Smart Home Energy Management

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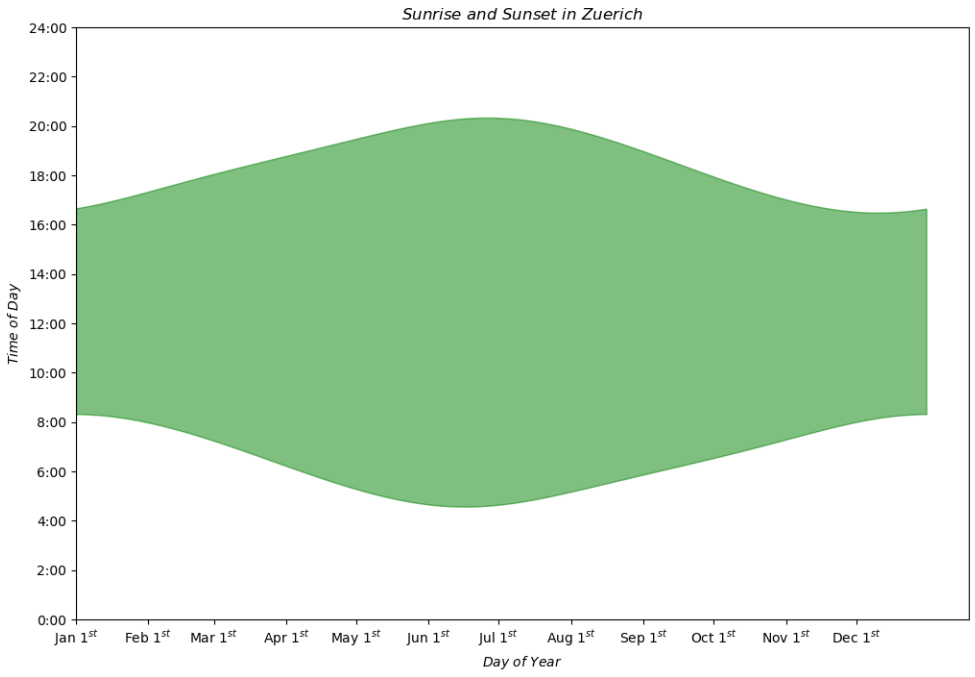
Notes

- the calculations for this simulation were performed with the *NumPy* fundamental package for scientific computing with Python
- this .docx document was created with the *python-docx* and *python-matplotlib* libraries, and converted to .pdf with the *comtypes.client* package for Python
- the corresponding .mp4 and .avi aminations were created with the *python-opencv* package for Python

I. Specifications and profiles

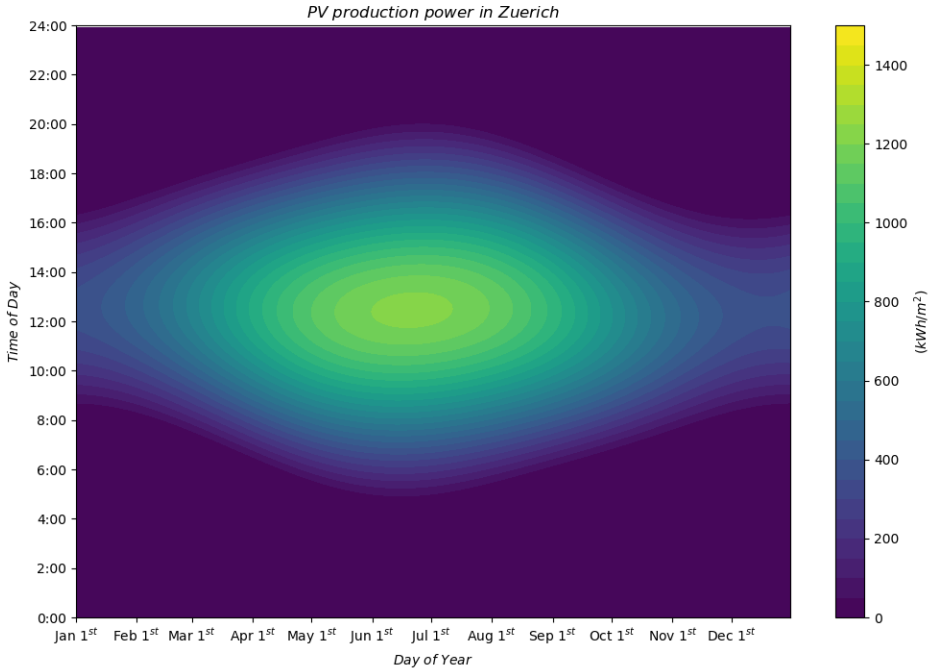
I-1. General

Location:	Zuerich	
Simulation start time:	January 1st at 0:00h	
Simulation end time:	December 31st at 23:59h	
Time resolution:	360	seconds



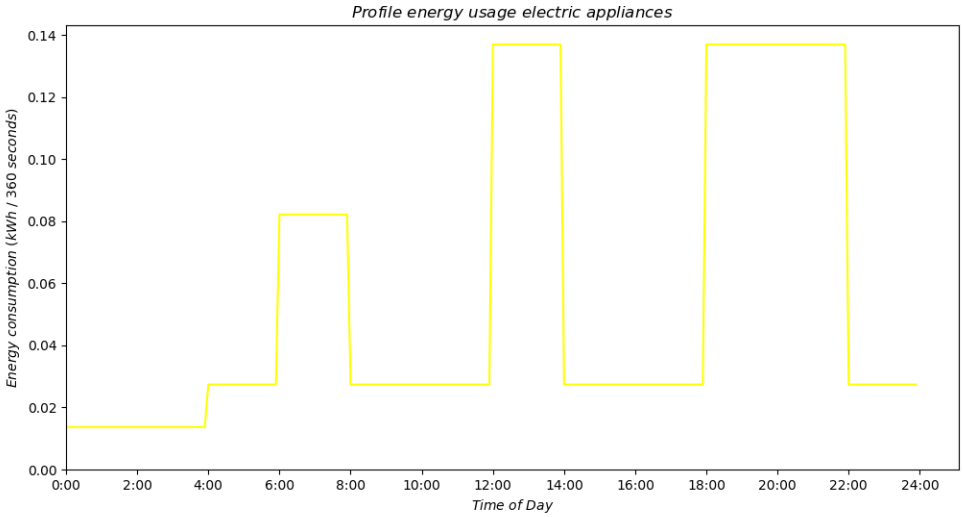
I-2. Photovoltaics installation

Size:	35.0	m^2
Efficiency of PV panels:	7.5	m^2/kWp
Annual production yield:	1,200.0	kWh/kWp



I-3. Electrical appliances

Annual energy consumption:	5,000	kWh



I-4. Battery

Capacity:	13.5	kWh
Discharge depth:	0	%
Charging limit:	7,000	W
Discharging limit:	7,000	W

I-5. Electrical car

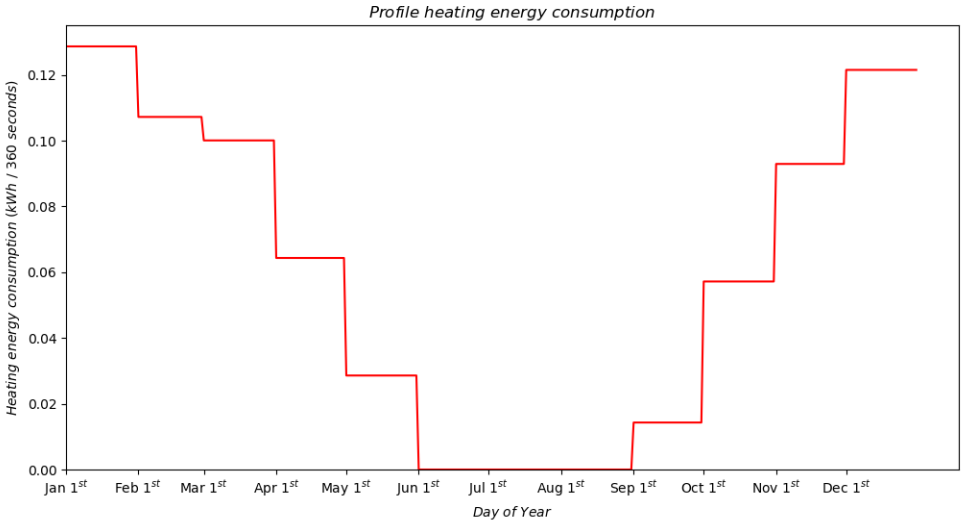
Battery capacity:	60.0	kWh
Efficiency:	13.0	kWh/100km
Charging limit:	3,300	W

User constraints

Minimum required driving range:	150	km
Car plugged into power socket at:	18	o'clock
Car unplugged from power socket at:	7	o'clock

I-6. Heatpump heating

Annual energy consumption:	5,200	kWh



I-7. Heatpump hot water

Size:	300	liter
Equivalent electrical capacity:	6.3	kWh
Coefficient of performance (COP):	2.5	
Water temperature increase:	45	°C
Charging limit:	1,500	W

User constraints

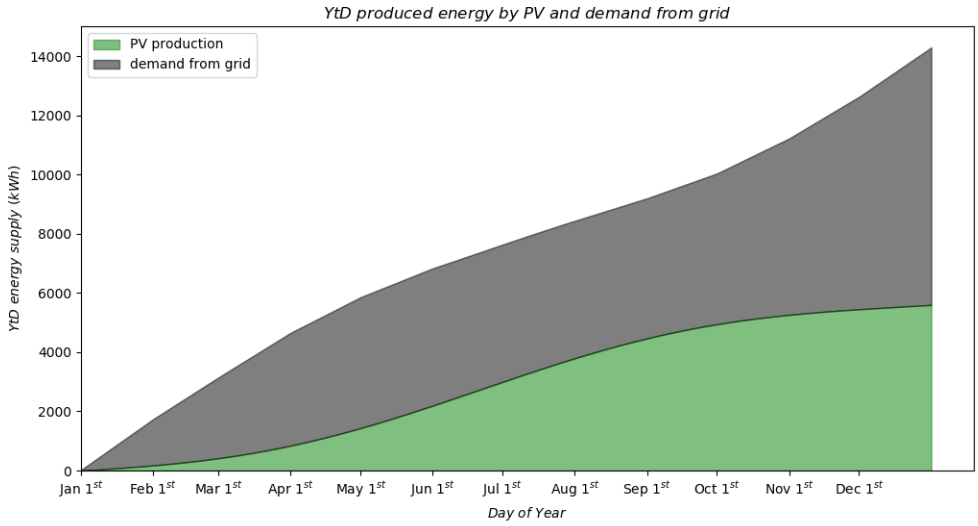
Minimum required amount hot water:	150	liter
Amount of tapped hot water each time:	60	liter
Hot water tapped at:	6	o'clock
Hot water tapped at:	7	o'clock
Hot water tapped at:	21	o'clock

II. Performance

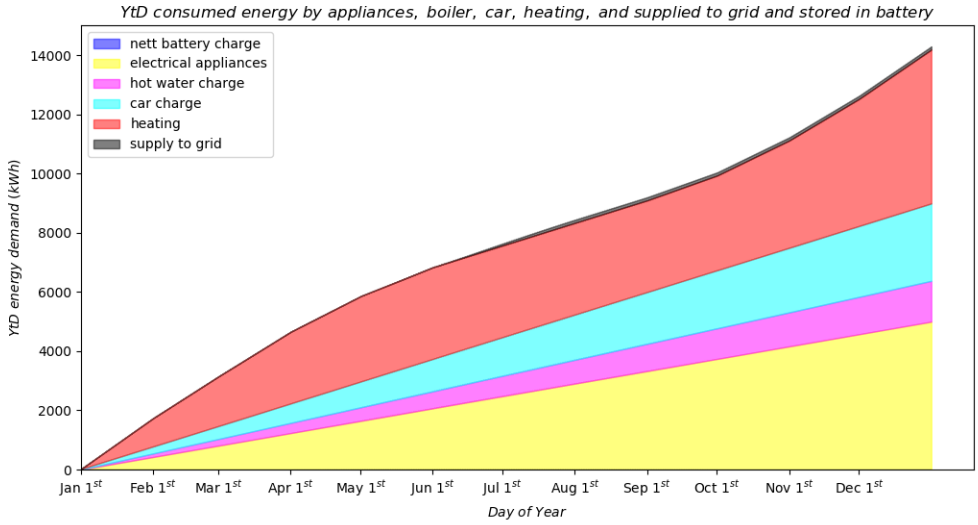
II-1. Summary

total produced PV energy:	5,600	kWh
total energy demand from grid:	8,705	kWh
TOTAL SUPPLIED ENERGY:	**14,305**	**kWh**
total energy consumption heating:	5,200	kWh
total energy consumption hot water:	1,380	kWh
total energy consumption appliances:	5,000	kWh
total energy consumption car:	2,619	kWh
total energy supply to grid:	106	kWh
energy stored in battery at year end:	0.0	kWh
TOTAL CONSUMED ENERGY:	**14,305**	**kWh**
energy stored in battery at year start:	0.0	kWh
energy stored in battery at year end:	0.0	kWh
energy stored in boiler at year start:	0.0	kWh
energy stored in boiler at year end:	3.1	kWh
hot water stored in boiler at year end:	150.0	liter
annual hot water usage:	65,700	liter
energy stored in car at year start:	0.0	kWh
energy stored in car at year end:	19.5	kWh
driving range of car at year end:	150.0	km
annual car usage:	20,000	km
own consumption:	98.1	%

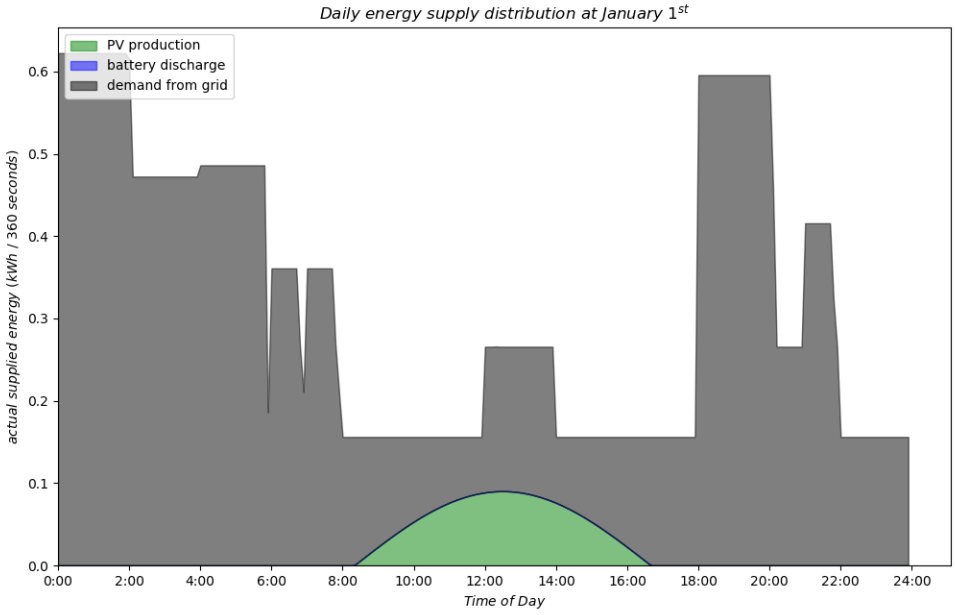
II-2. Total annual energy supply

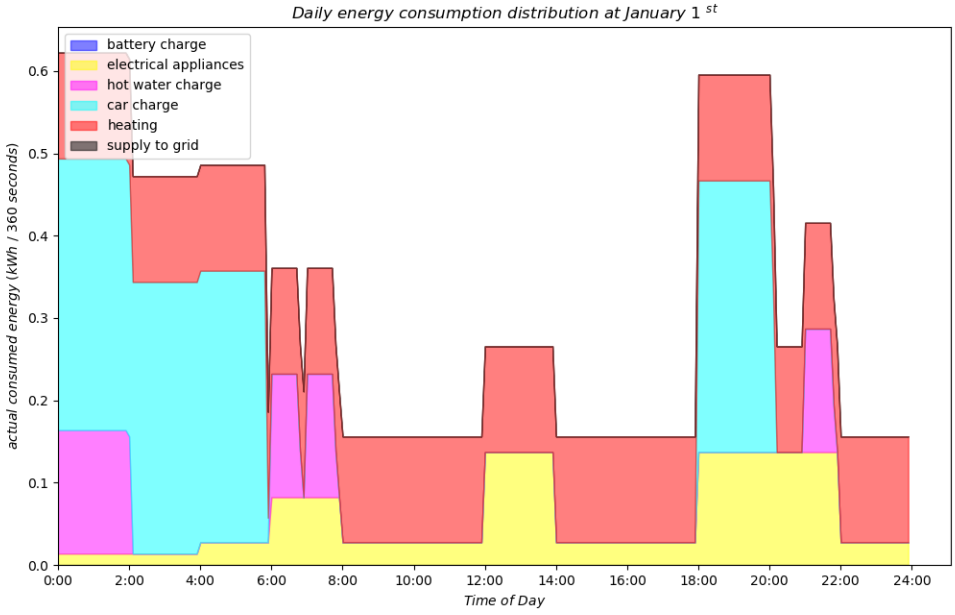


II-3. Total annual energy demand

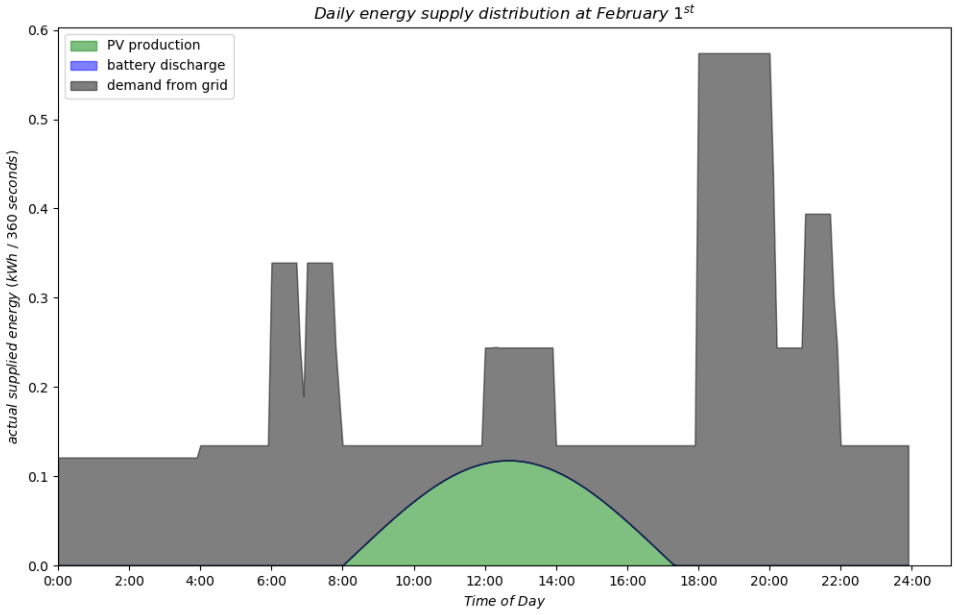


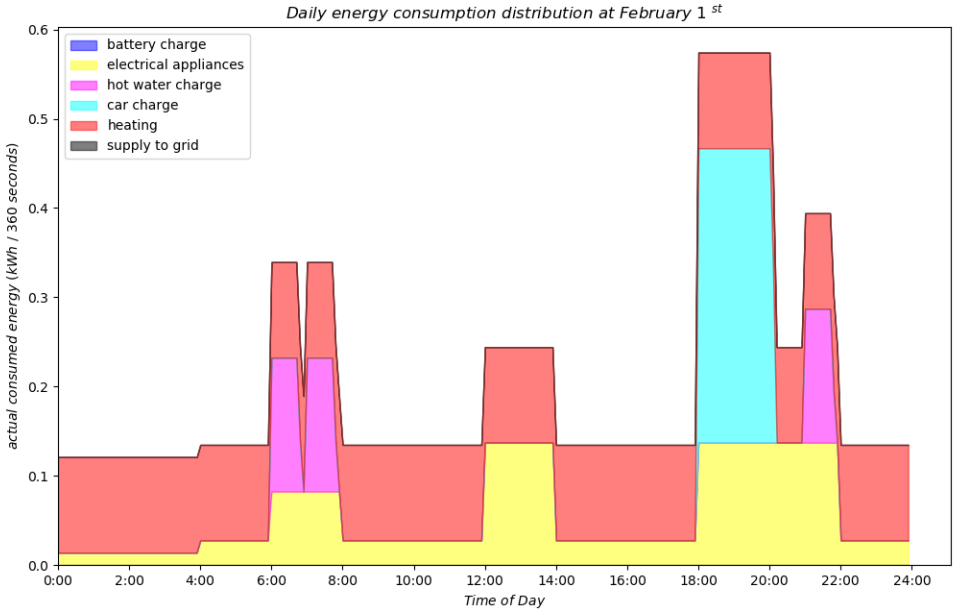
II-4. Total daily energy demand and supply



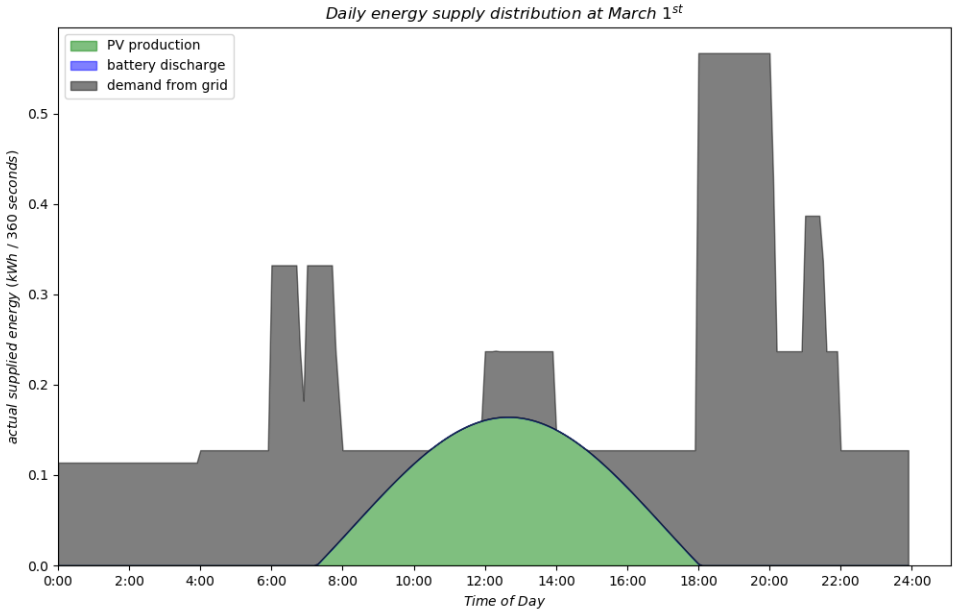


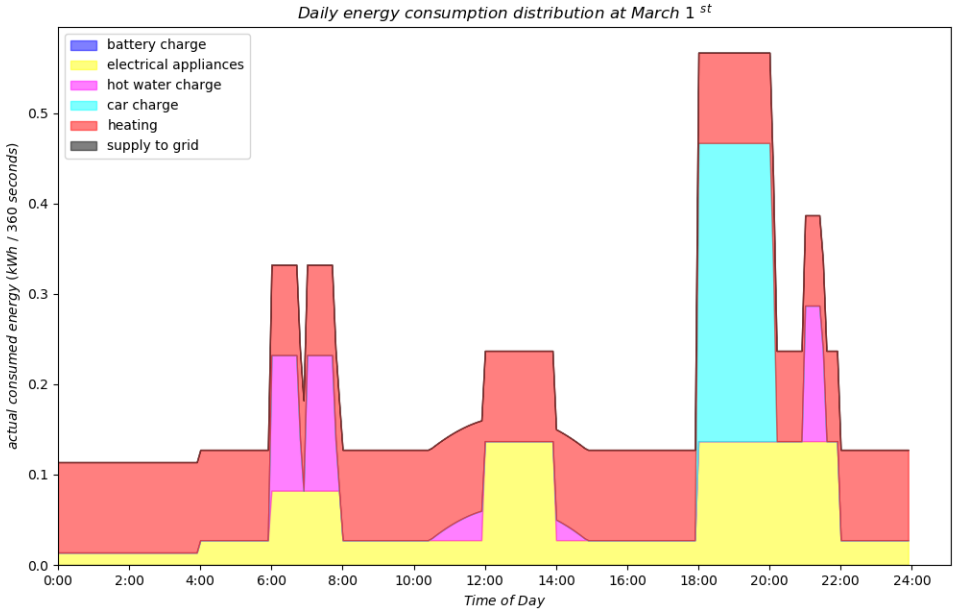
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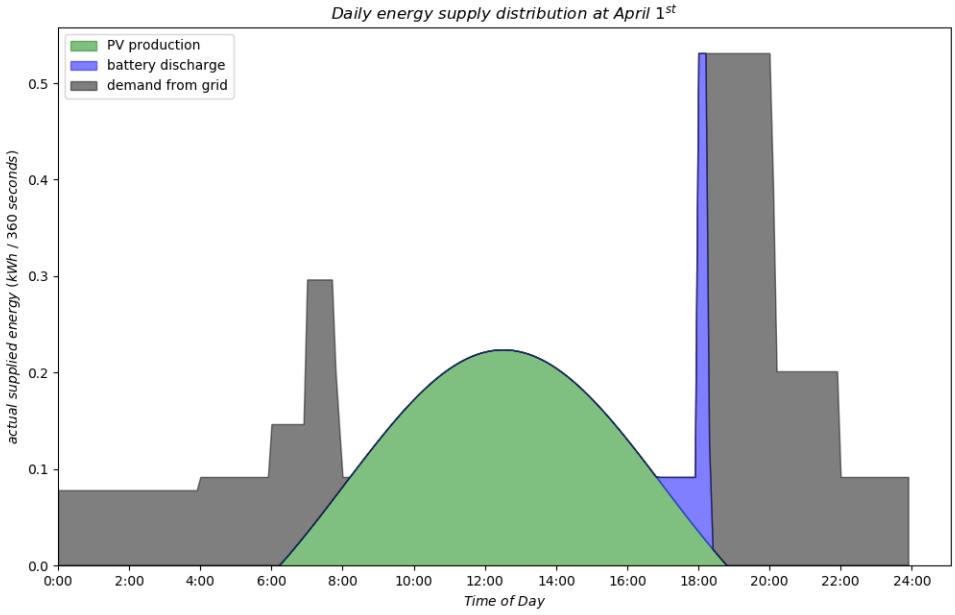


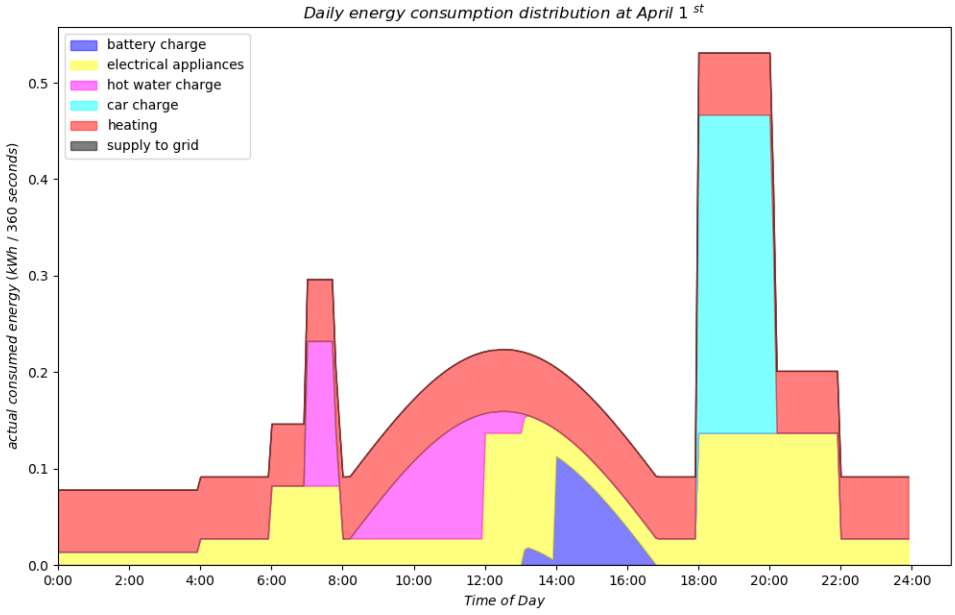
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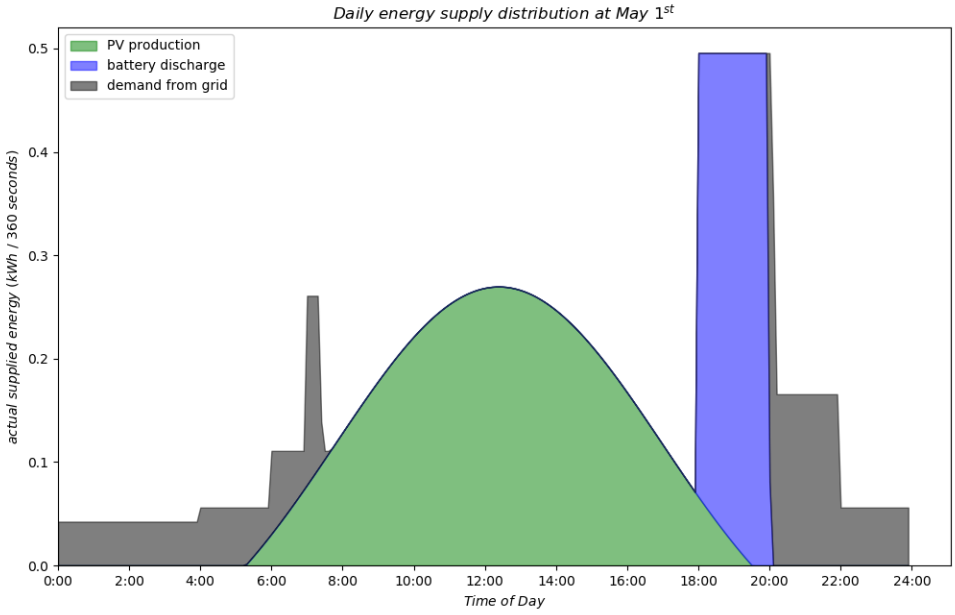


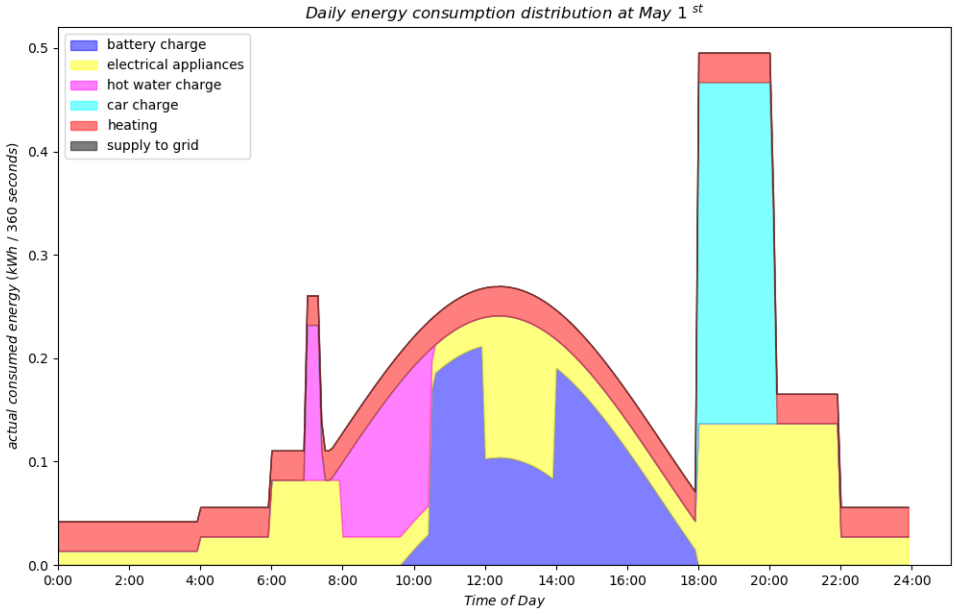
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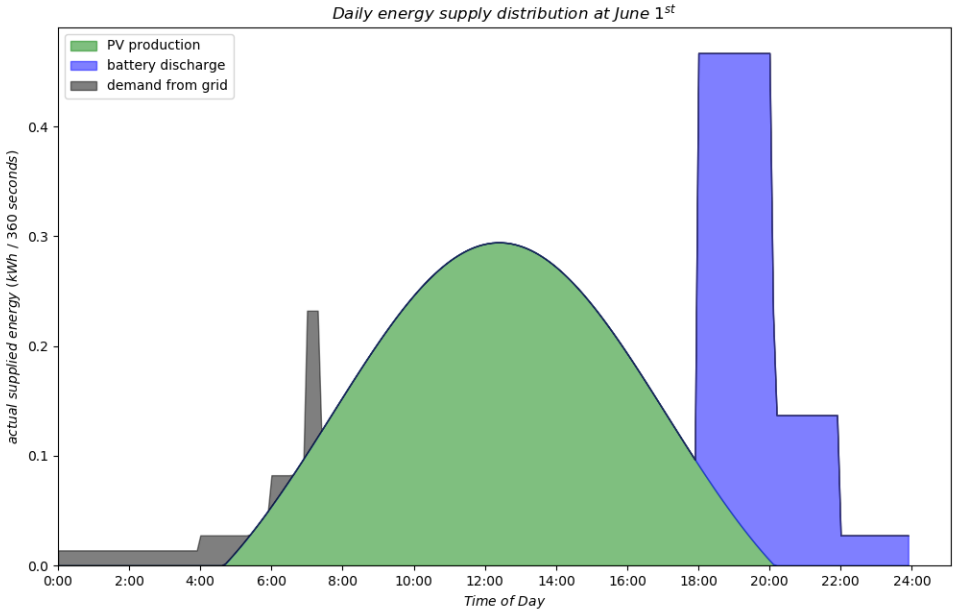


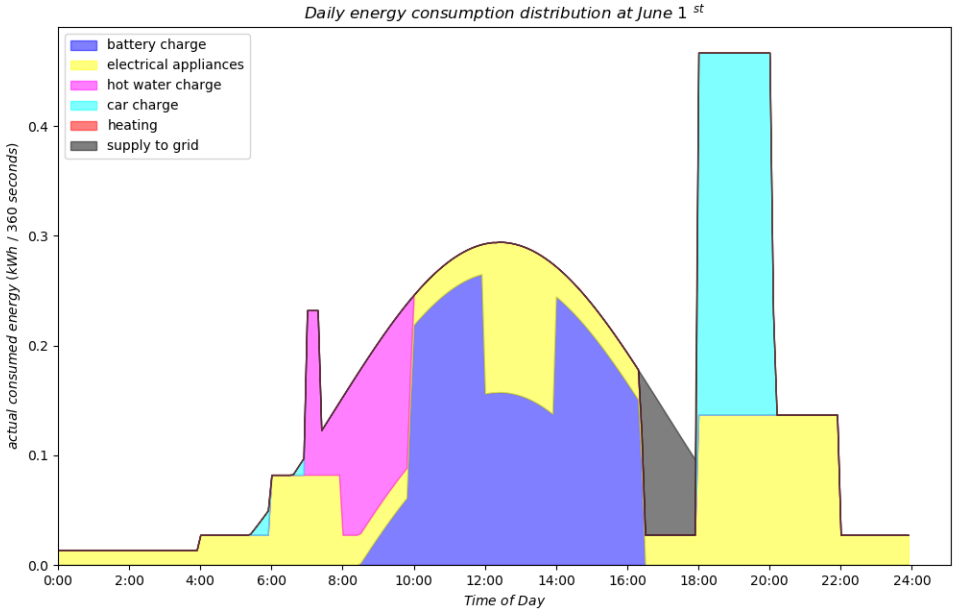
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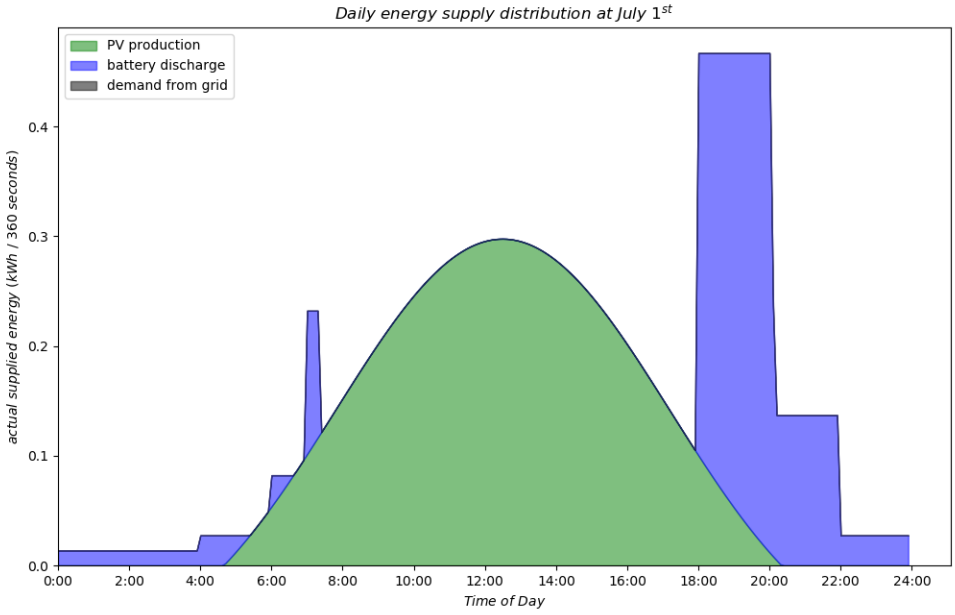


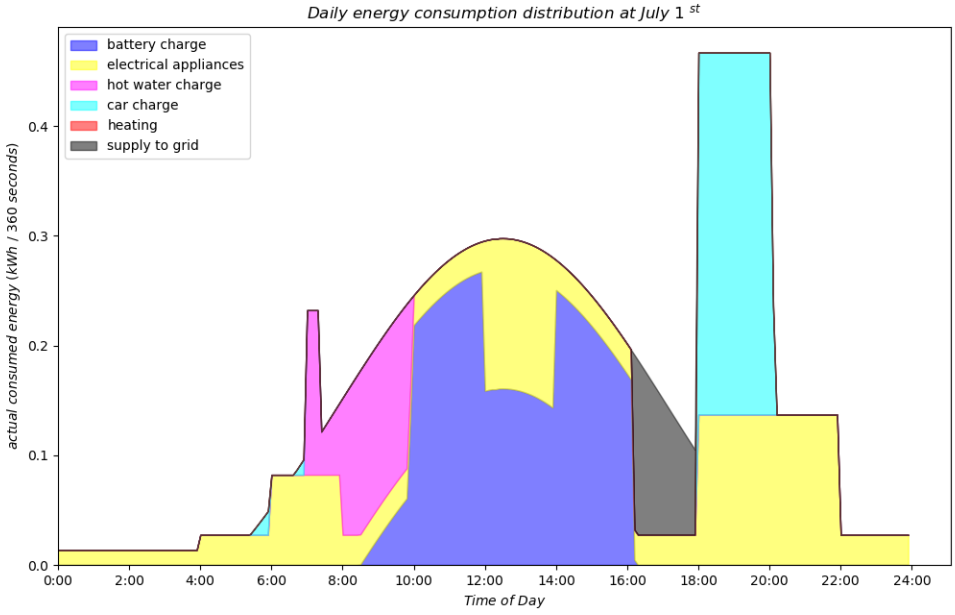
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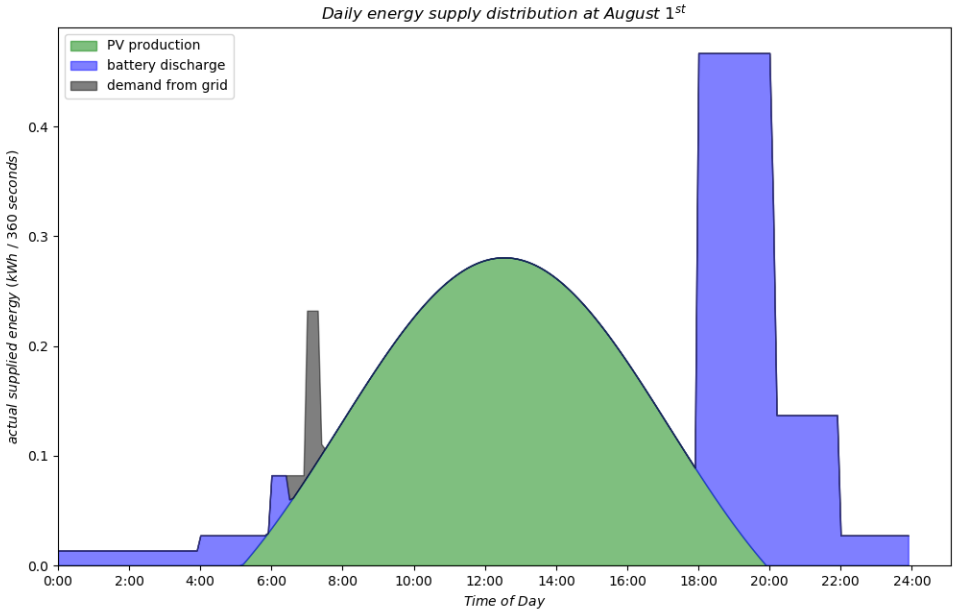


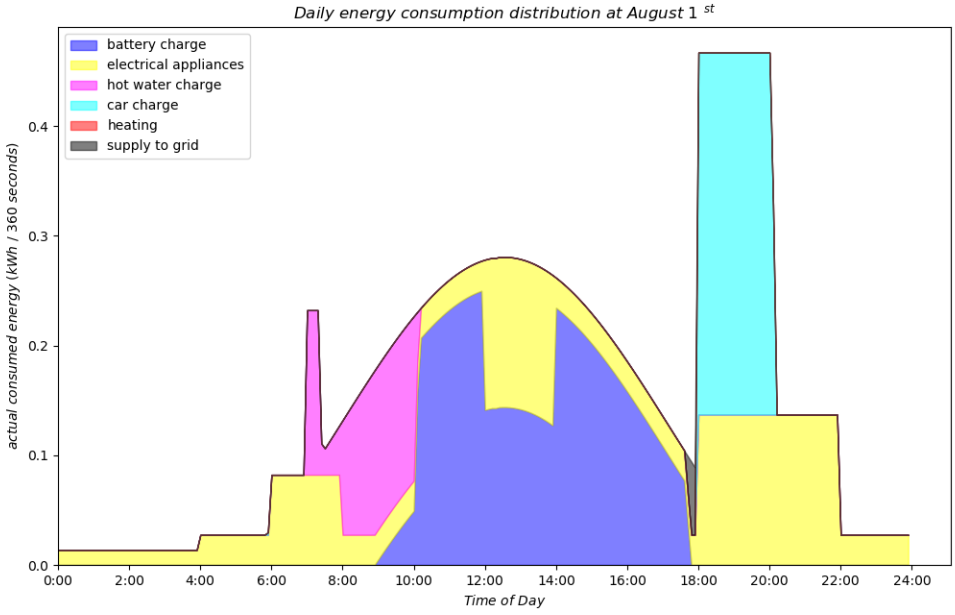
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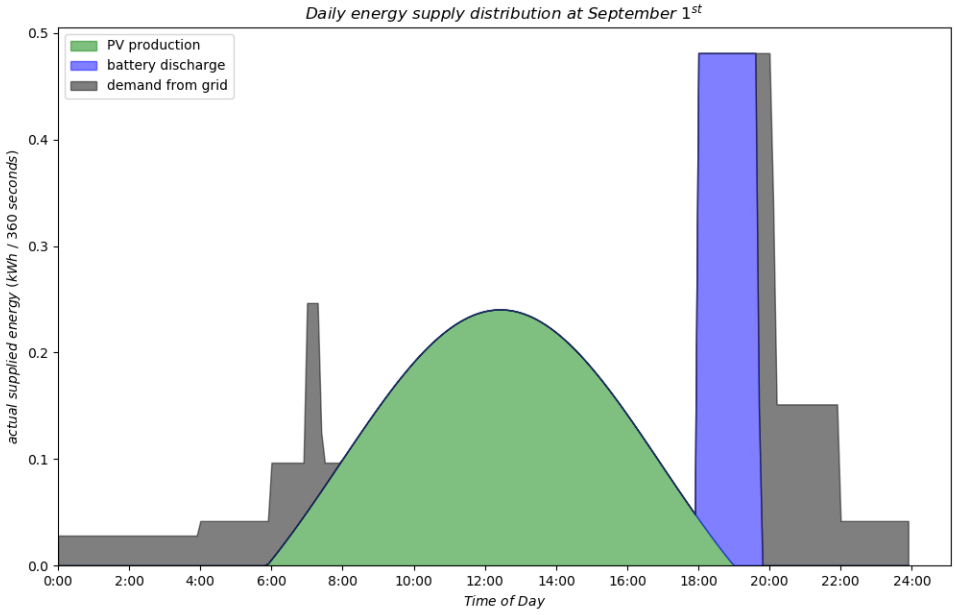


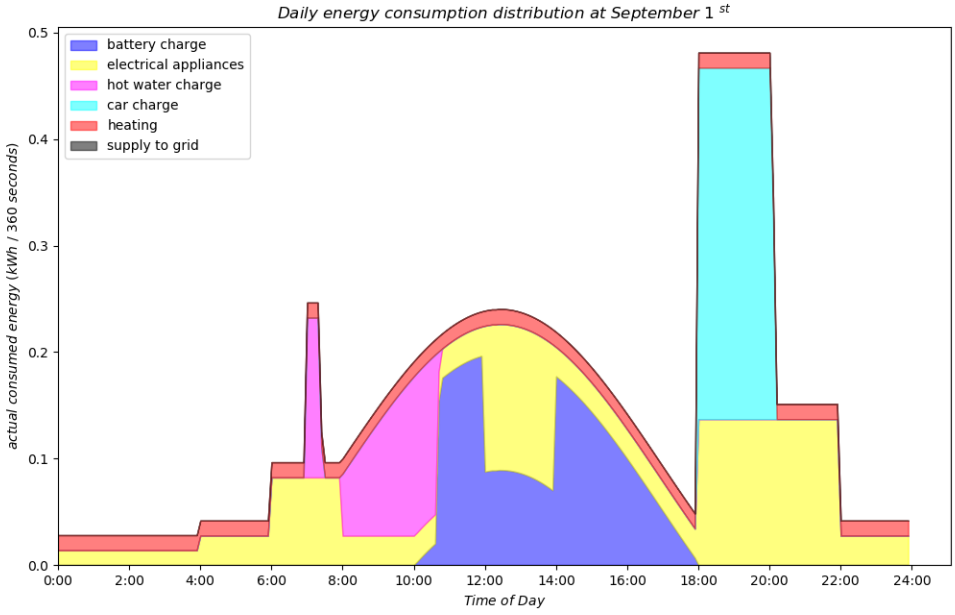
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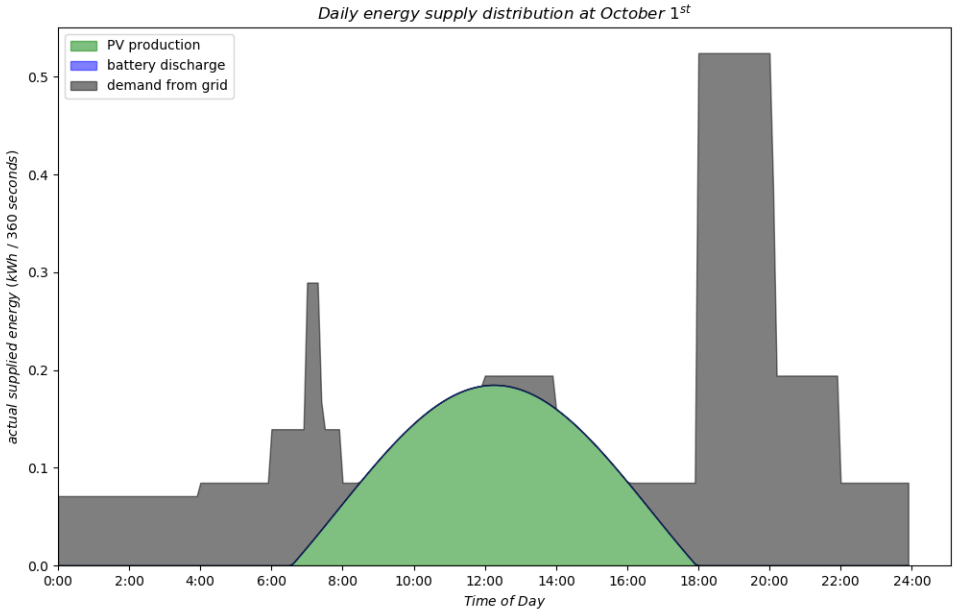


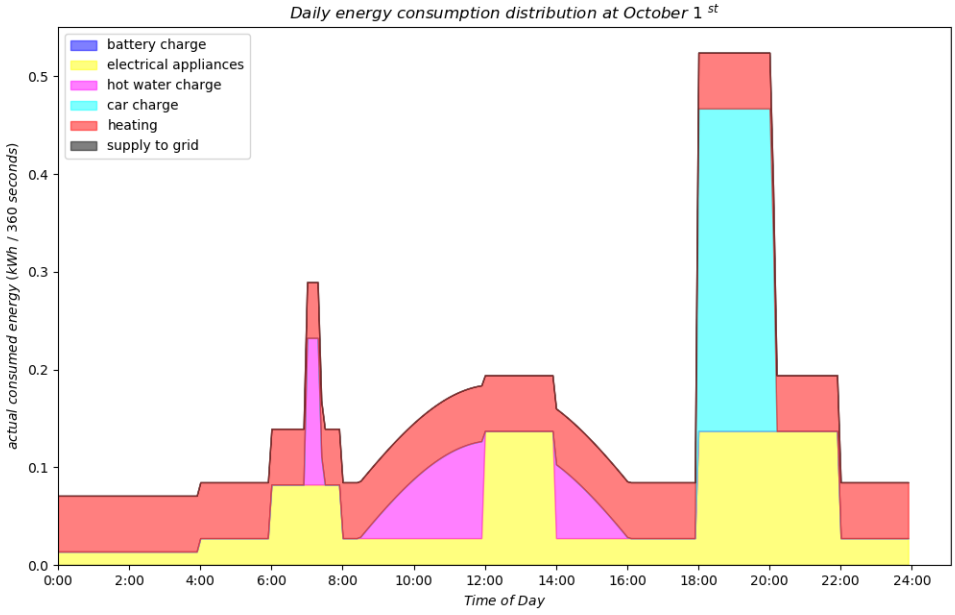
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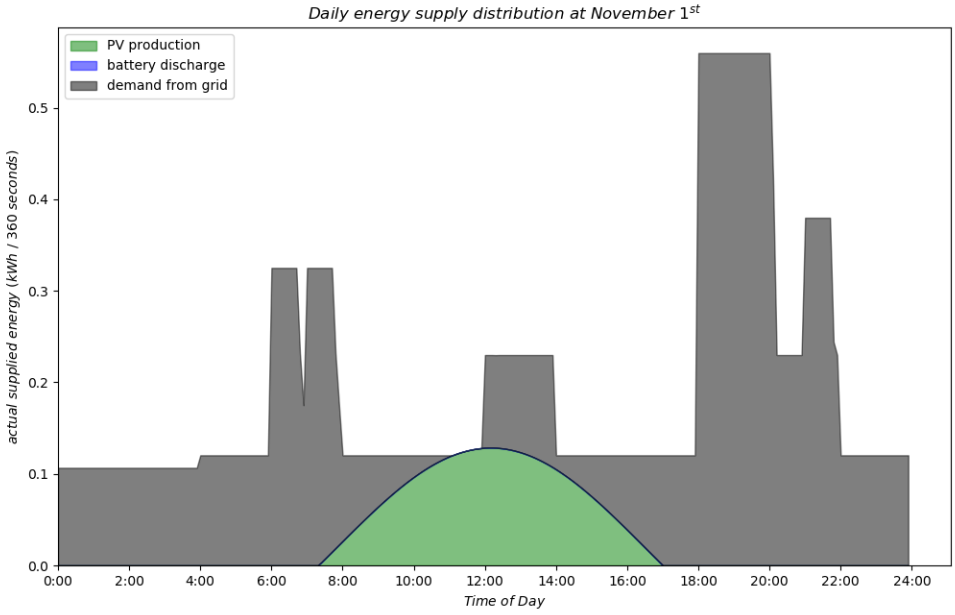


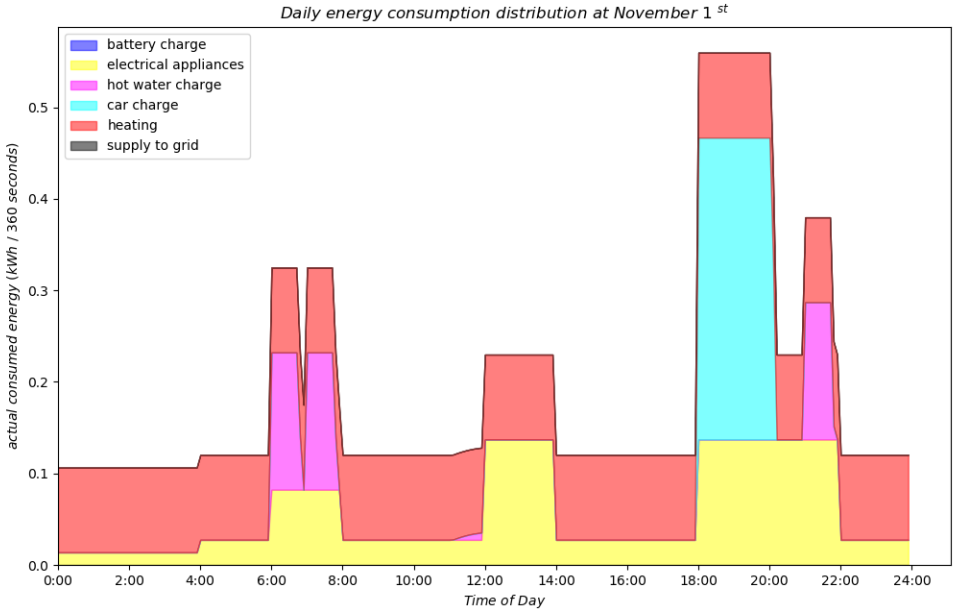
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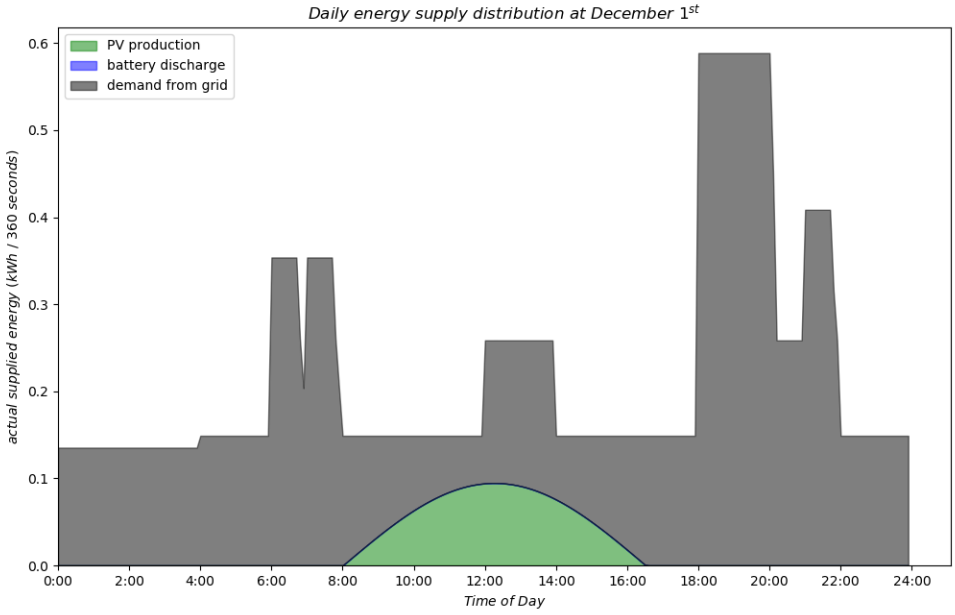


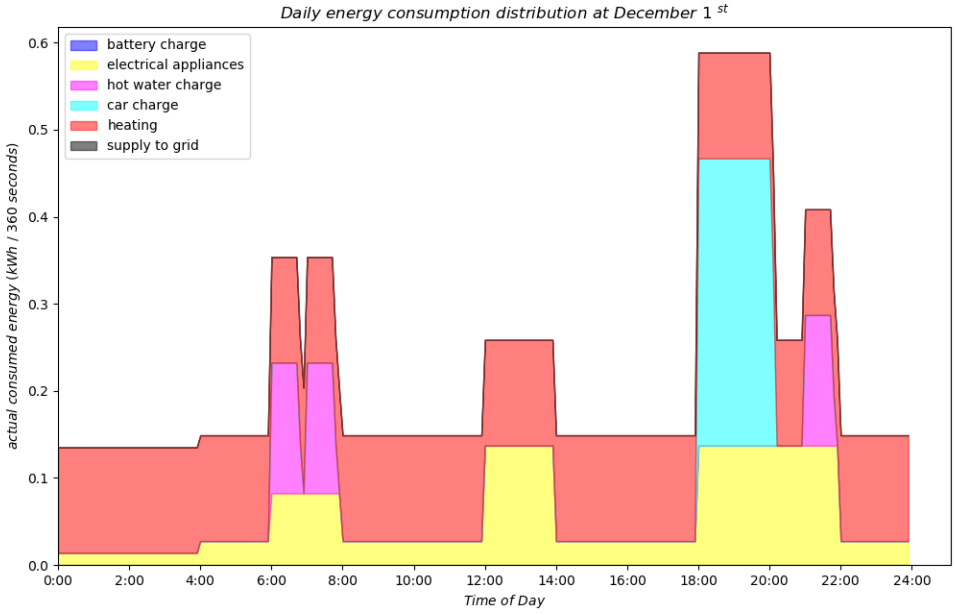
II-4. Total daily energy demand and supply





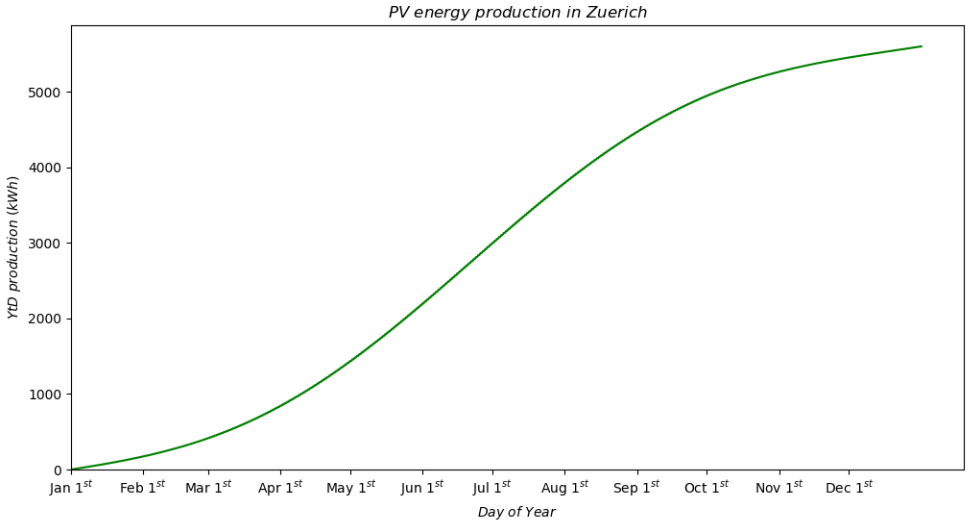
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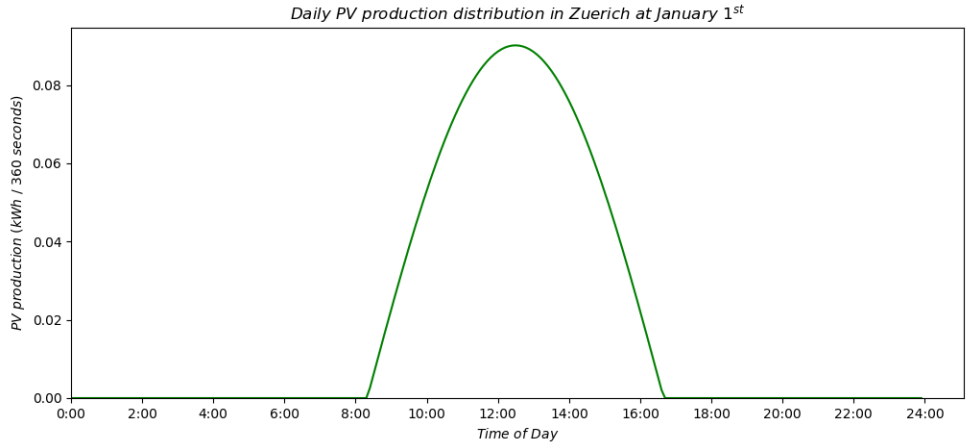


Appendix - breakdown

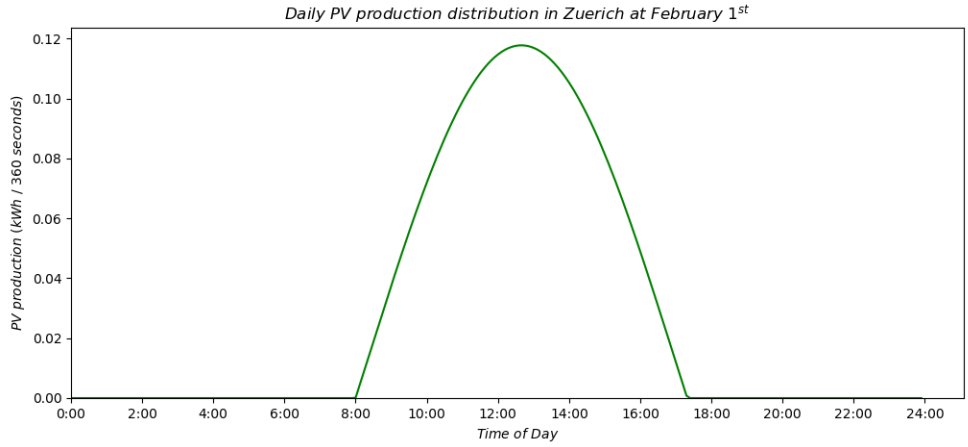
A-1. Photovoltaics installation - annual production



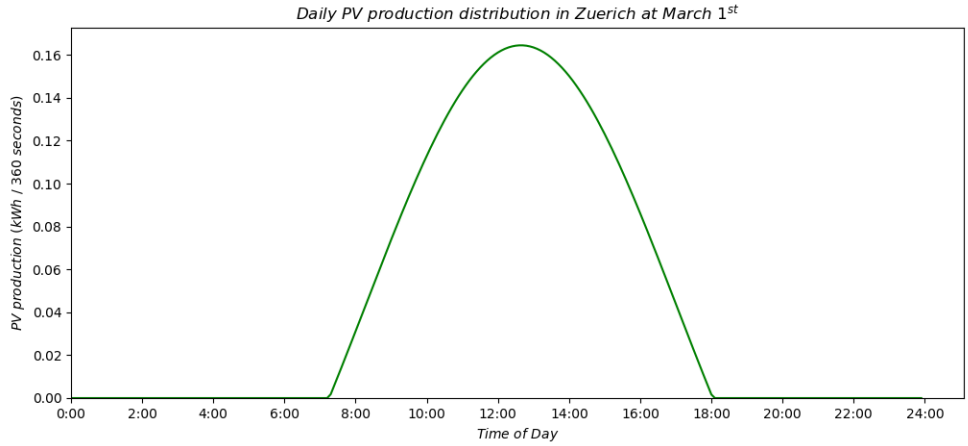
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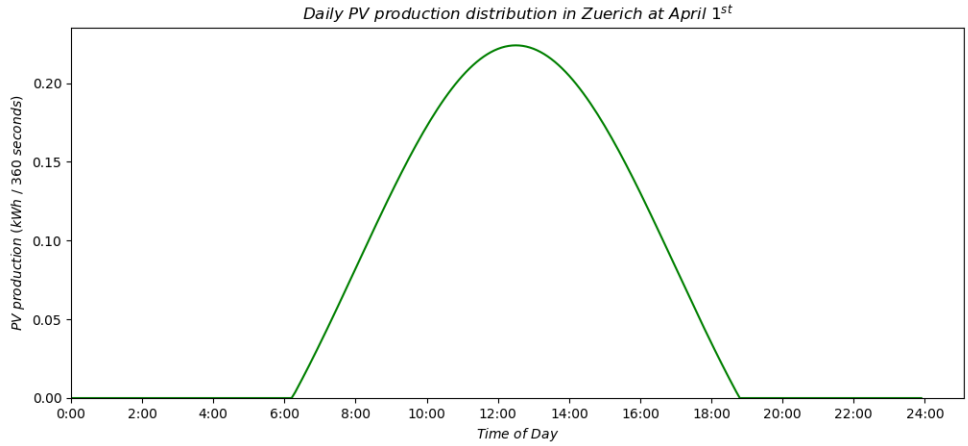
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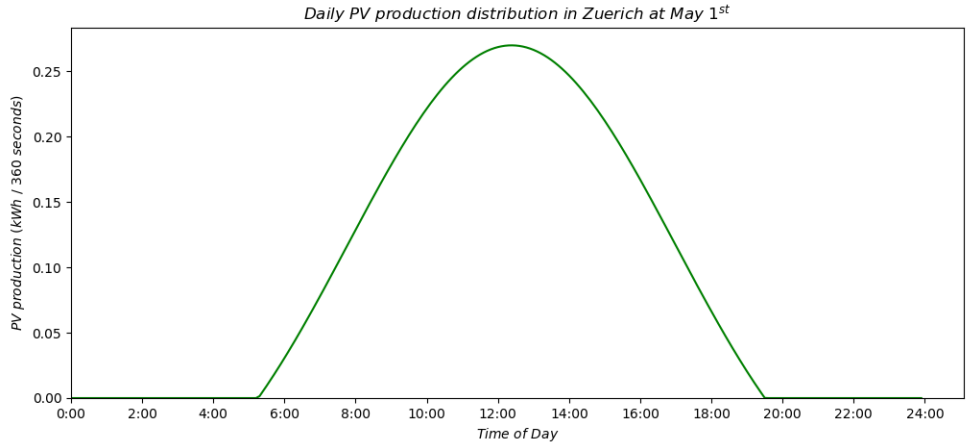
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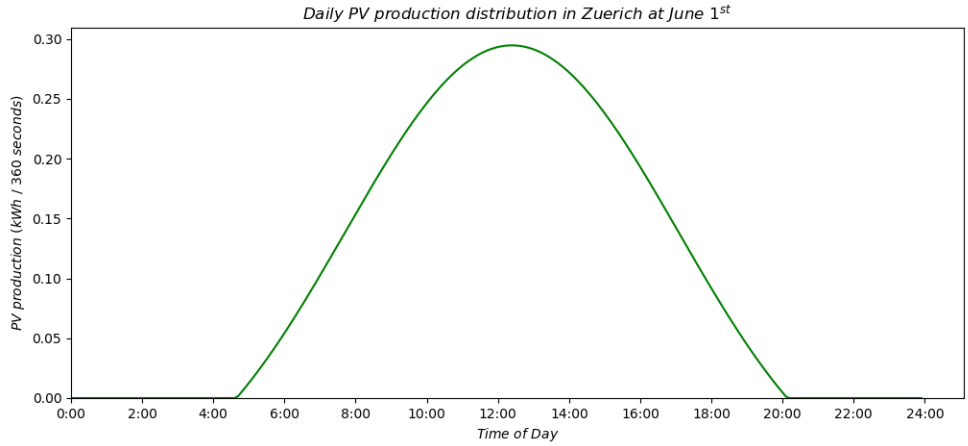
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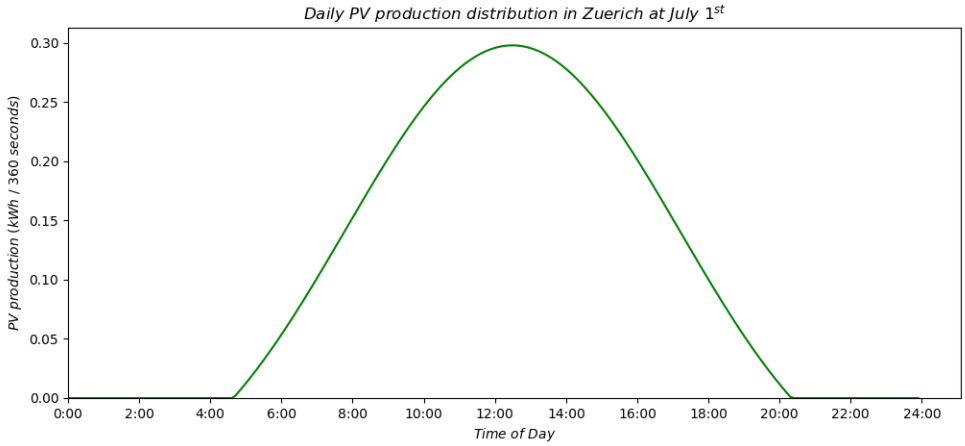
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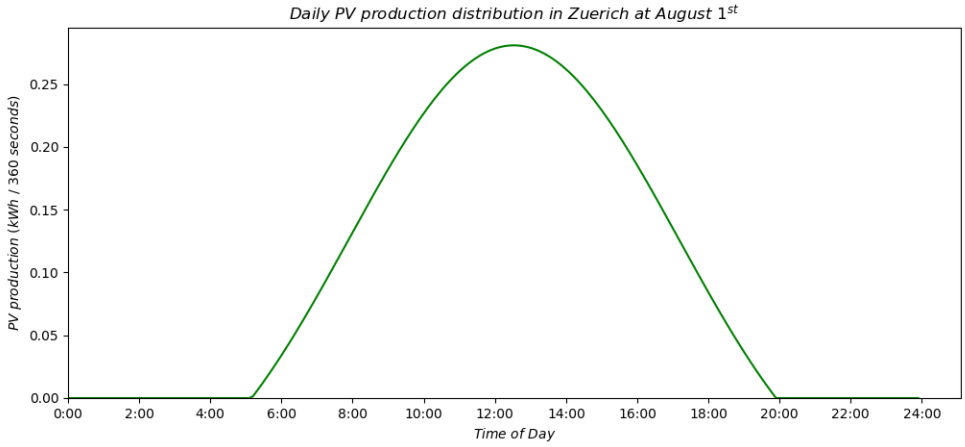
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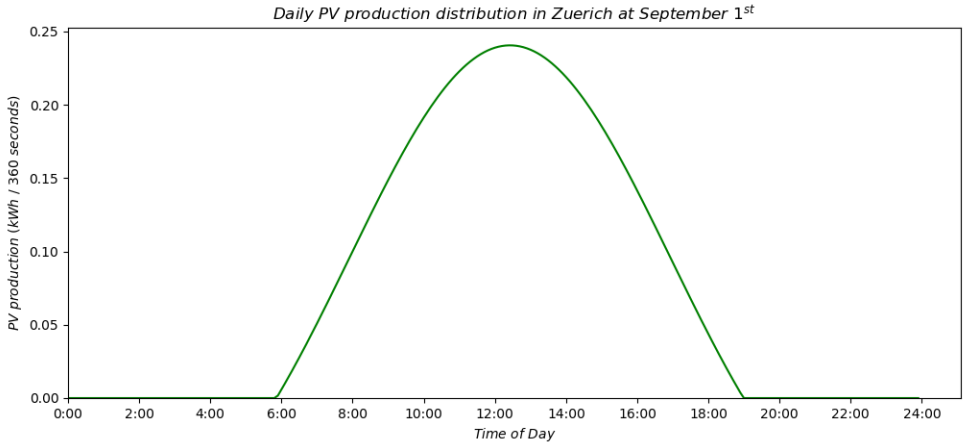
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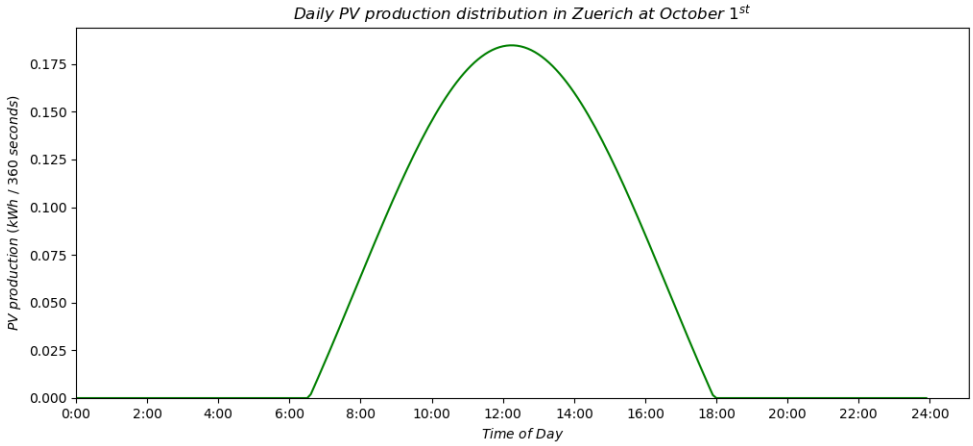
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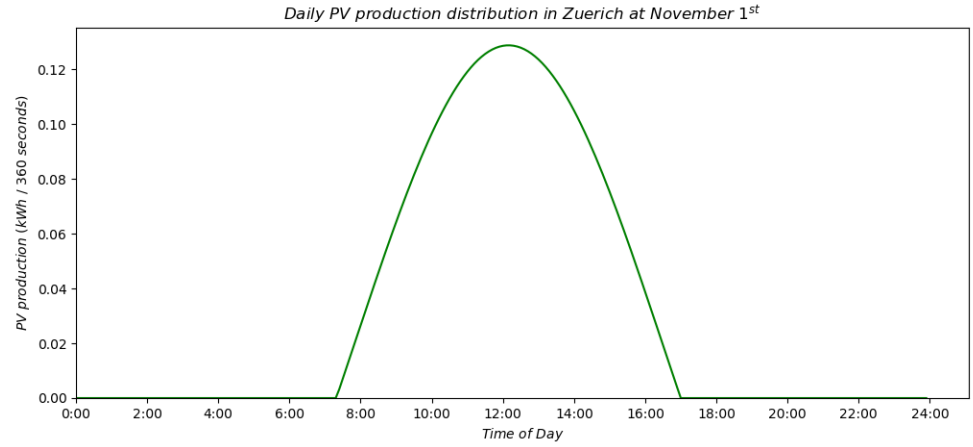
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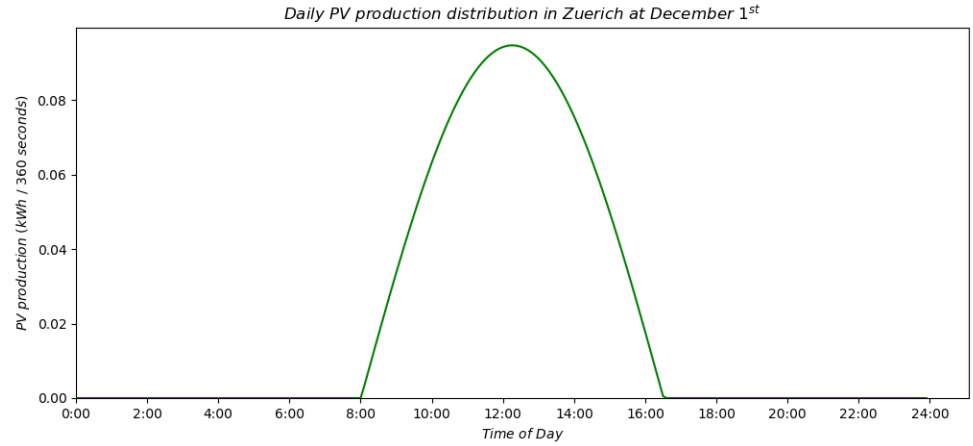
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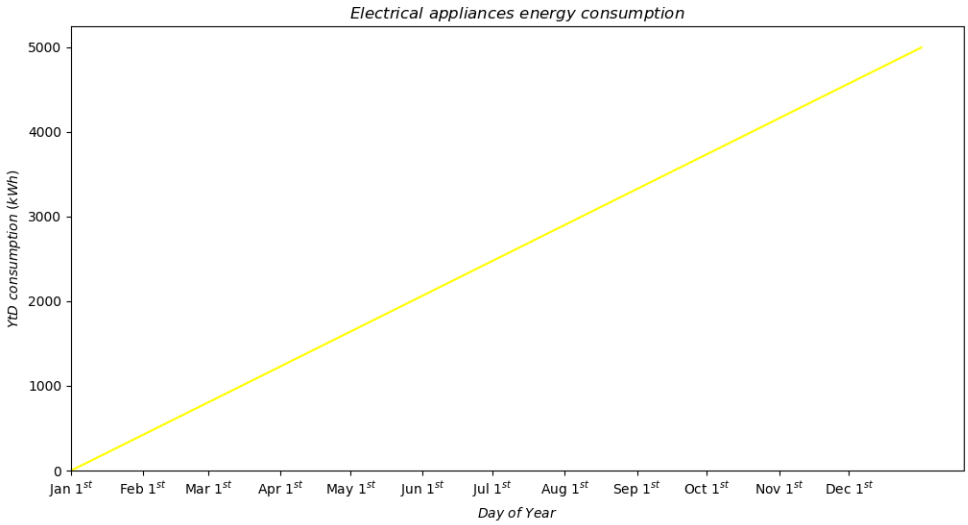
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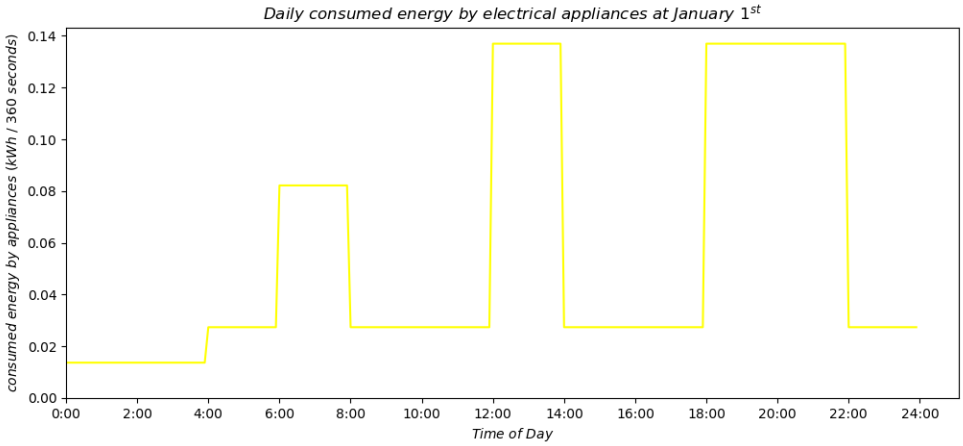
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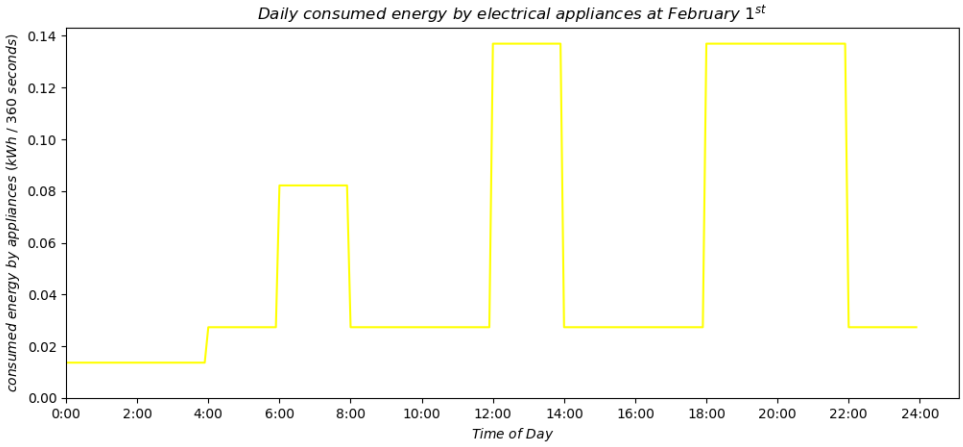
A-2. Electrical appliances - annual consumption



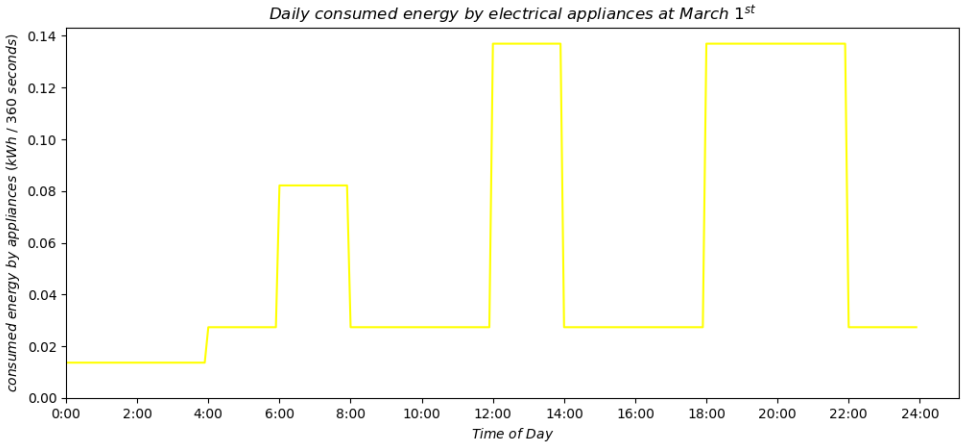
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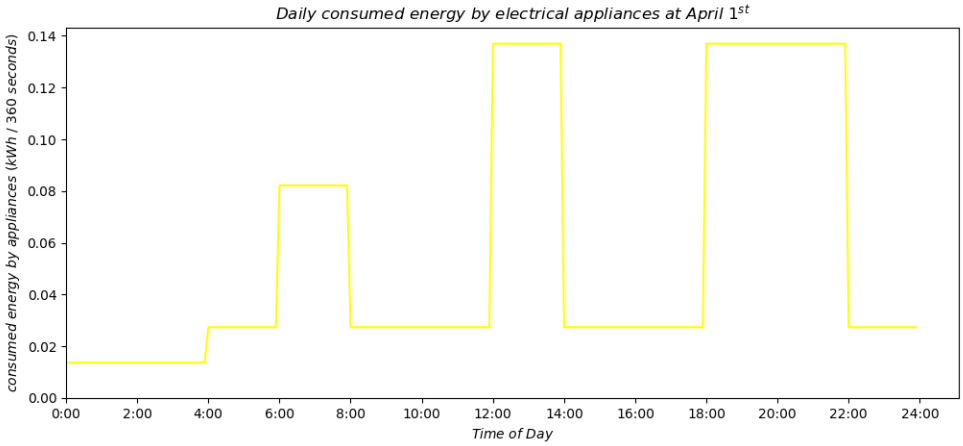
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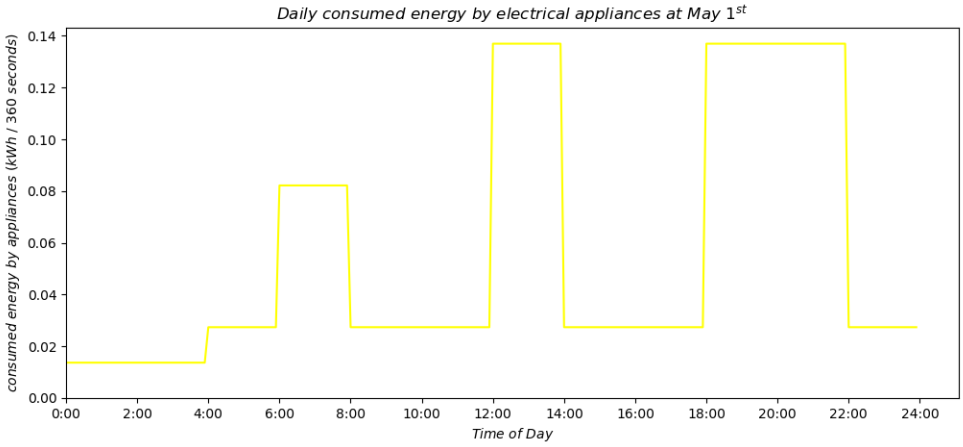
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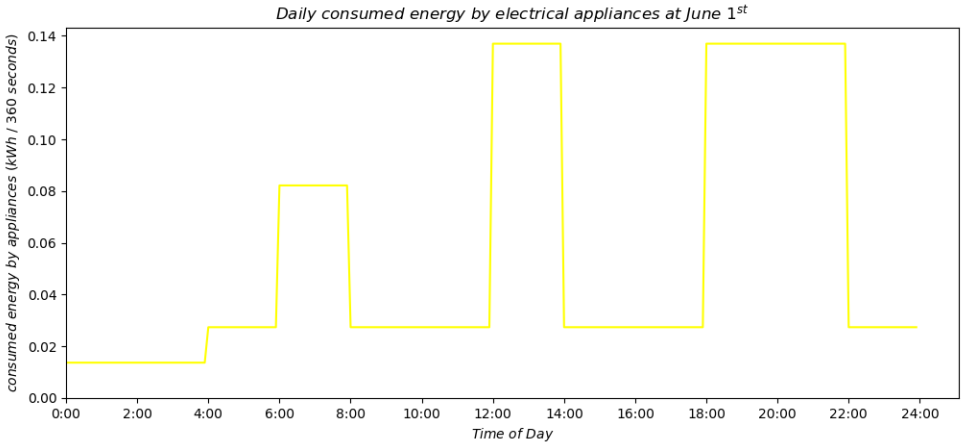
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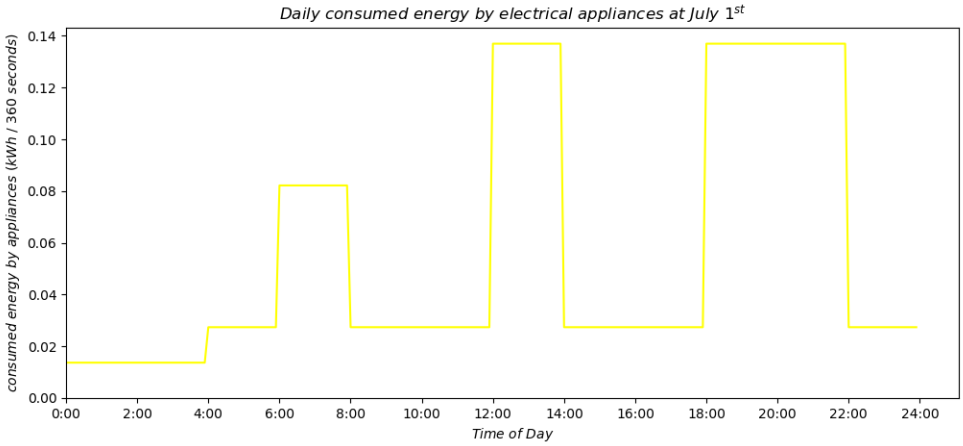
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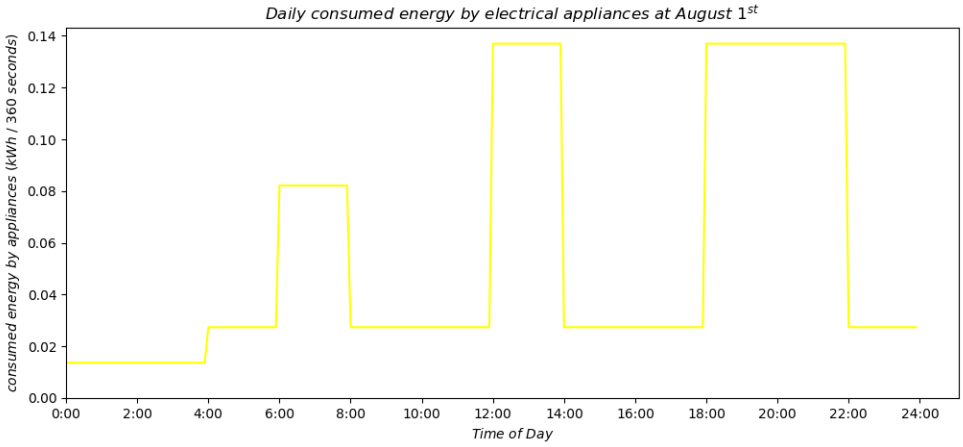
A-2. Electrical appliances - daily consumption



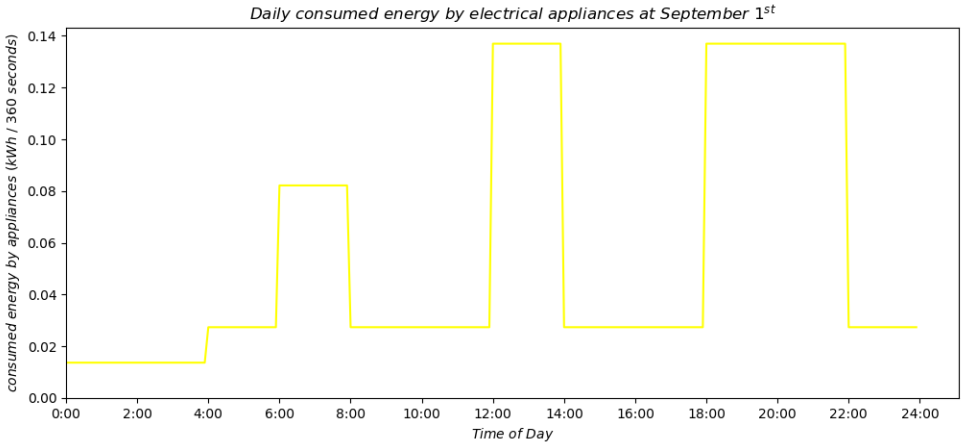
A-2. Electrical appliances - daily consumption



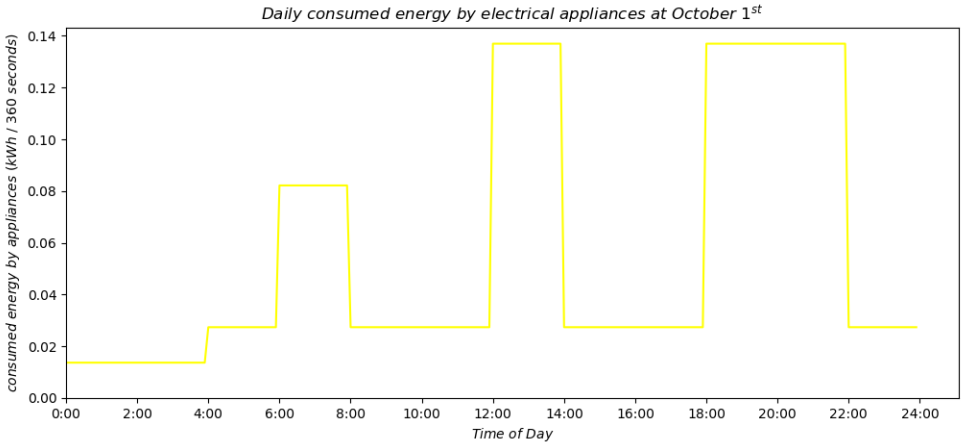
A-2. Electrical appliances - daily consumption



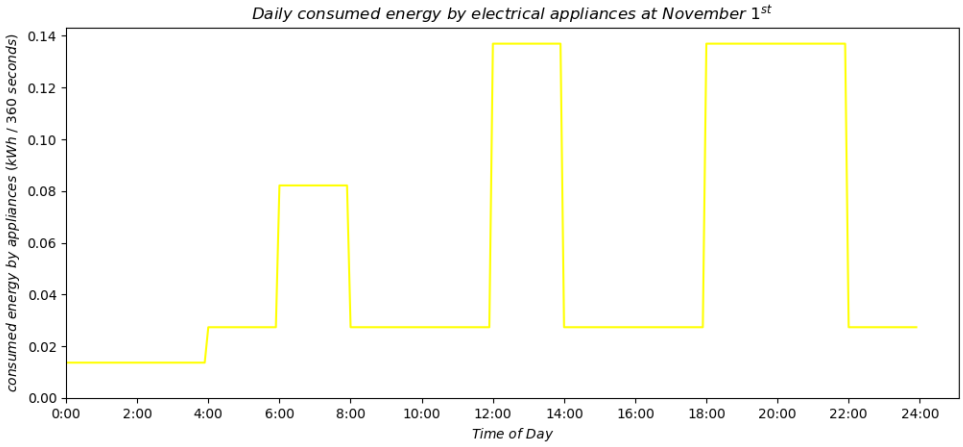
A-2. Electrical appliances - daily consumption



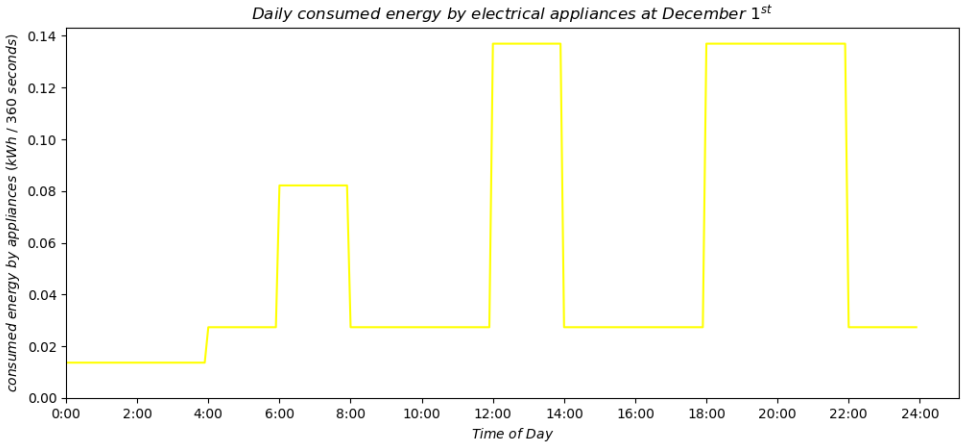
A-2. Electrical appliances - daily consumption



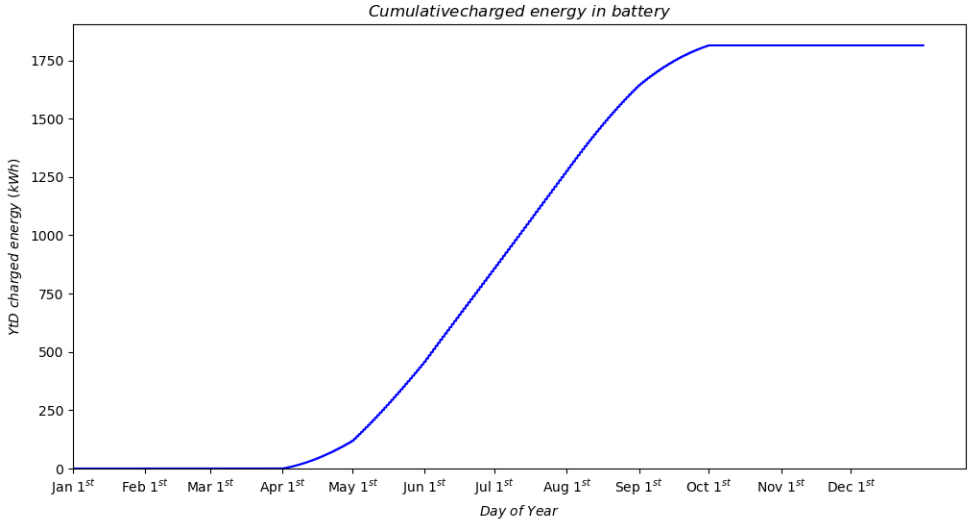
A-2. Electrical appliances - daily consumption

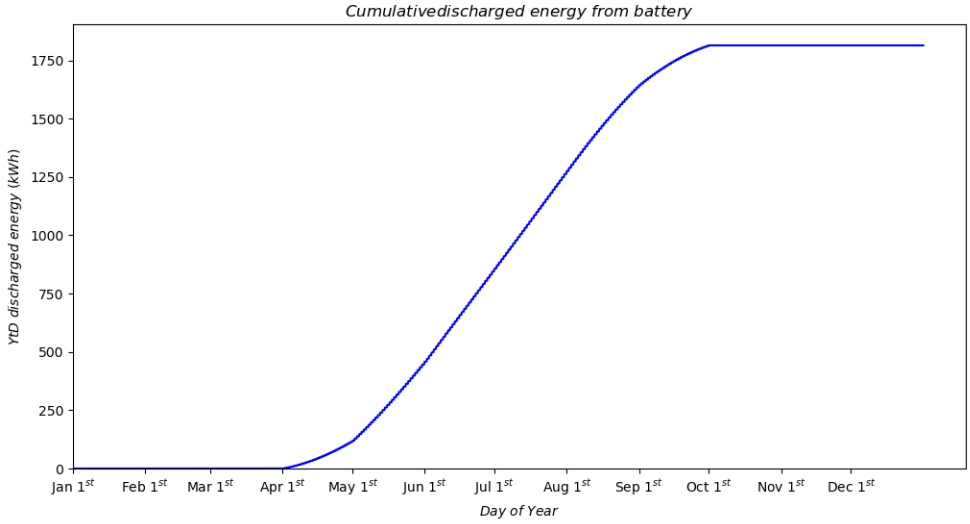


A-2. Electrical appliances - daily consumption

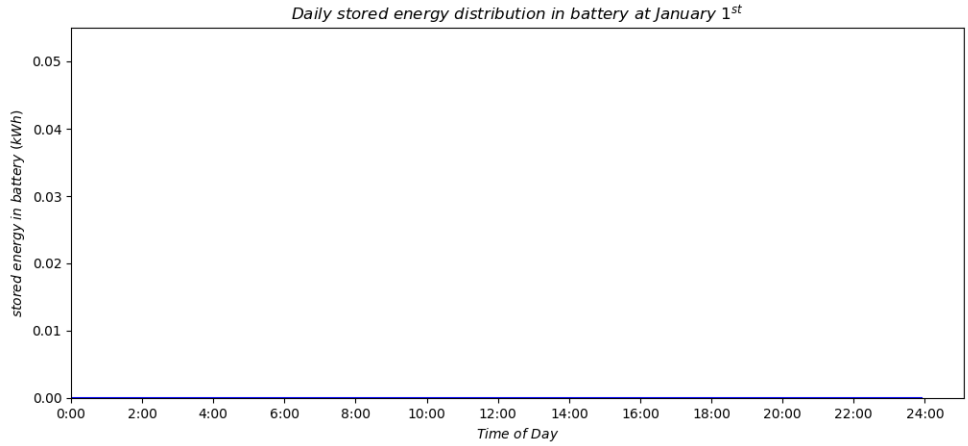


A-3. Battery - annual (dis)charged energy

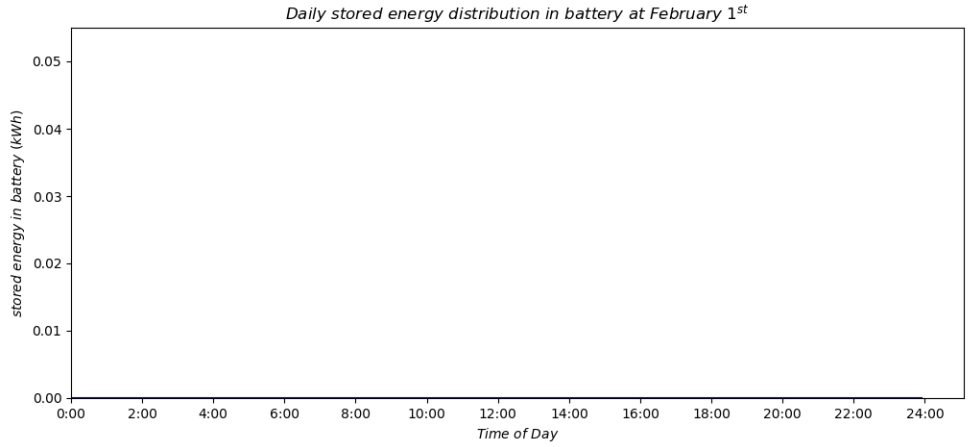




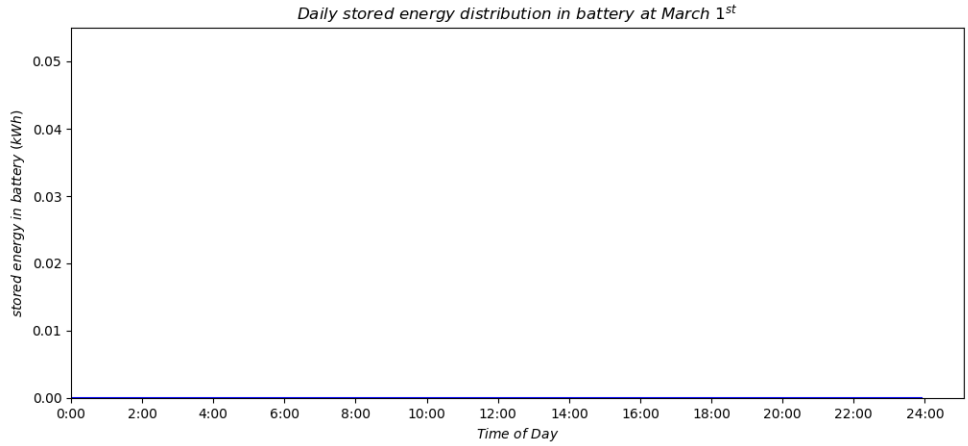
A-3. Battery - daily charge level



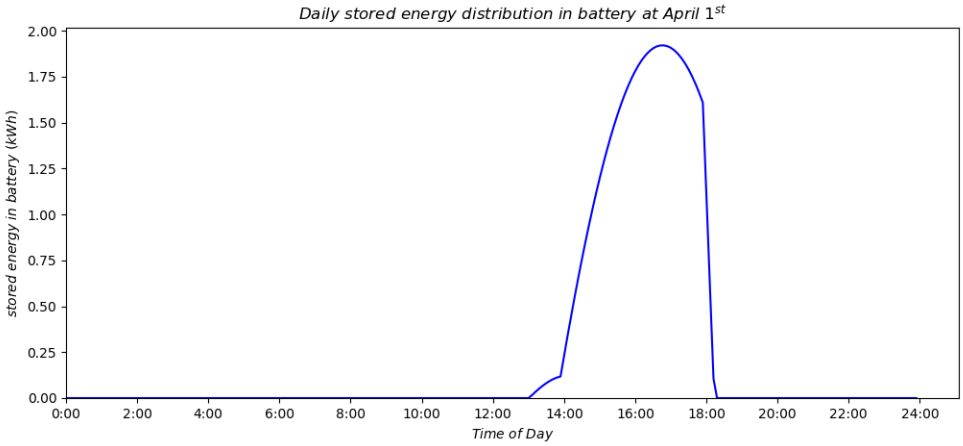
A-3. Battery - daily charge level



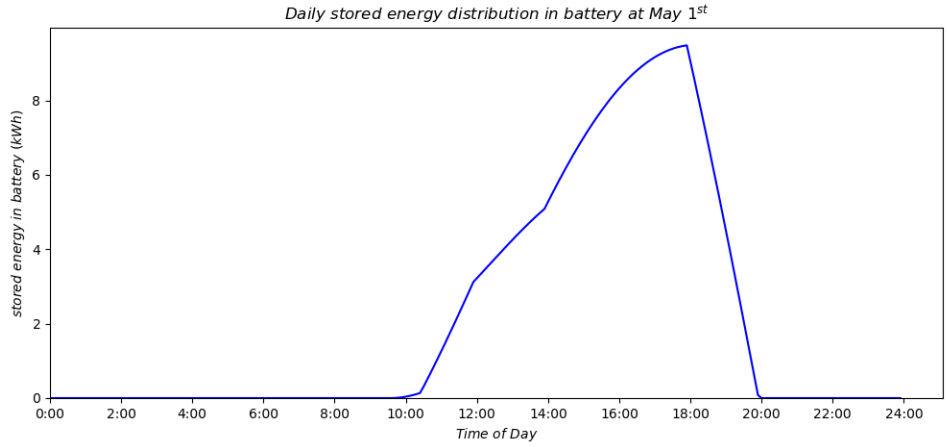
A-3. Battery - daily charge level



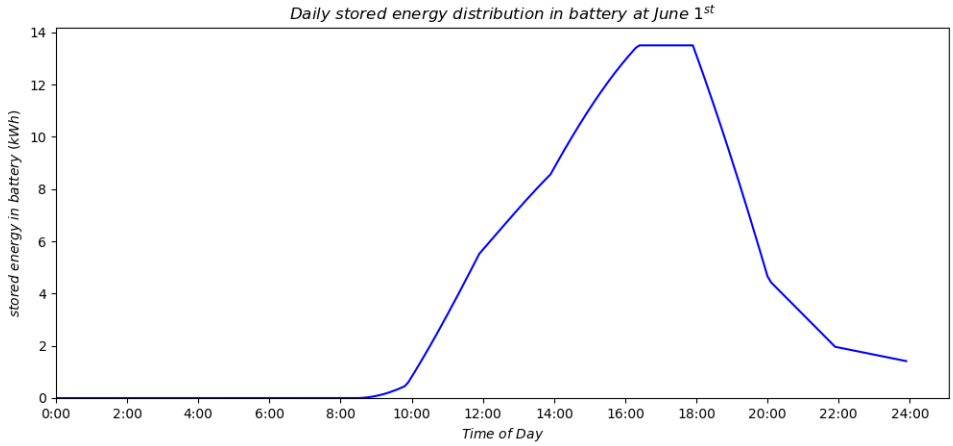
A-3. Battery - daily charge level



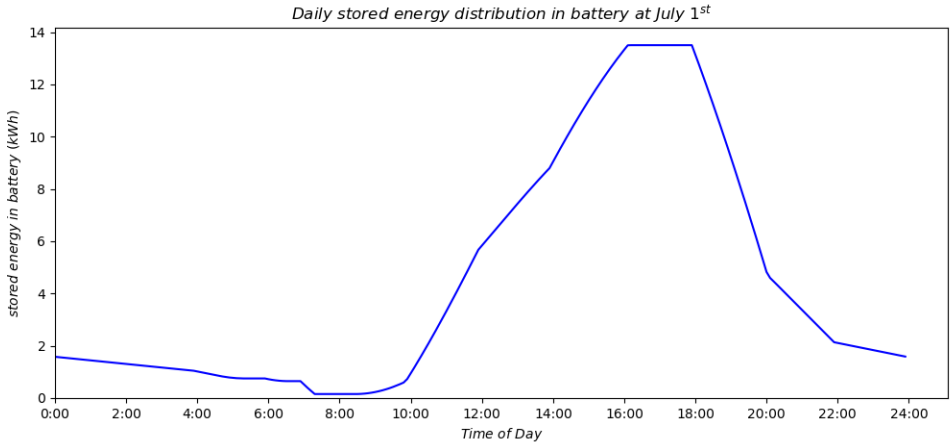
A-3. Battery - daily charge level



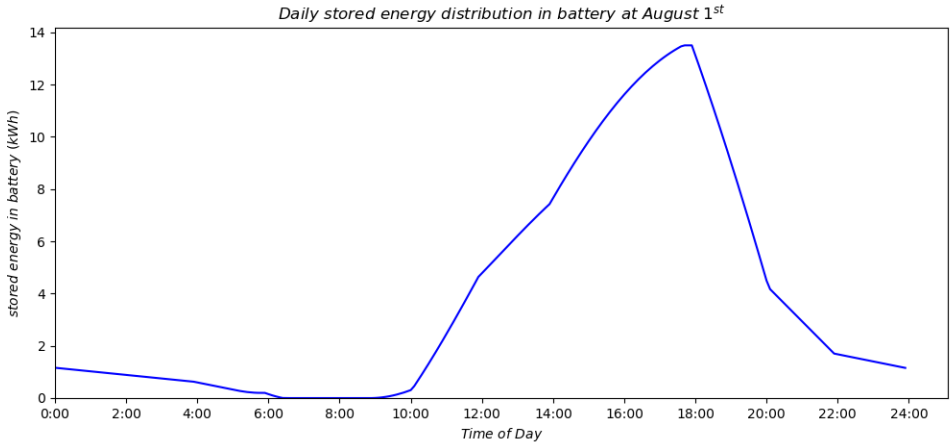
A-3. Battery - daily charge level



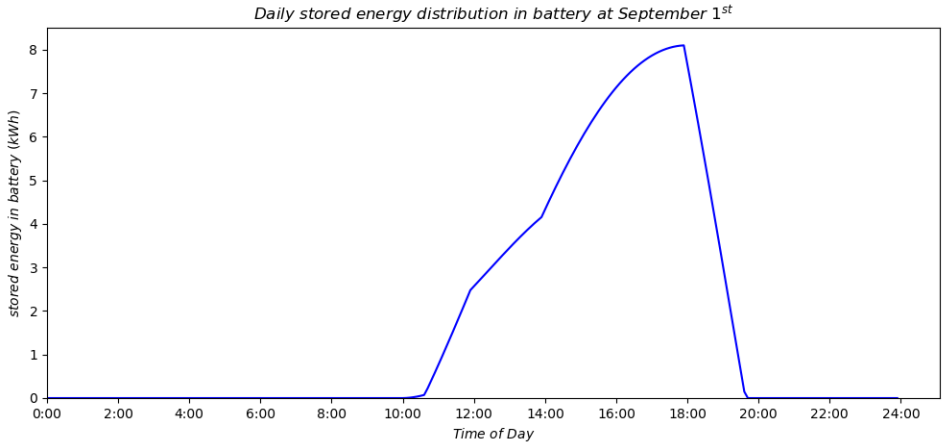
A-3. Battery - daily charge level



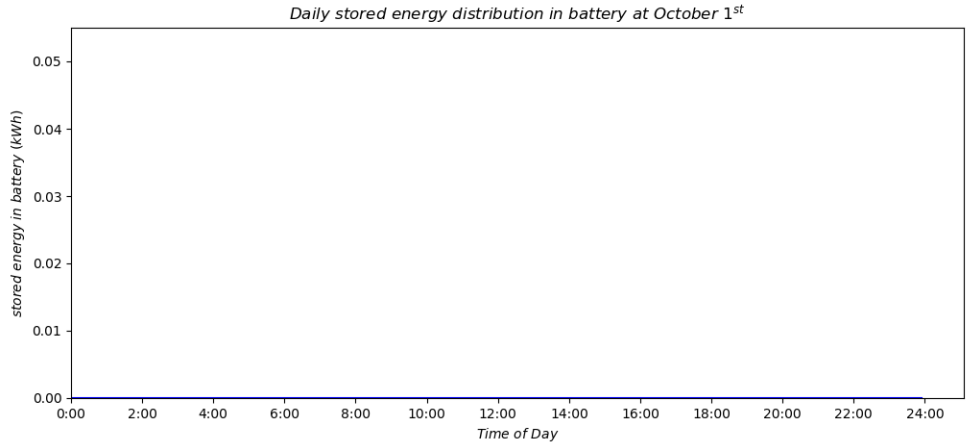
A-3. Battery - daily charge level



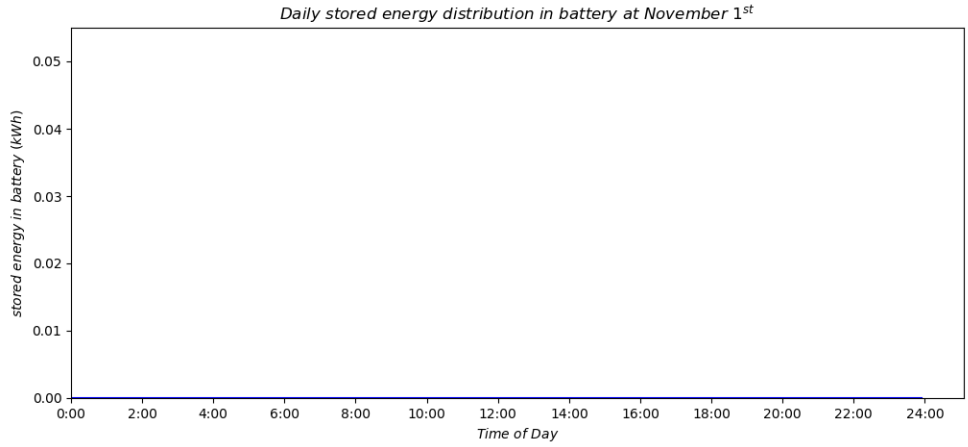
A-3. Battery - daily charge level



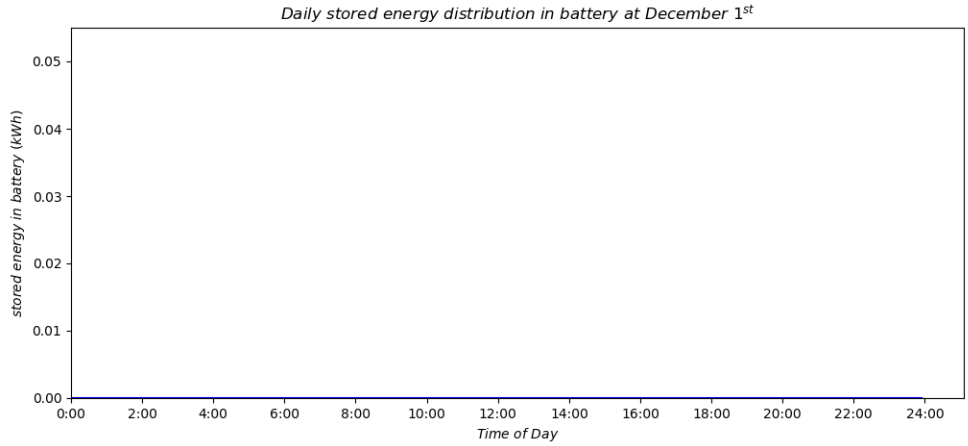
A-3. Battery - daily charge level



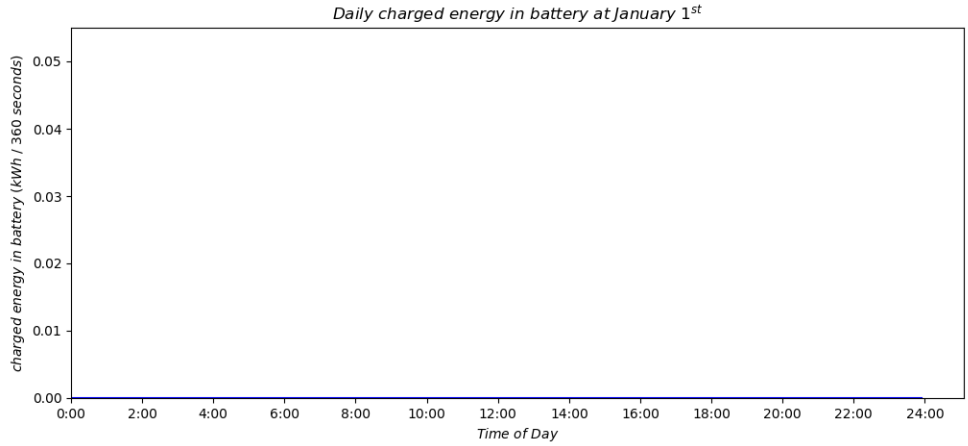
A-3. Battery - daily charge level



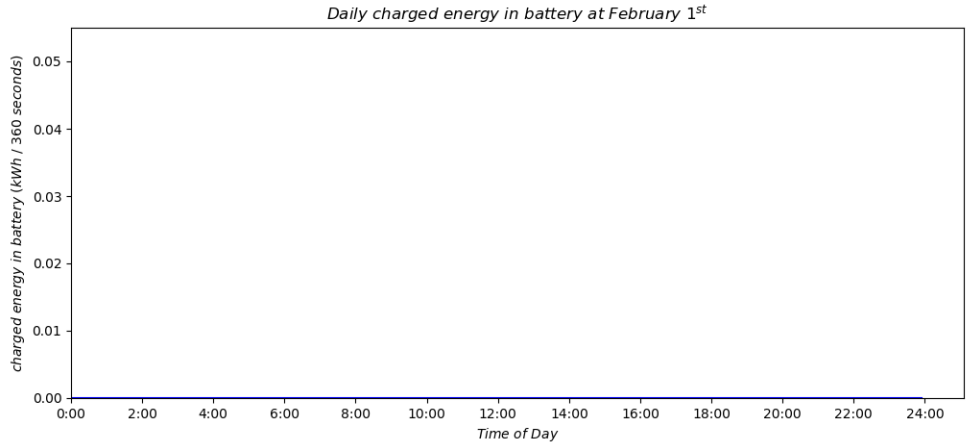
A-3. Battery - daily charge level



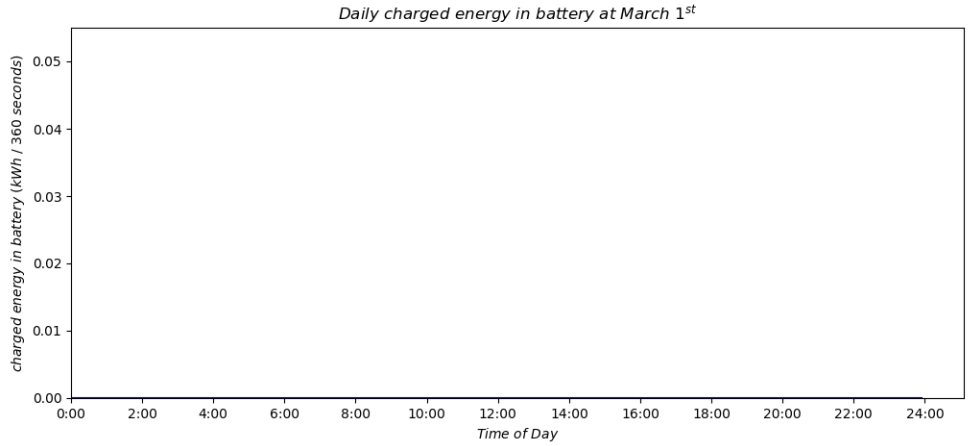
A-3. Battery - daily charged energy



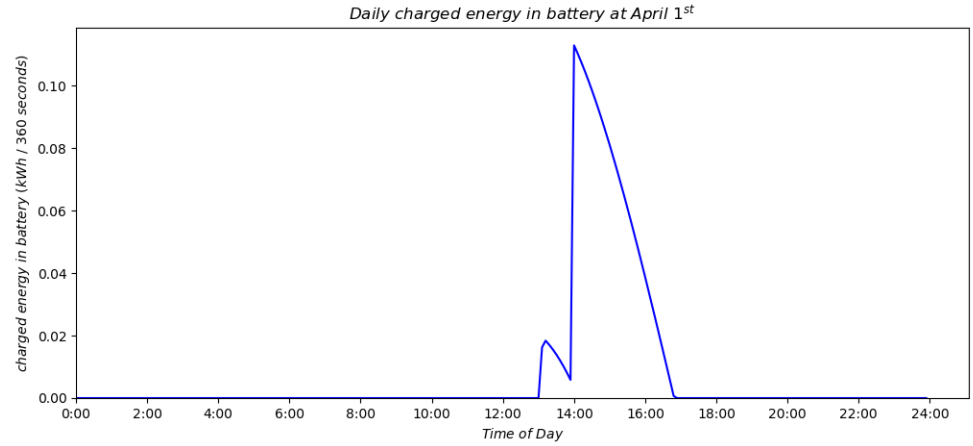
A-3. Battery - daily charged energy



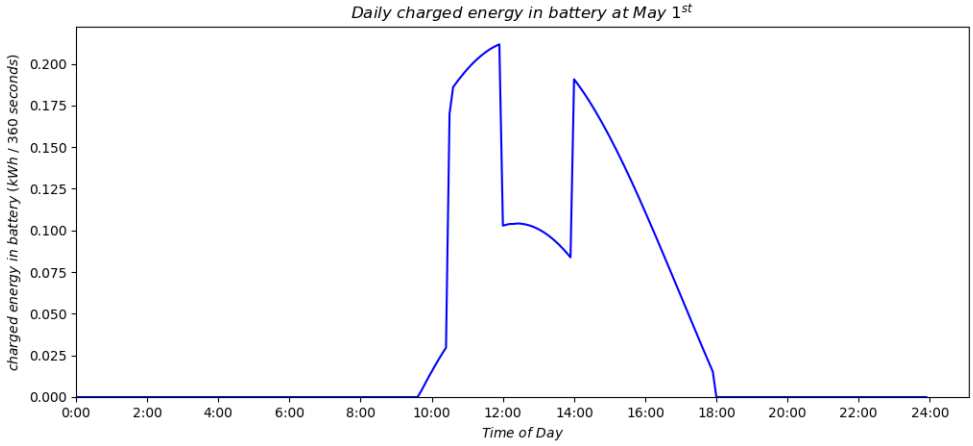
A-3. Battery - daily charged energy



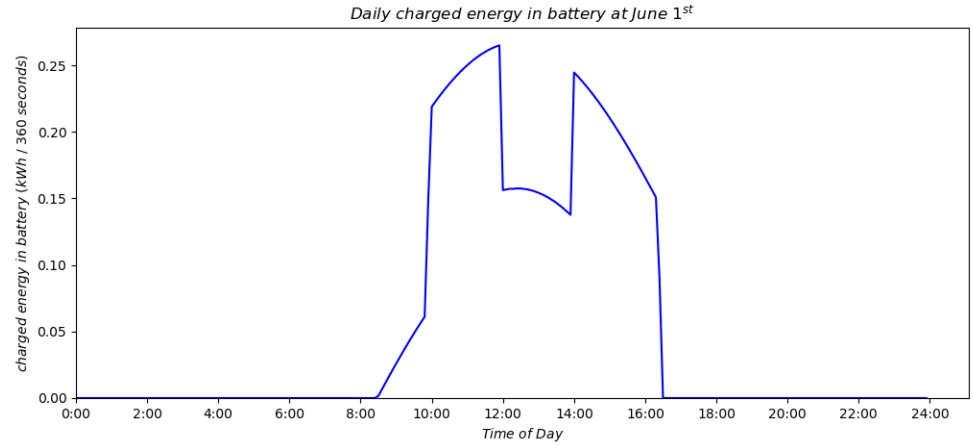
A-3. Battery - daily charged energy



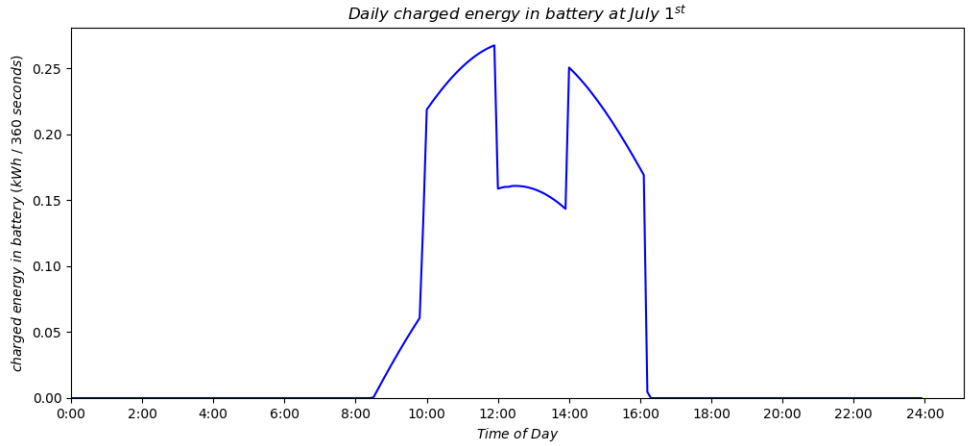
A-3. Battery - daily charged energy



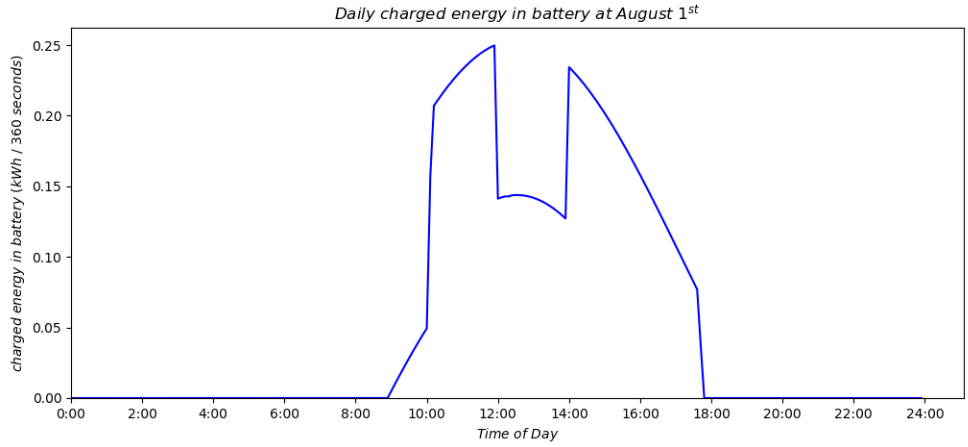
A-3. Battery - daily charged energy



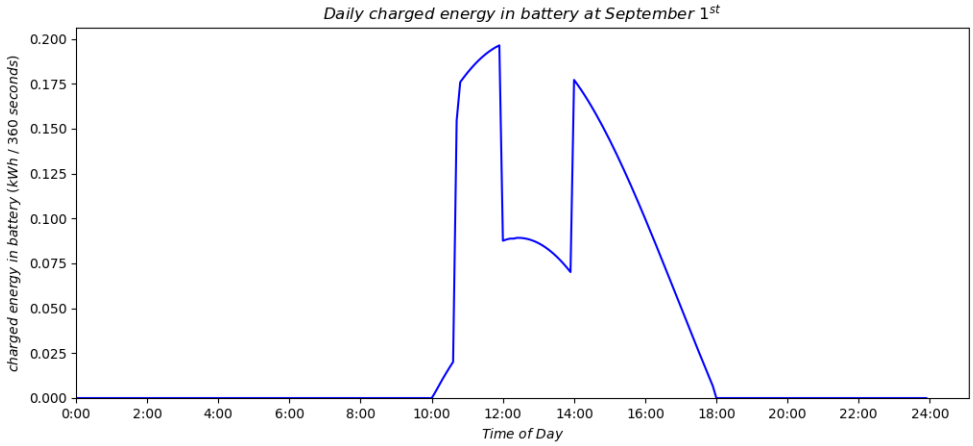
A-3. Battery - daily charged energy



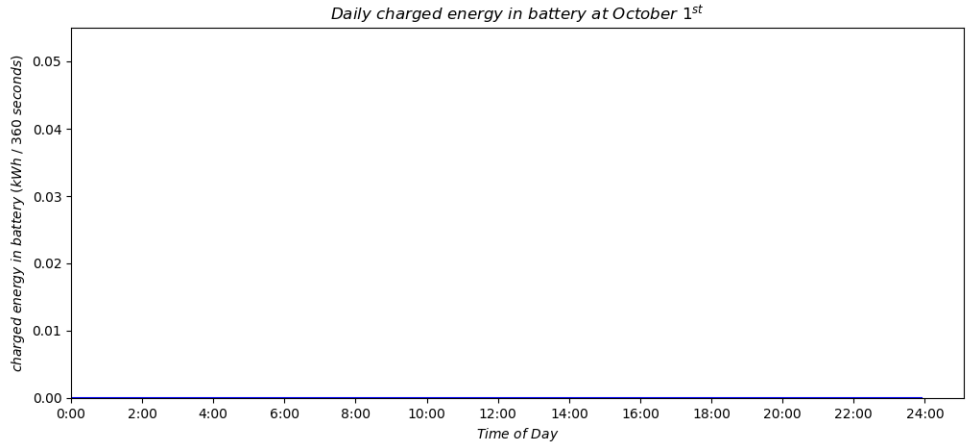
A-3. Battery - daily charged energy



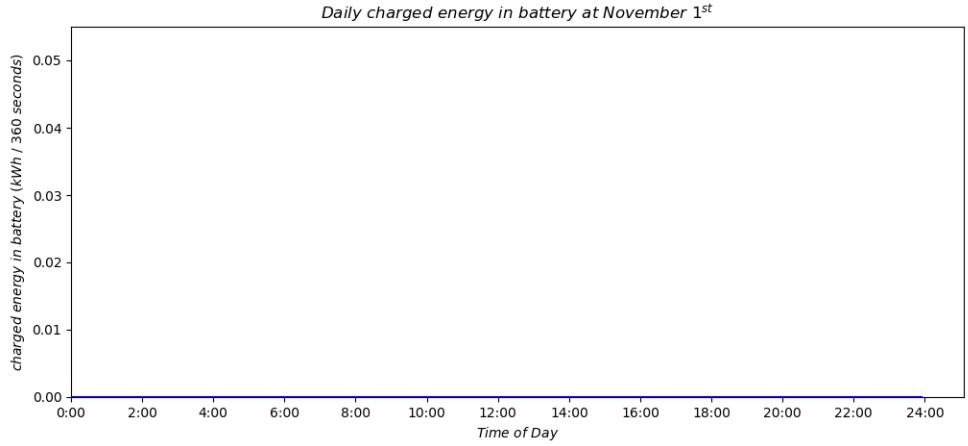
A-3. Battery - daily charged energy



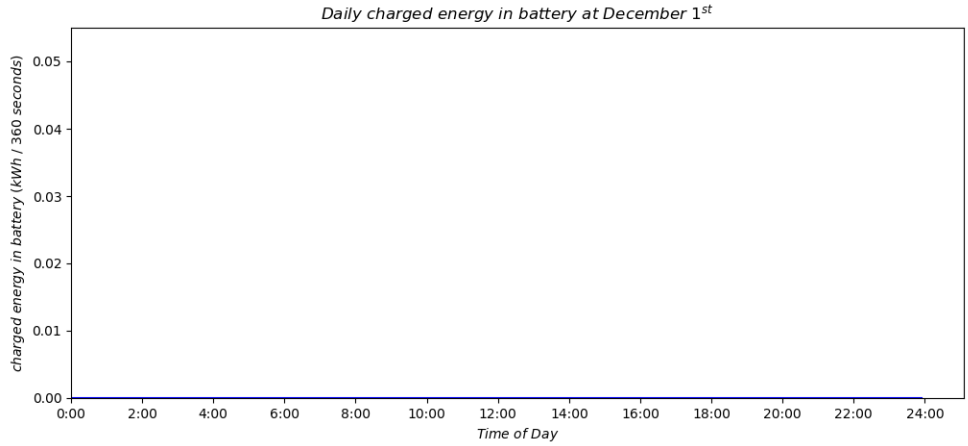
A-3. Battery - daily charged energy



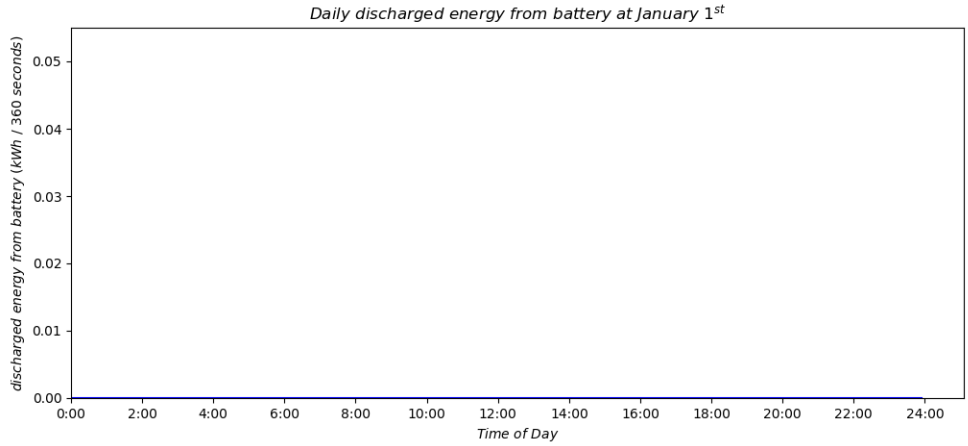
A-3. Battery - daily charged energy



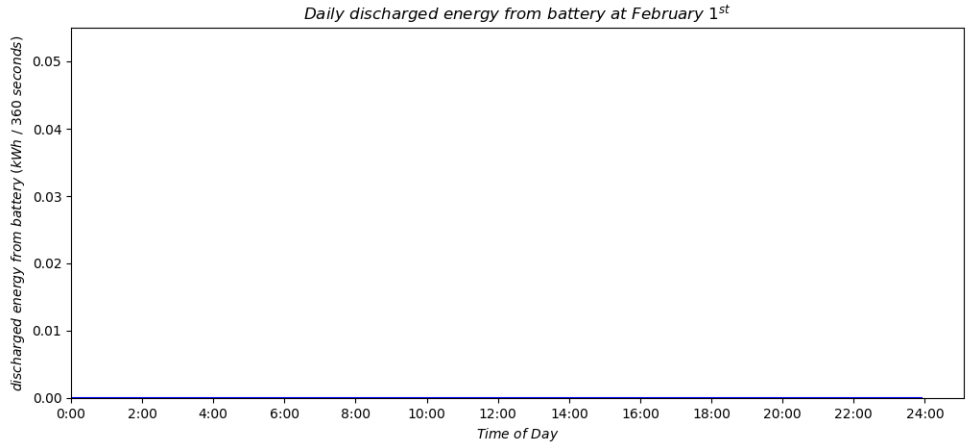
A-3. Battery - daily charged energy



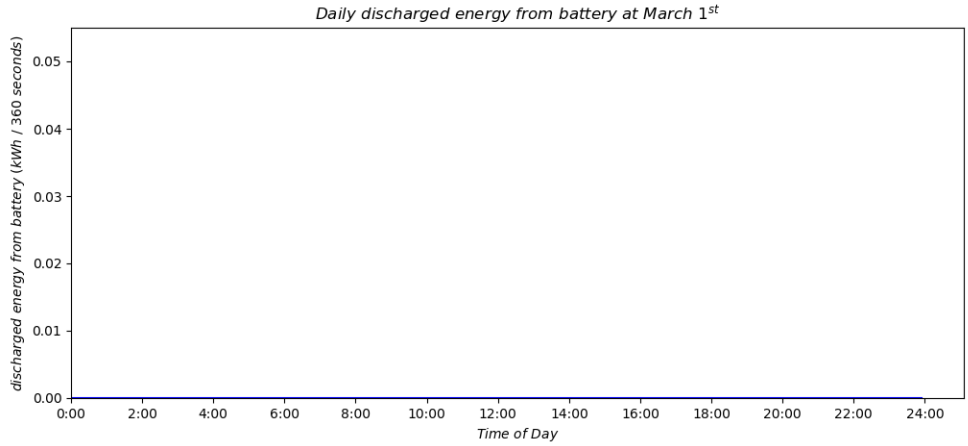
A-3. Battery - daily discharged energy



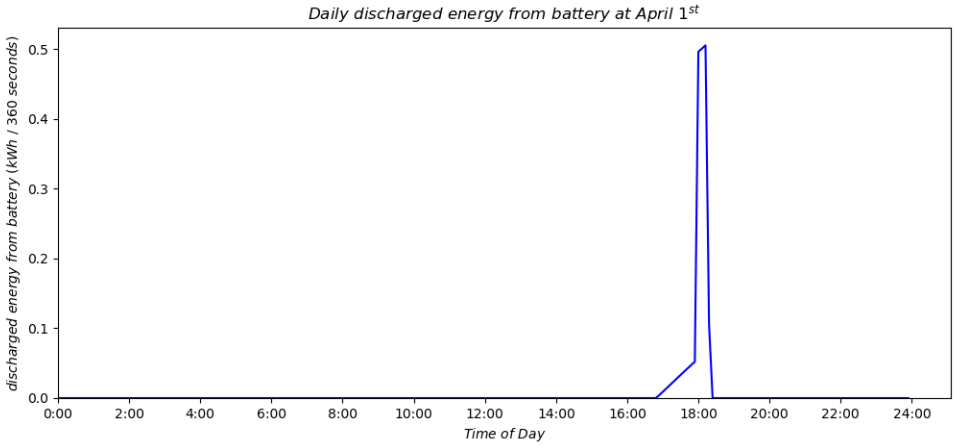
A-3. Battery - daily discharged energy



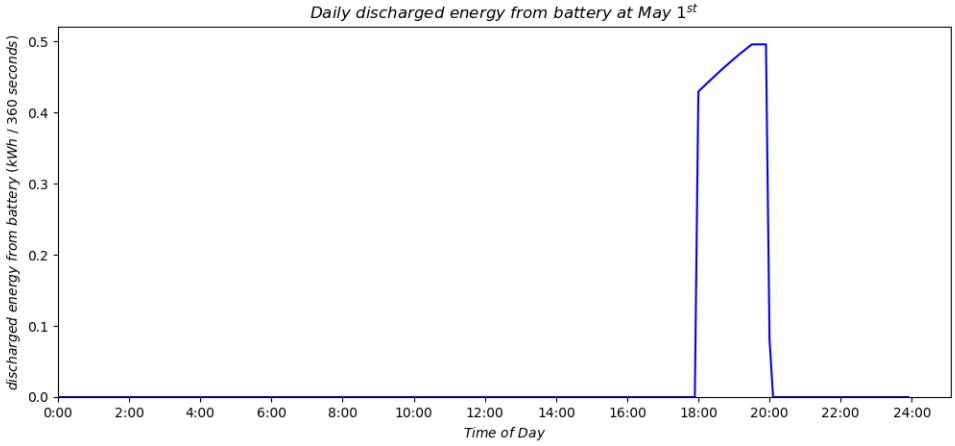
A-3. Battery - daily discharged energy



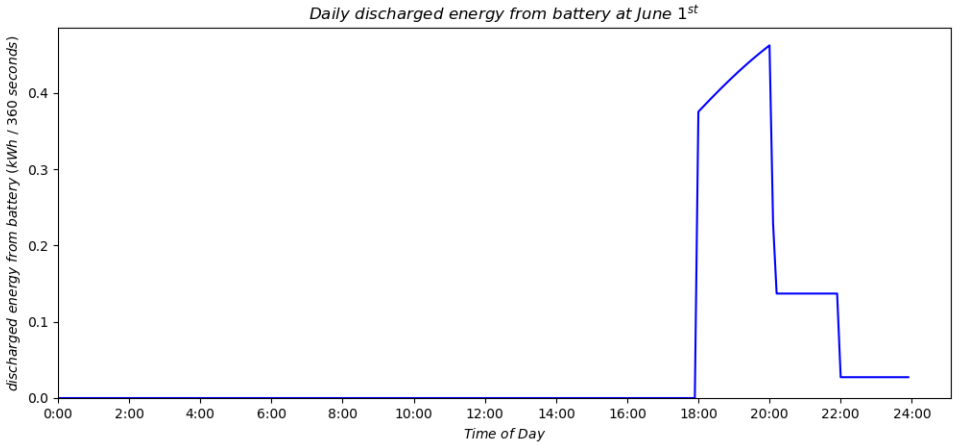
A-3. Battery - daily discharged energy



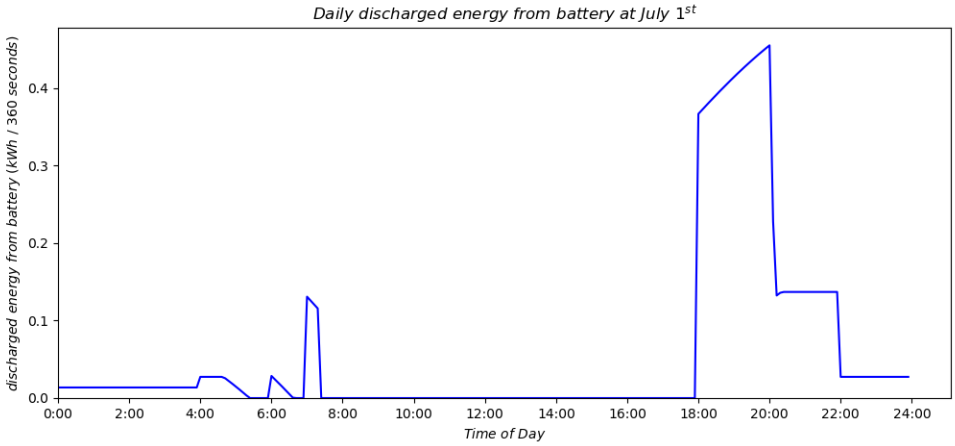
A-3. Battery - daily discharged energy



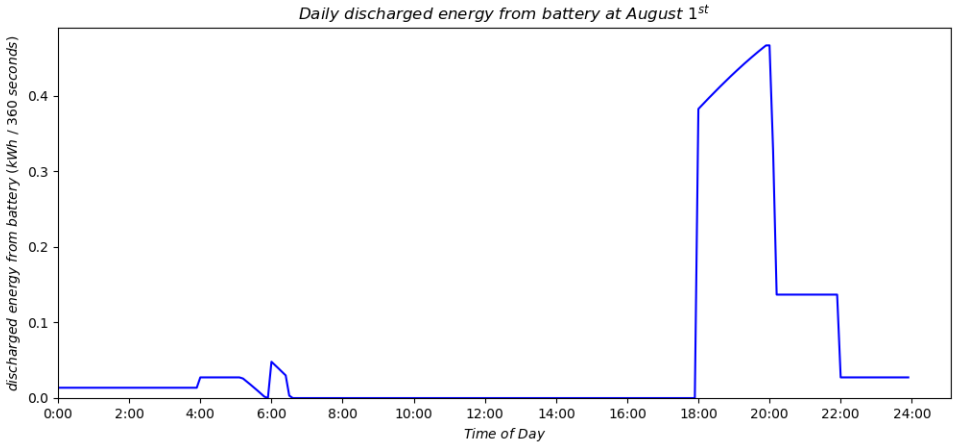
A-3. Battery - daily discharged energy



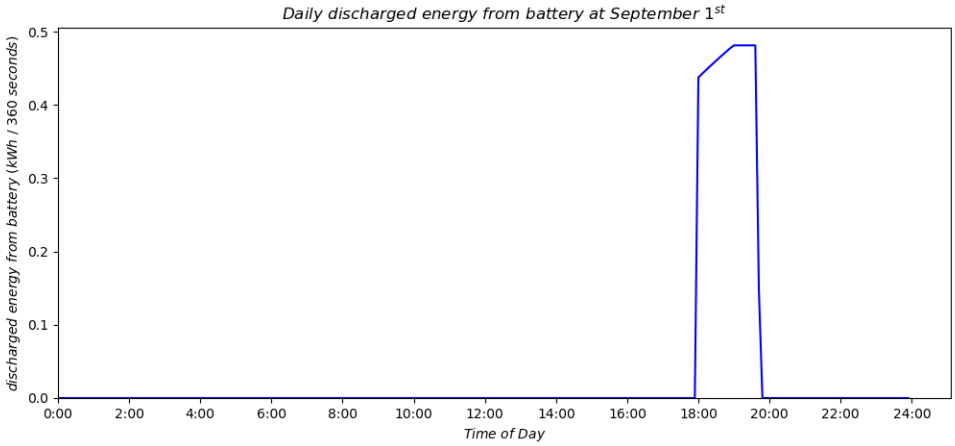
A-3. Battery - daily discharged energy



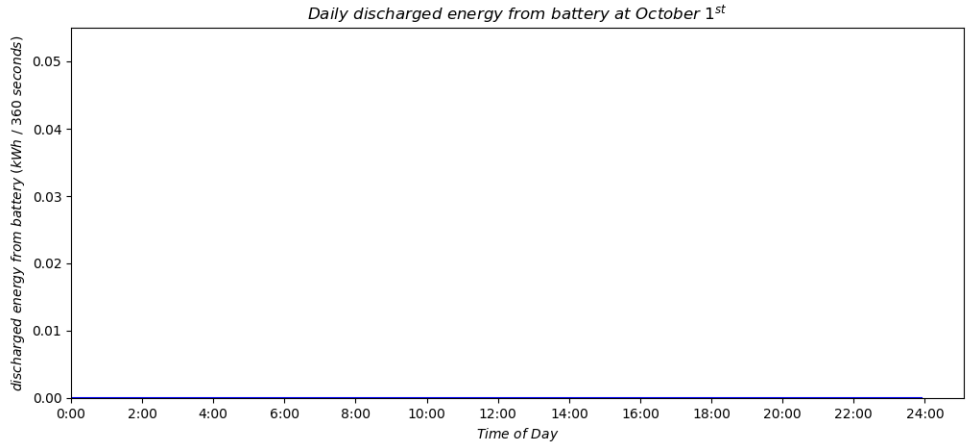
A-3. Battery - daily discharged energy



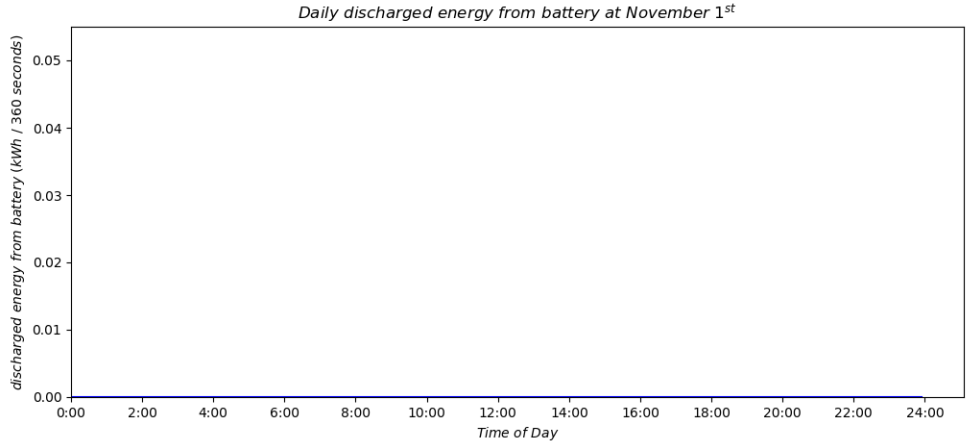
A-3. Battery - daily discharged energy



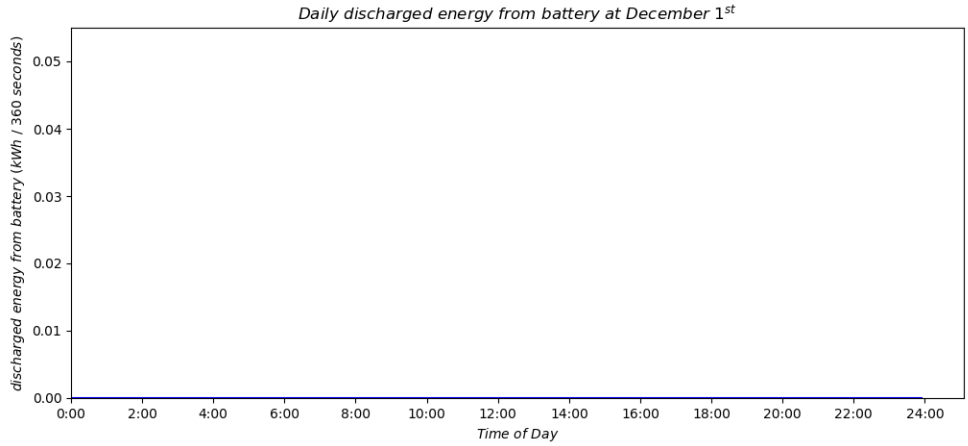
A-3. Battery - daily discharged energy



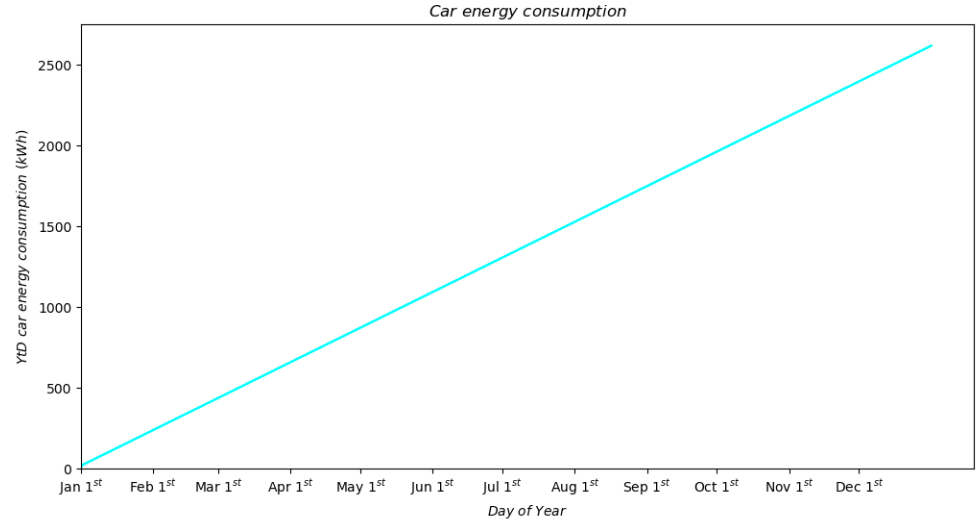
A-3. Battery - daily discharged energy

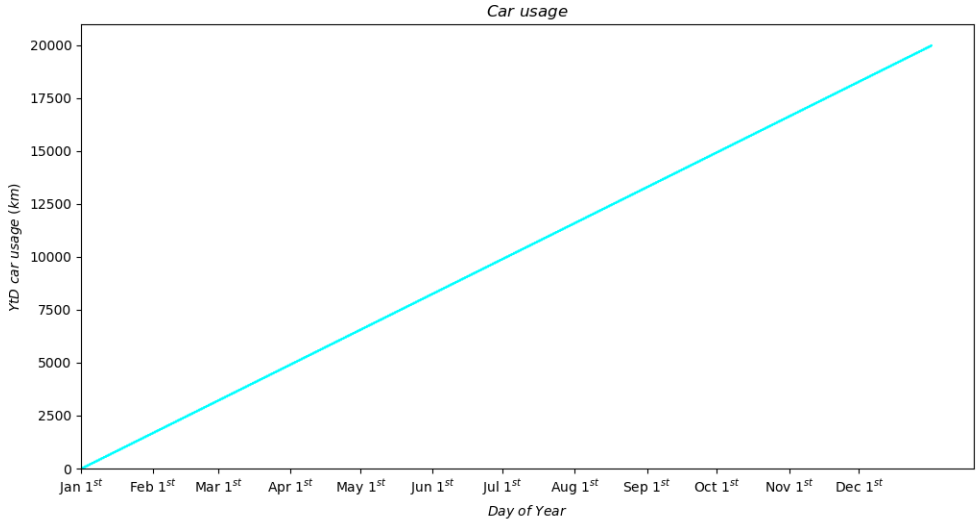


A-3. Battery - daily discharged energy

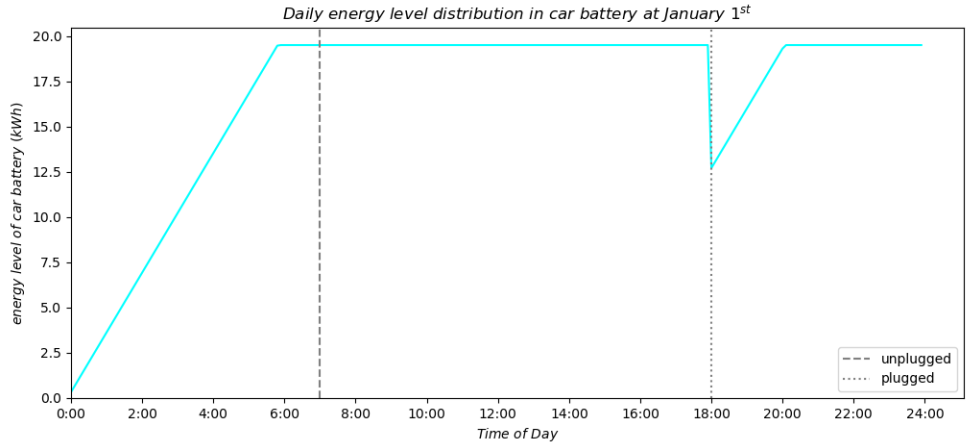


A-4. Electrical car - annual consumption and usage

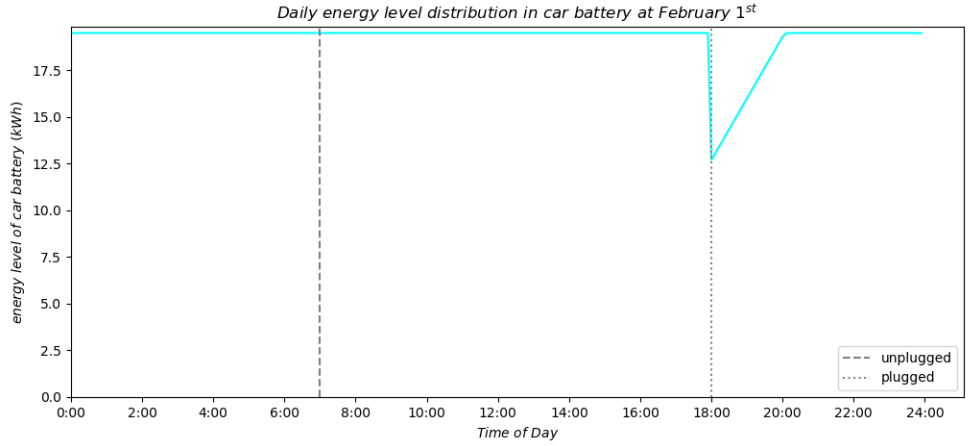




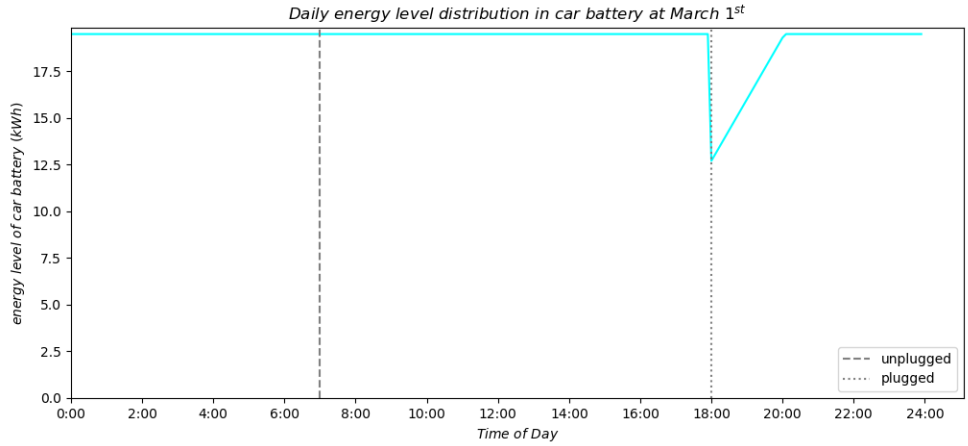
A-4. Electrical car - daily charge level



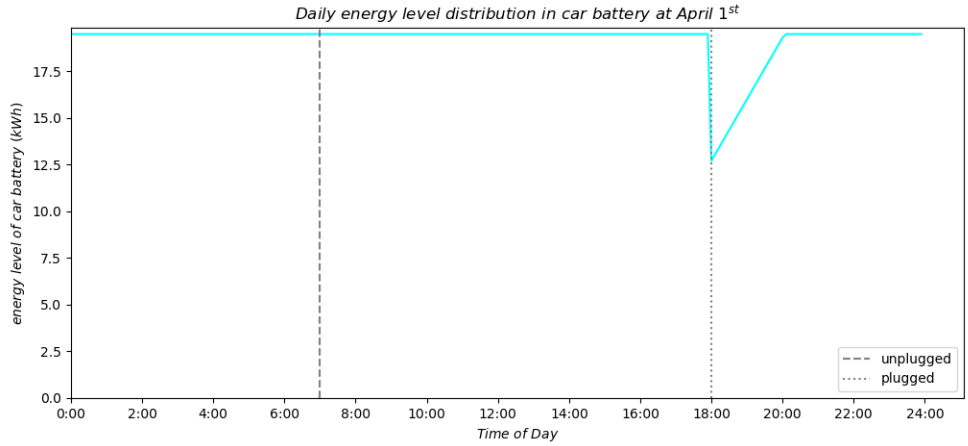
A-4. Electrical car - daily charge level



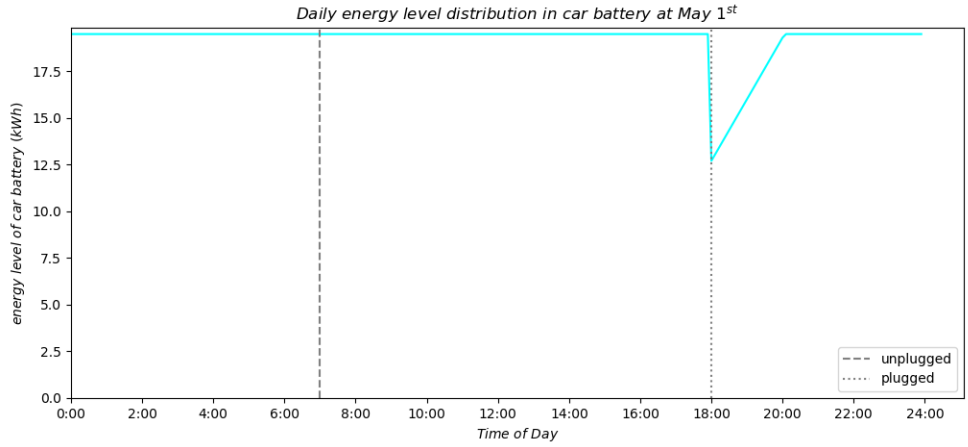
A-4. Electrical car - daily charge level



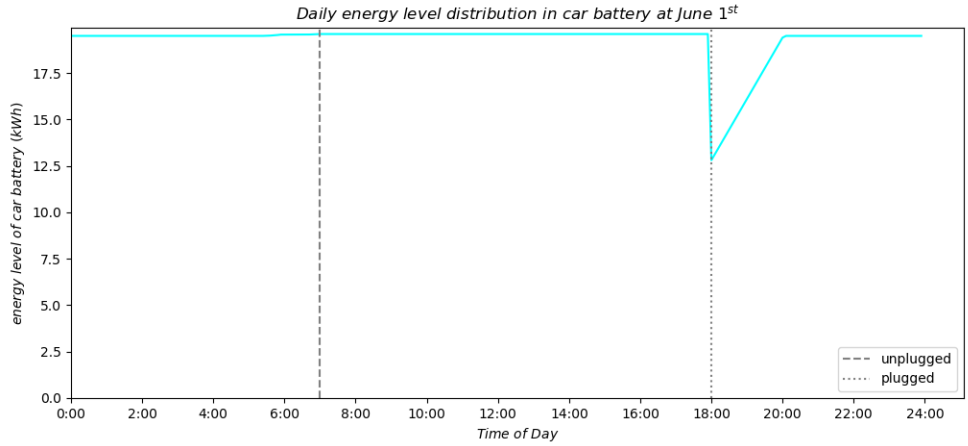
A-4. Electrical car - daily charge level



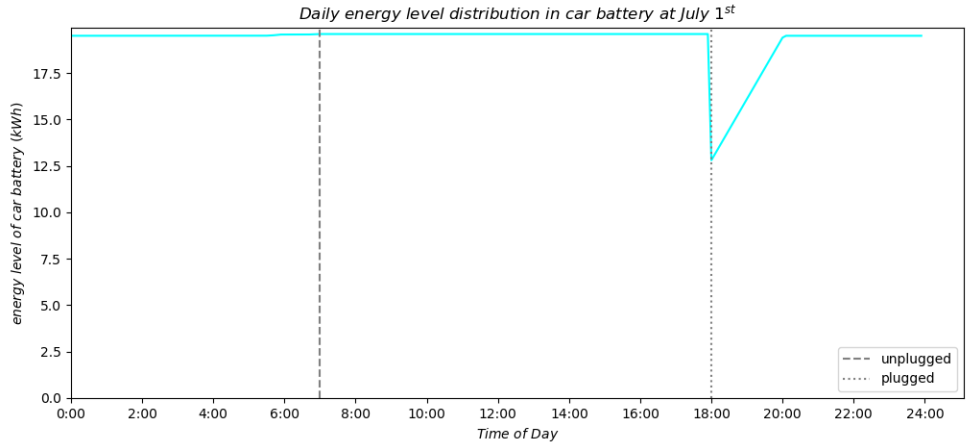
A-4. Electrical car - daily charge level



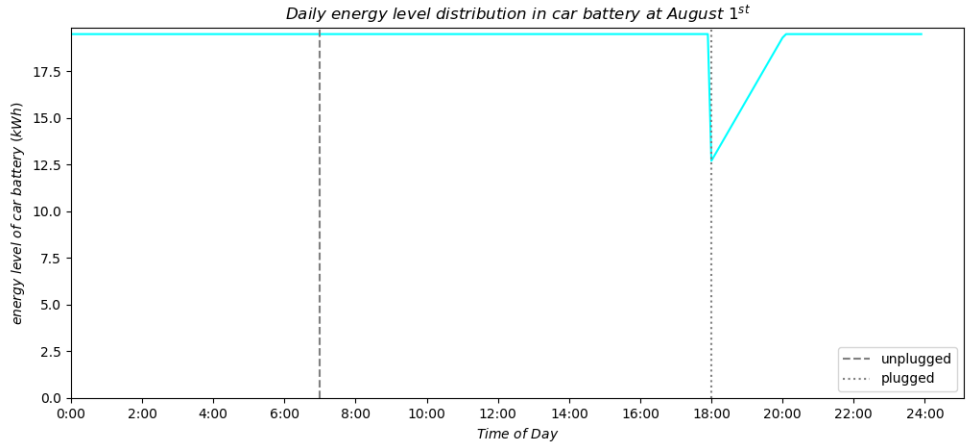
A-4. Electrical car - daily charge level



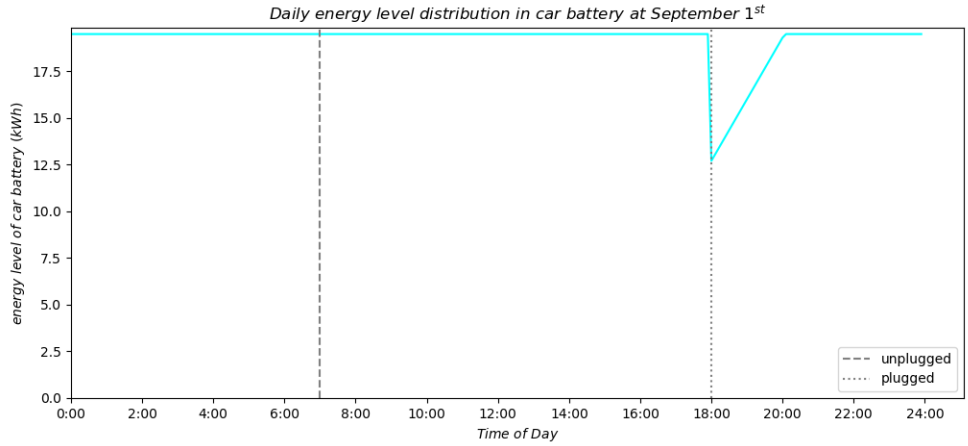
A-4. Electrical car - daily charge level



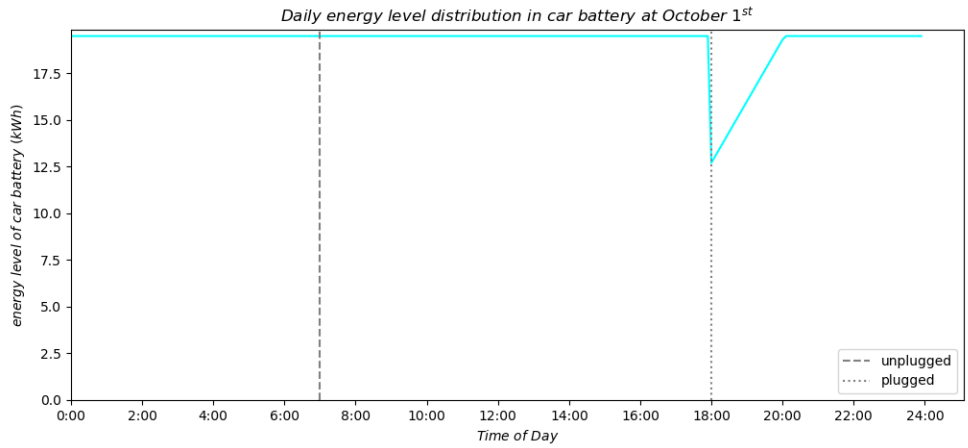
A-4. Electrical car - daily charge level



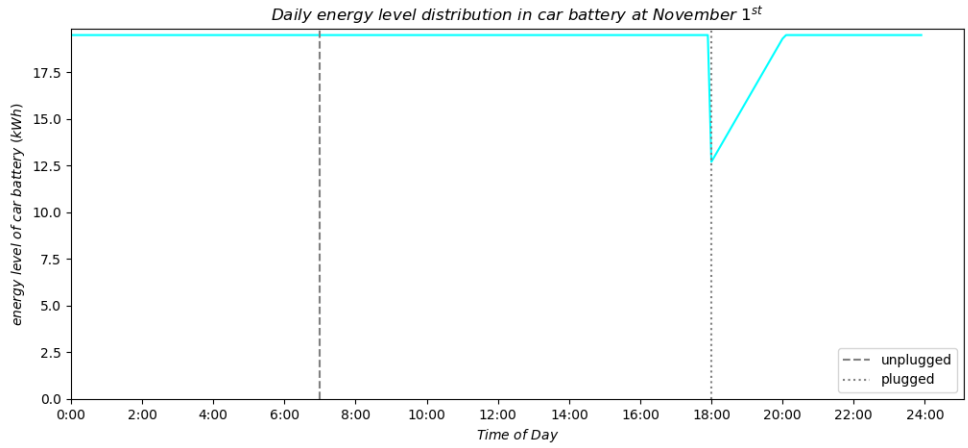
A-4. Electrical car - daily charge level



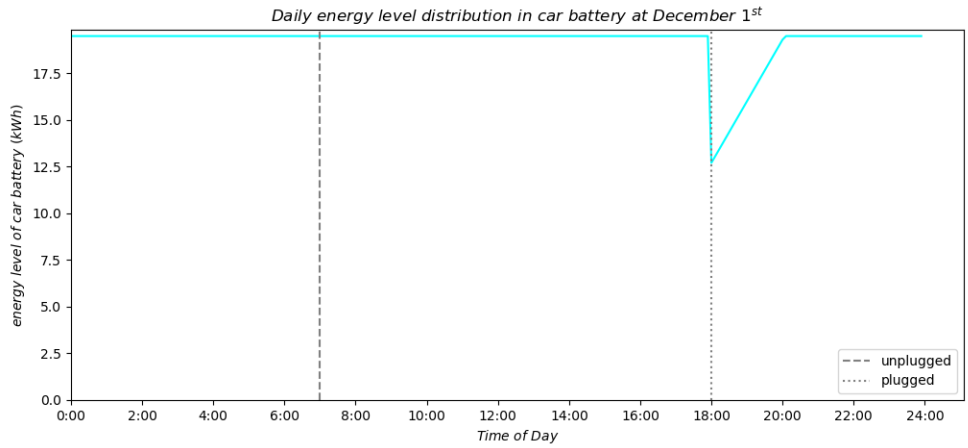
A-4. Electrical car - daily charge level



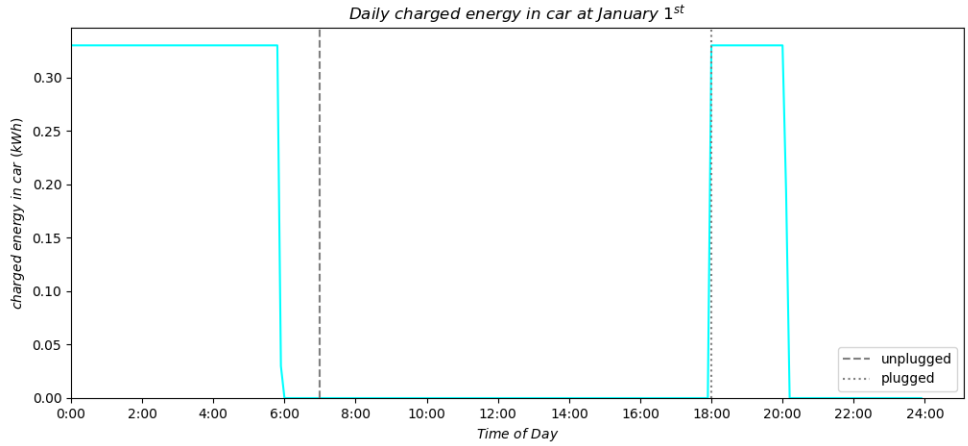
A-4. Electrical car - daily charge level



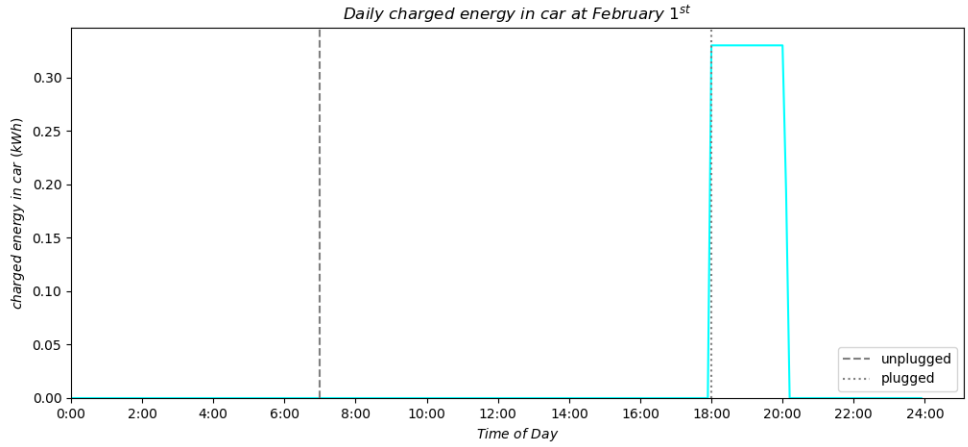
A-4. Electrical car - daily charge level



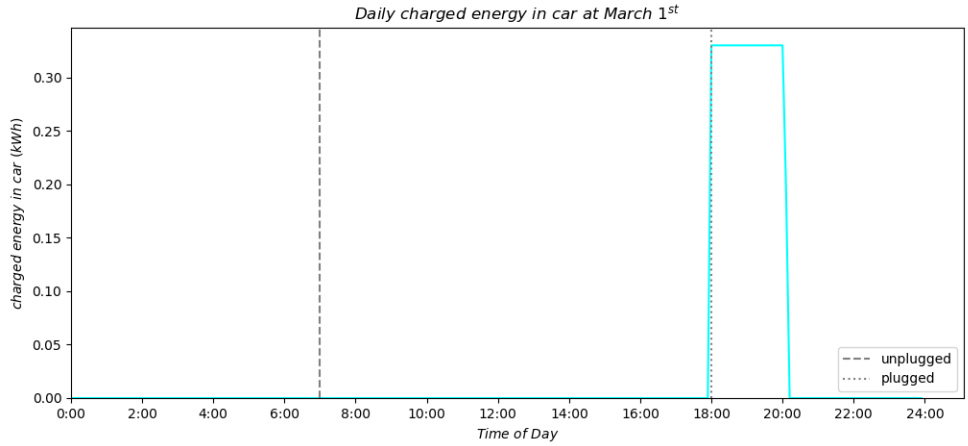
A-4. Electrical car - daily charged energy



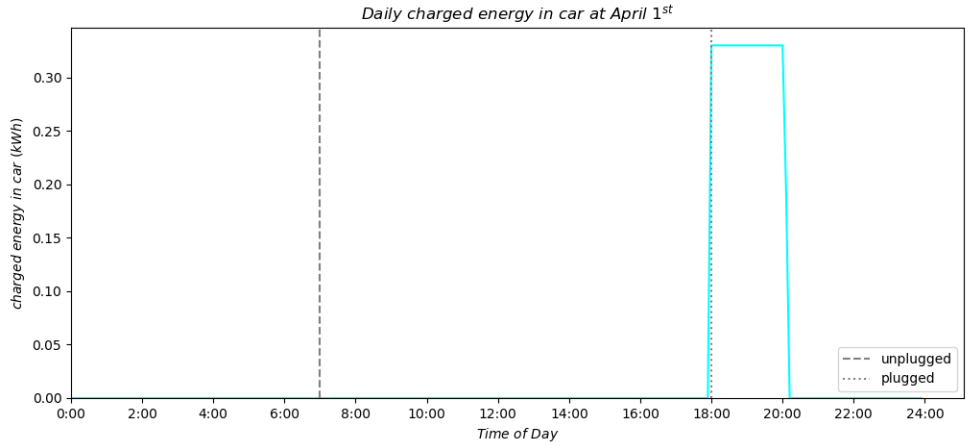
A-4. Electrical car - daily charged energy



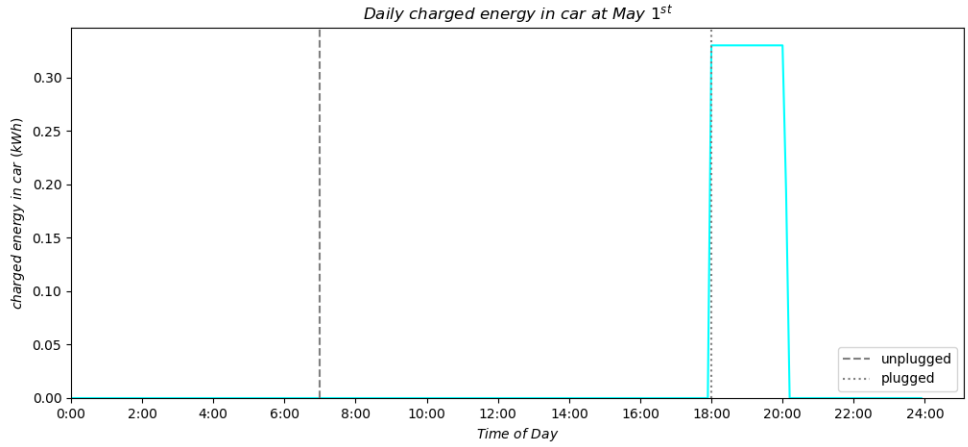
A-4. Electrical car - daily charged energy



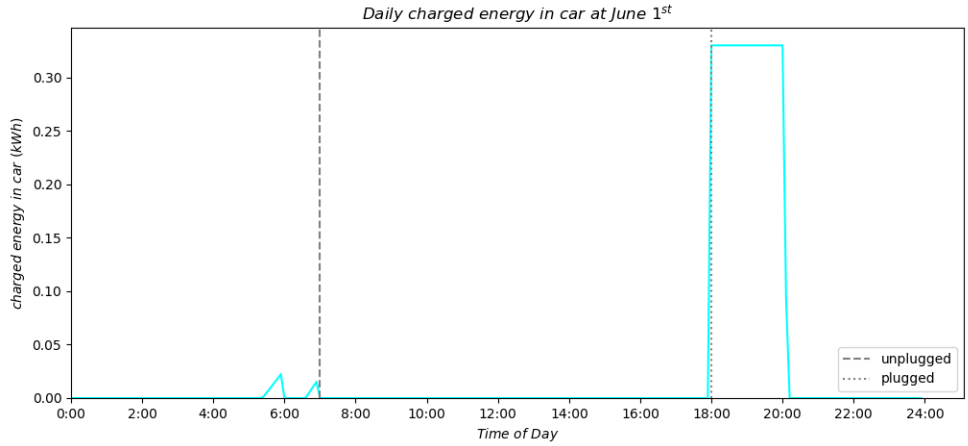
A-4. Electrical car - daily charged energy



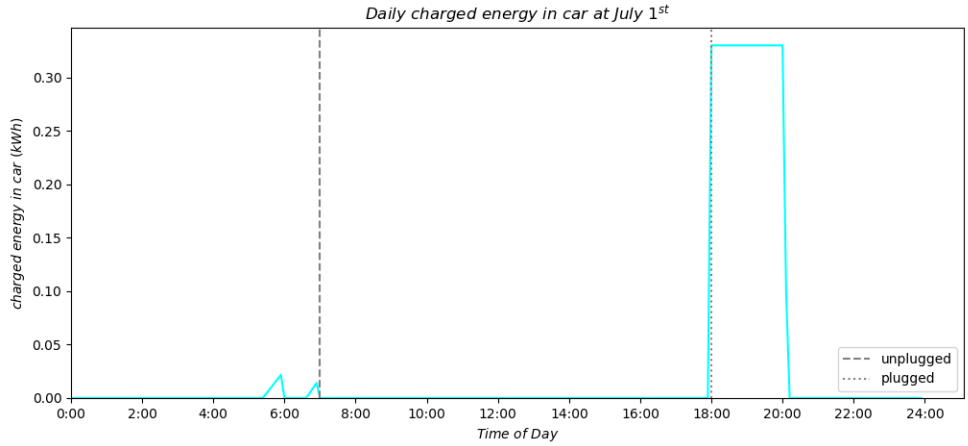
A-4. Electrical car - daily charged energy



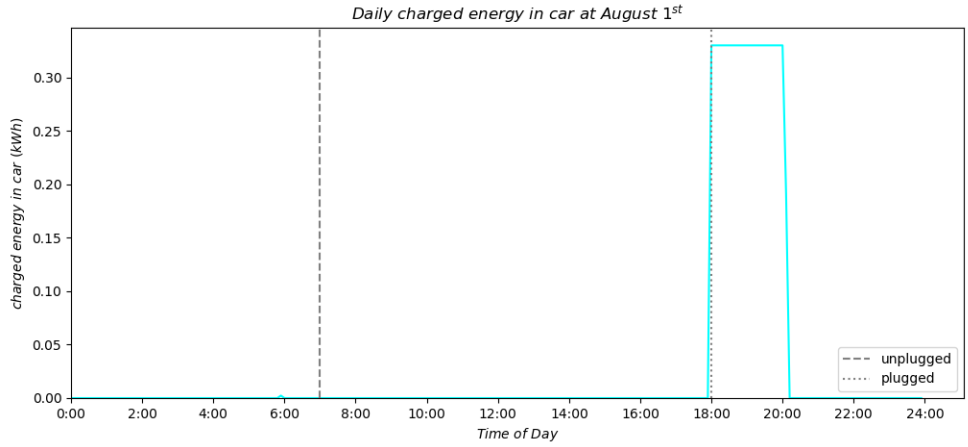
A-4. Electrical car - daily charged energy



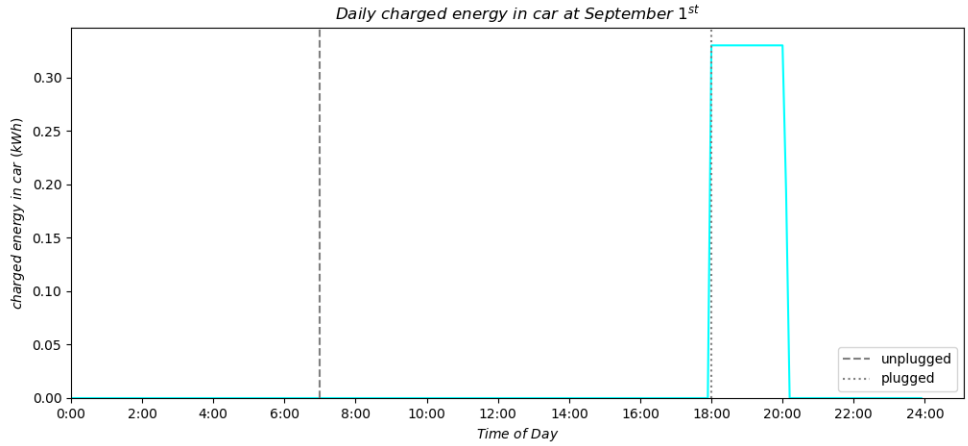
A-4. Electrical car - daily charged energy



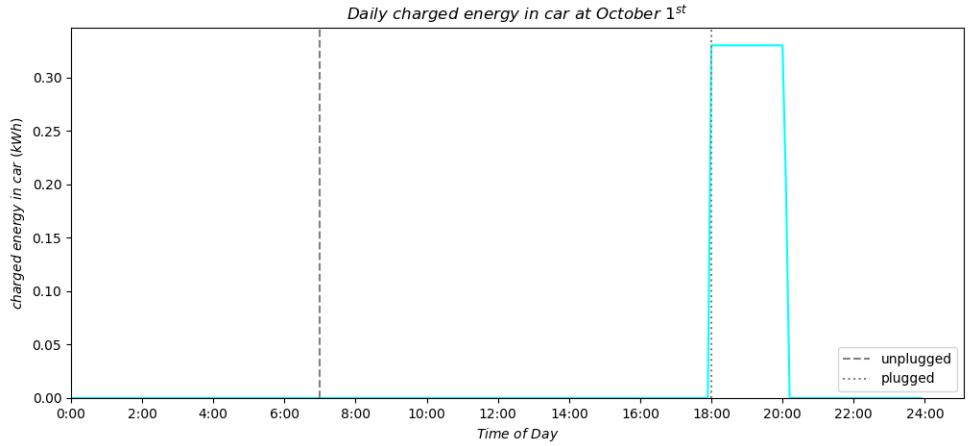
A-4. Electrical car - daily charged energy



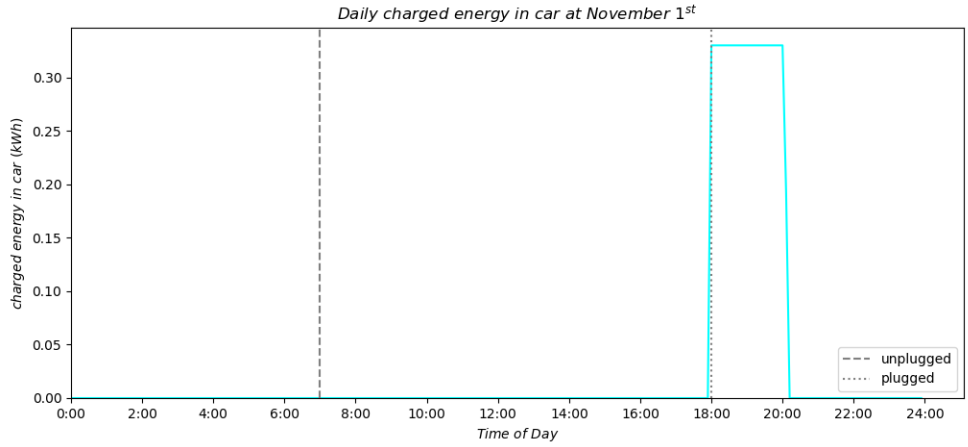
A-4. Electrical car - daily charged energy



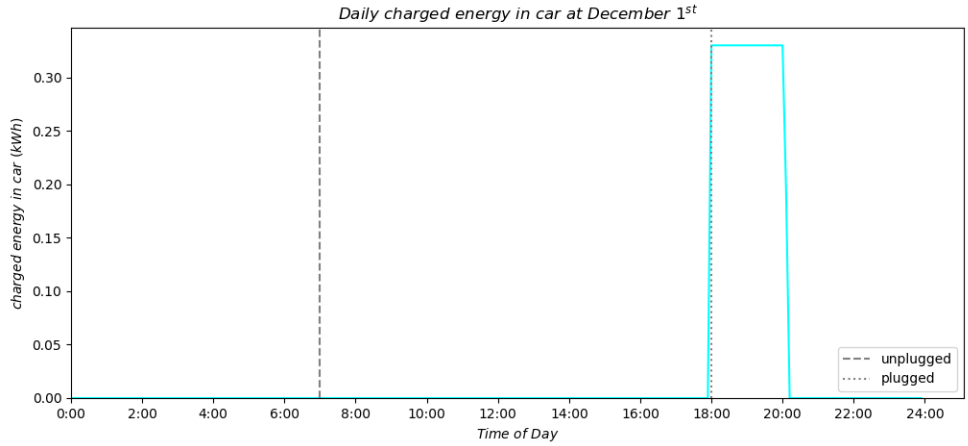
A-4. Electrical car - daily charged energy



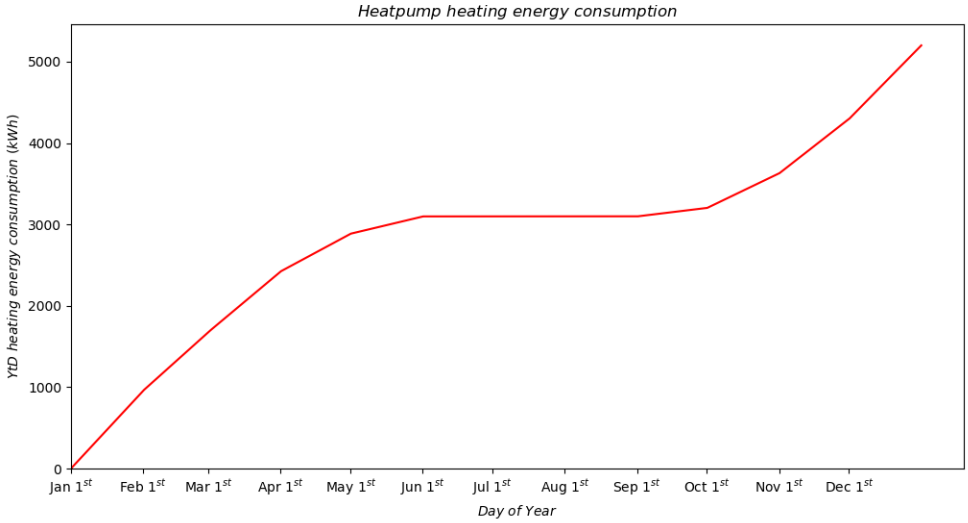
A-4. Electrical car - daily charged energy



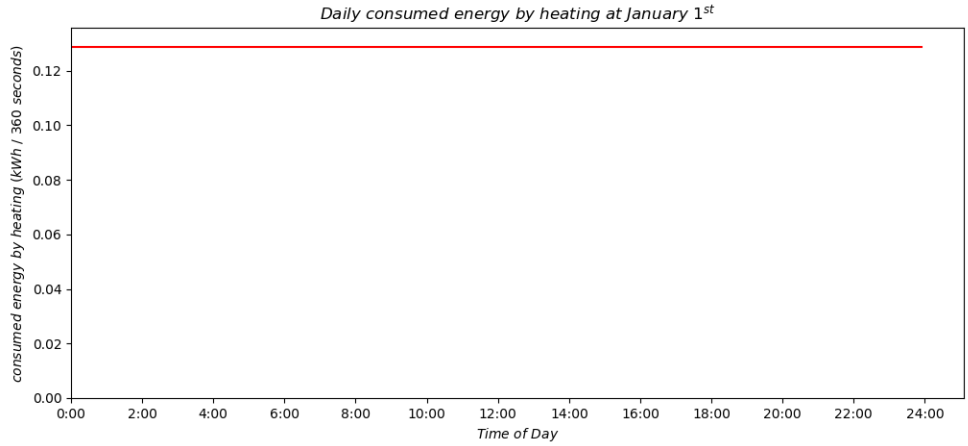
A-4. Electrical car - daily charged energy



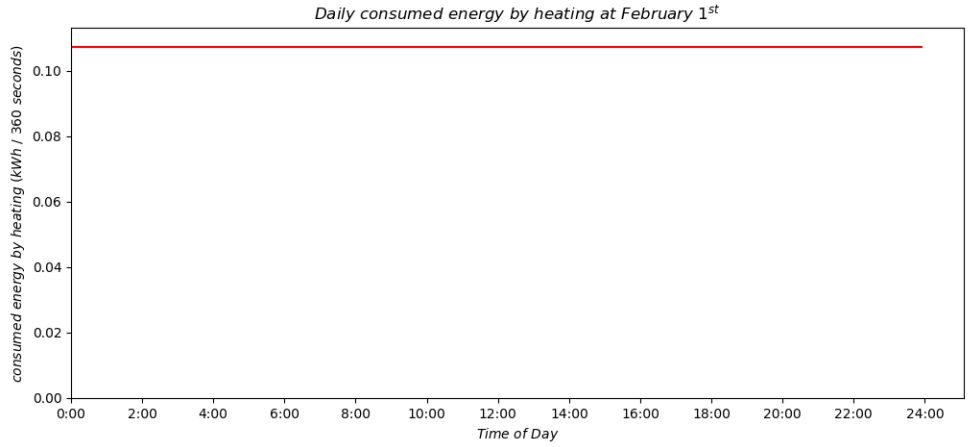
A-5. Heatpump heating - annual consumption



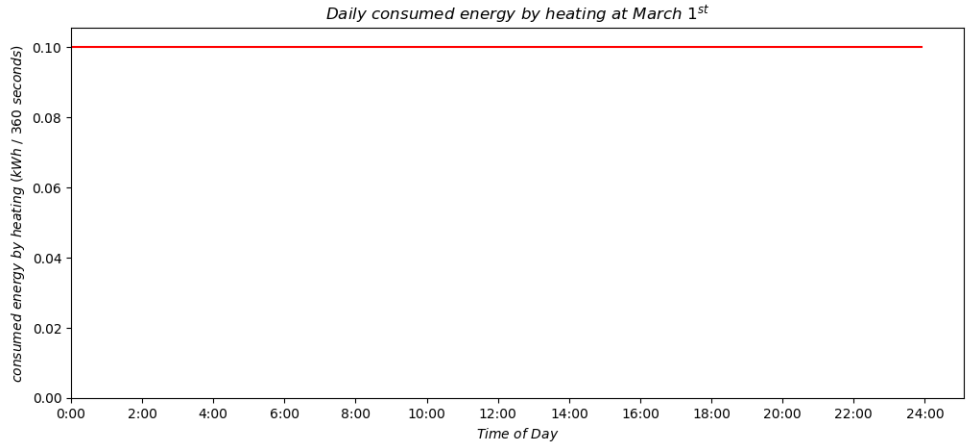
A-5. Heatpump heating - daily consumption



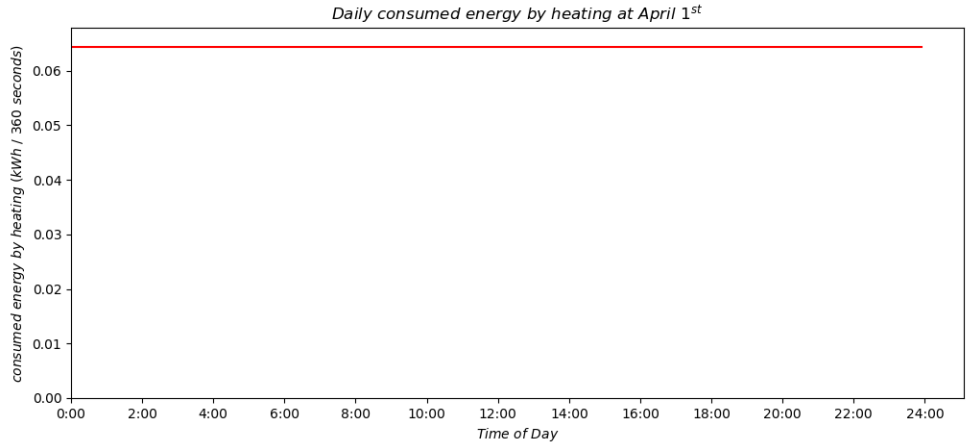
A-5. Heatpump heating - daily consumption



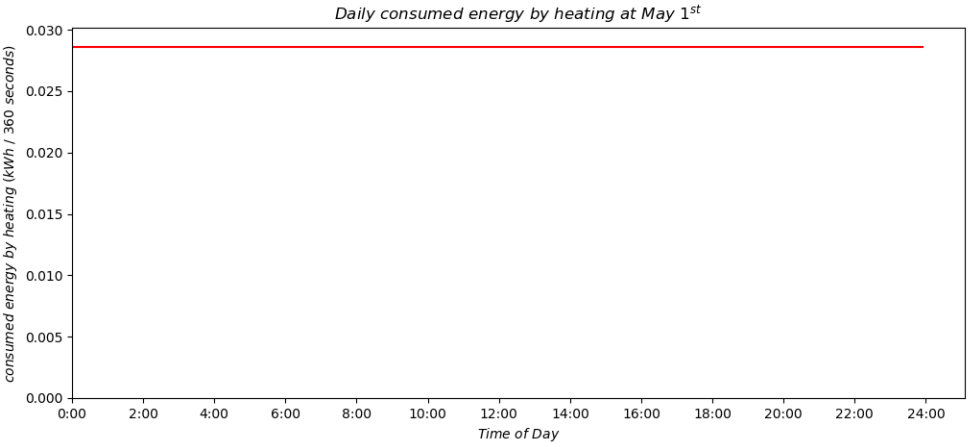
A-5. Heatpump heating - daily consumption



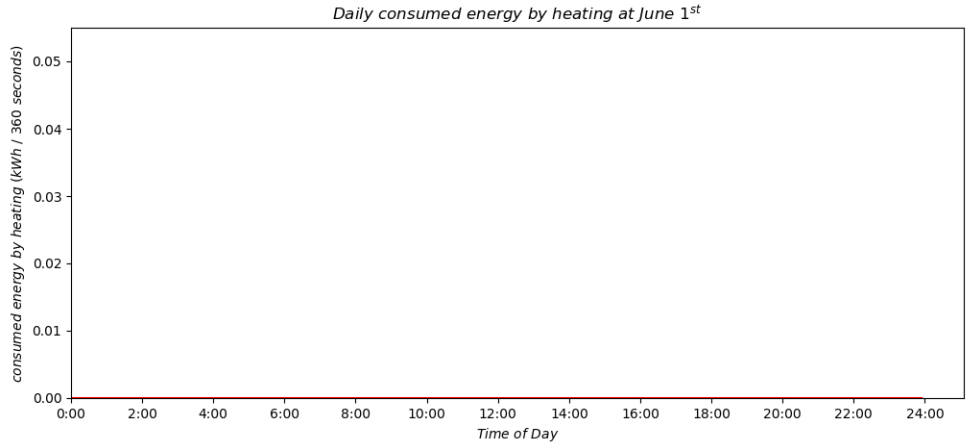
A-5. Heatpump heating - daily consumption



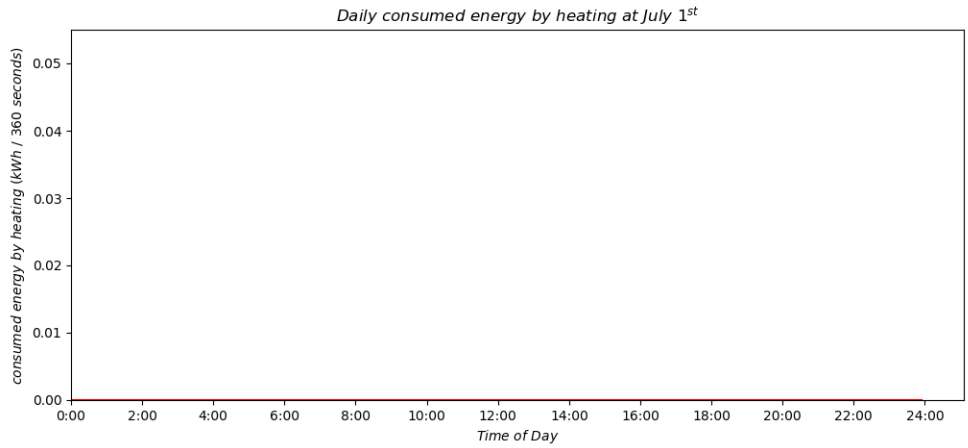
A-5. Heatpump heating - daily consumption



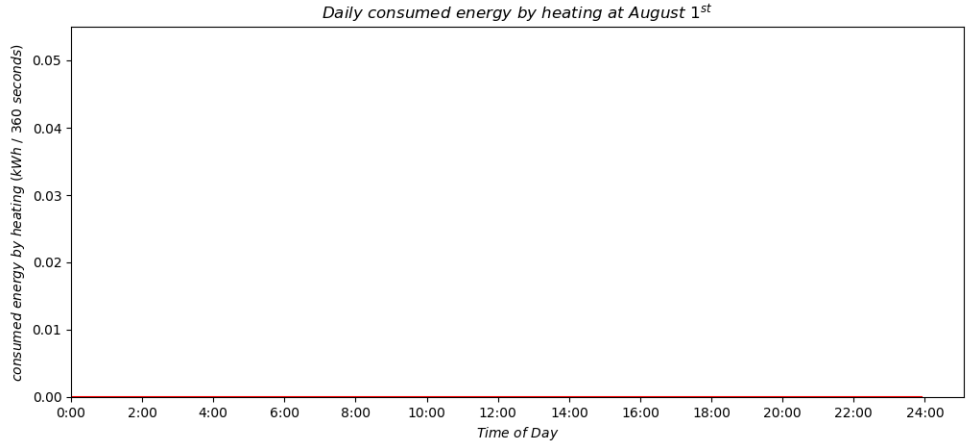
A-5. Heatpump heating - daily consumption



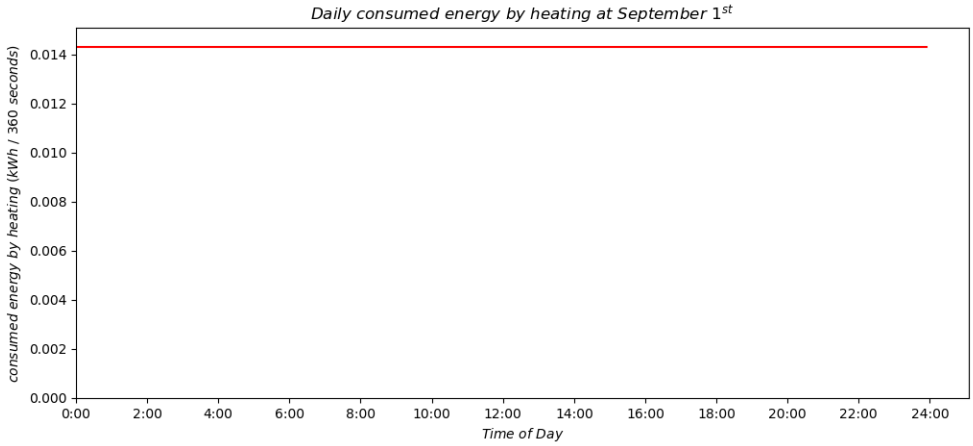
A-5. Heatpump heating - daily consumption



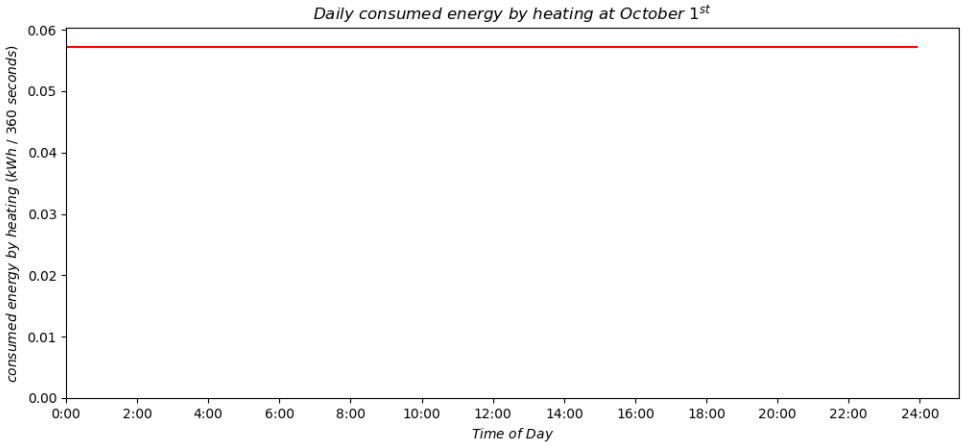
A-5. Heatpump heating - daily consumption



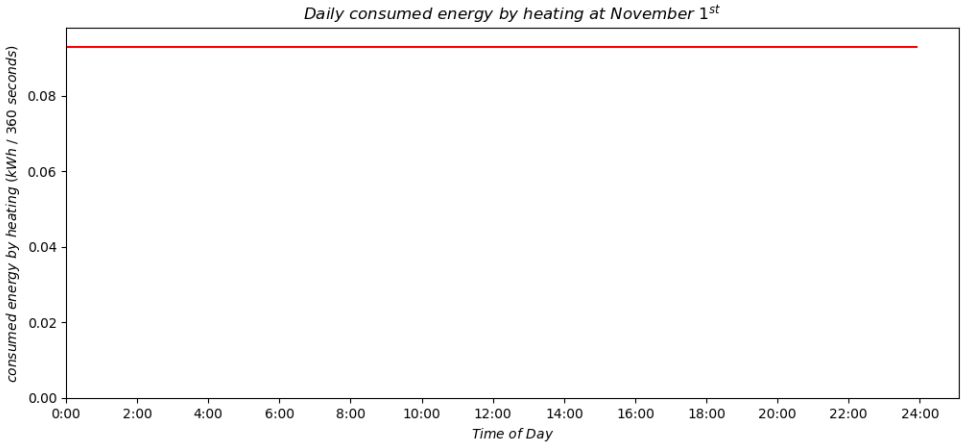
A-5. Heatpump heating - daily consumption



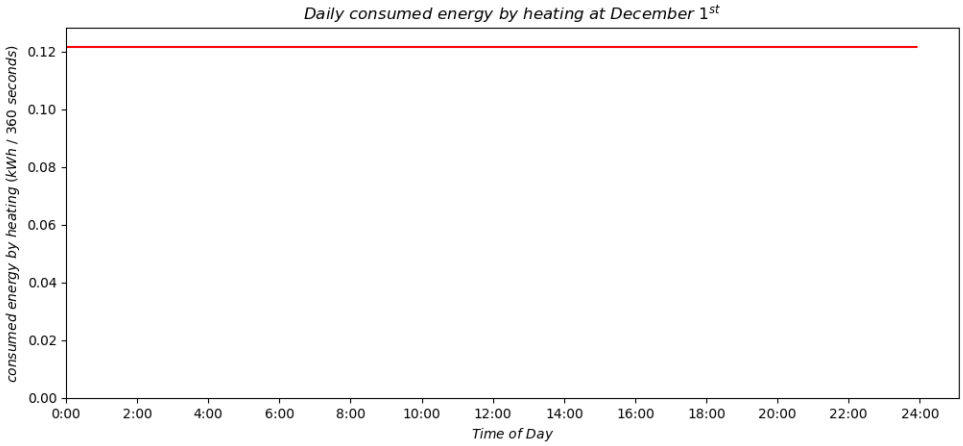
A-5. Heatpump heating - daily consumption



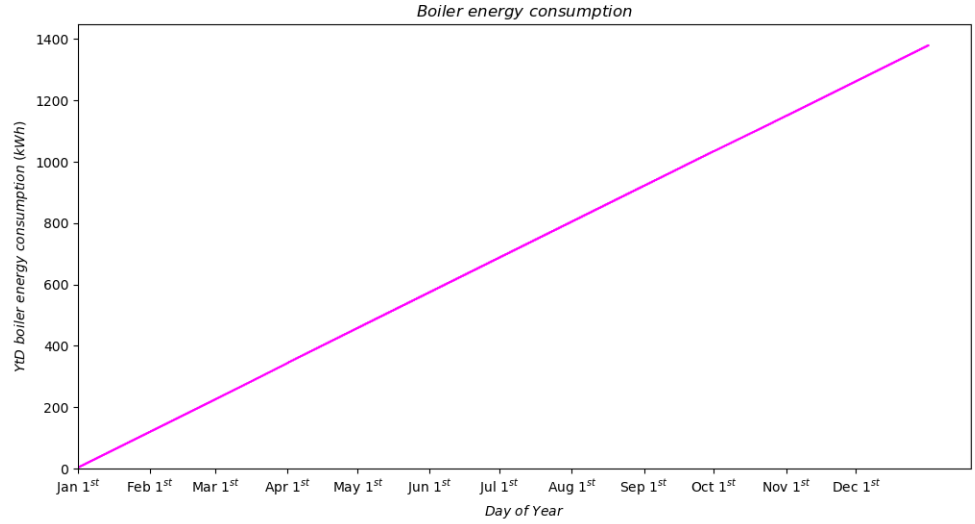
A-5. Heatpump heating - daily consumption

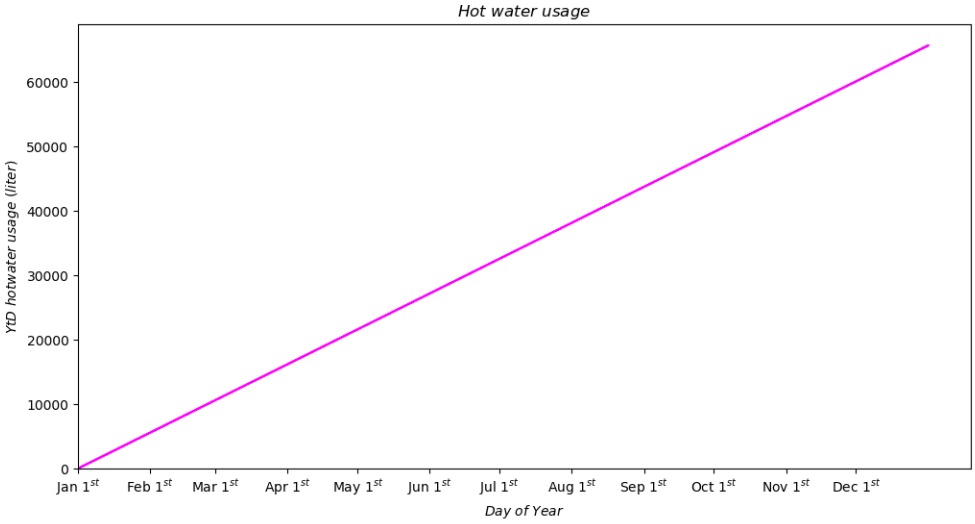


A-5. Heatpump heating - daily consumption

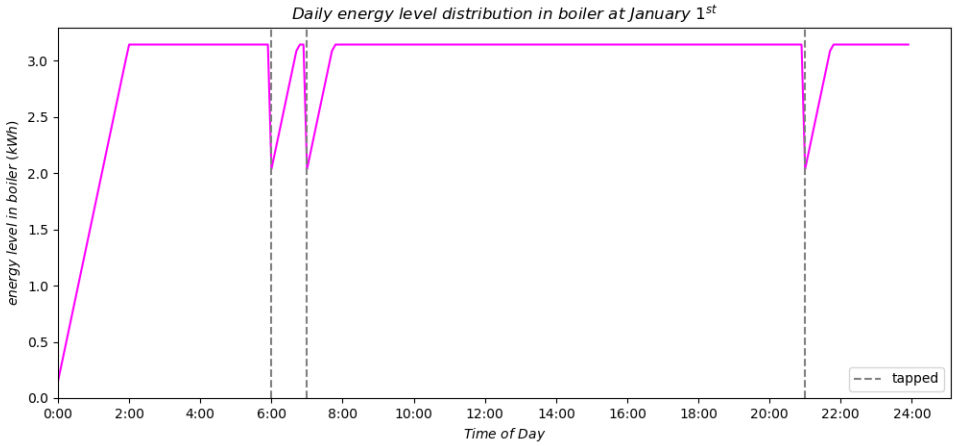


A-6. Heatpump hot water - annual consumption and usage

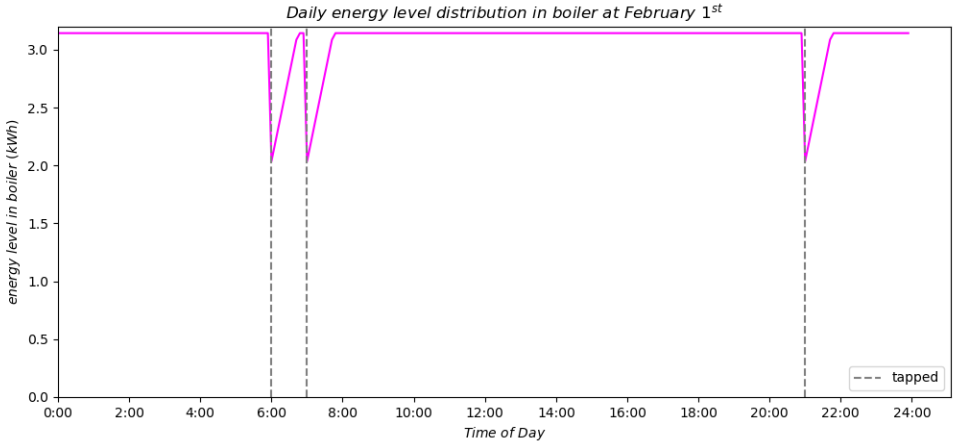




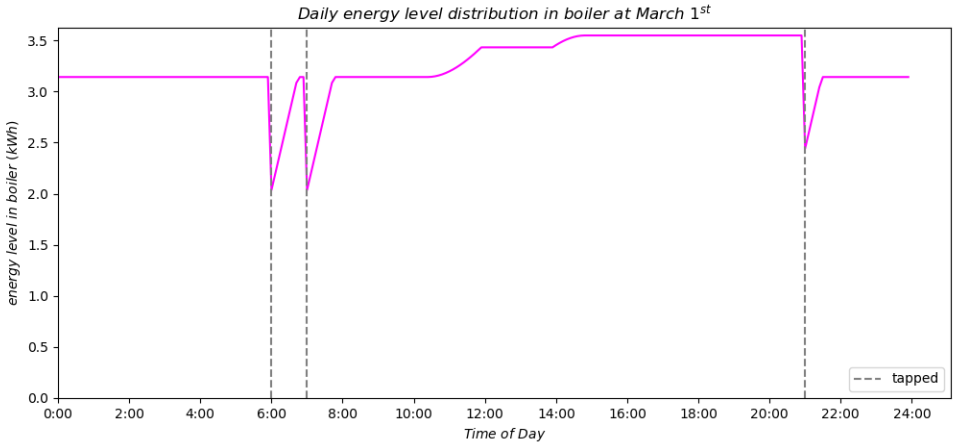
A-6. Heatpump hot water - daily charge level



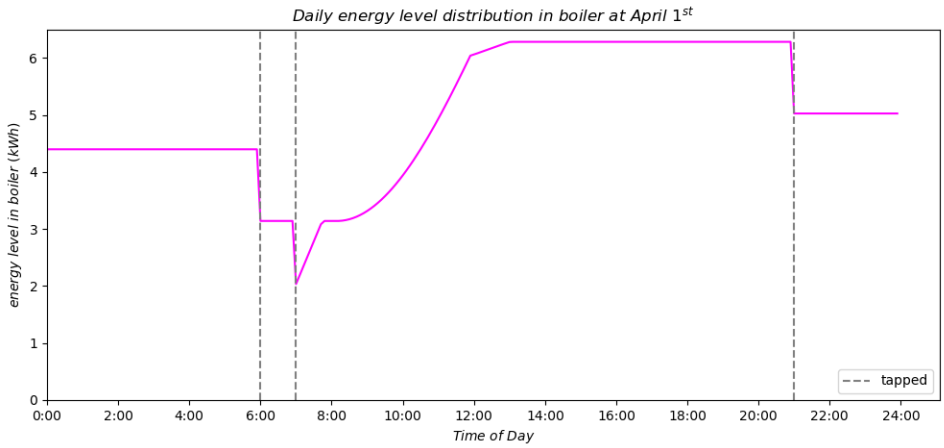
A-6. Heatpump hot water - daily charge level



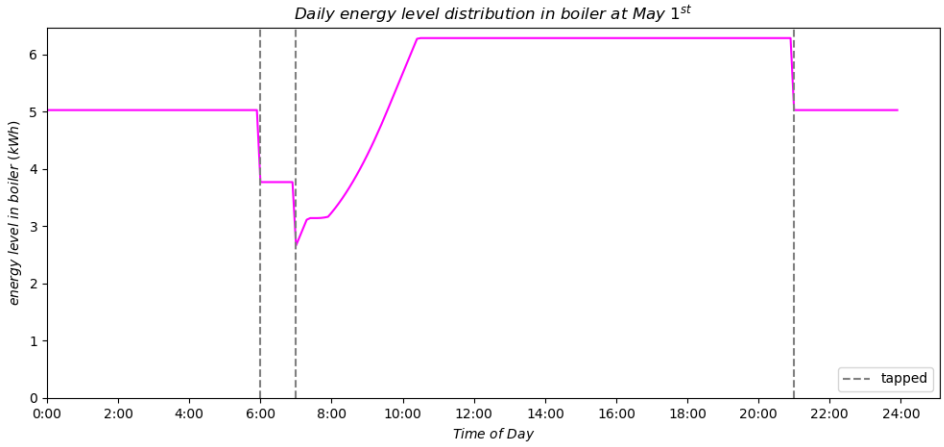
A-6. Heatpump hot water - daily charge level



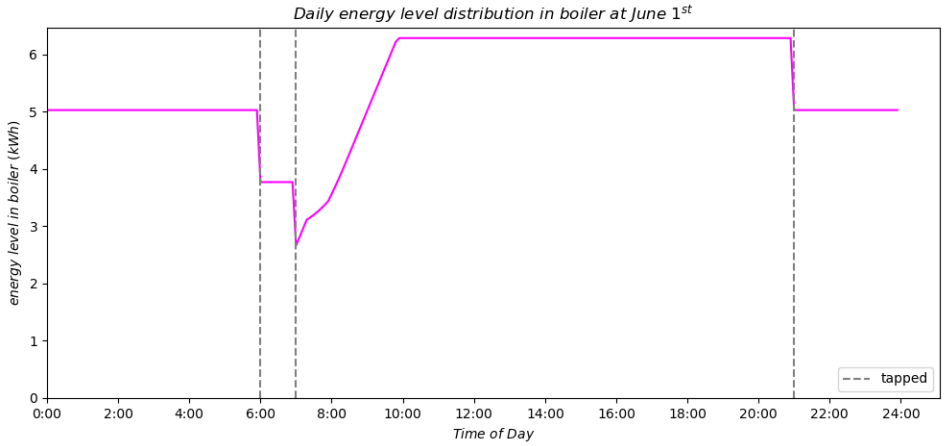
A-6. Heatpump hot water - daily charge level



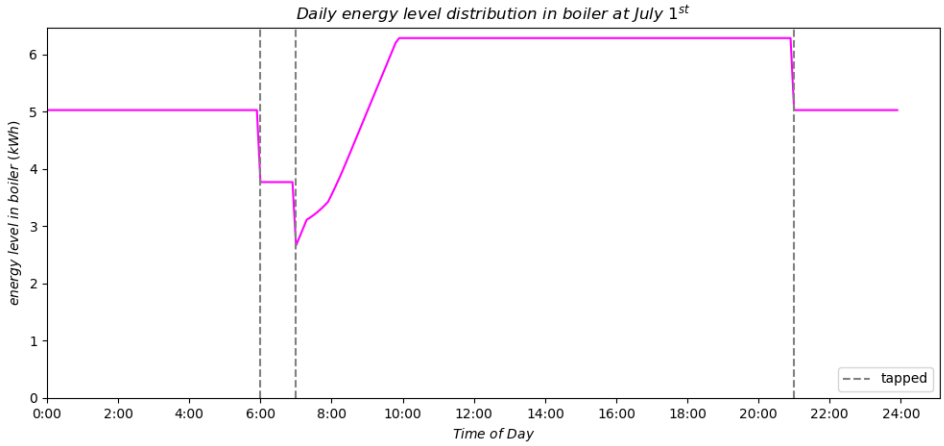
A-6. Heatpump hot water - daily charge level



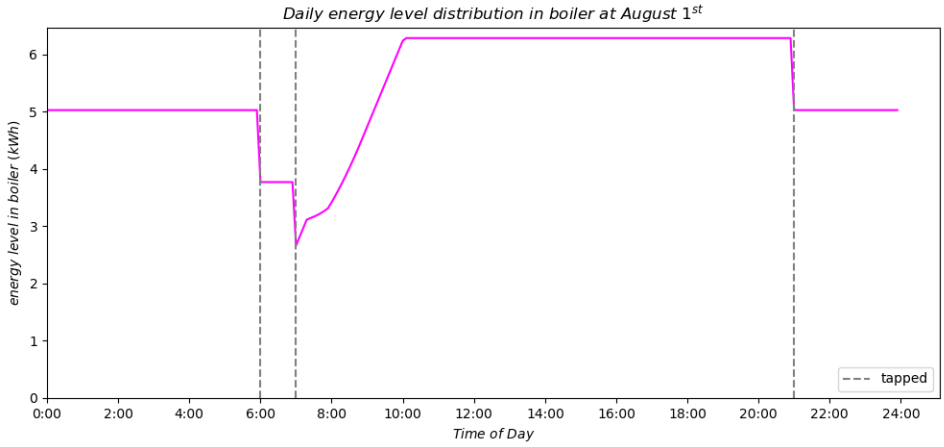
A-6. Heatpump hot water - daily charge level



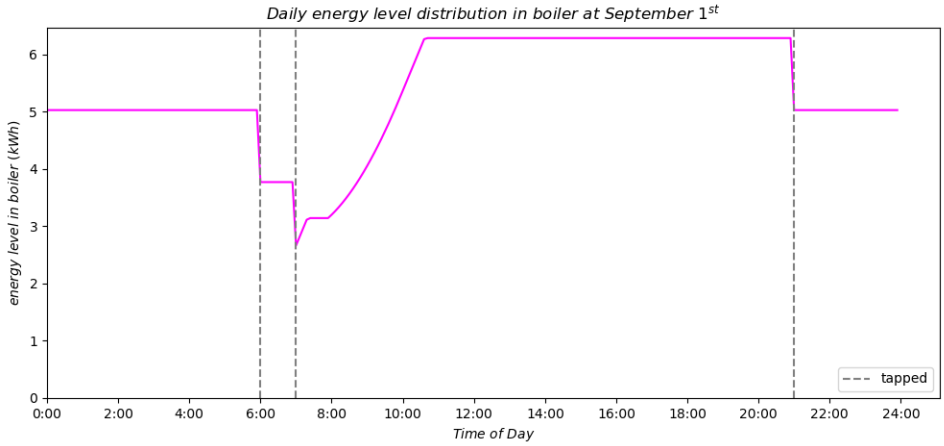
A-6. Heatpump hot water - daily charge level



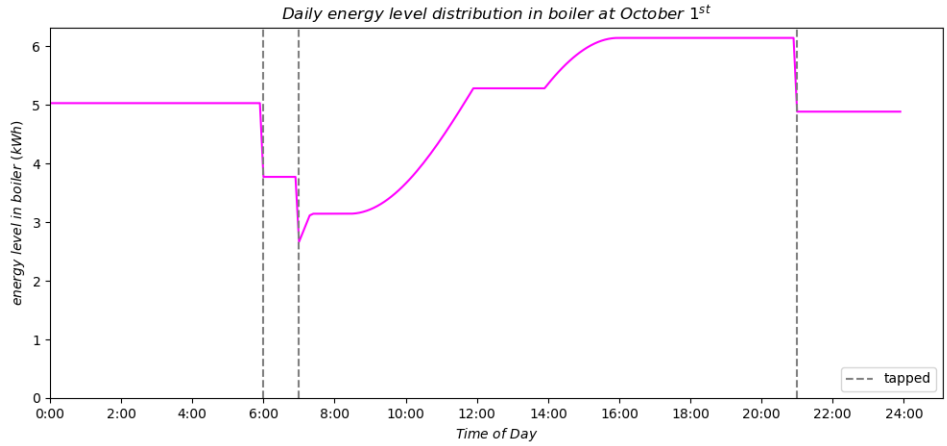
A-6. Heatpump hot water - daily charge level



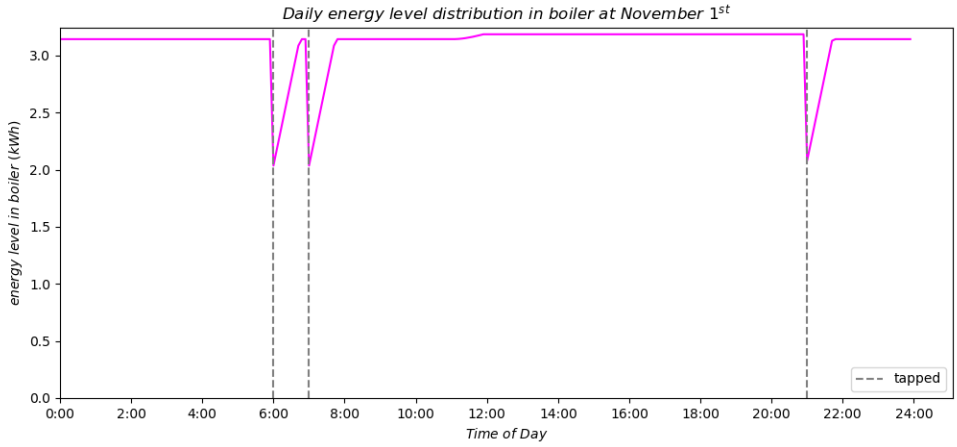
A-6. Heatpump hot water - daily charge level



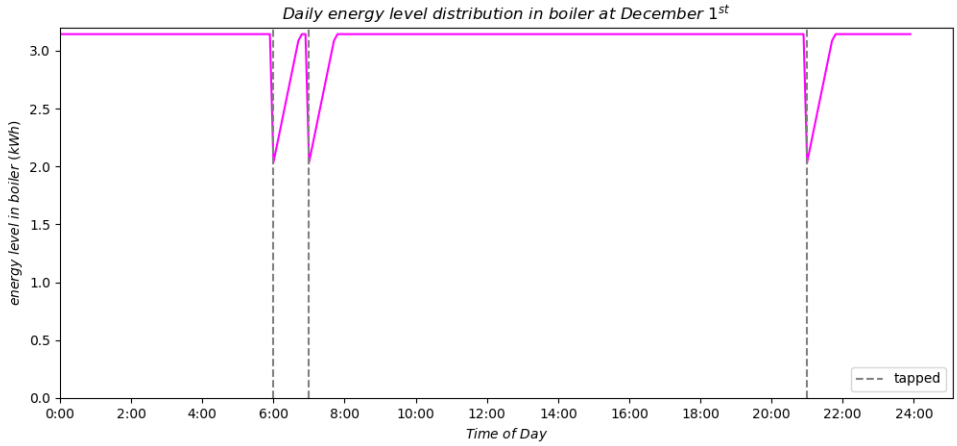
A-6. Heatpump hot water - daily charge level



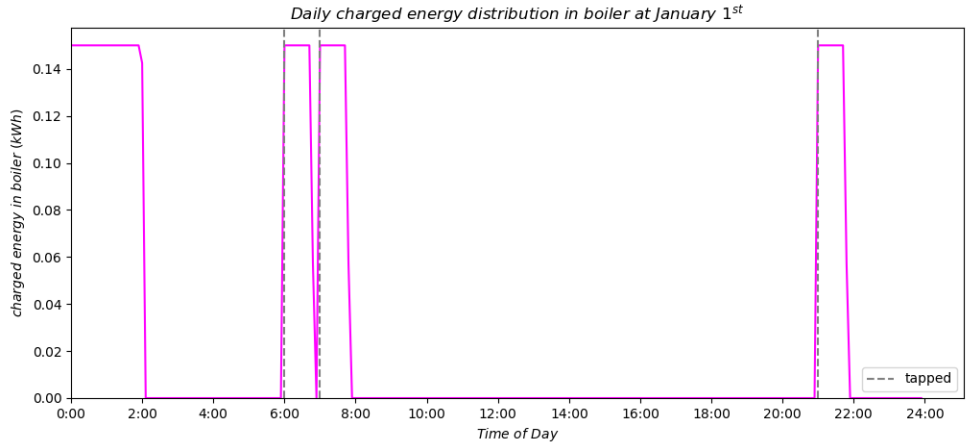
A-6. Heatpump hot water - daily charge level



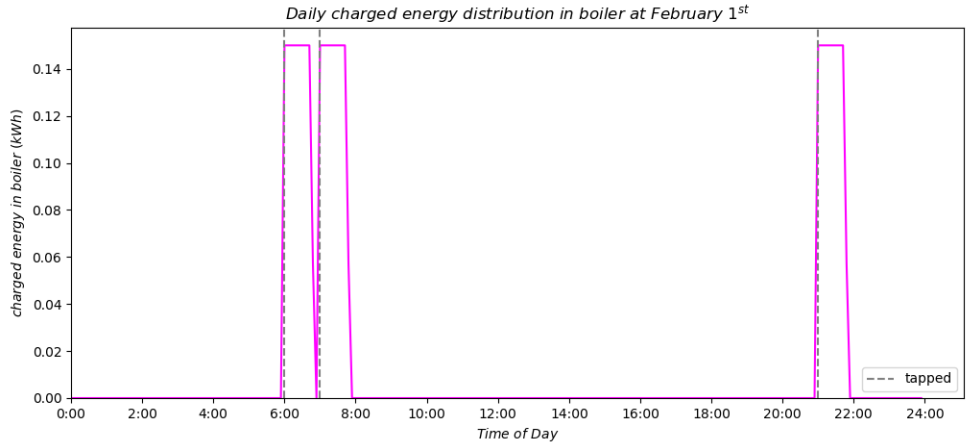
A-6. Heatpump hot water - daily charge level



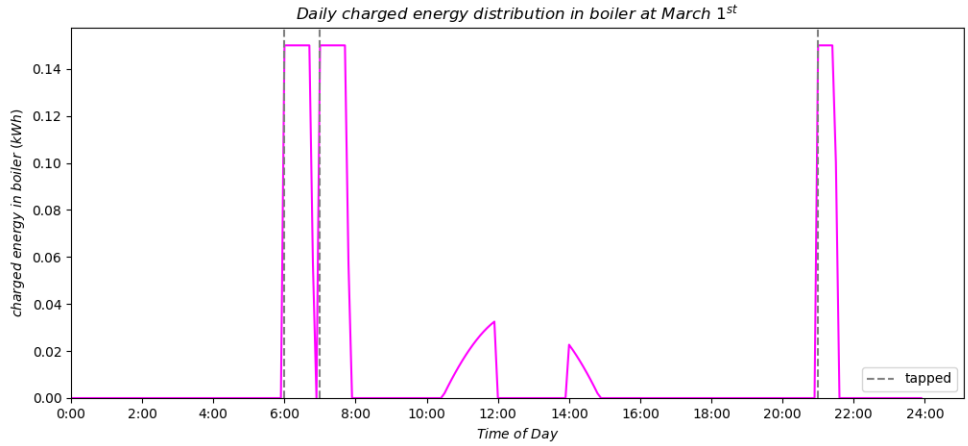
A-6. Heatpump hot water - daily charged energy



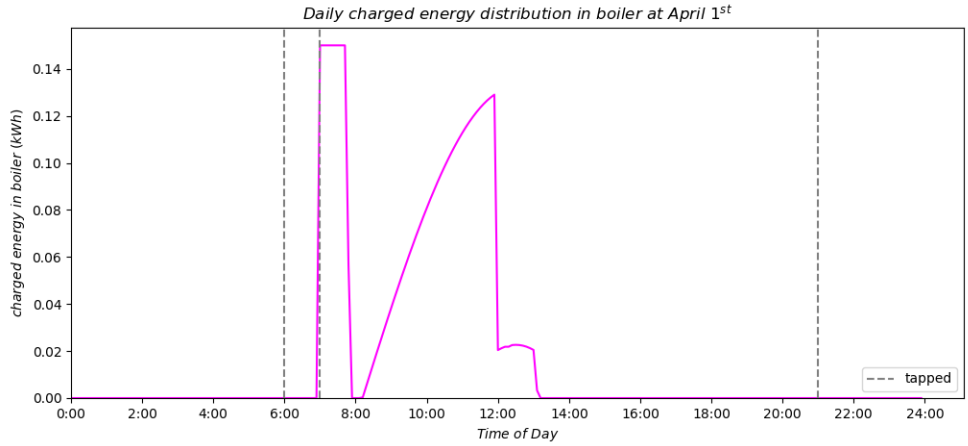
A-6. Heatpump hot water - daily charged energy



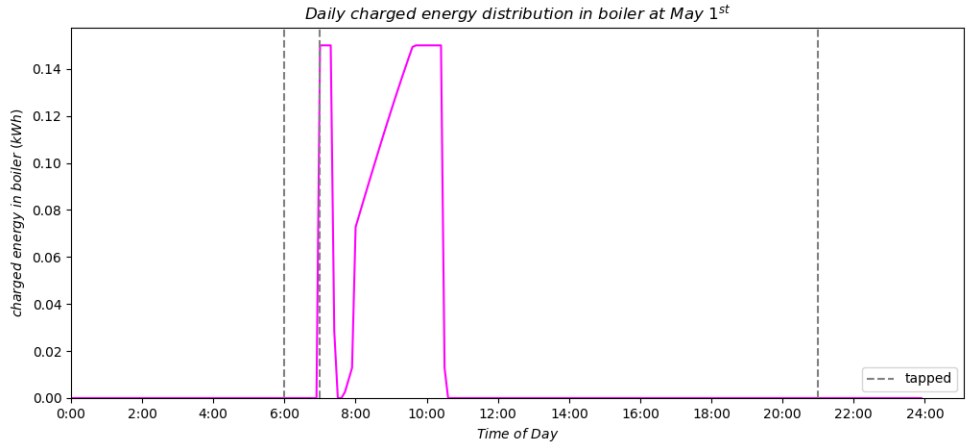
A-6. Heatpump hot water - daily charged energy



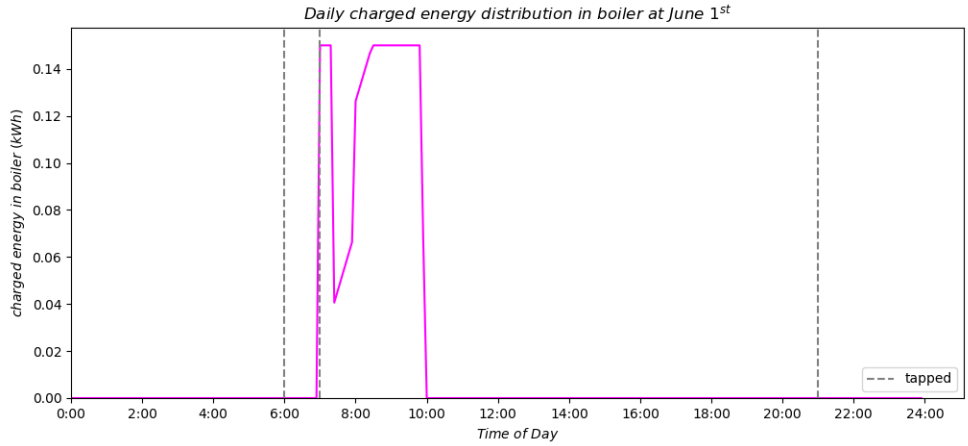
A-6. Heatpump hot water - daily charged energy



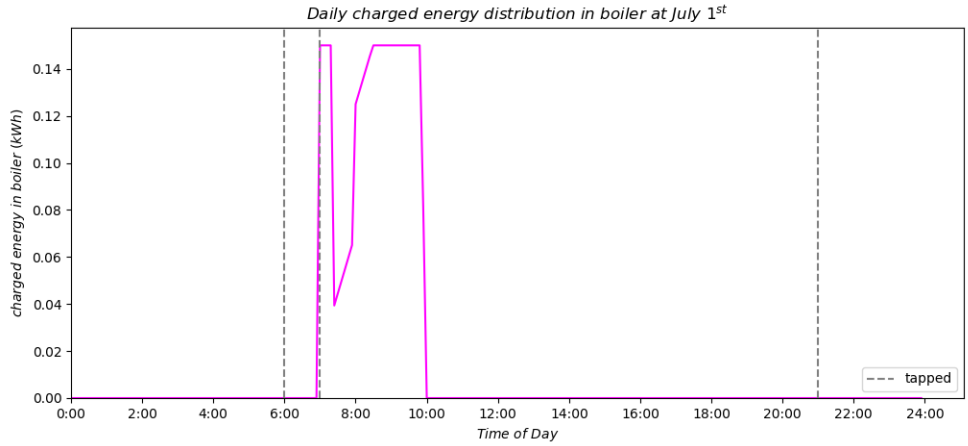
A-6. Heatpump hot water - daily charged energy



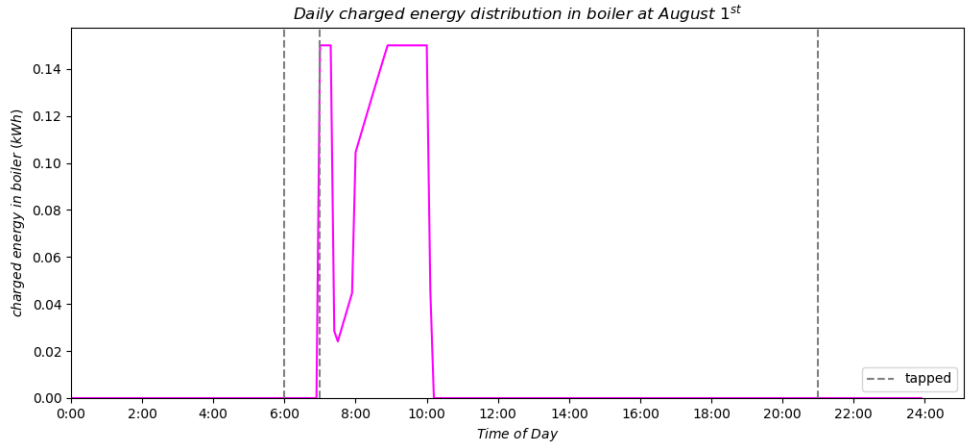
A-6. Heatpump hot water - daily charged energy



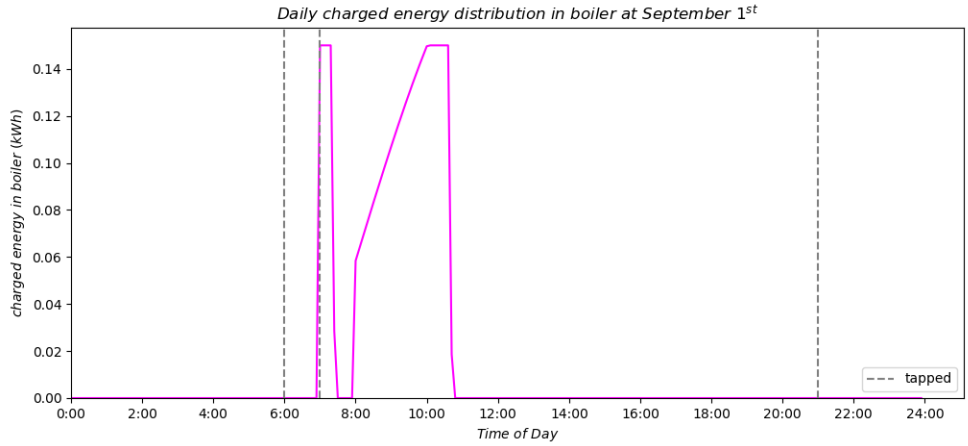
A-6. Heatpump hot water - daily charged energy



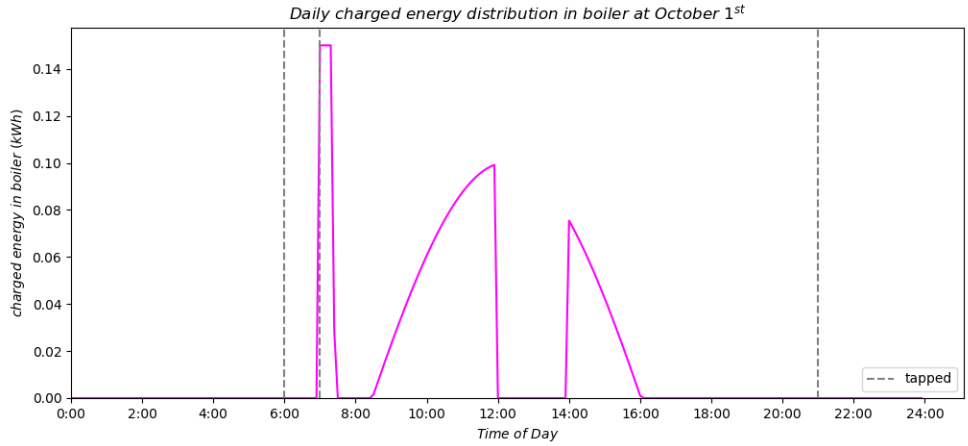
A-6. Heatpump hot water - daily charged energy



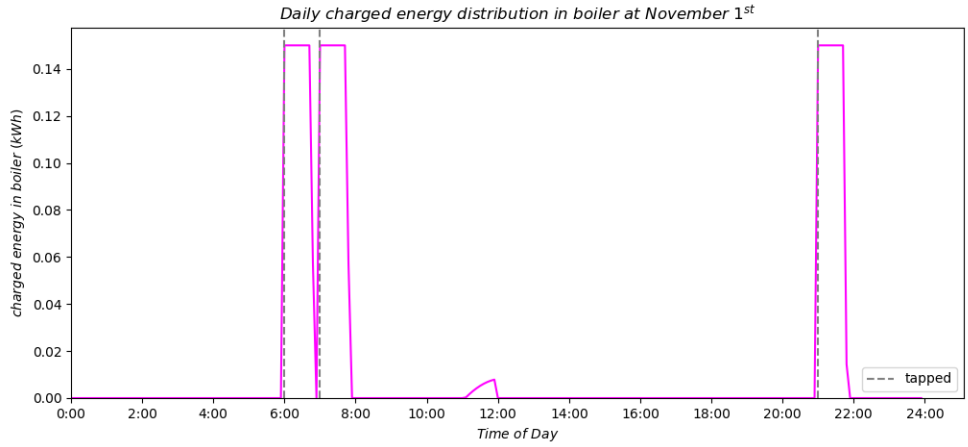
A-6. Heatpump hot water - daily charged energy



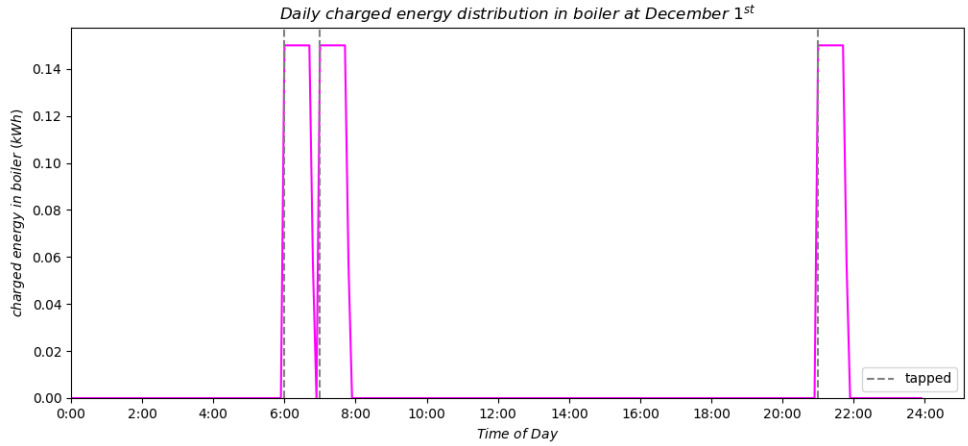
A-6. Heatpump hot water - daily charged energy



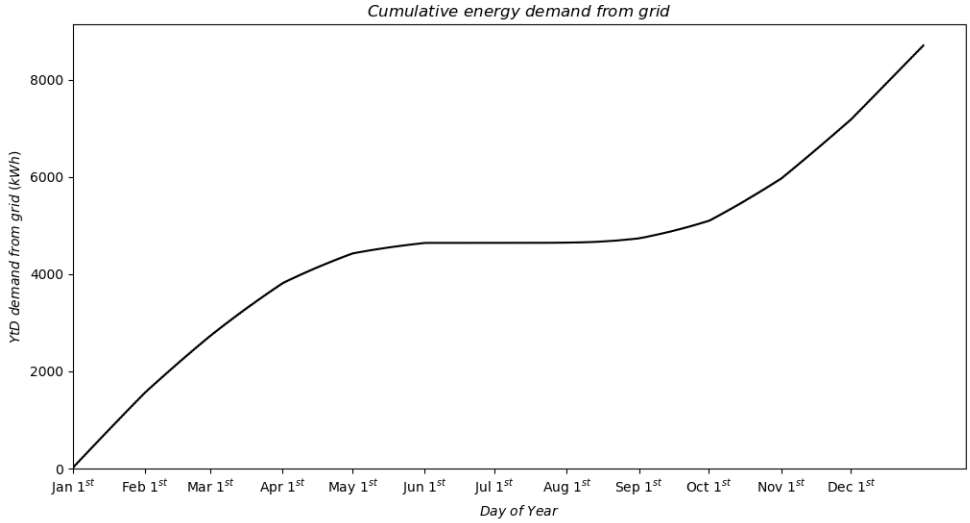
A-6. Heatpump hot water - daily charged energy



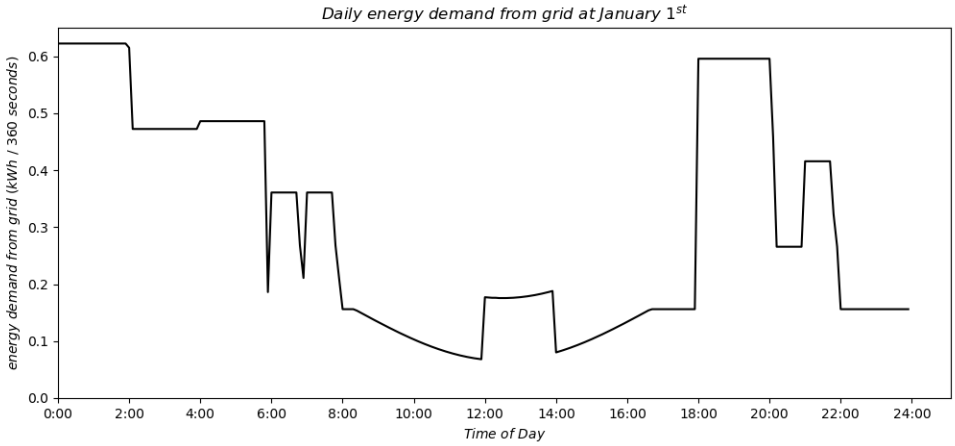
A-6. Heatpump hot water - daily charged energy



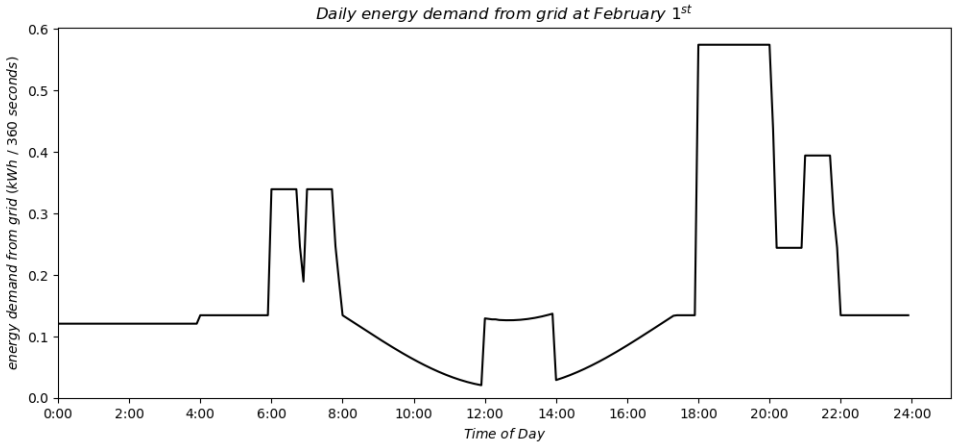
A-7. Energy demand from grid - annual



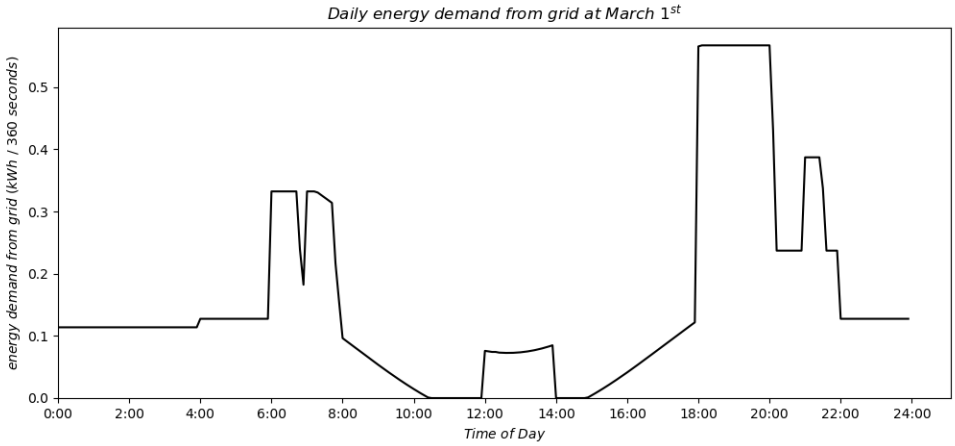
A-7. Energy demand from grid - daily



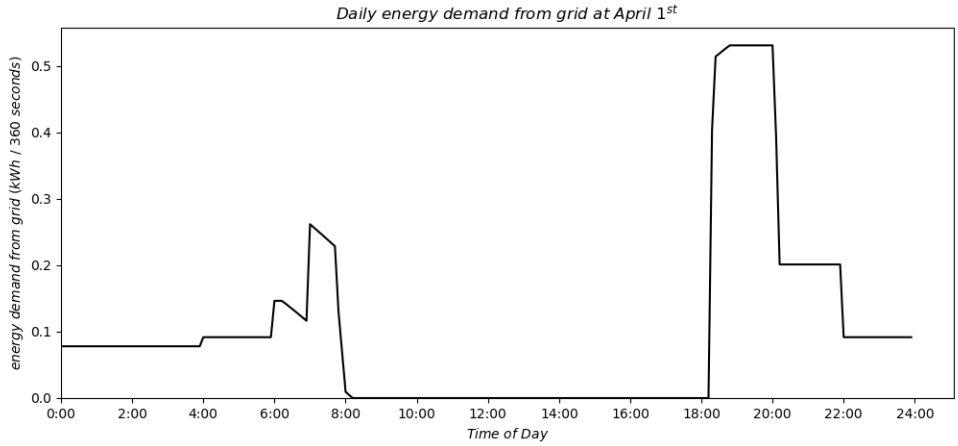
A-7. Energy demand from grid - daily



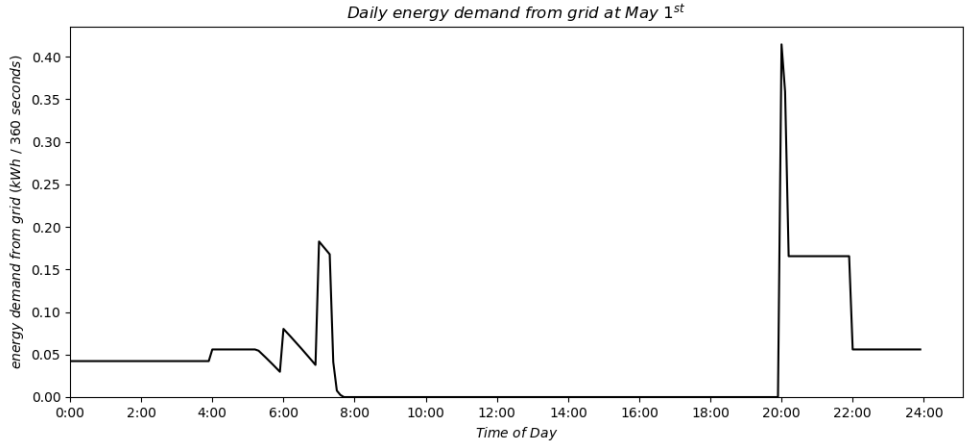
A-7. Energy demand from grid - daily



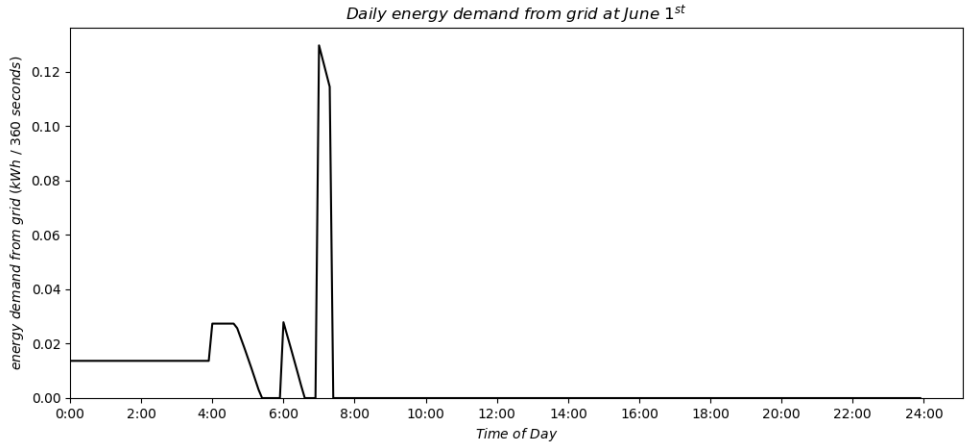
A-7. Energy demand from grid - daily



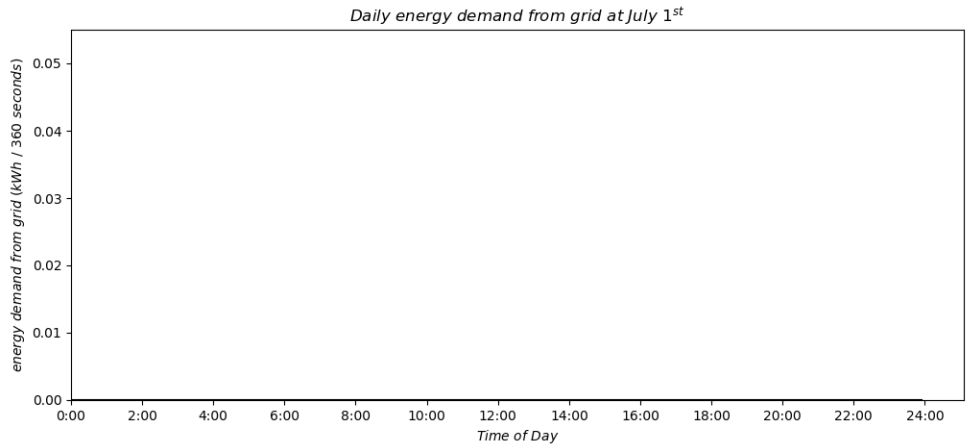
A-7. Energy demand from grid - daily



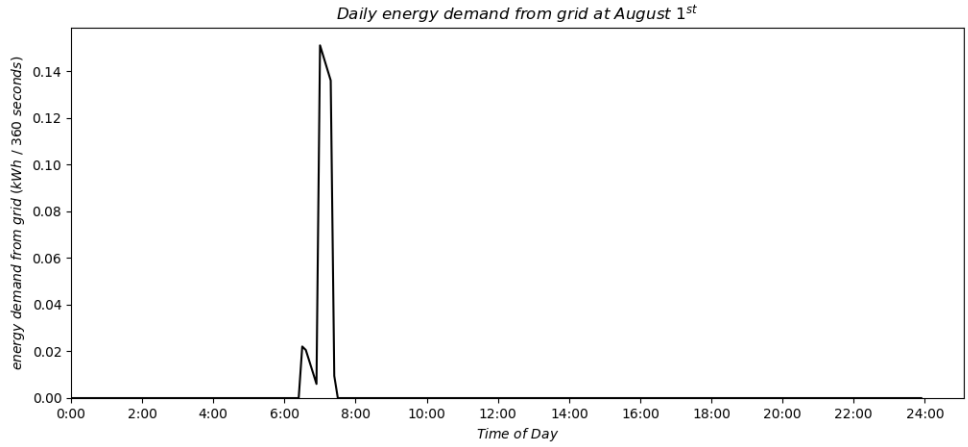
A-7. Energy demand from grid - daily



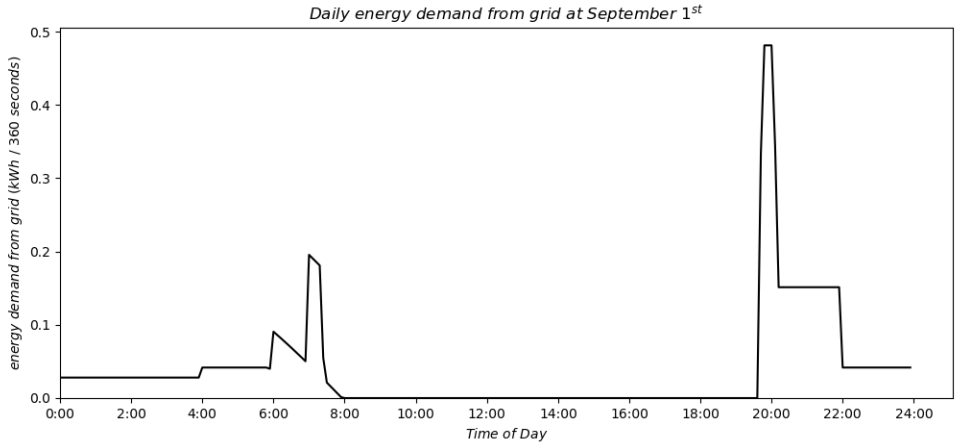
A-7. Energy demand from grid - daily



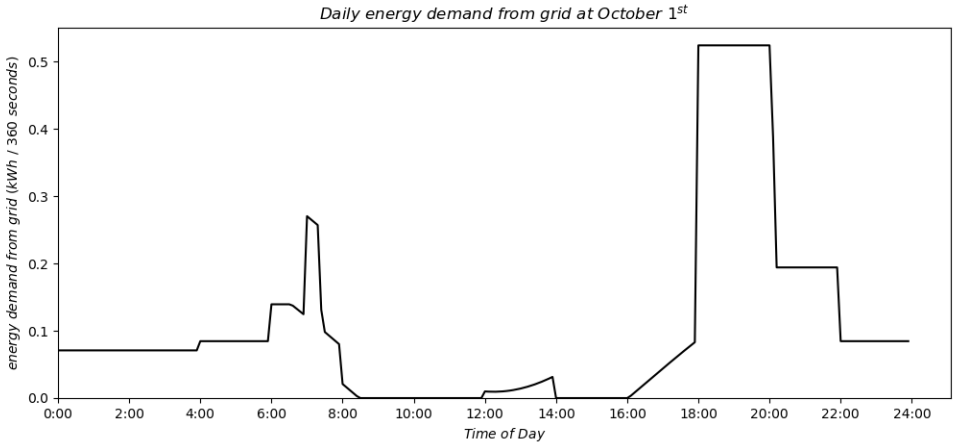
A-7. Energy demand from grid - daily



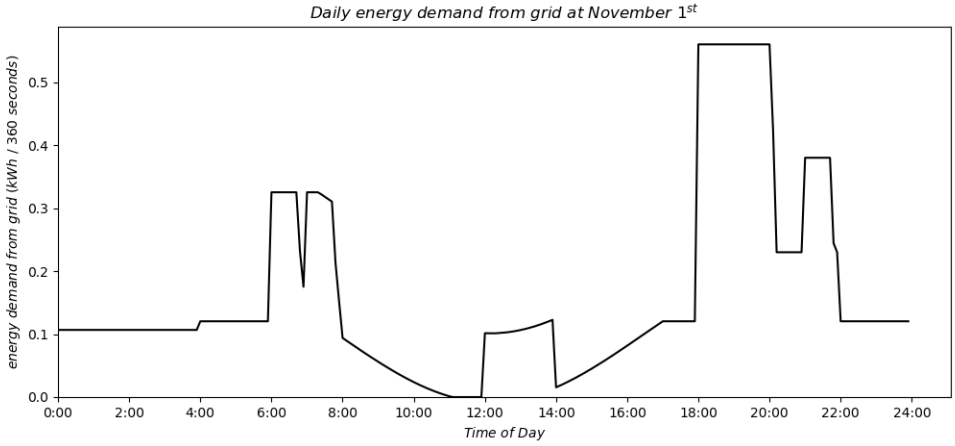
A-7. Energy demand from grid - daily



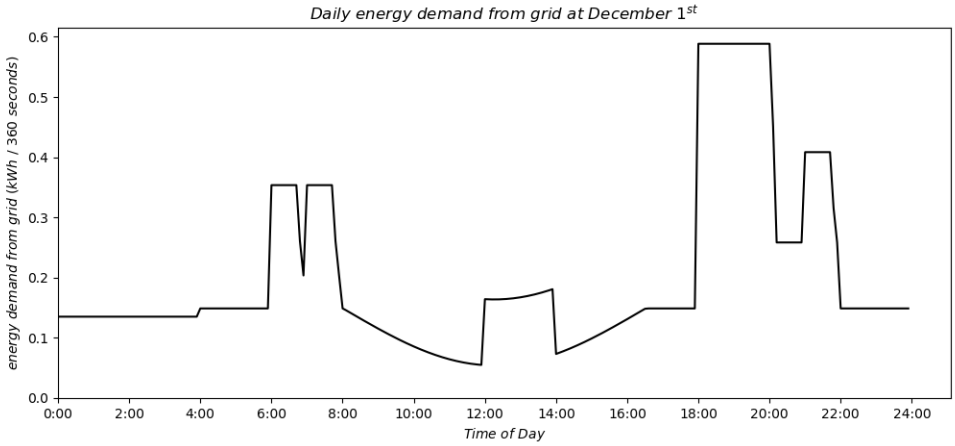
A-7. Energy demand from grid - daily



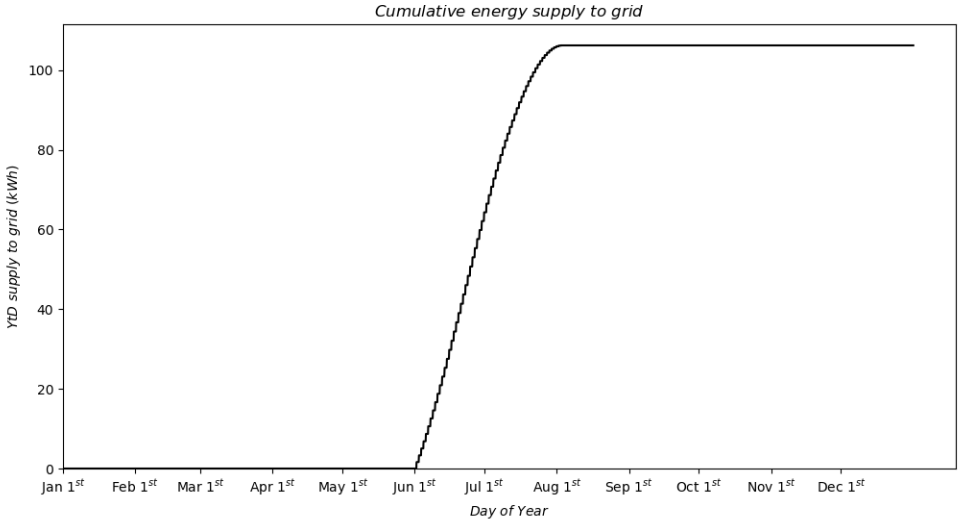
A-7. Energy demand from grid - daily



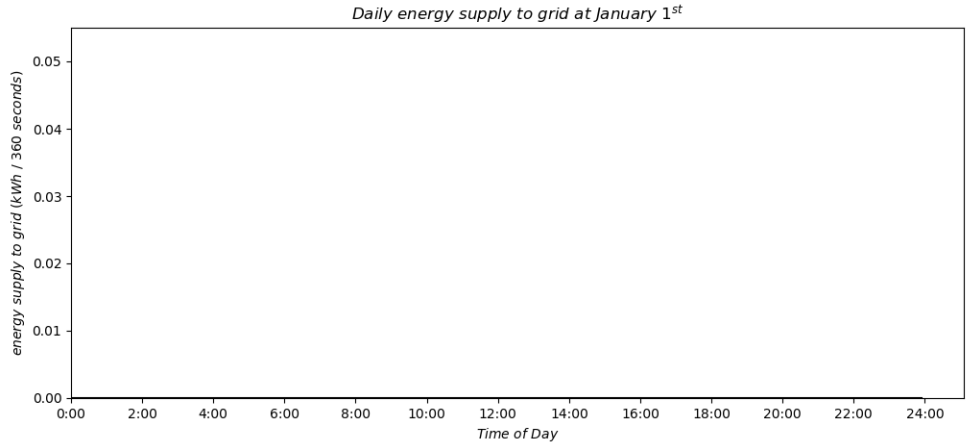
A-7. Energy demand from grid - daily



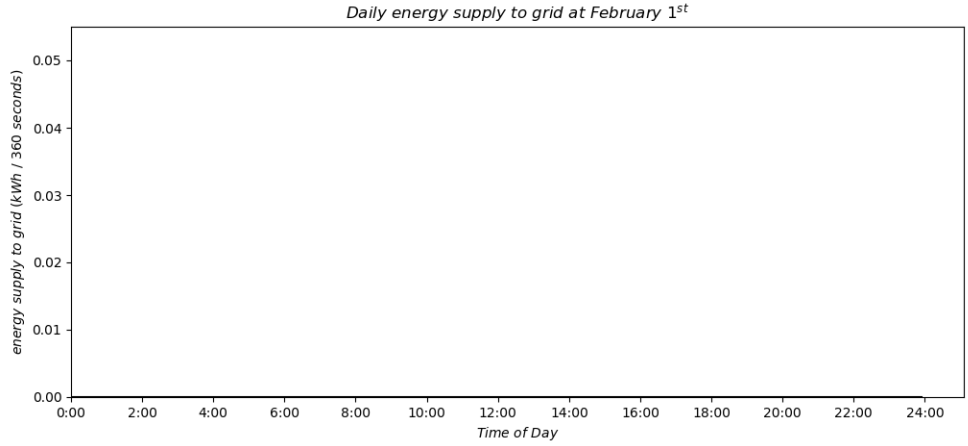
A-8. Energy supply to grid - annual



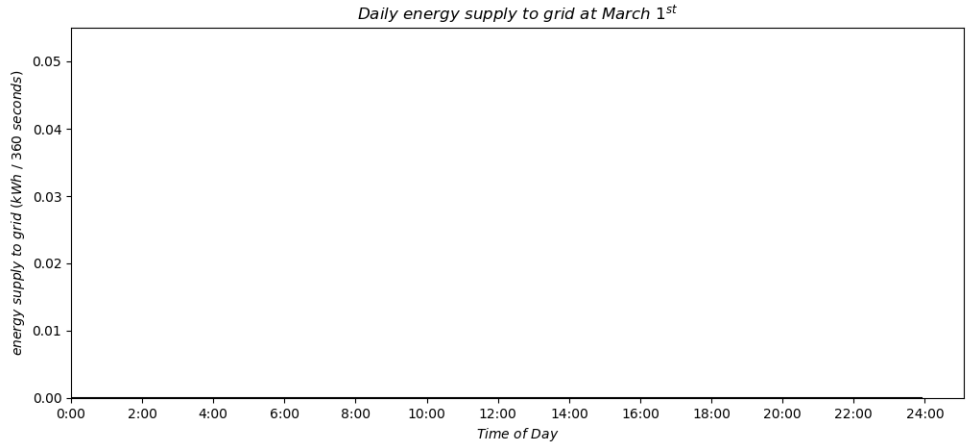
A-8. Energy supply to grid - daily



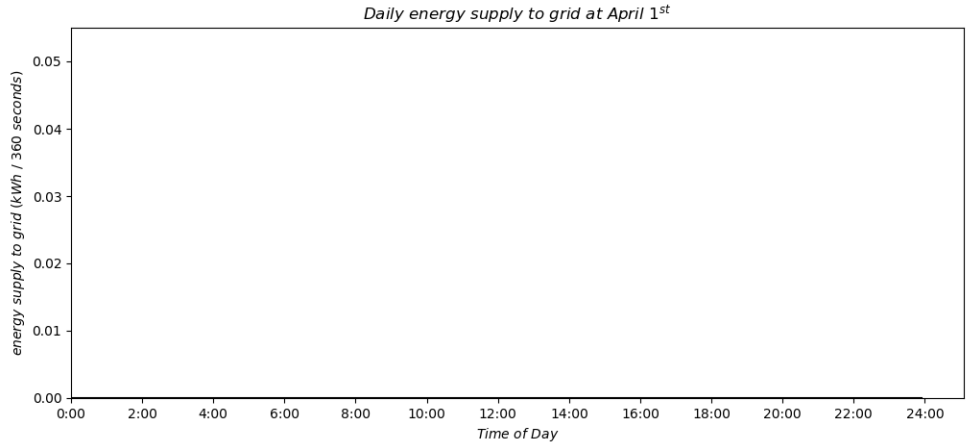
A-8. Energy supply to grid - daily



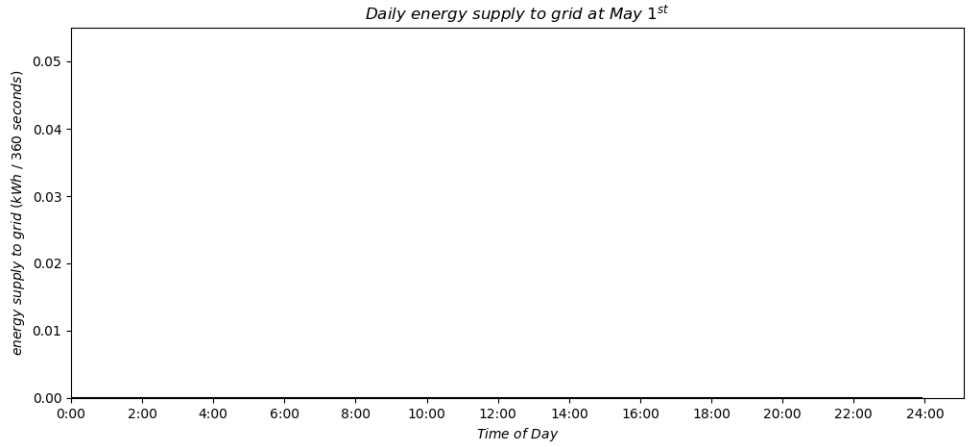
A-8. Energy supply to grid - daily



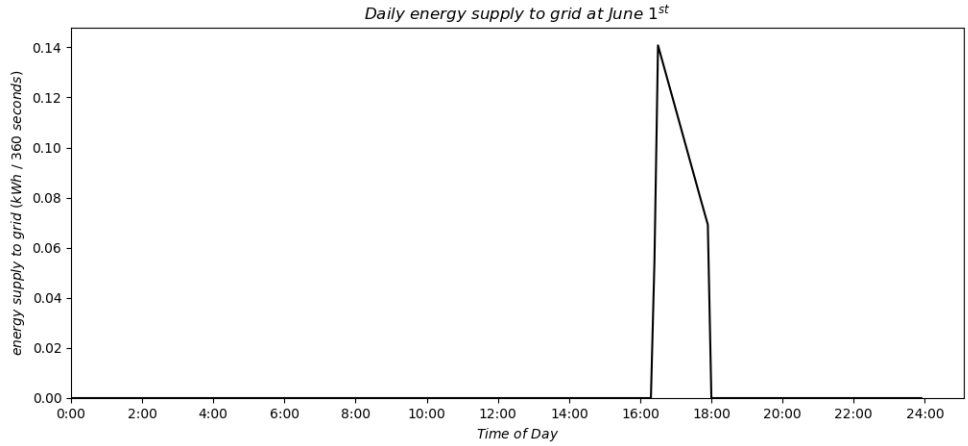
A-8. Energy supply to grid - daily



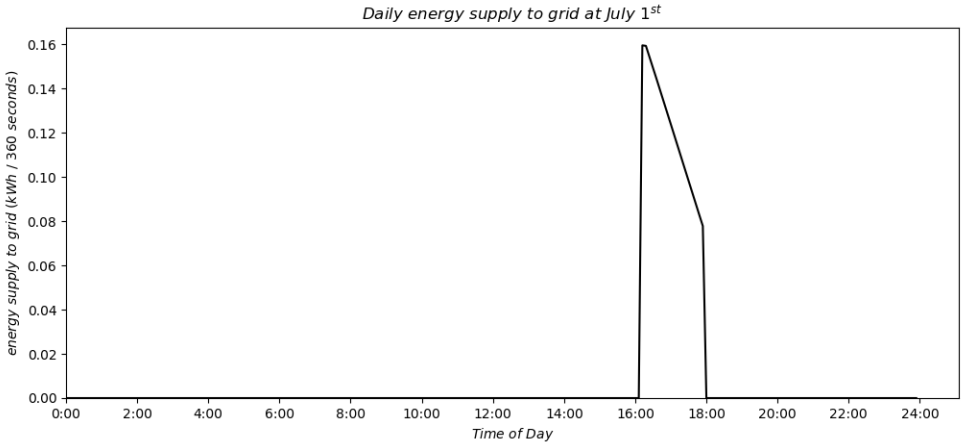
A-8. Energy supply to grid - daily



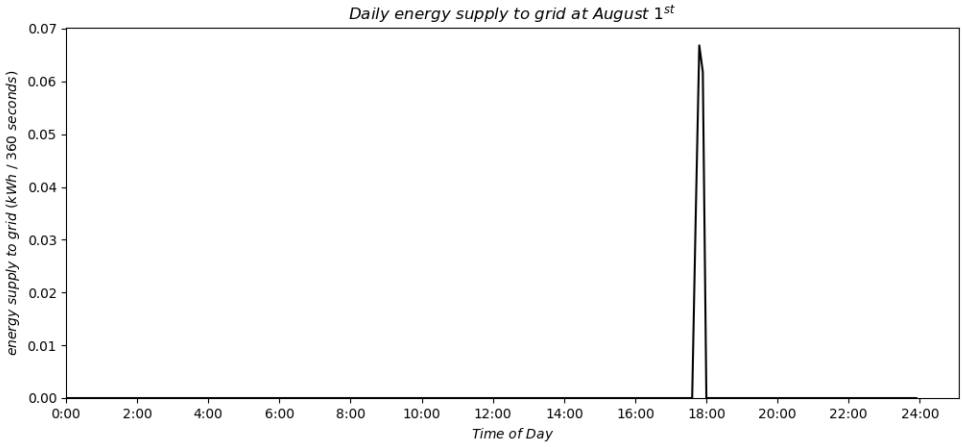
A-8. Energy supply to grid - daily



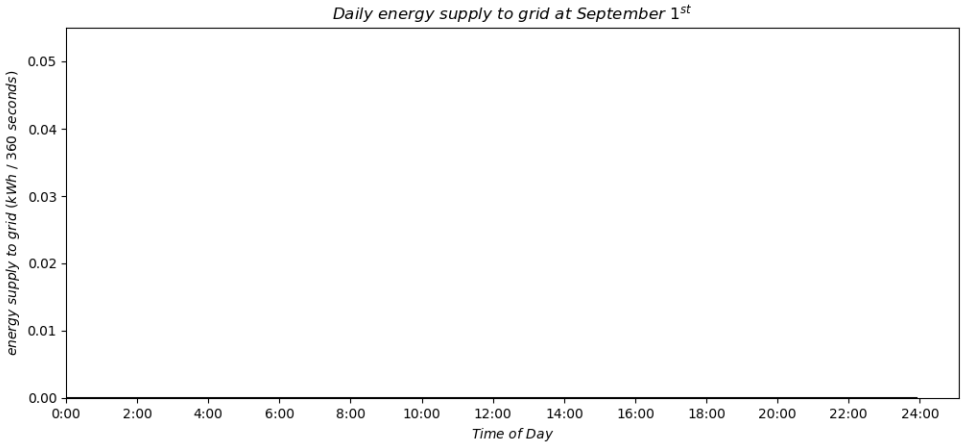
A-8. Energy supply to grid - daily



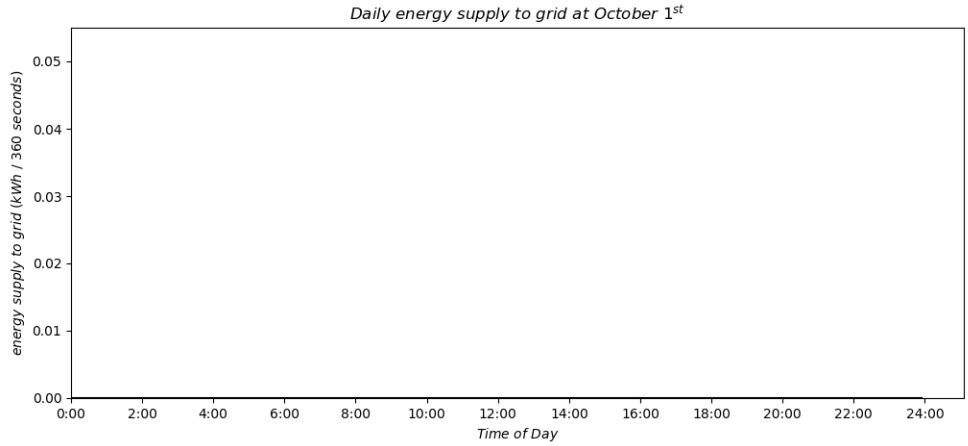
A-8. Energy supply to grid - daily



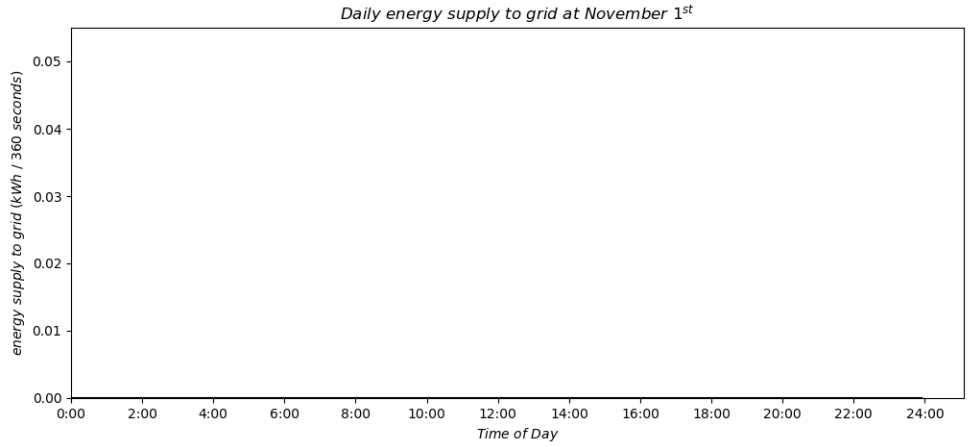
A-8. Energy supply to grid - daily



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