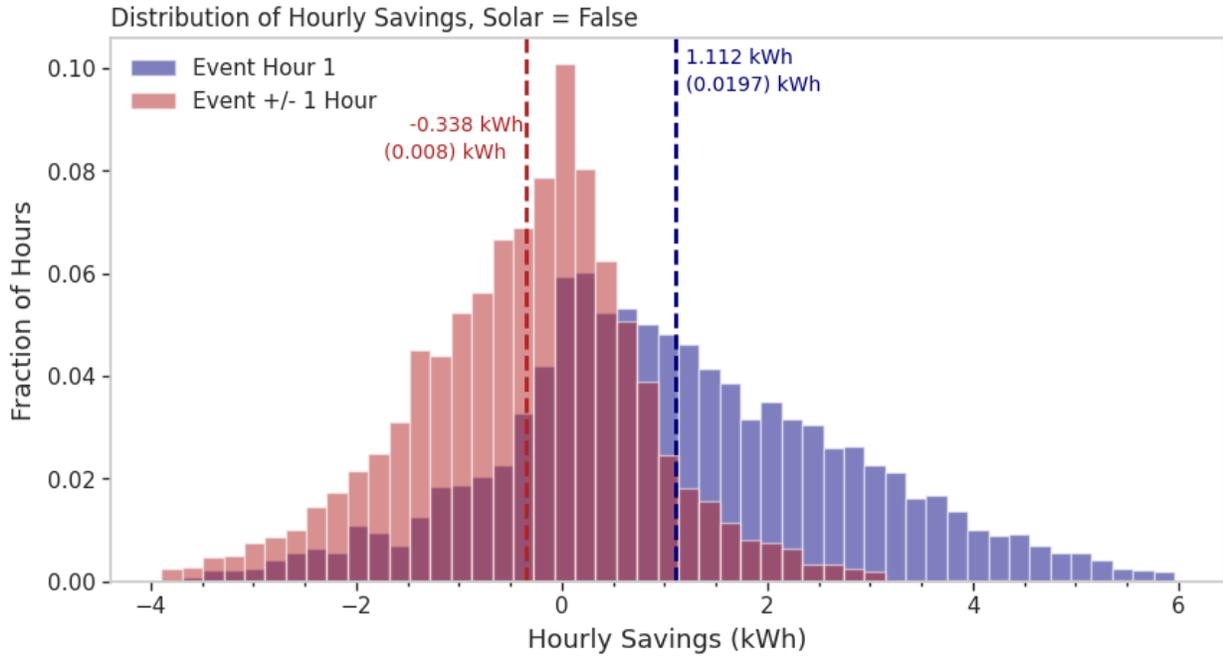


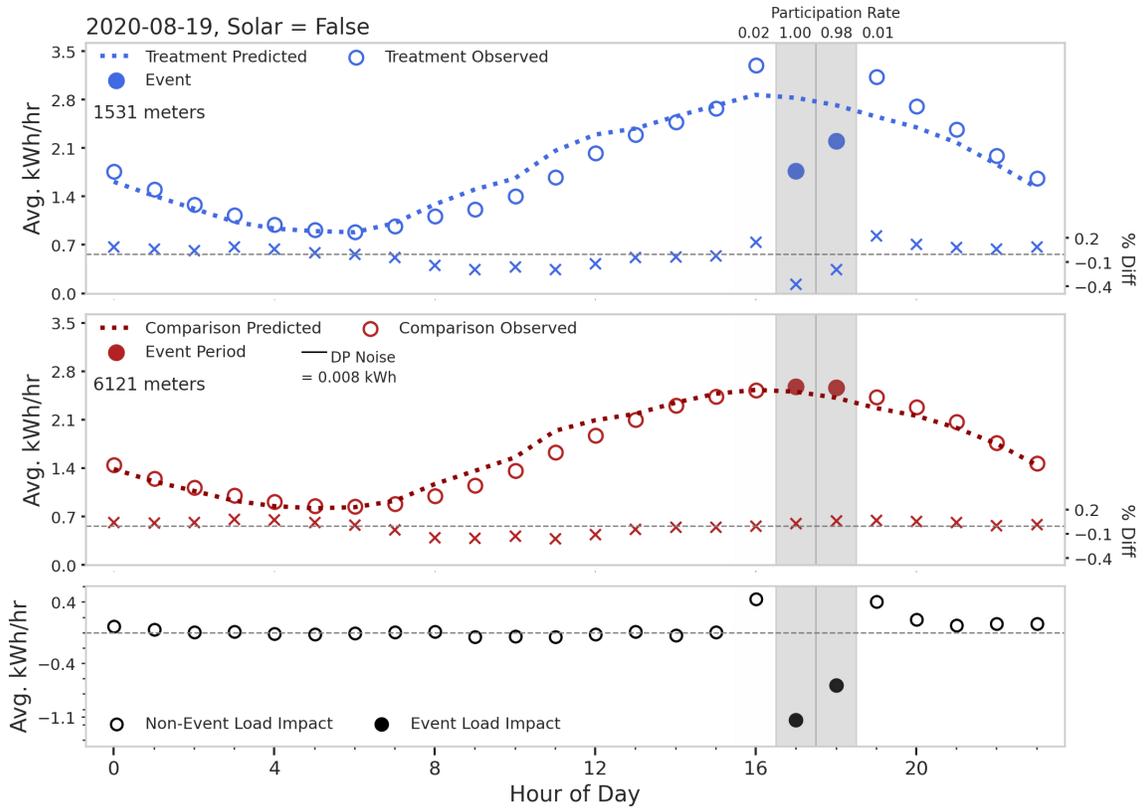
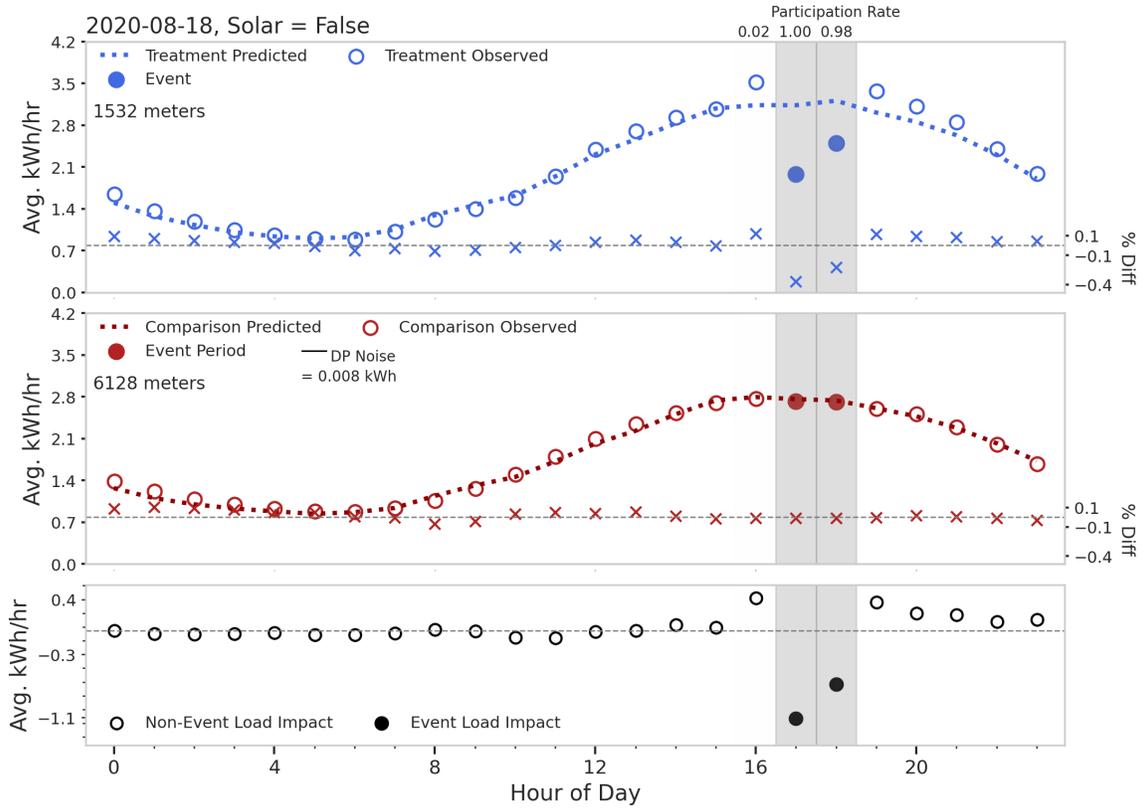
Savings vs. Temperature, Solar = False

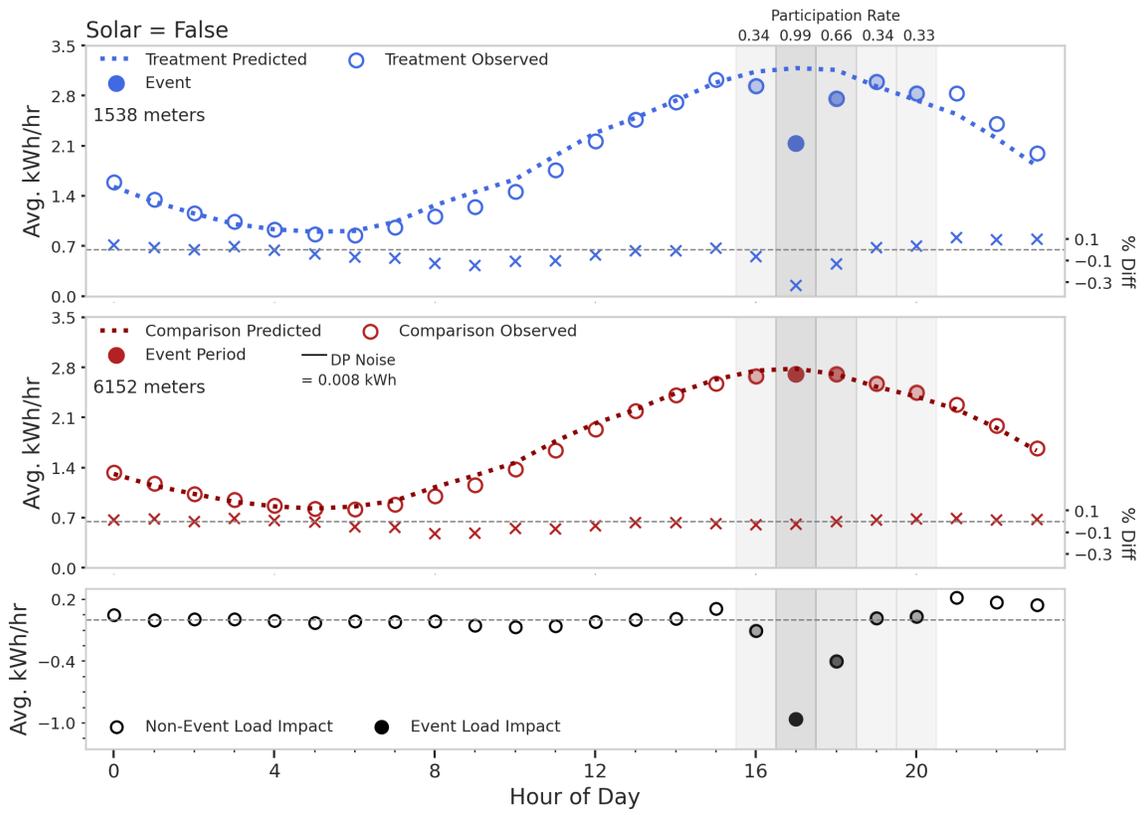




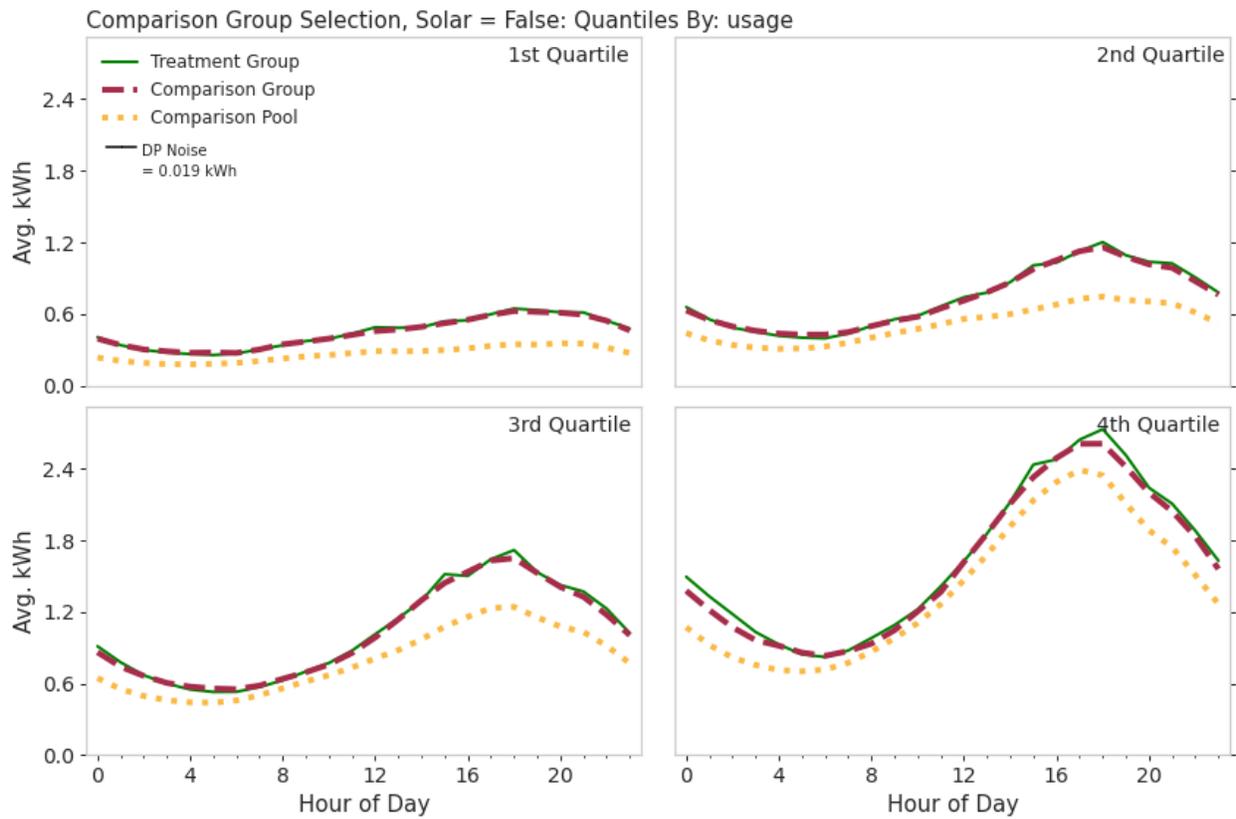
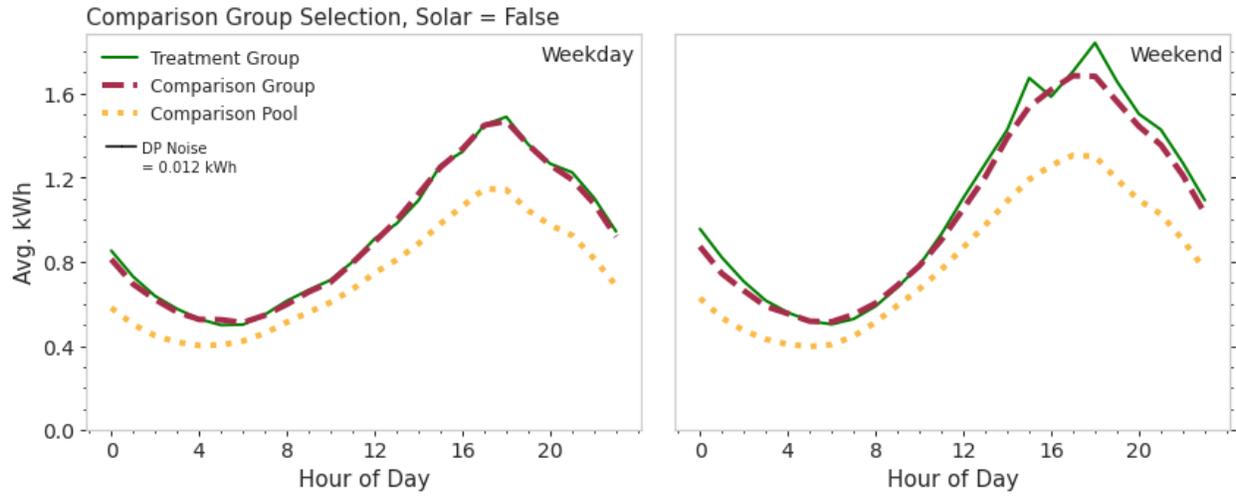




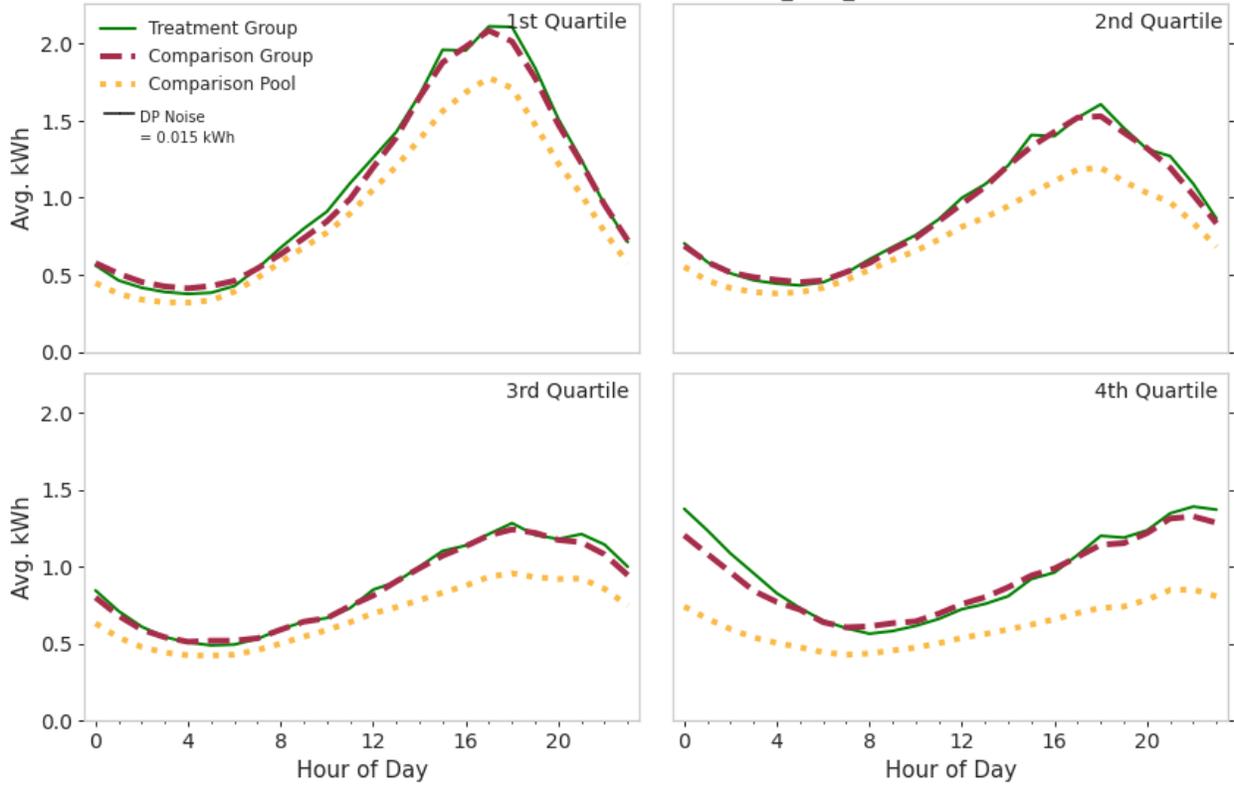




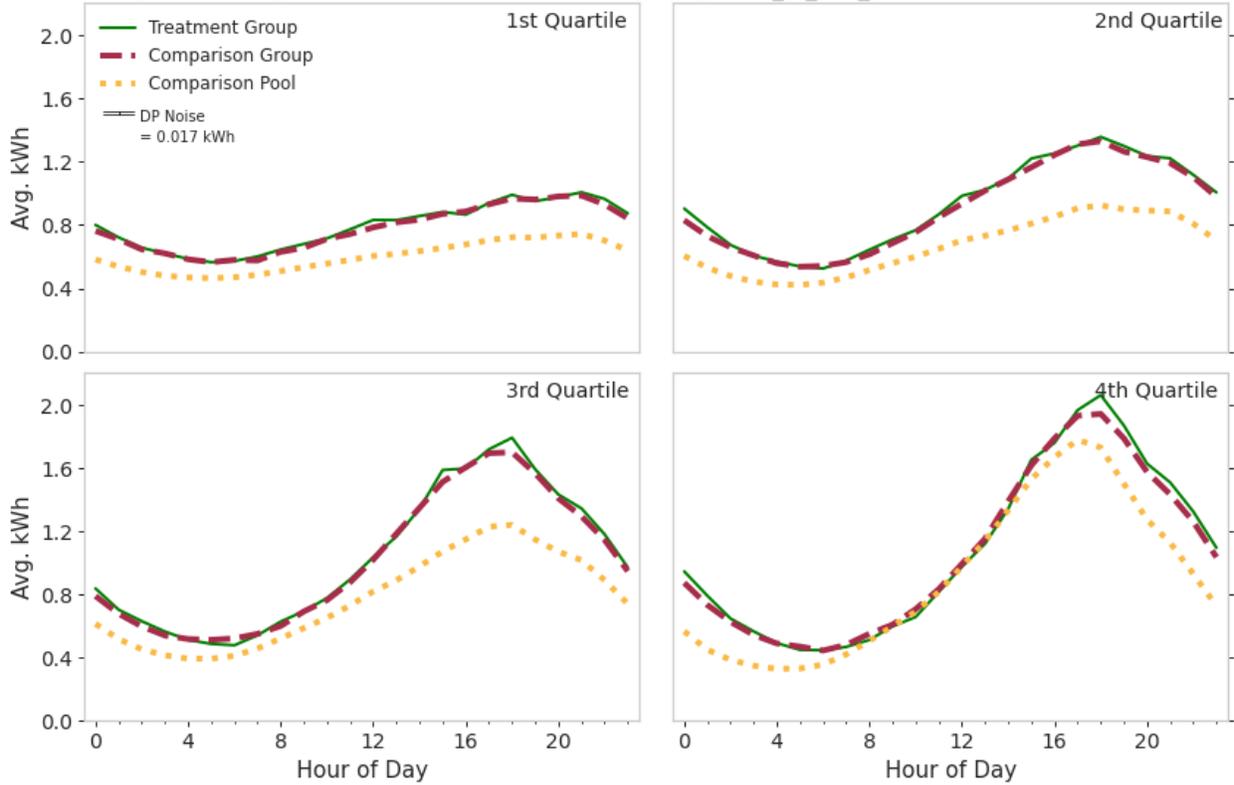
Additional Results: DRP B, LSE 4, Residential



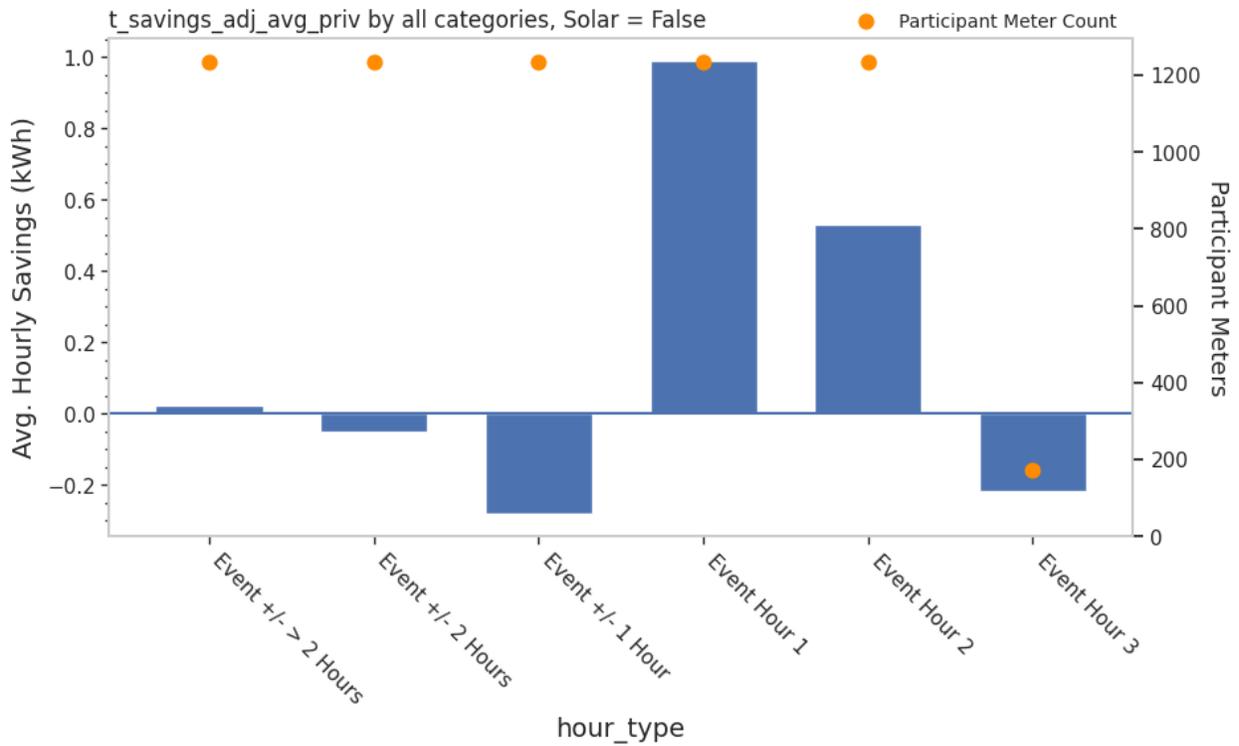
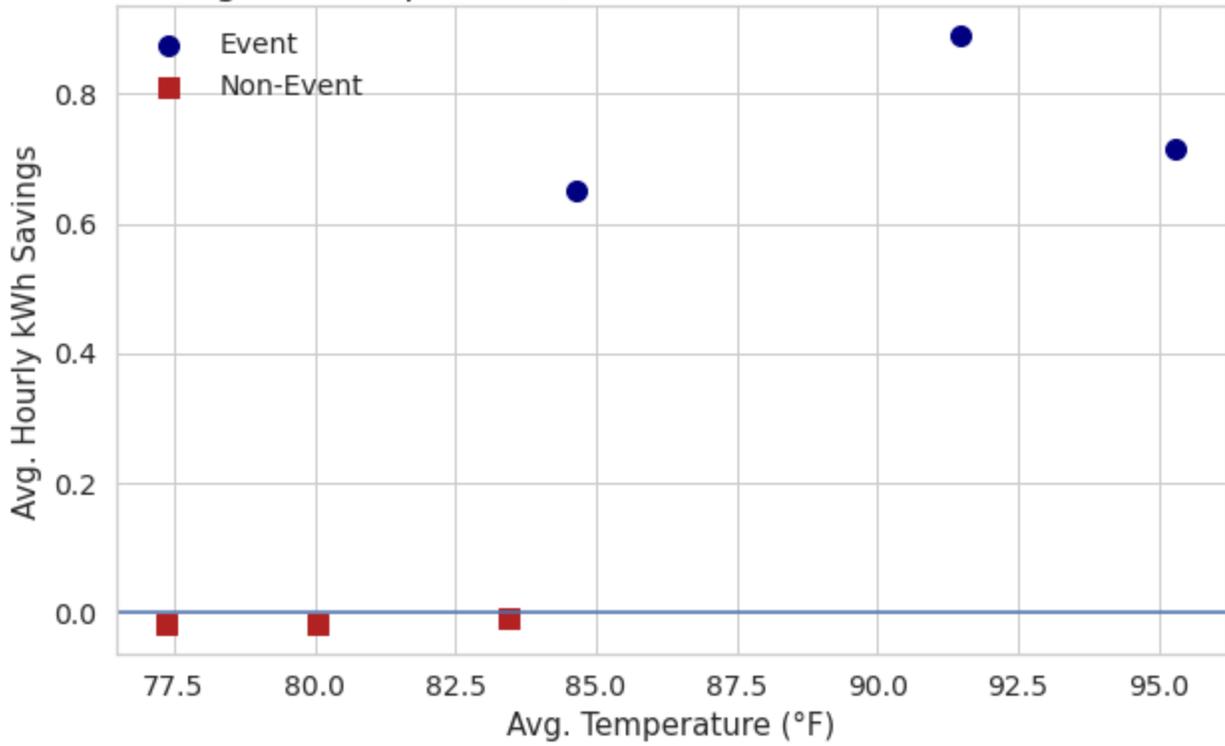
Comparison Group Selection, Solar = False: Quantiles By: night_total_ratio

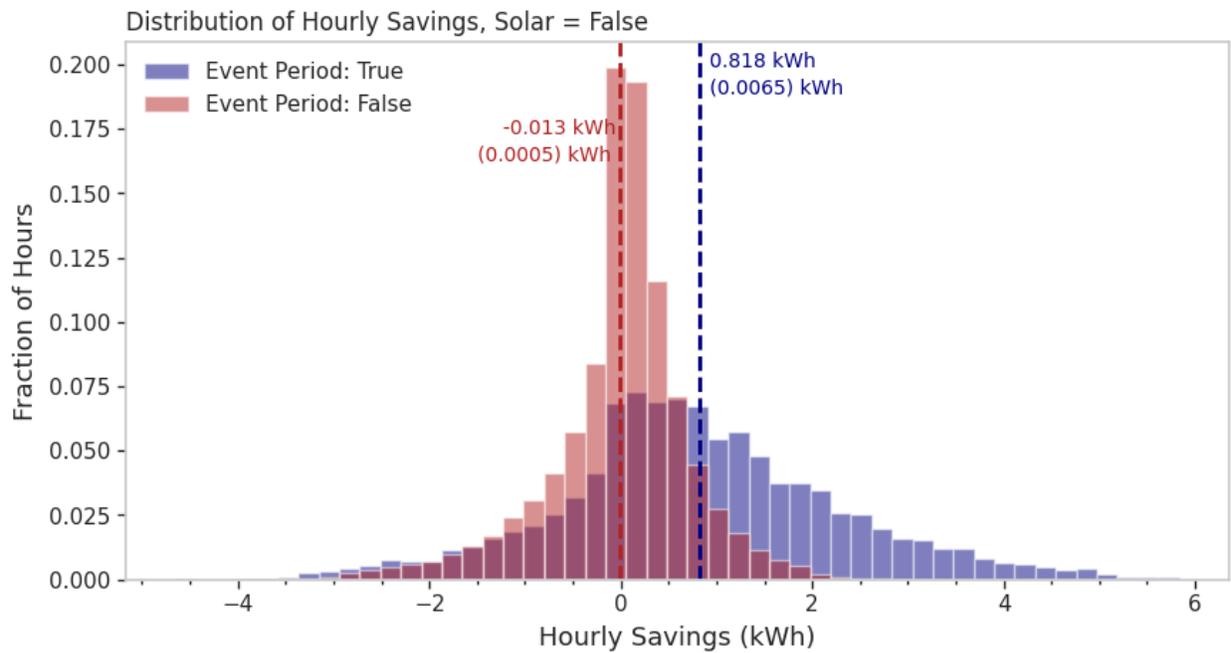
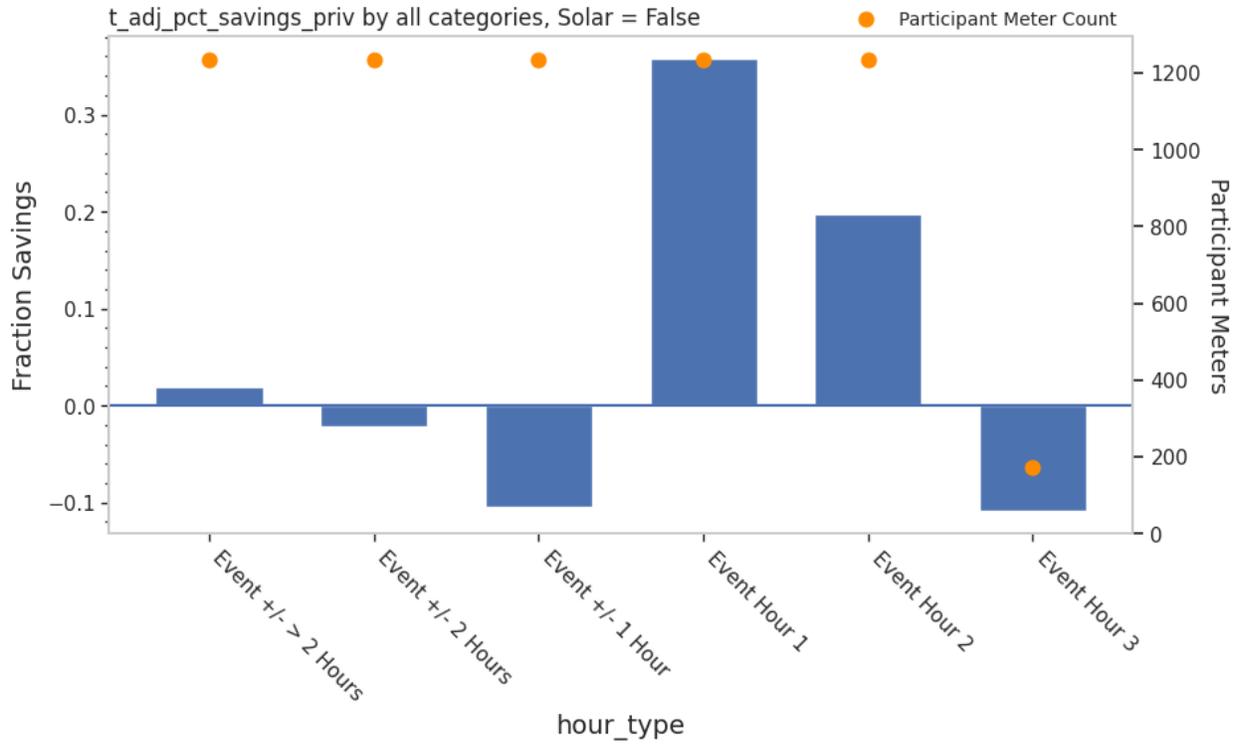


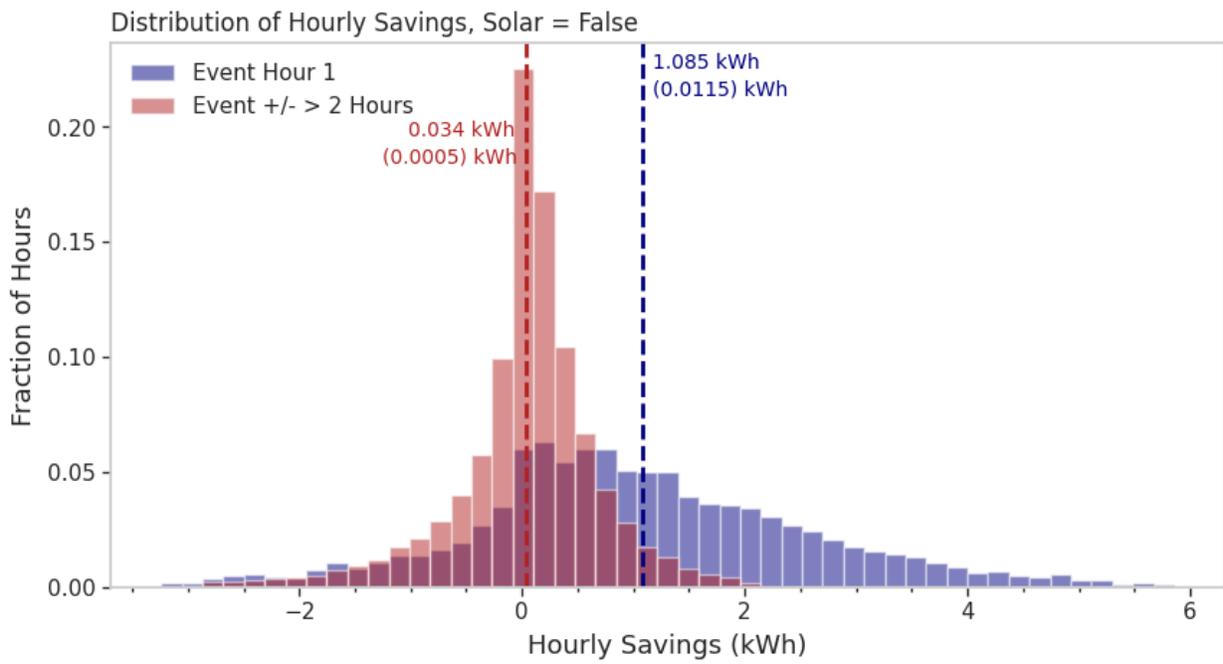
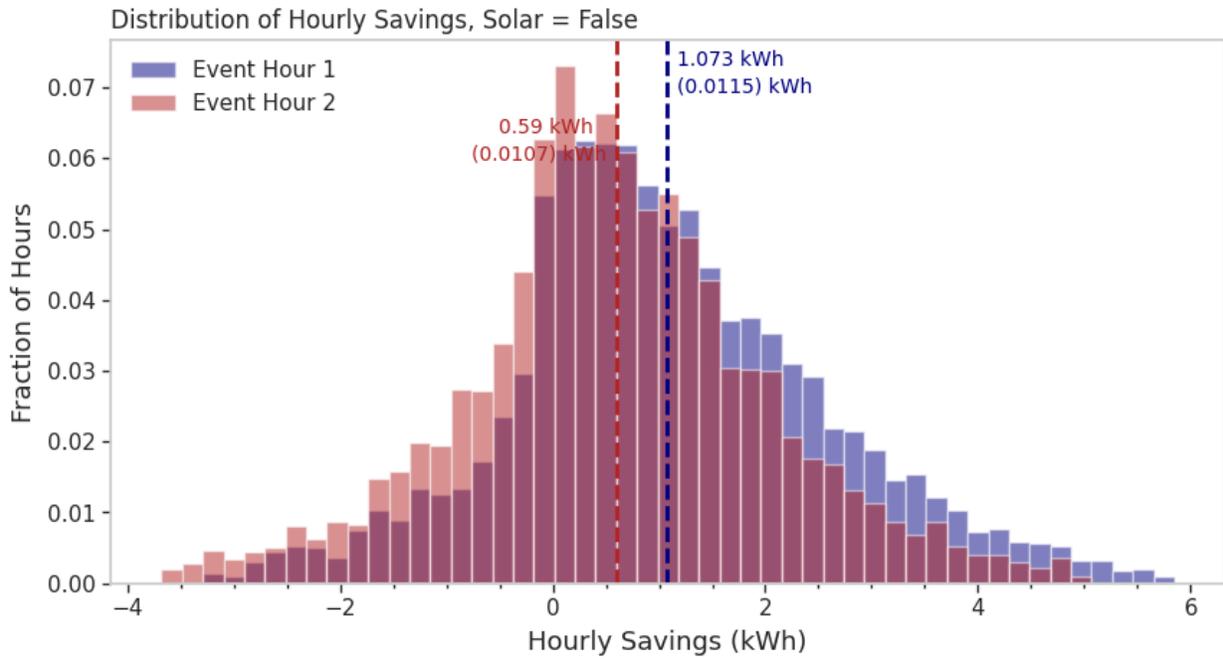
Comparison Group Selection, Solar = False: Quantiles By: max_to_min_ratio

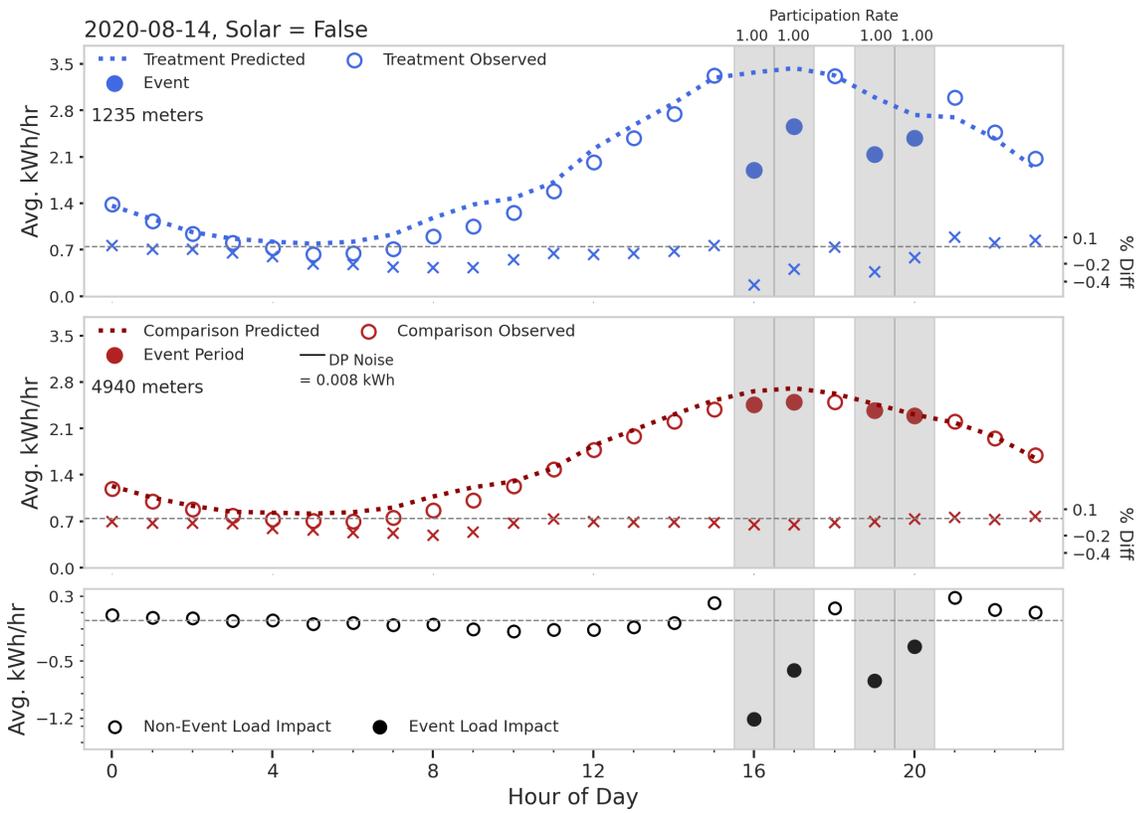
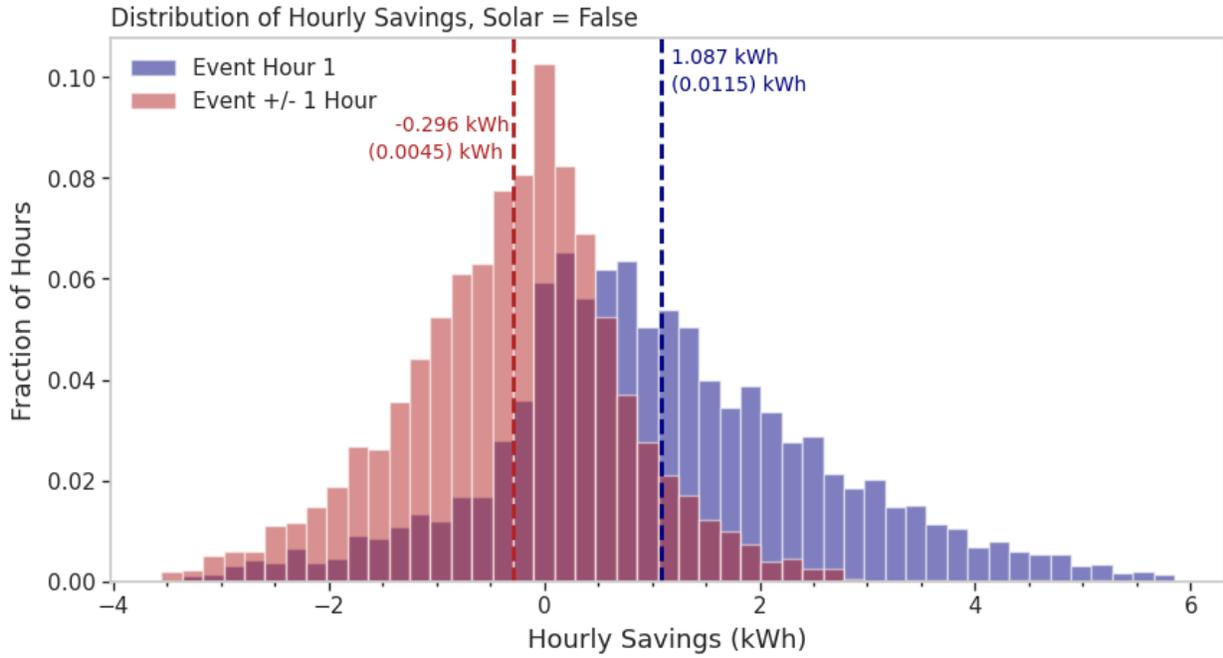


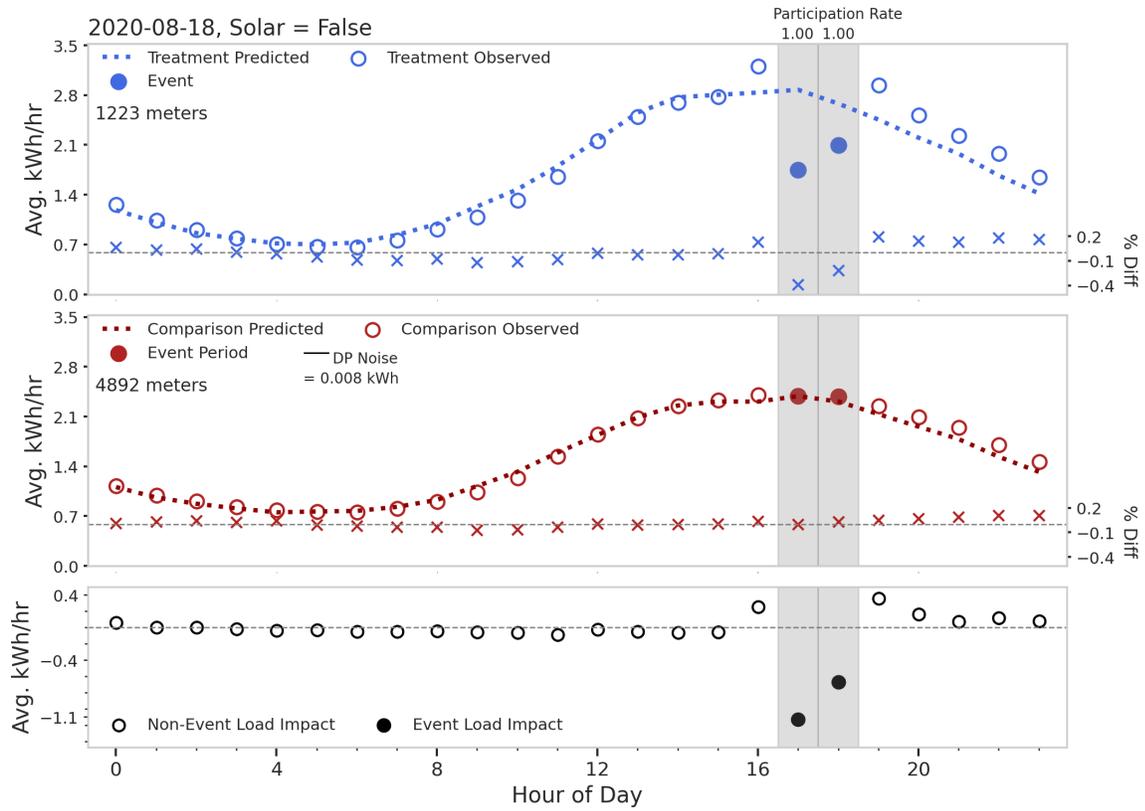
Savings vs. Temperature, Solar = False

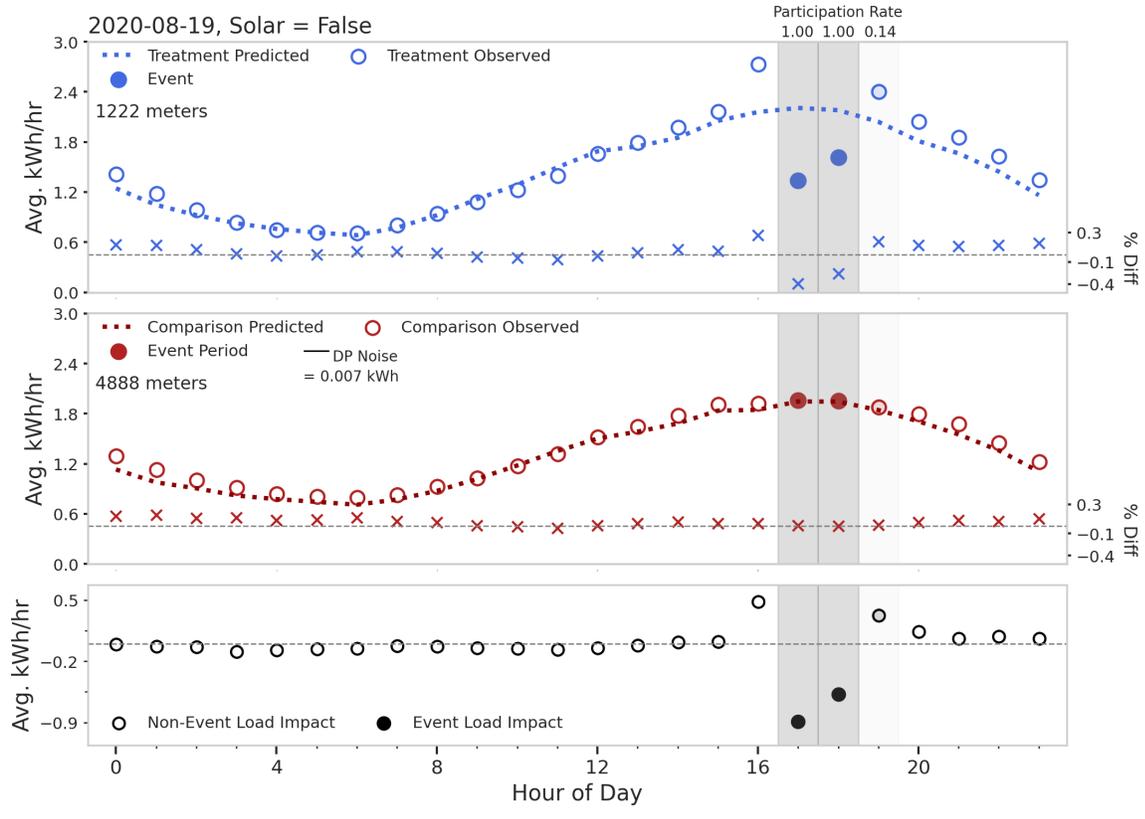


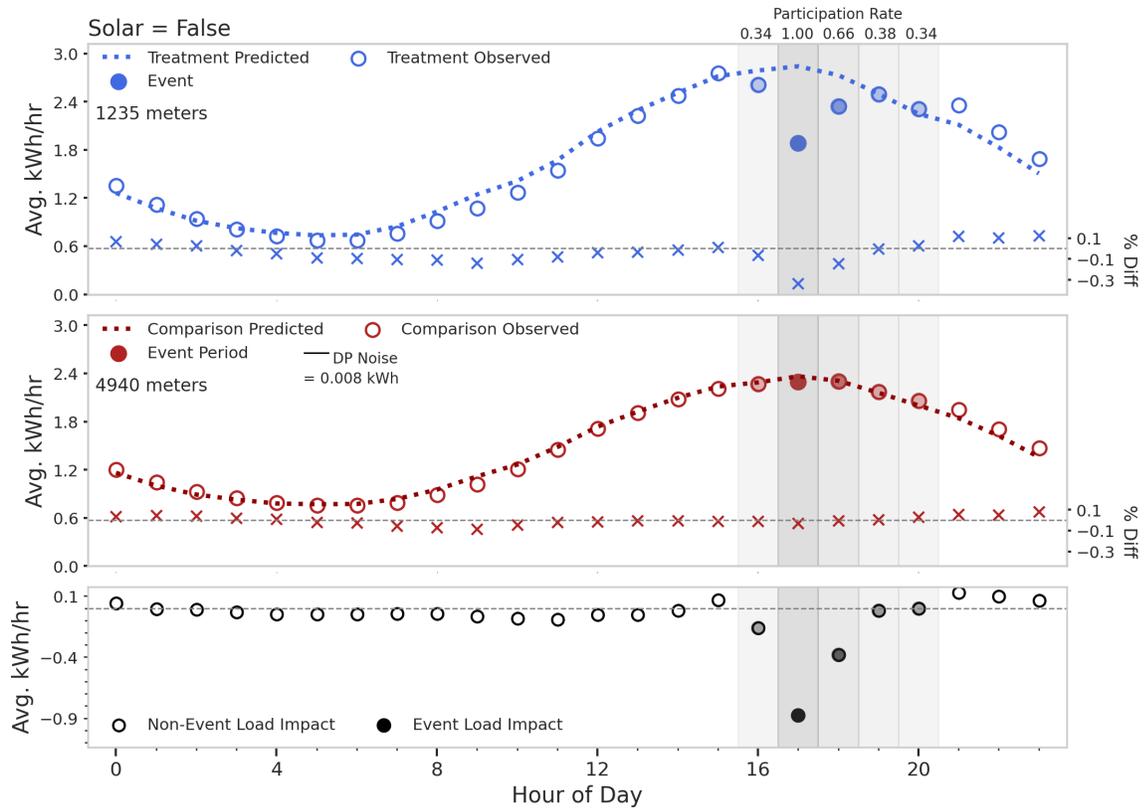




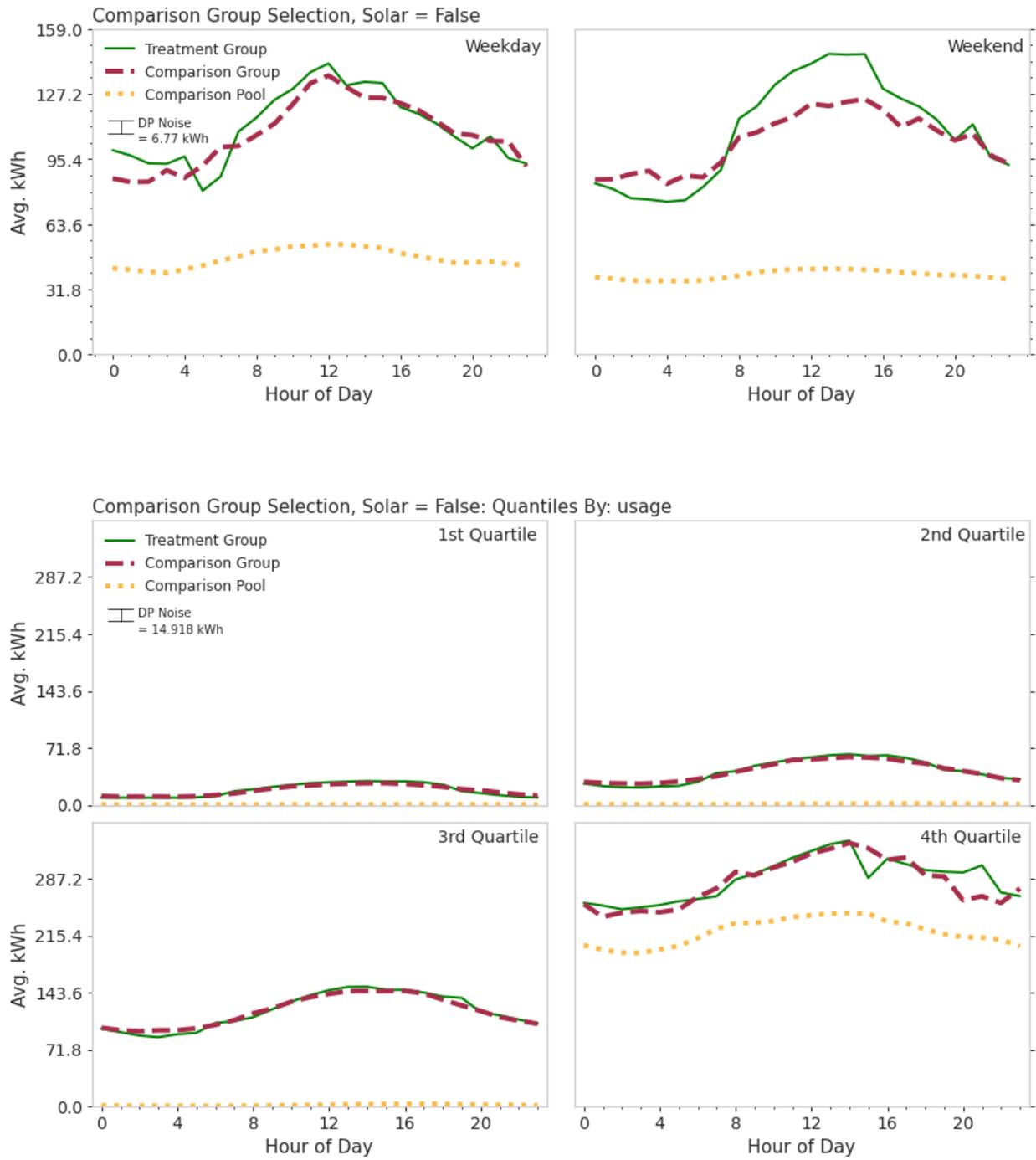




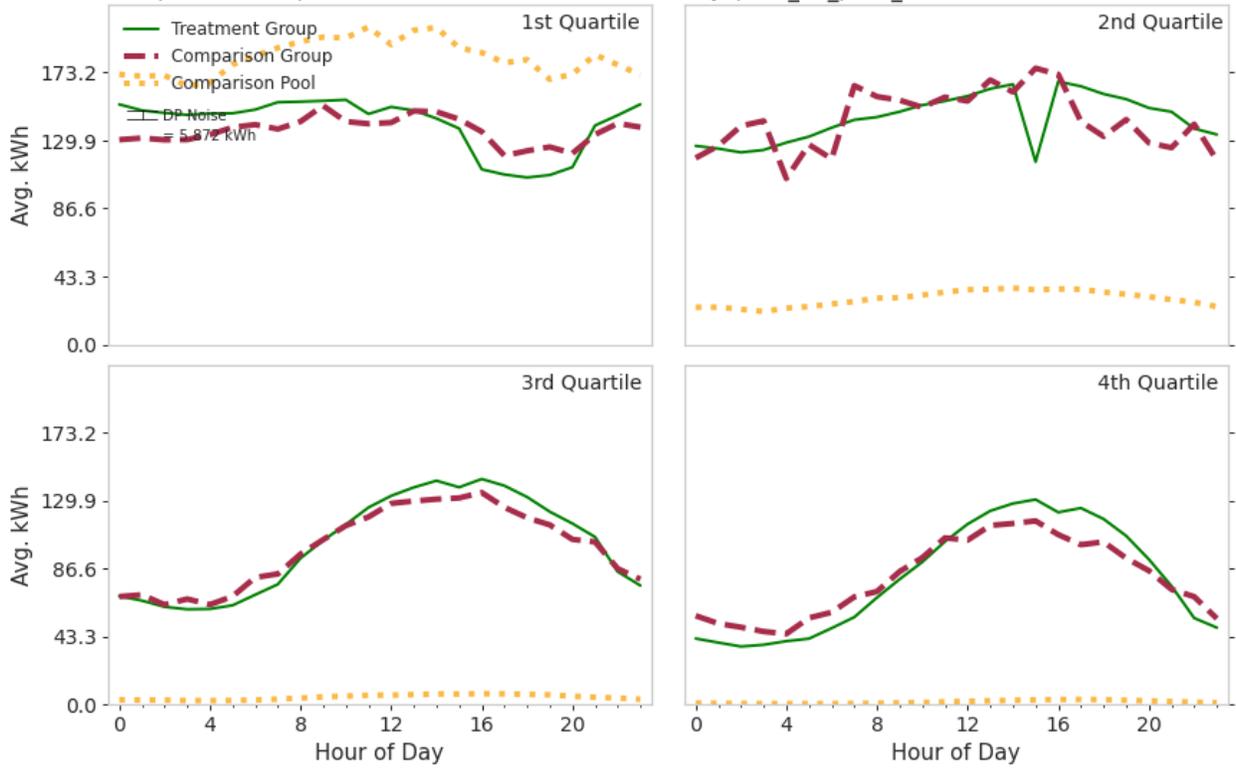




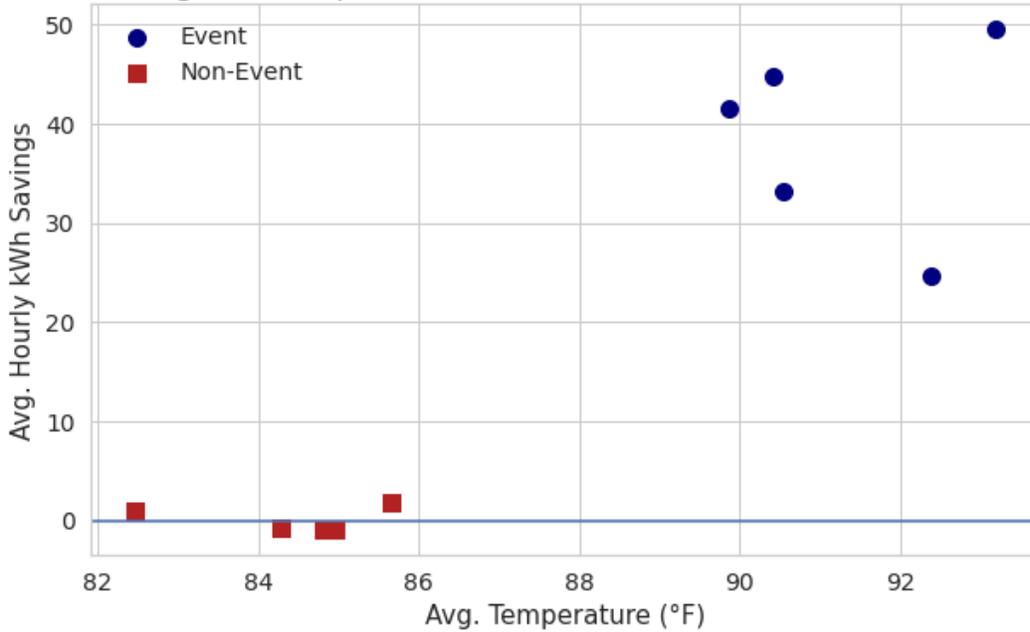
Additional Results: DRP C, LSE 1, Non-Residential

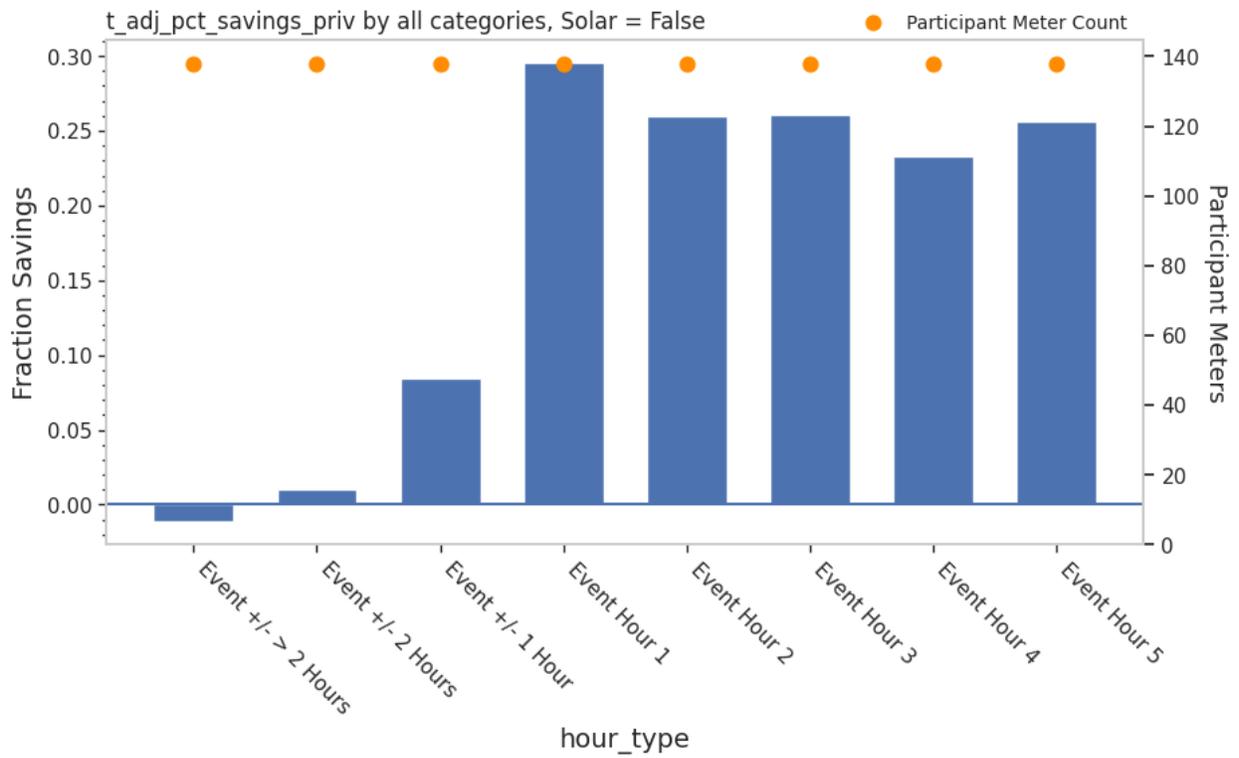
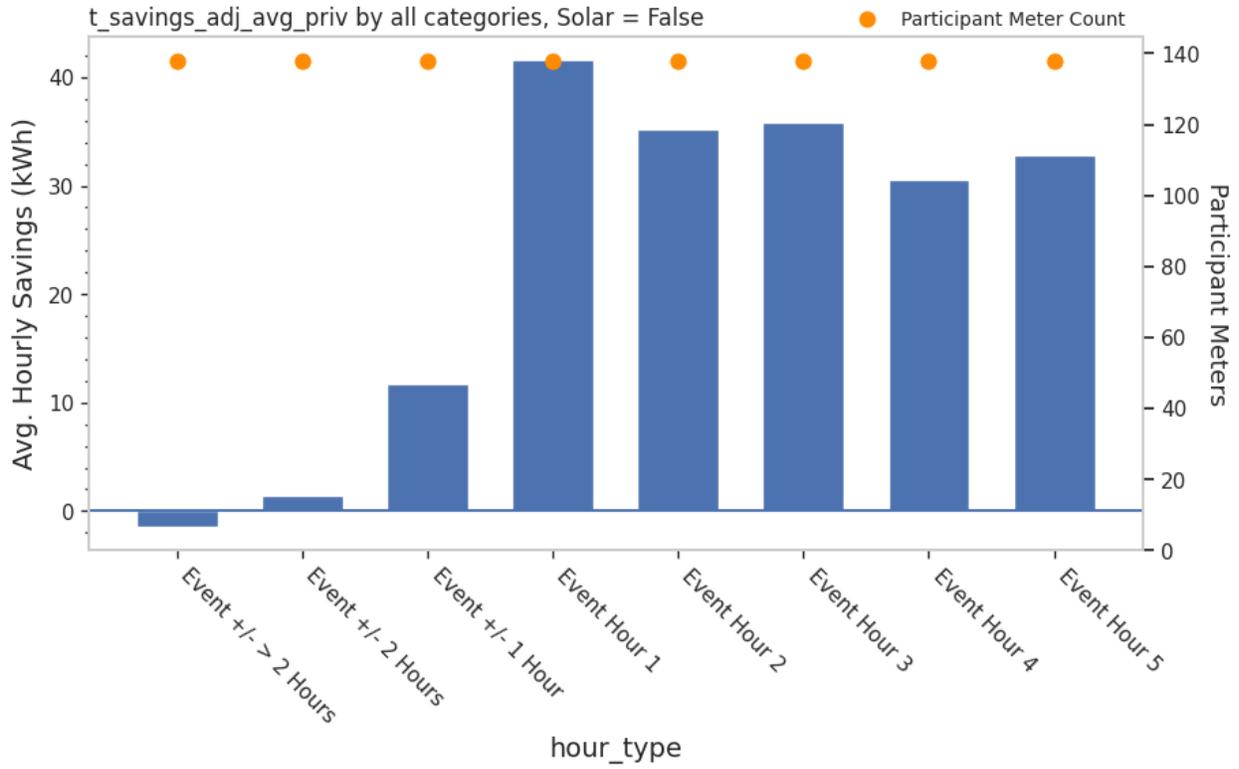


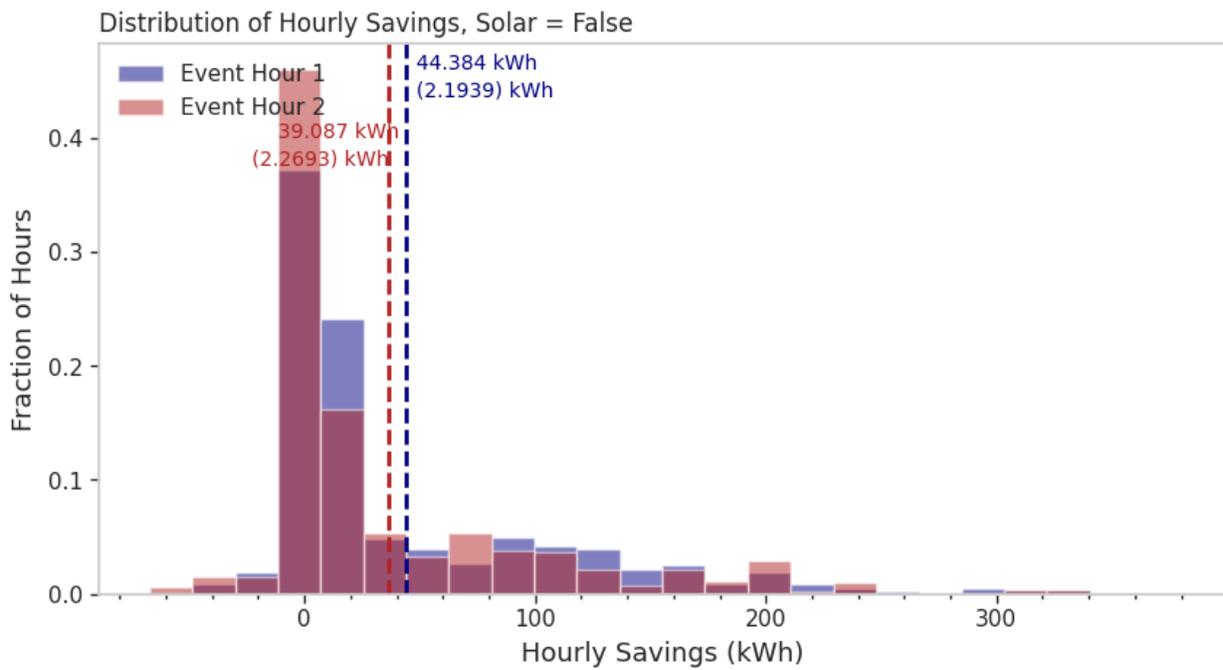
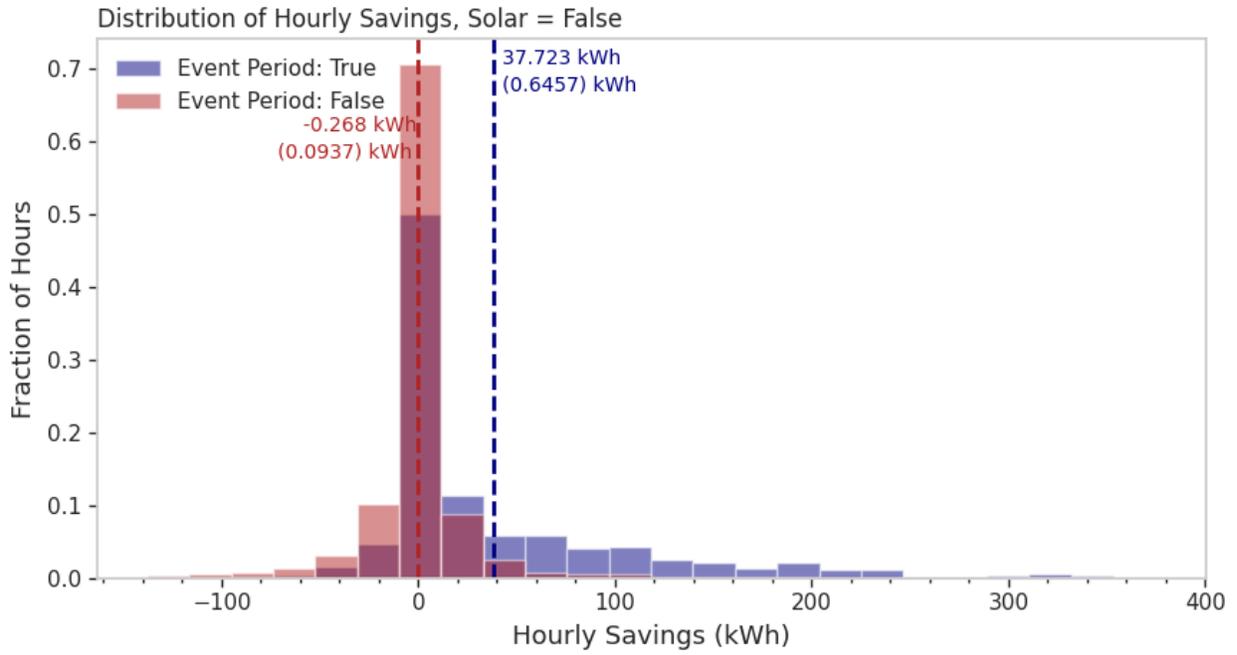
Comparison Group Selection, Solar = False: Quantiles By: peak_off_peak_ratio

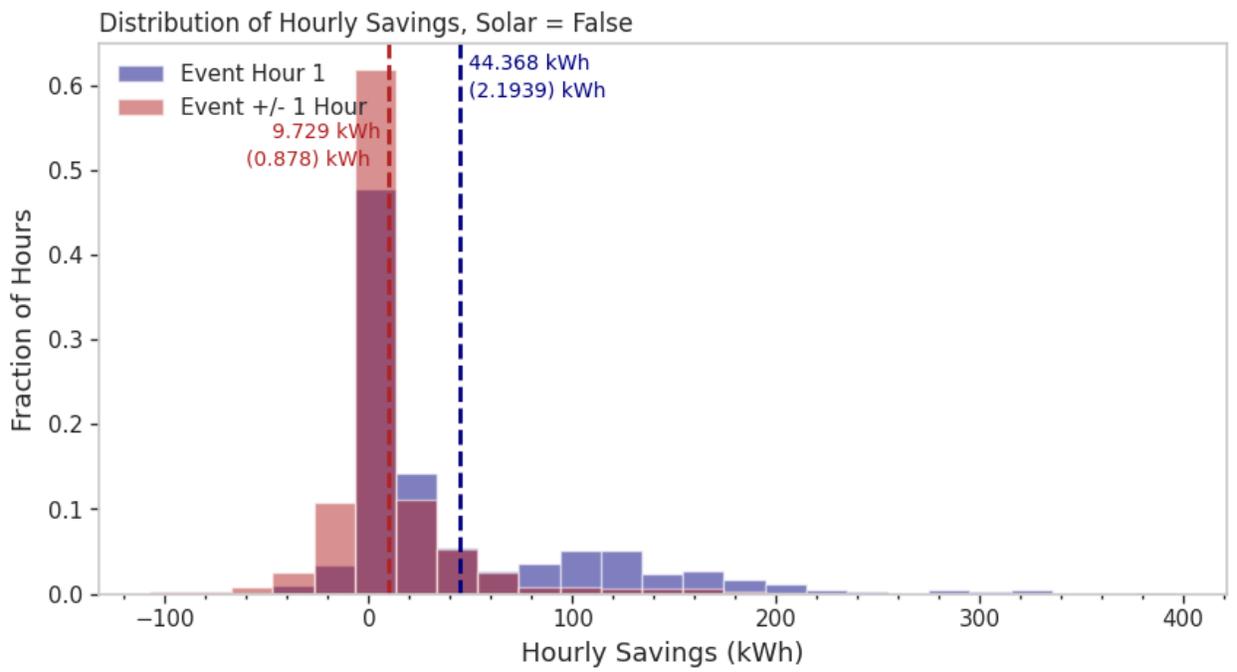
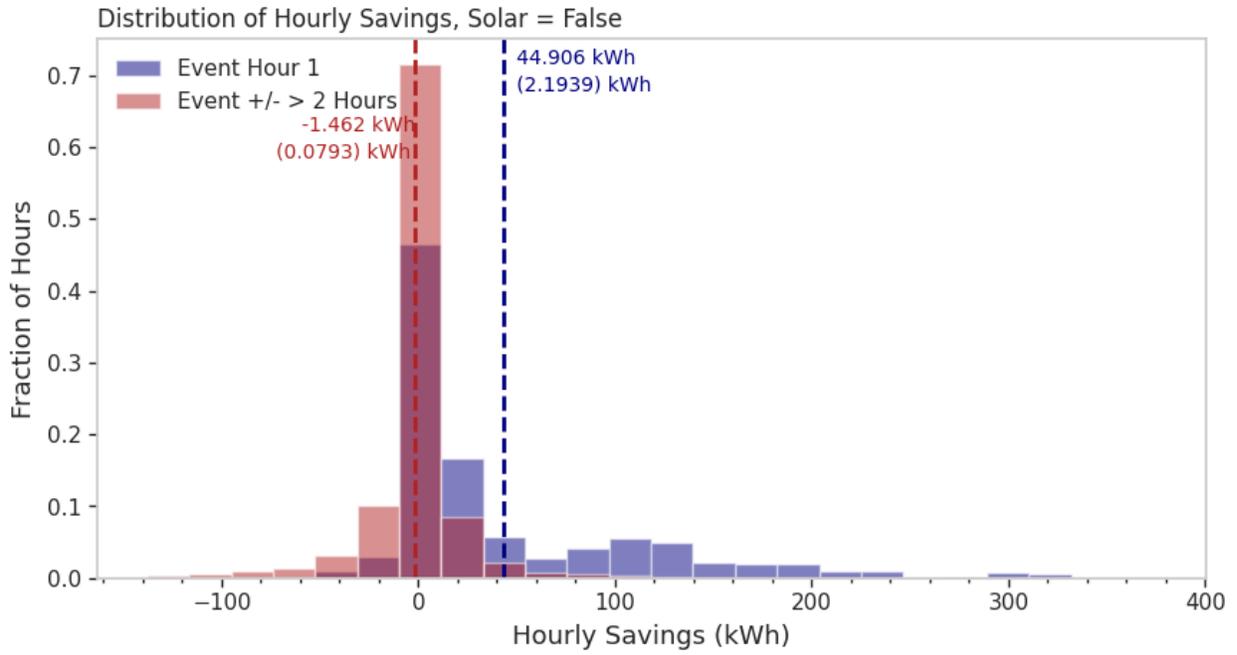


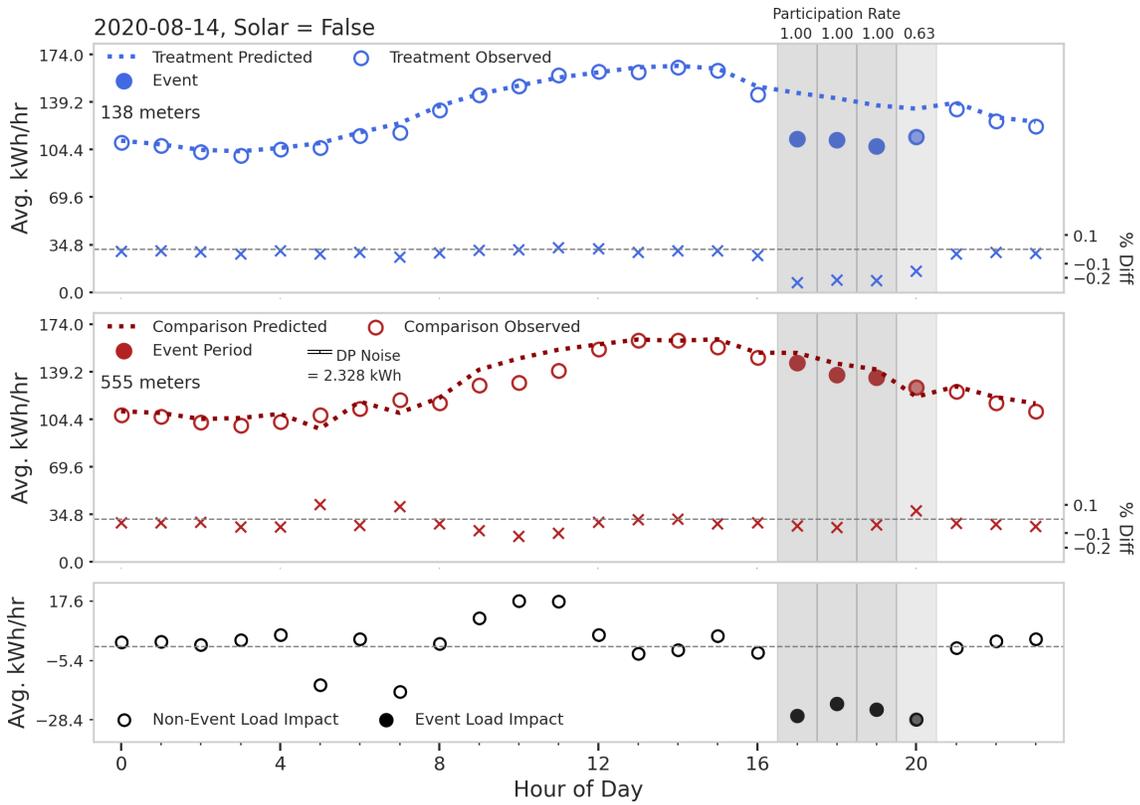
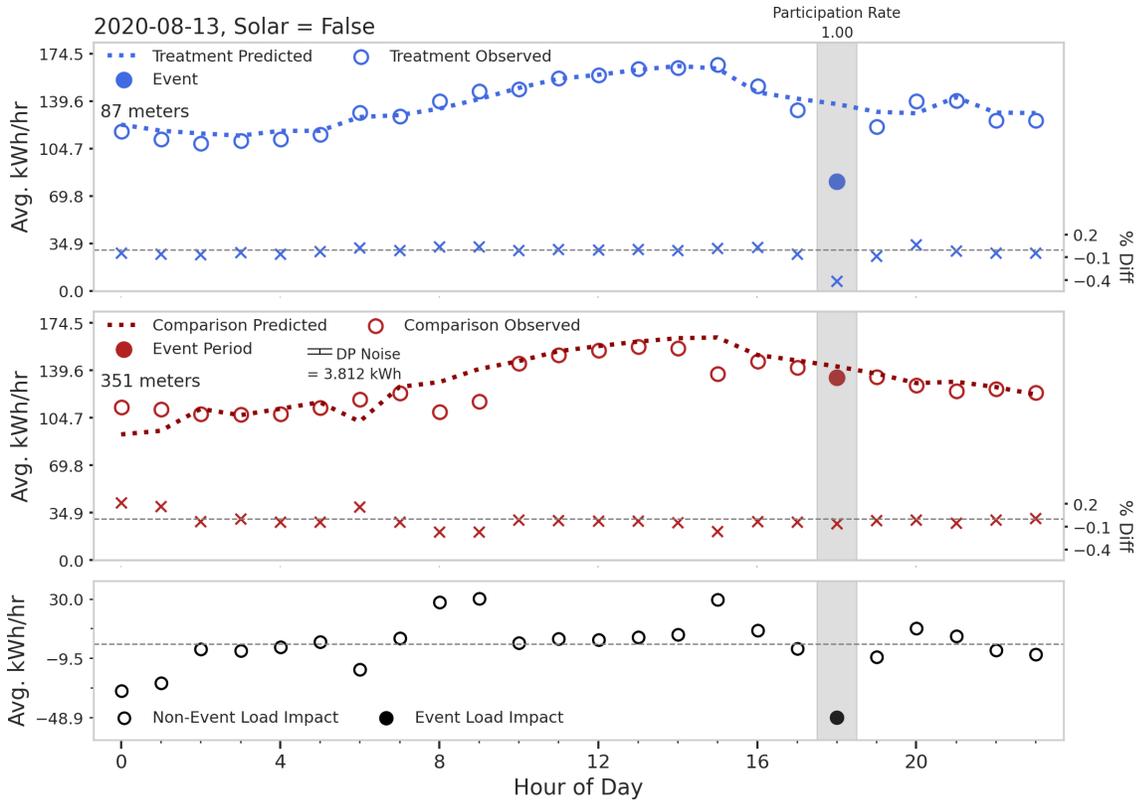
Savings vs. Temperature, Solar = False

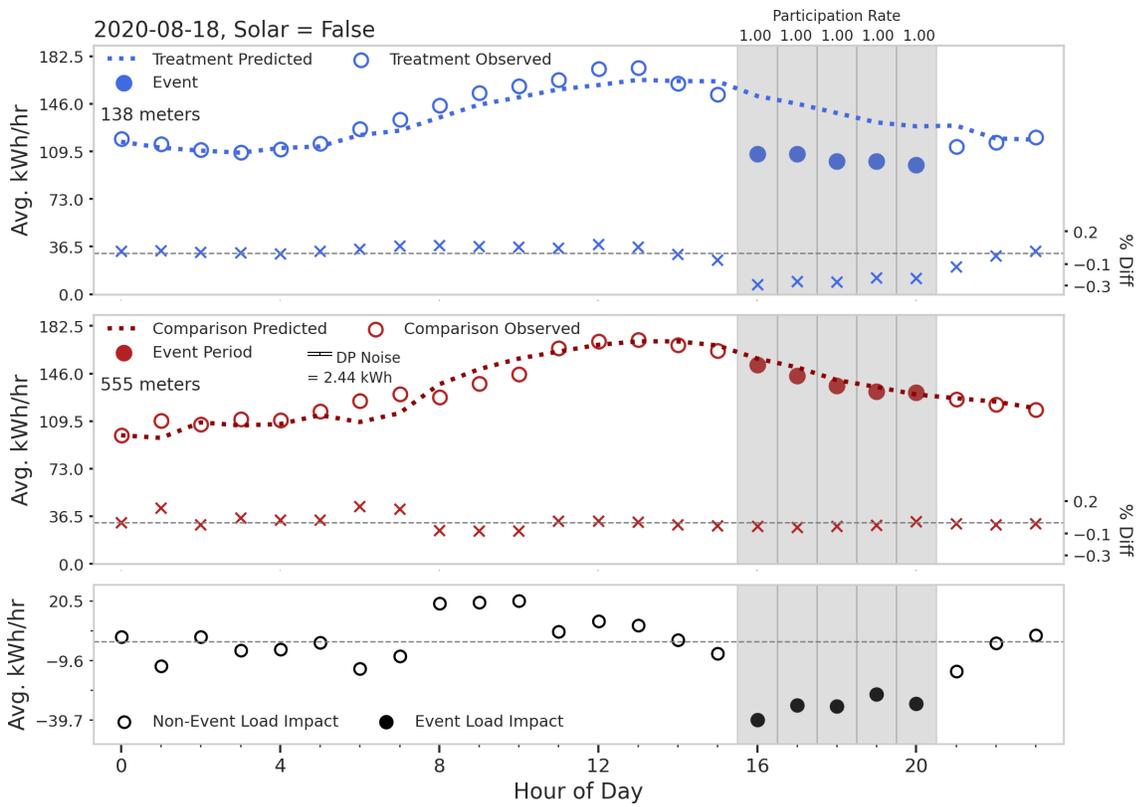
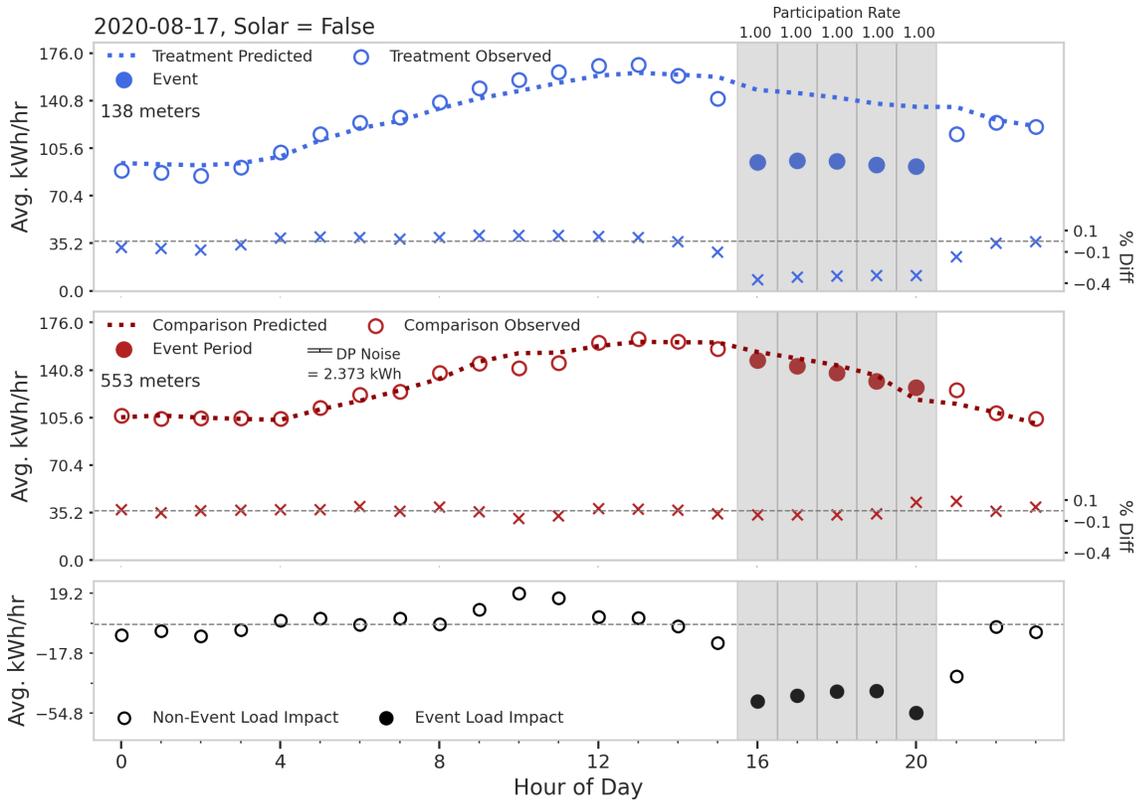


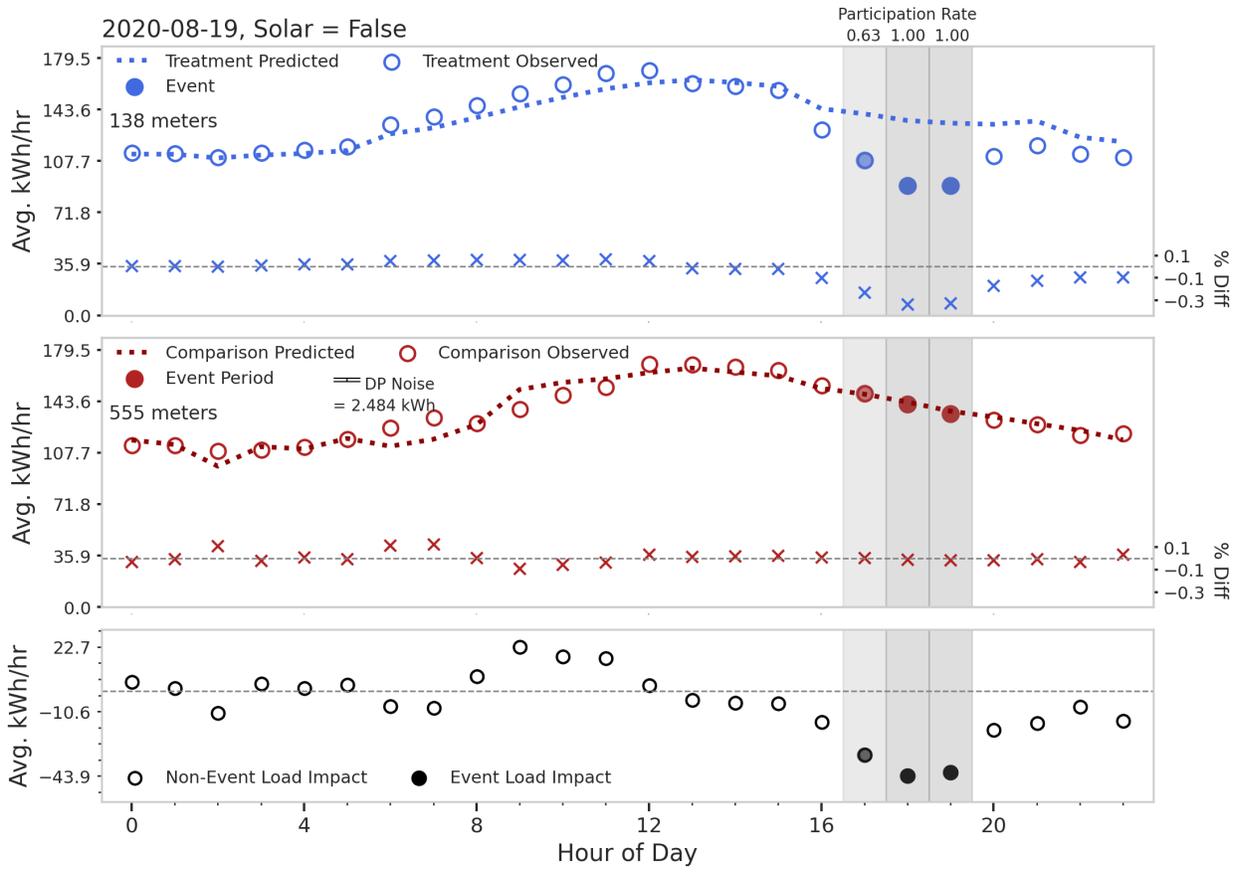


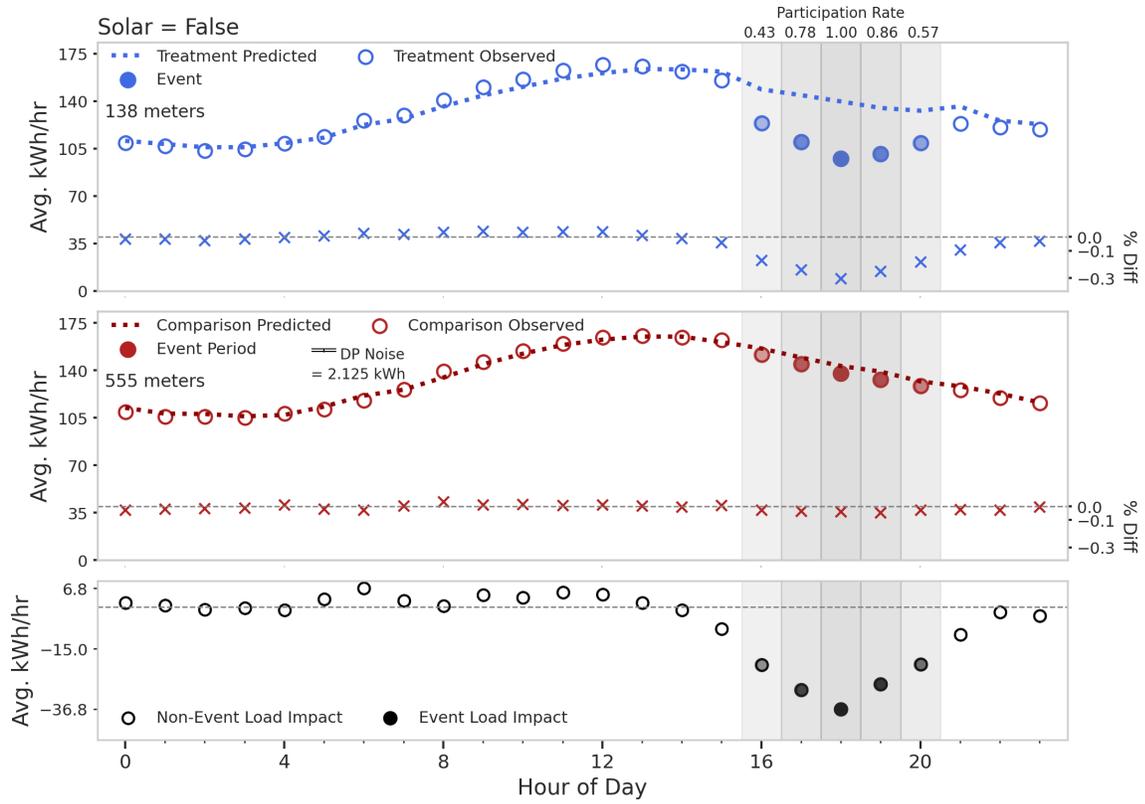




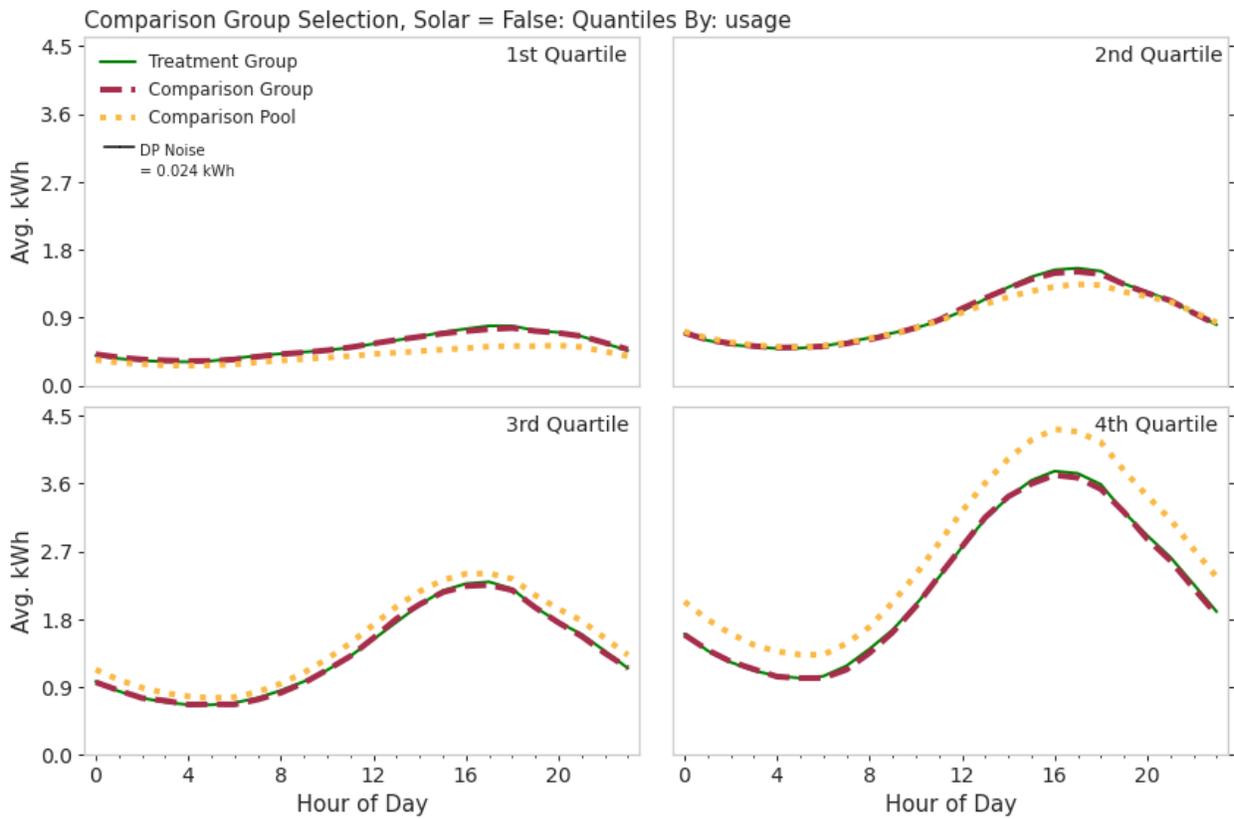
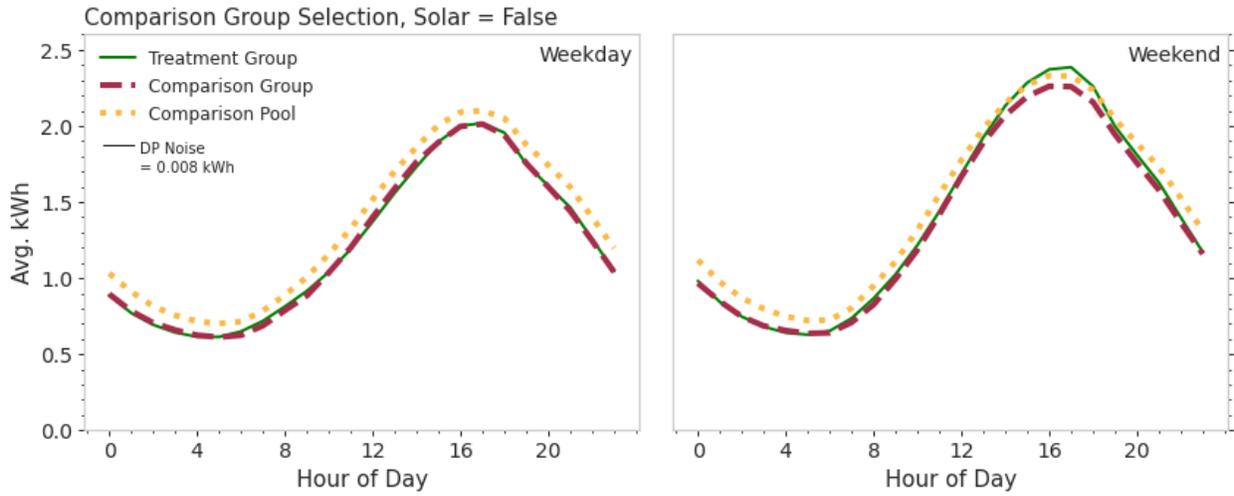




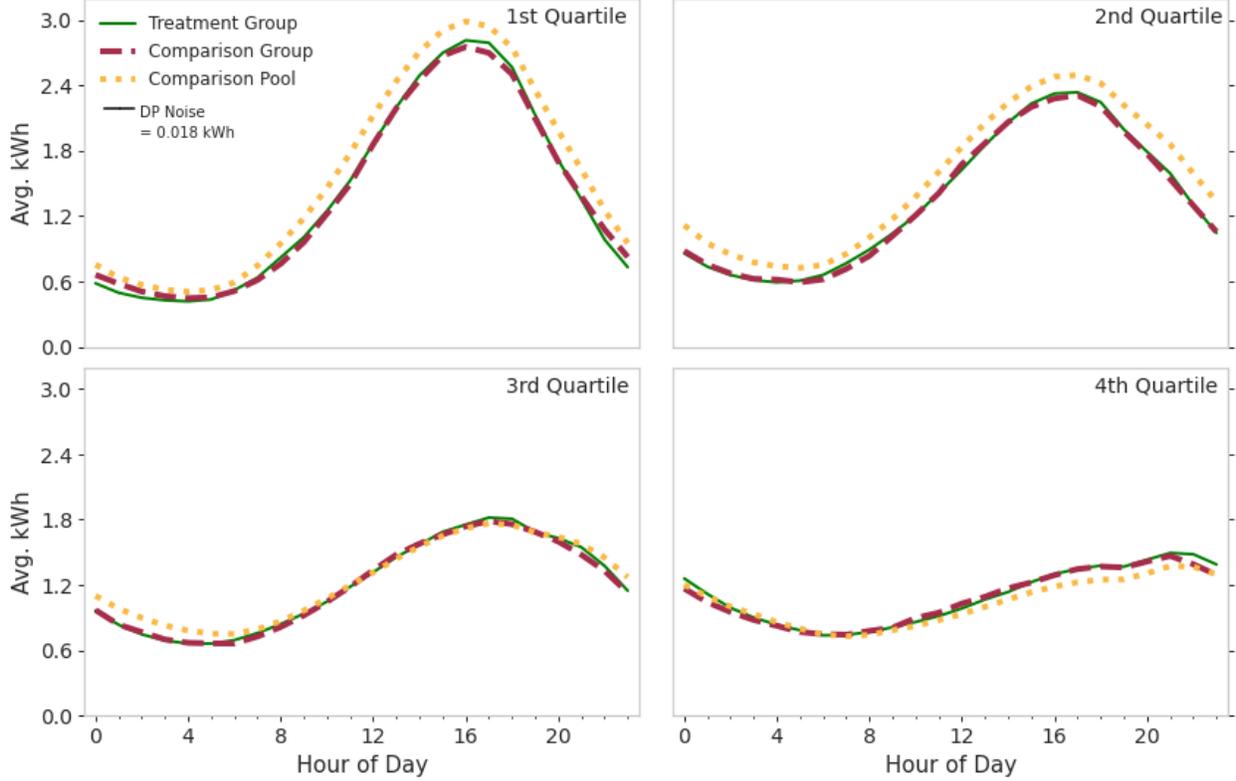




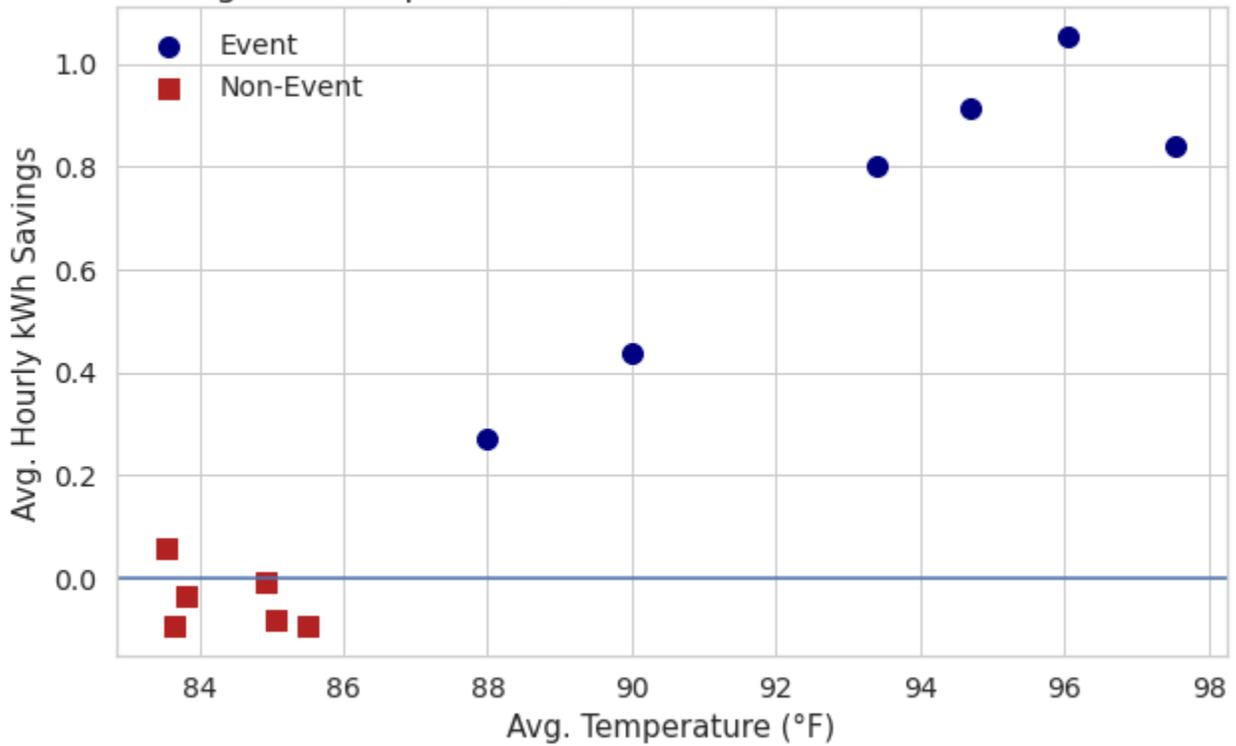
Additional Results: DRP D, LSE 1, Residential

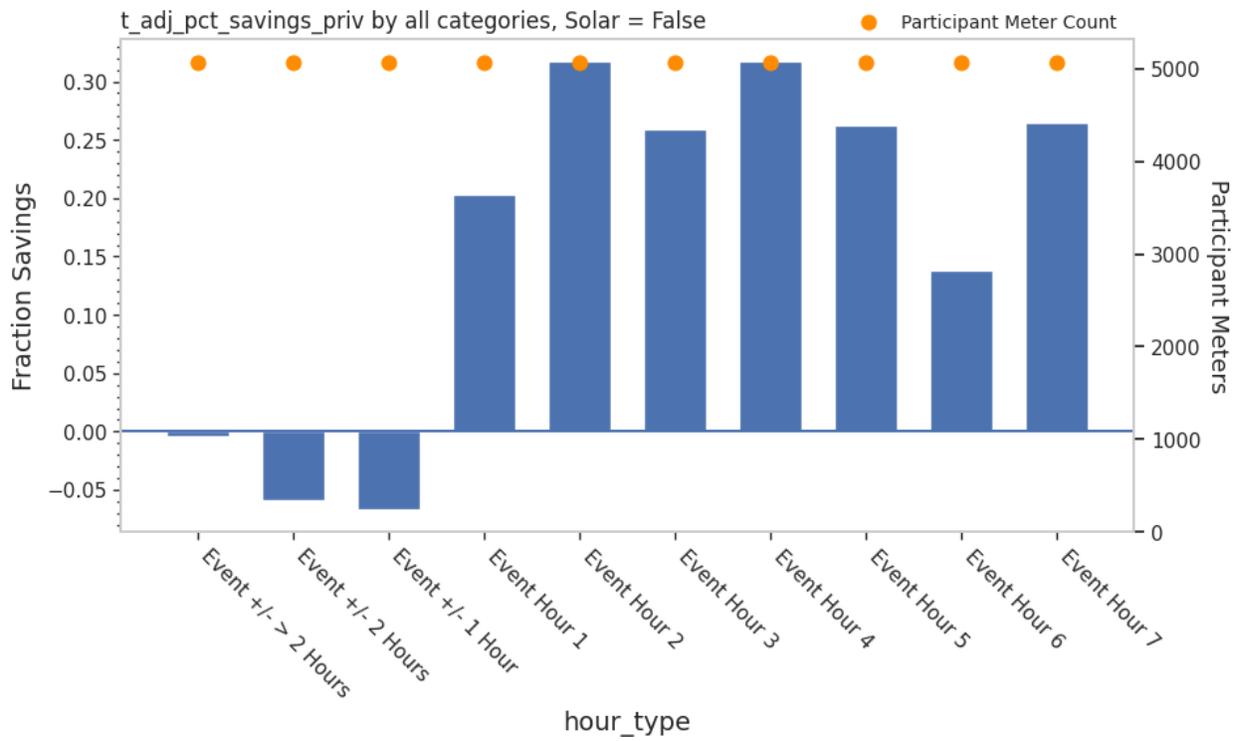
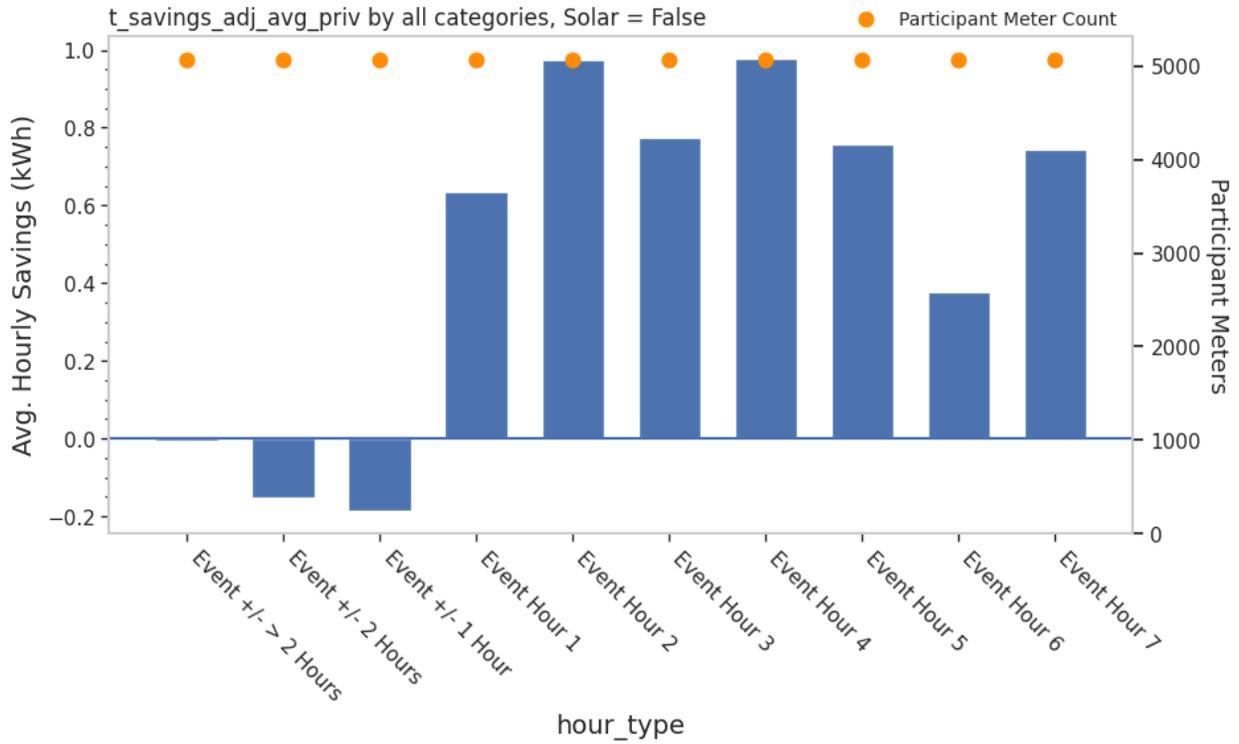


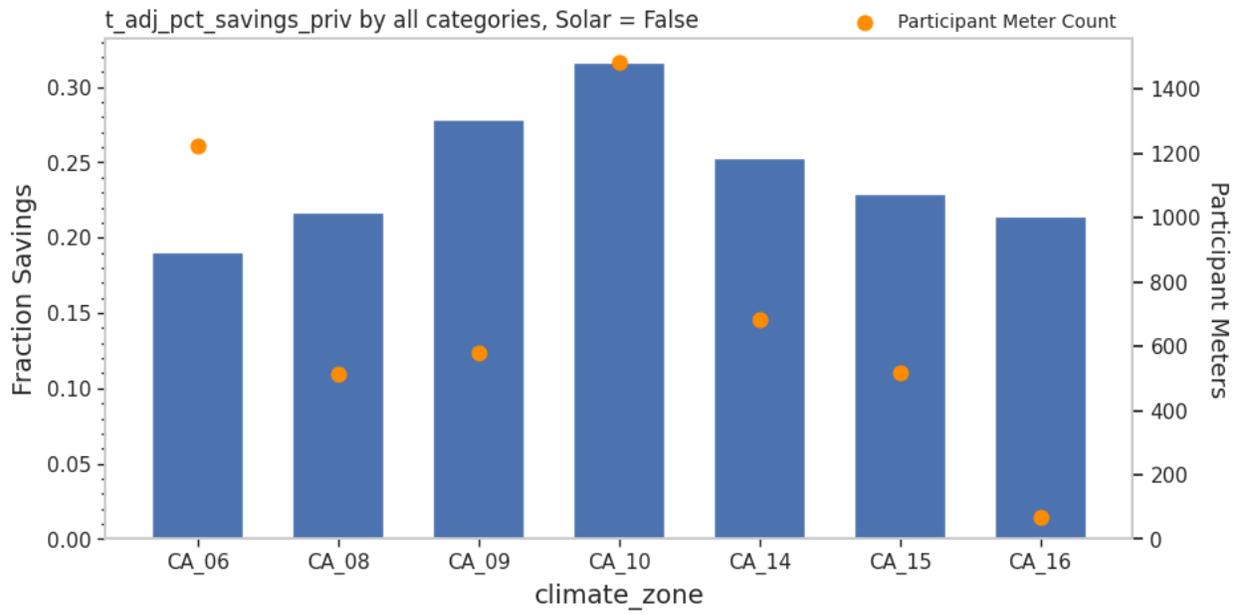
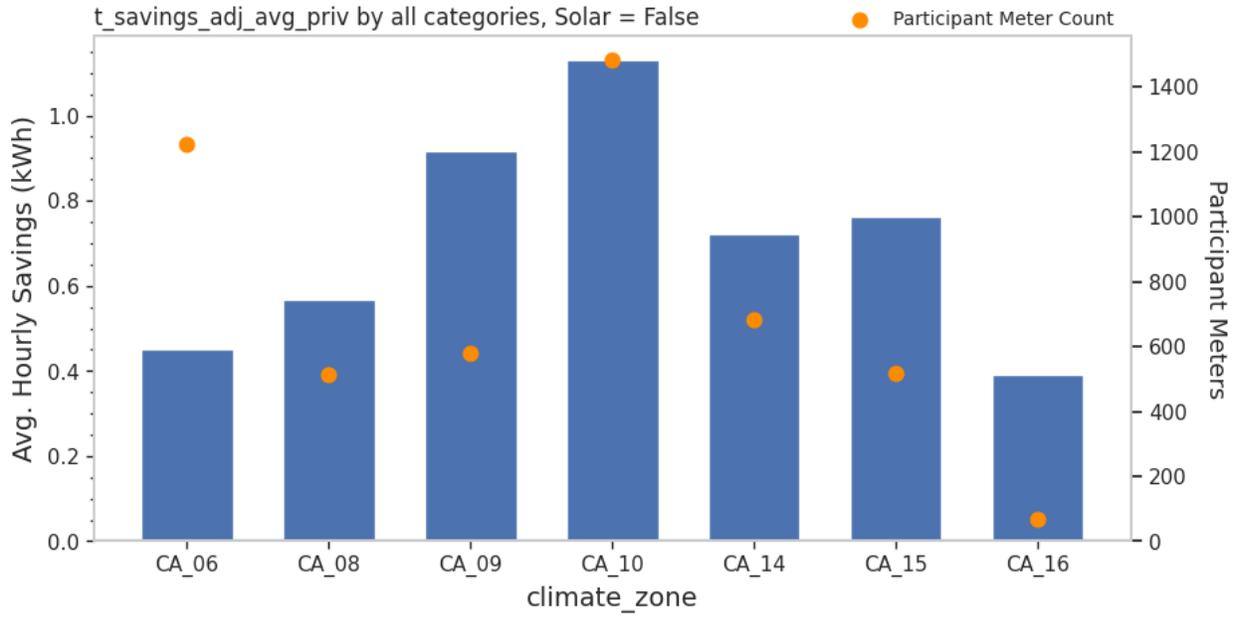
Comparison Group Selection, Solar = False: Quantiles By: night_total_ratio

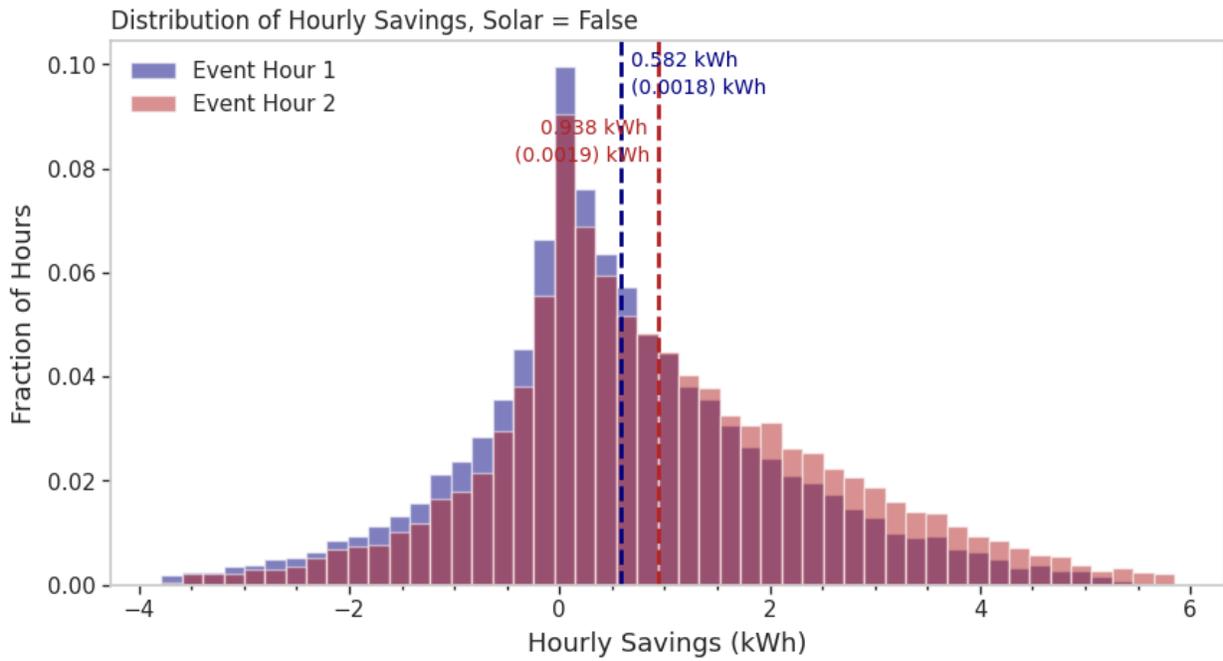
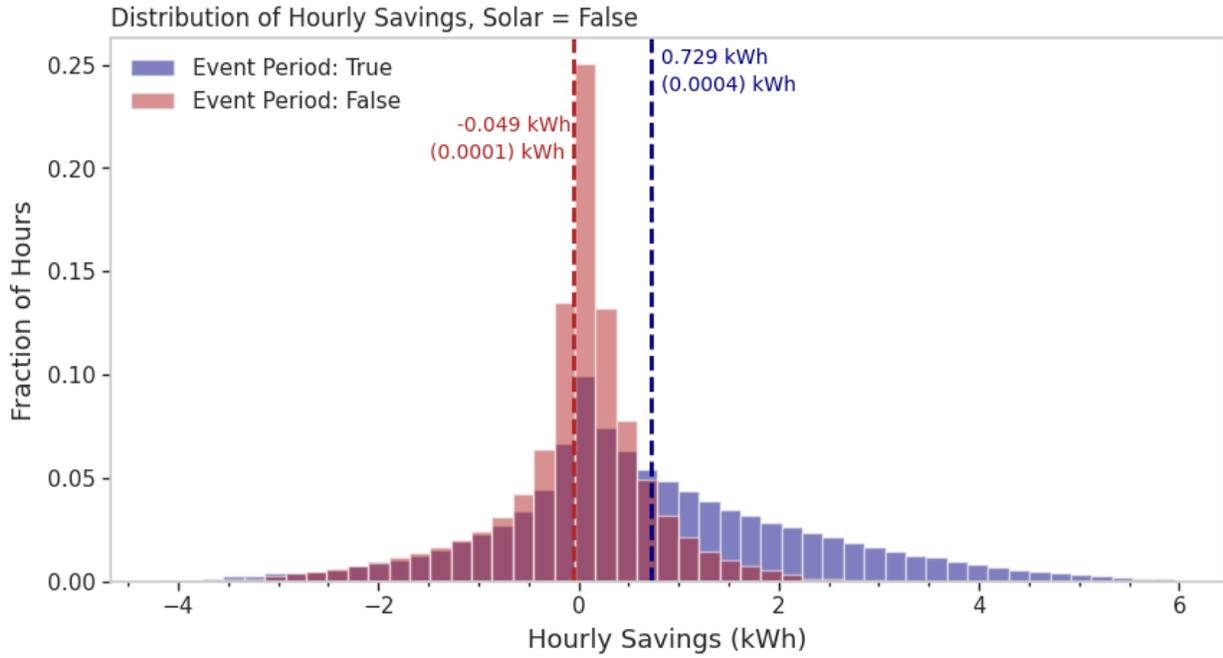


Savings vs. Temperature, Solar = False

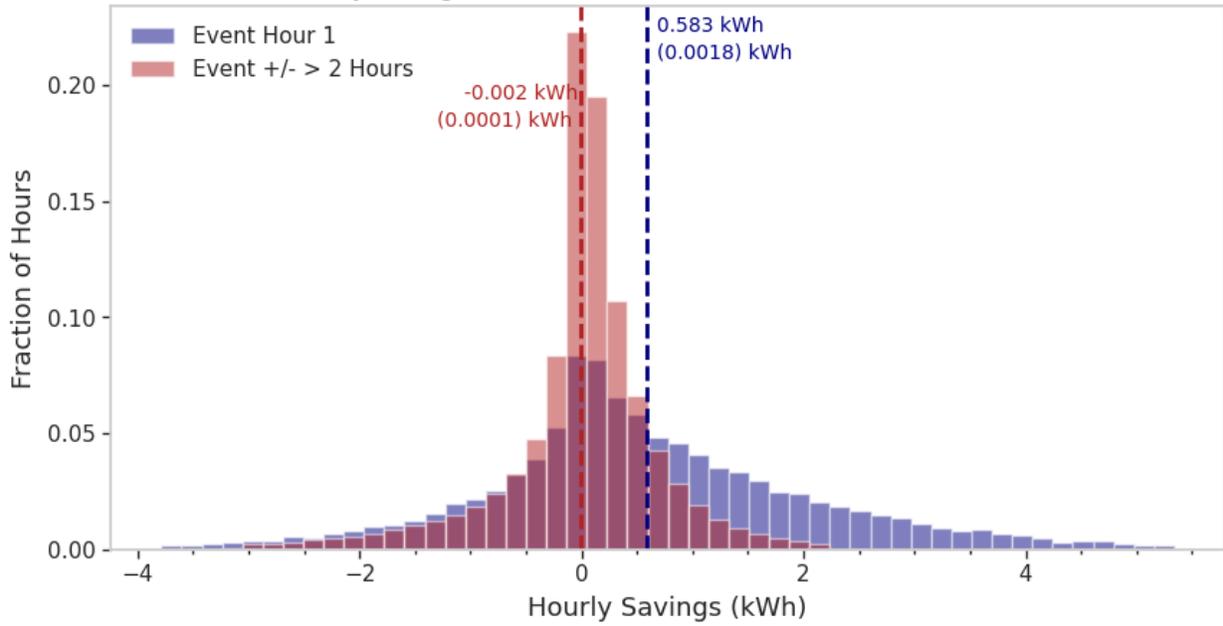




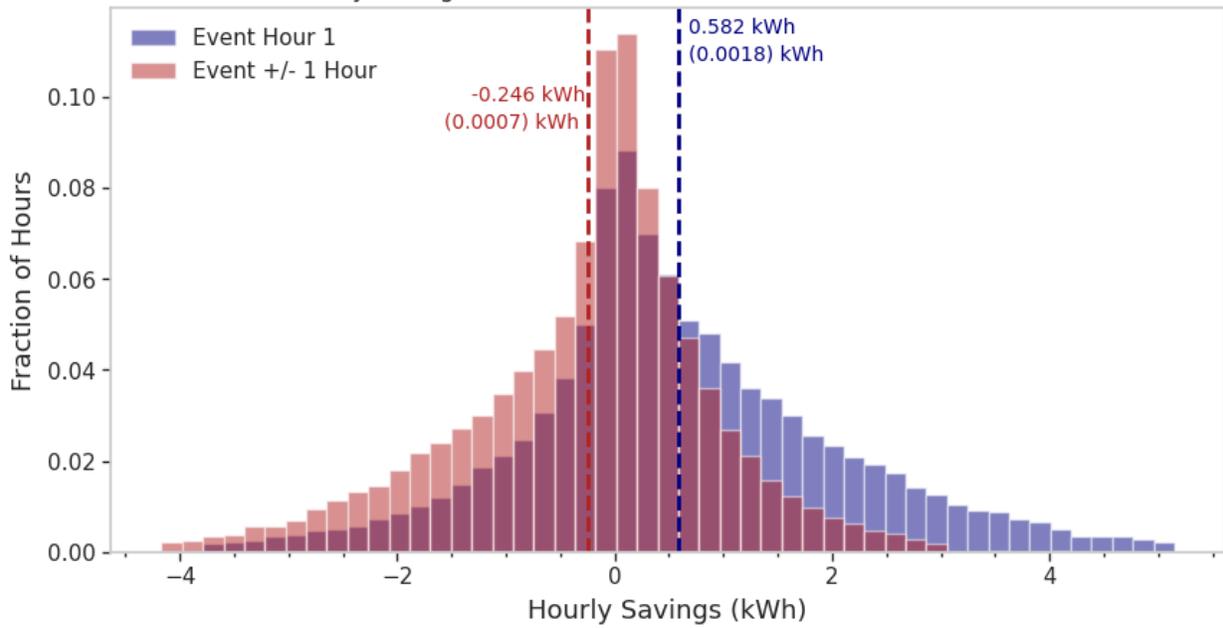


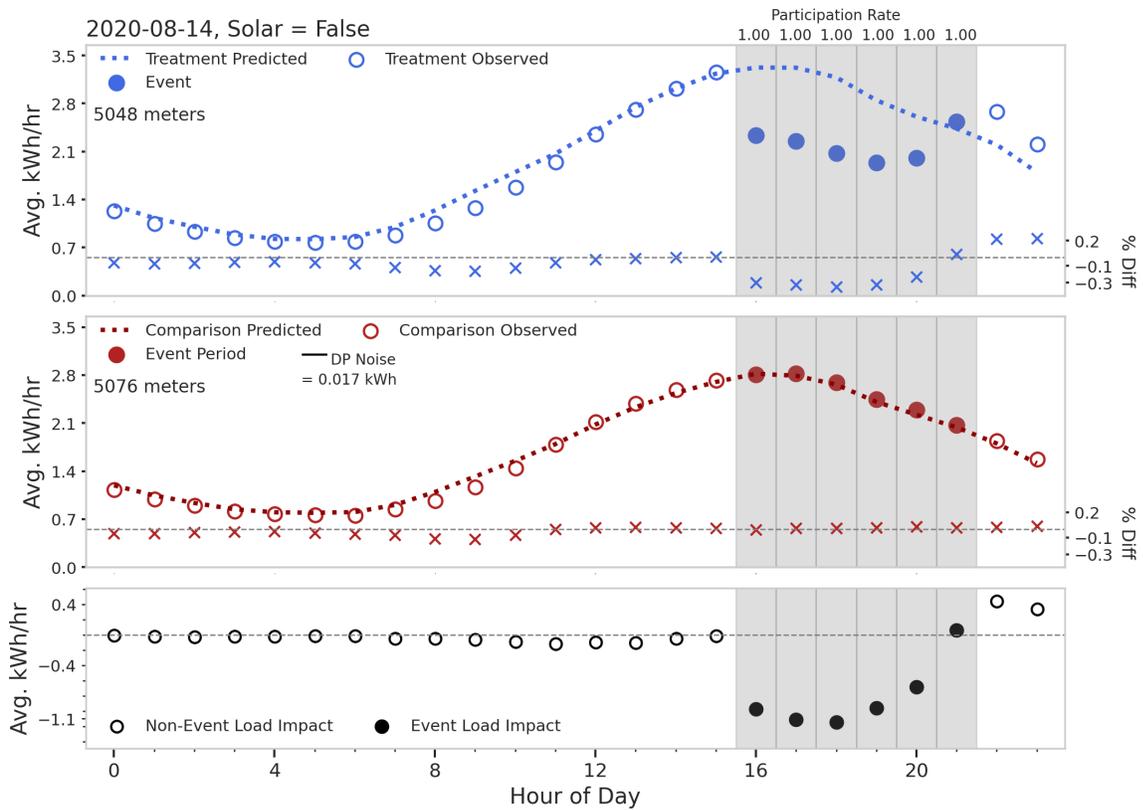
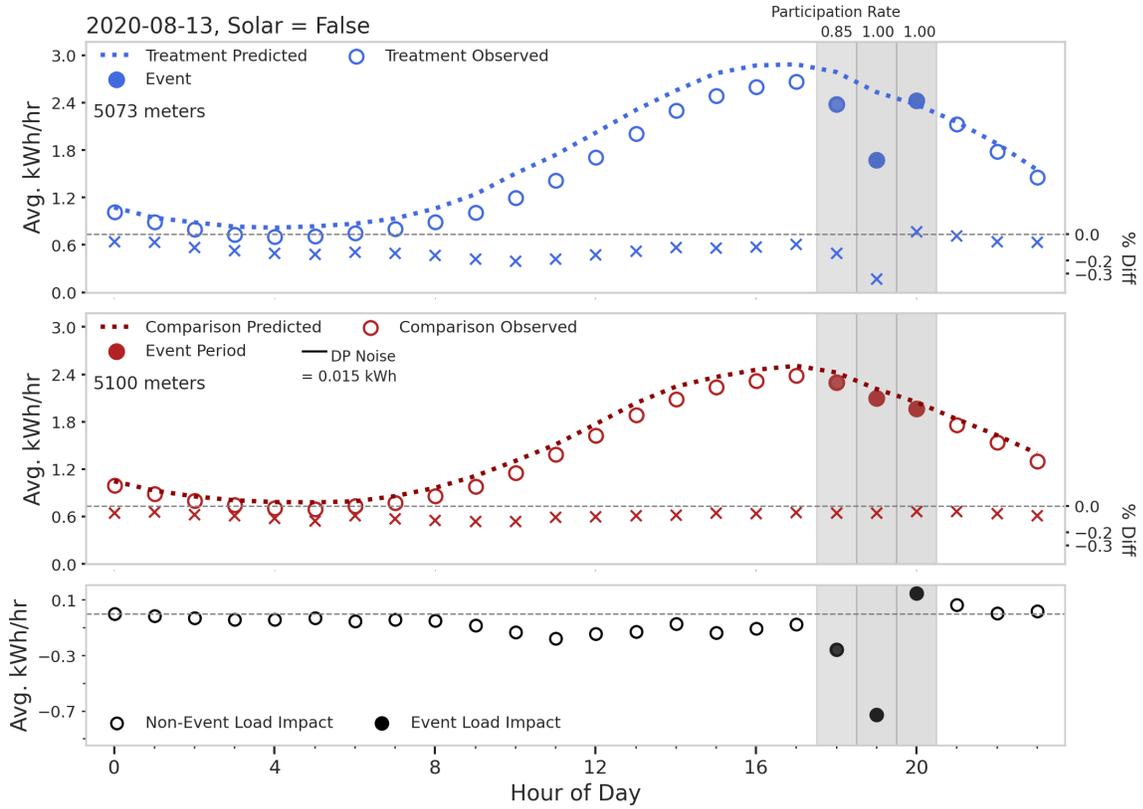


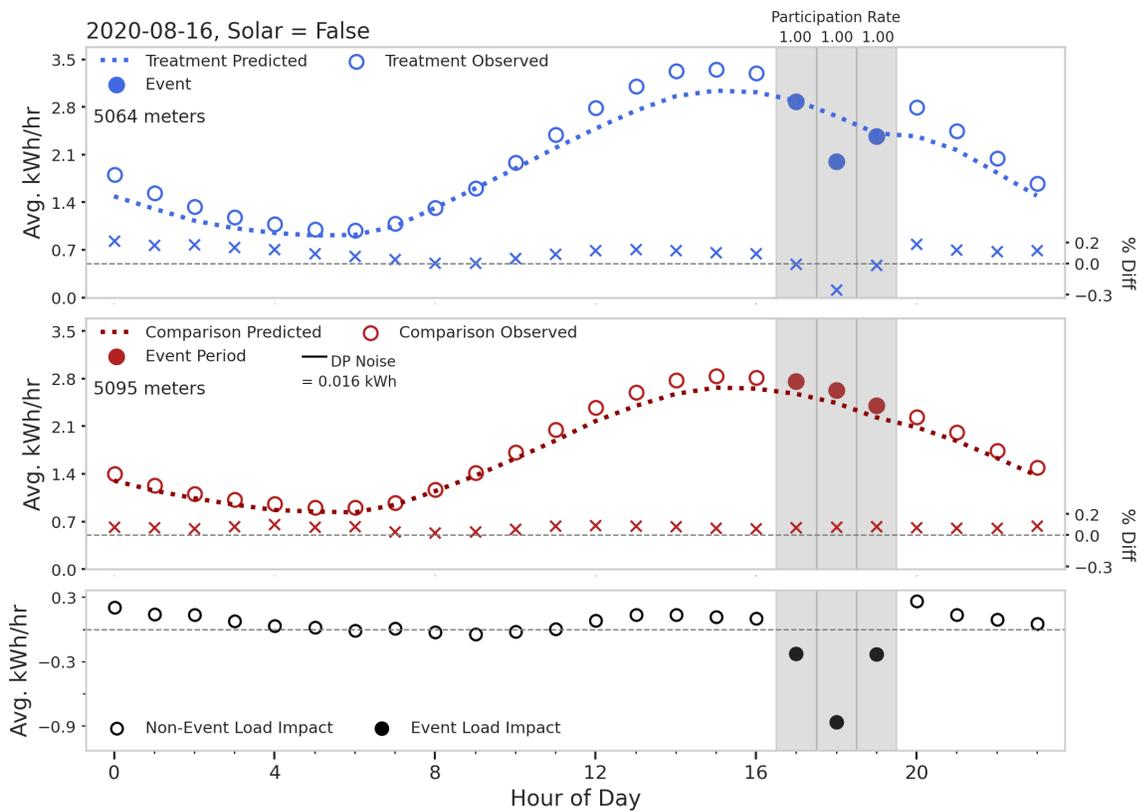
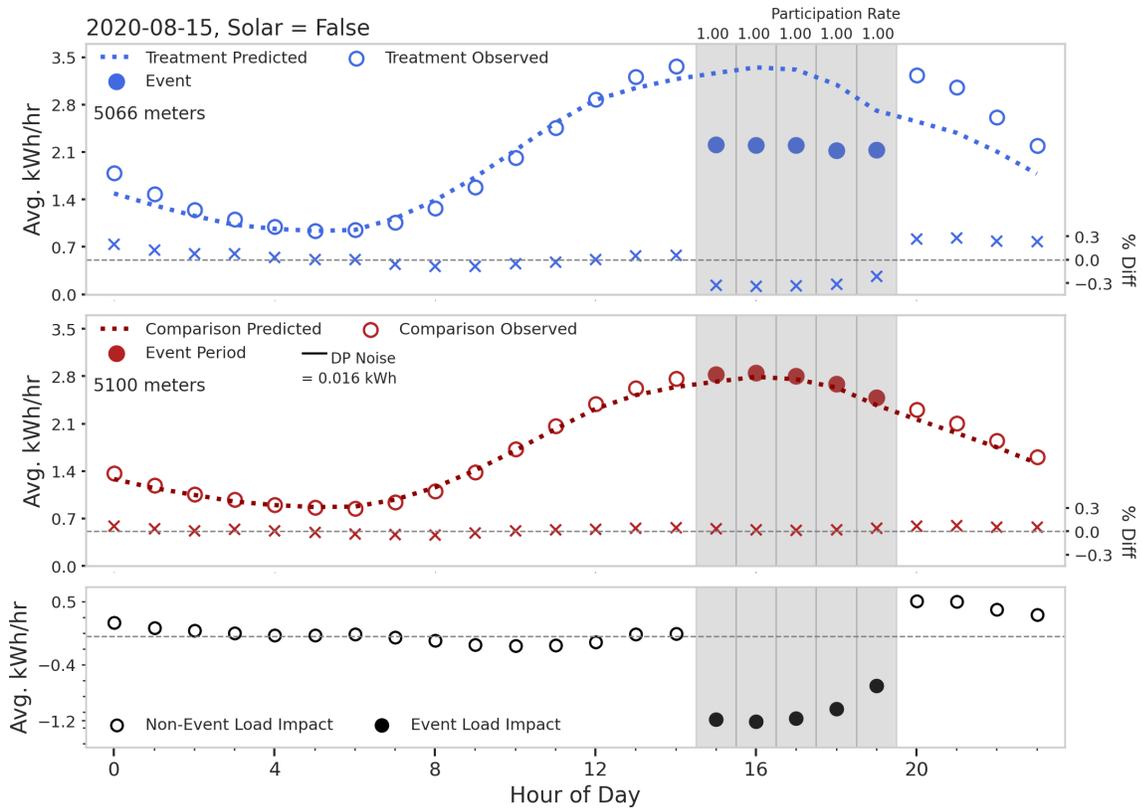
Distribution of Hourly Savings, Solar = False

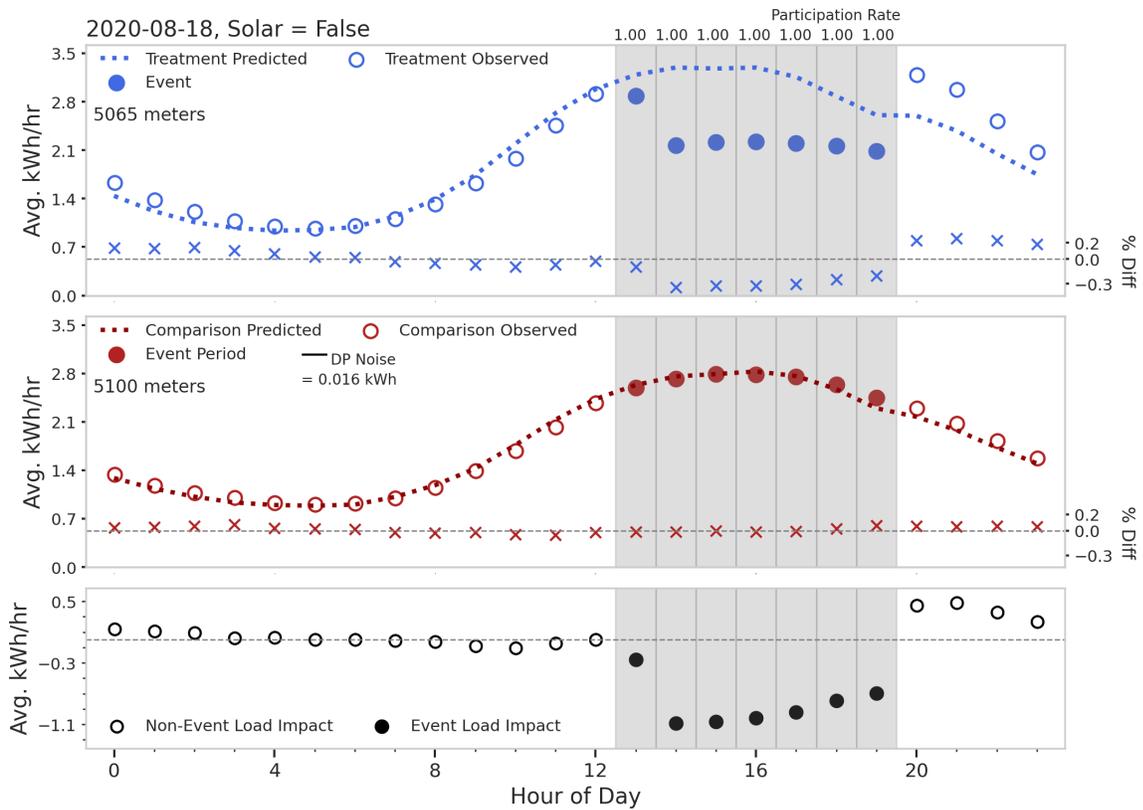
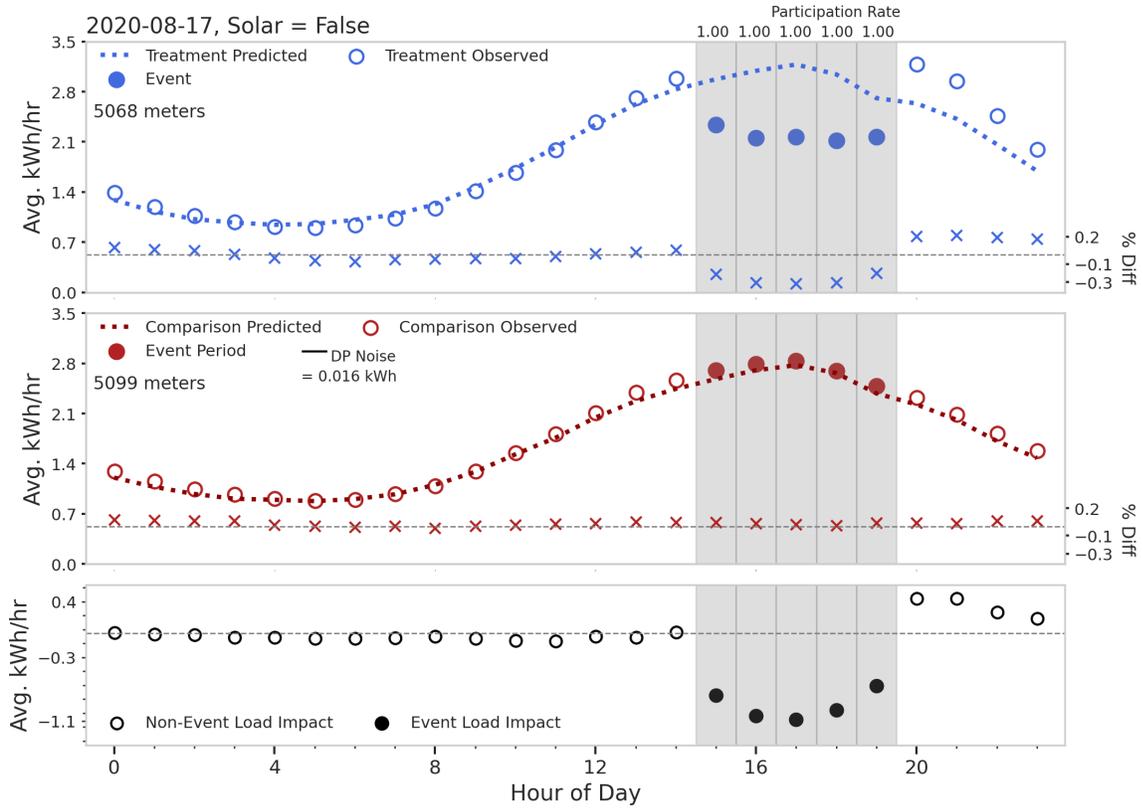


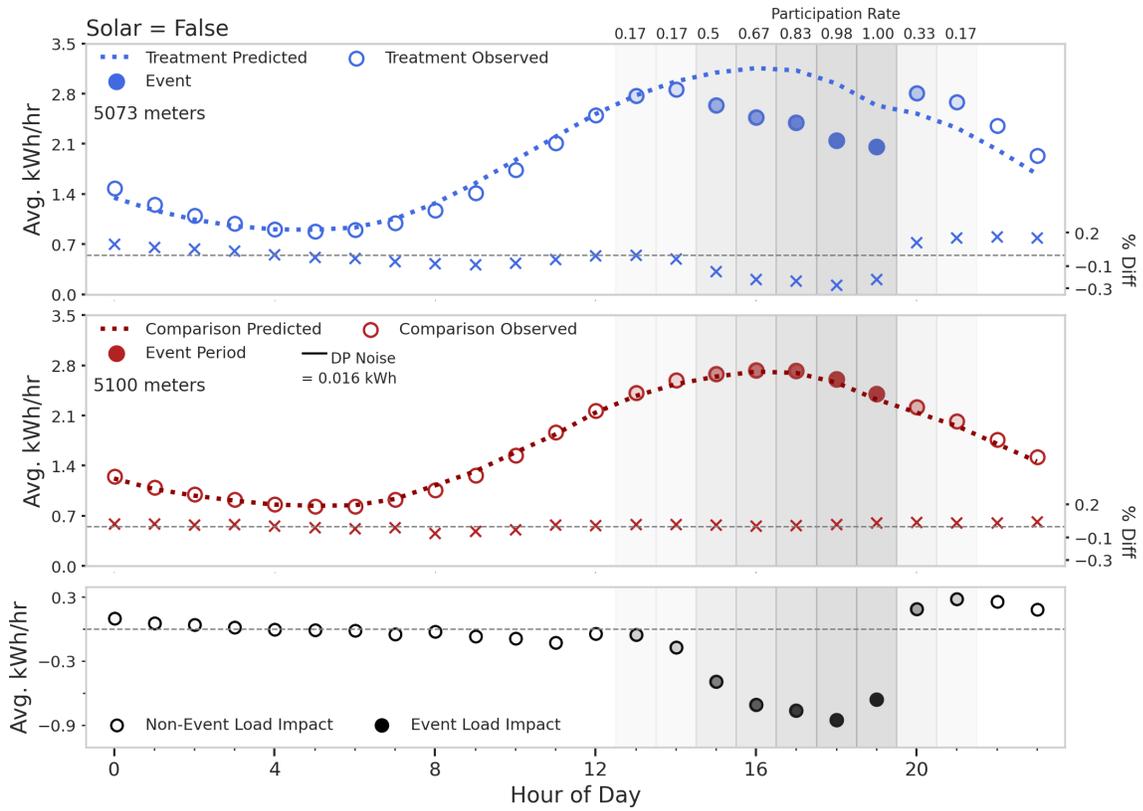
Distribution of Hourly Savings, Solar = False



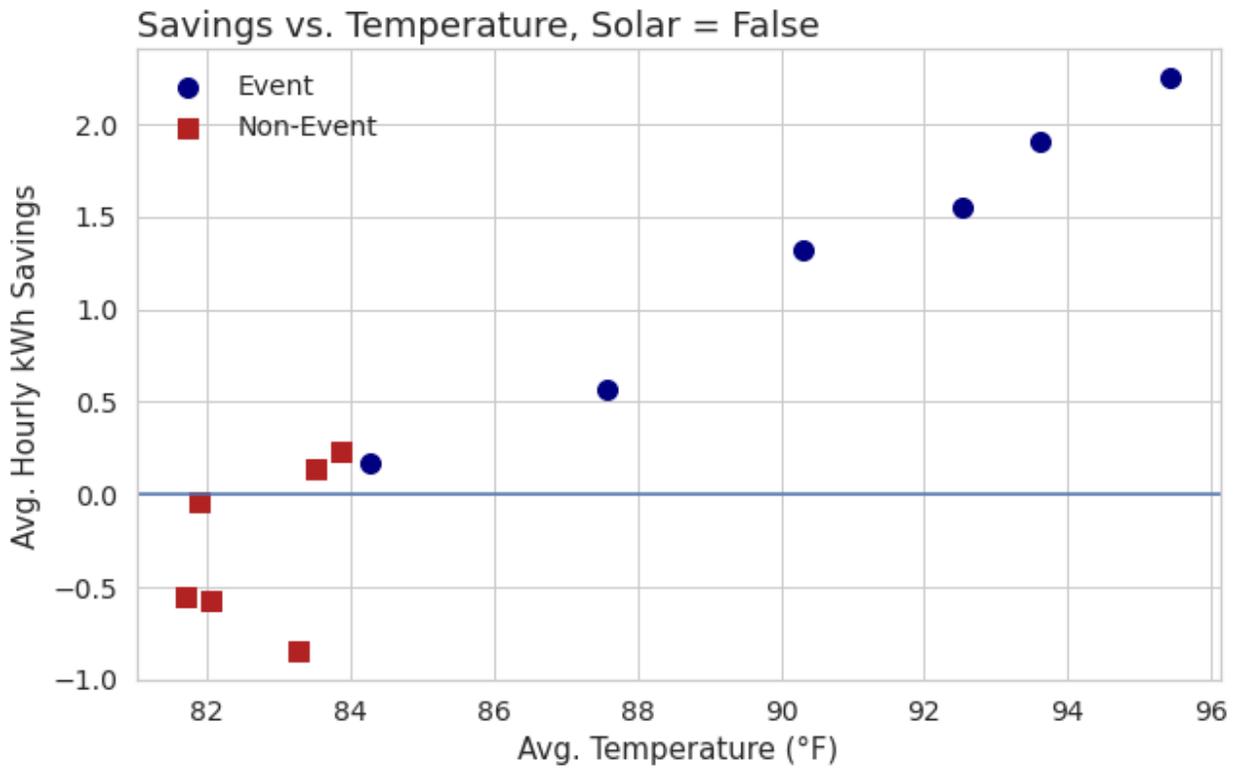
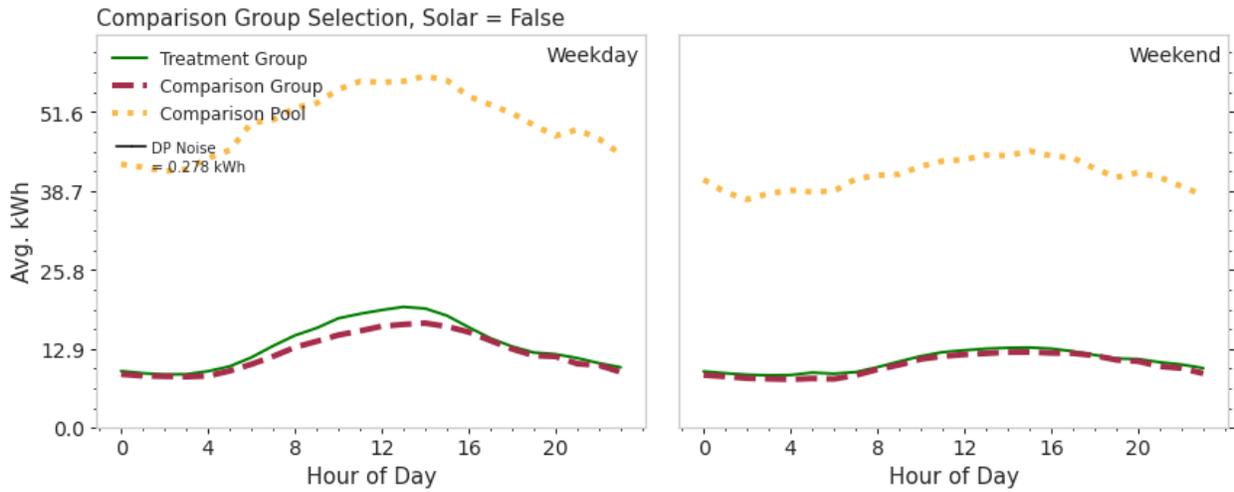


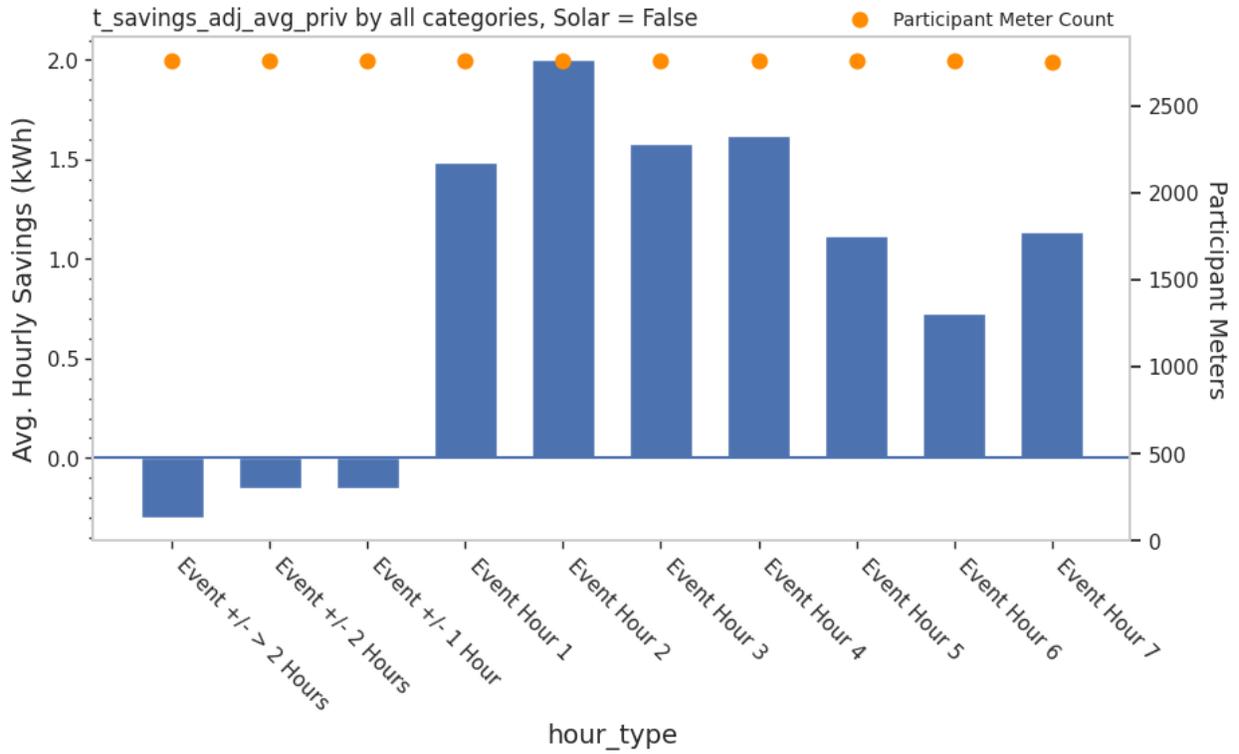






Additional Results: DRP D, LSE 1, Non-Residential





Max DP Noise Fraction = 0.0418

