Pre-interview Task

Rongxing Hu

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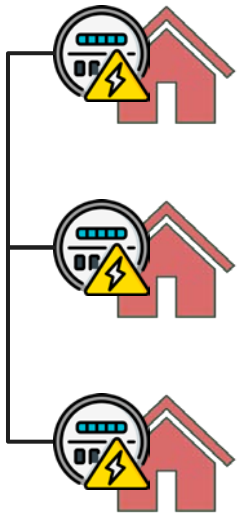
Basic

- Assumption
  - Initial and ending SoC: 20%
  - SoC limit: [10%-100%]
  - Charging/discharging efficiency: 95%
- Coding
  - Julia @ JuMP
  - Solver: Cbc
  - Link: https://github.com/rxhu89/pretask_house_cost/tree/main
- Key factor
  - Max. export price (10.5 p/kWh) @ Min. import price (9.744 p/kWh)
  - Battery cannot earn arbitrage considering charging/discharging loss
  - Distinct load profiles of houses

Modeling

- Single house (3 meters)



$$\sum_{t=1}^{T}(\rho_t^{\text{imp}} P_t^{\text{imp}} - \rho_t^{\text{exp}} P_t^{\text{exp}})\,\Delta t$$

$$P_t^{\text{net}} = P_t^{\text{load}} - P_t^{\text{dis}} + P_t^{\text{ch}} - P_t^{\text{pv}}$$

$$P_t^{\text{net}} = P_t^{\text{imp}} - P_t^{\text{exp}}$$

$$0 \le P_t^{\text{imp}} \le M$$

$$0 \le P_t^{\text{exp}} \le M$$

$$E_t = E_{t-1} + (\eta P_t^{\text{ch}} - \frac{P_t^{\text{dis}}}{\eta})\,\Delta t$$

$$E^{\text{rate}} * SOC^{\min} \le E_t \le E^{\text{rate}} * SOC^{\max}$$

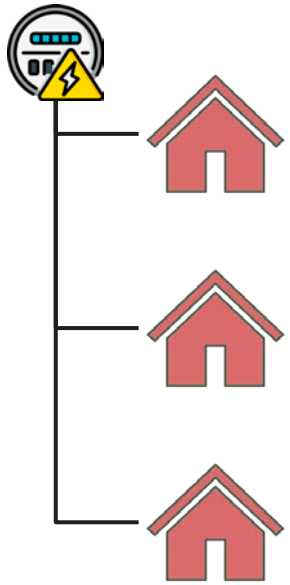
$$E_T = SOC^{\text{ini}} * E^{\text{rate}}$$

$$0 \le P_t^{\text{ch}} \le P^{\max}$$

$$0 \le P_t^{\text{dis}} \le P^{\max}$$

$$0 \le P_t^{\text{pv}} \le P_t^{\text{pv\_pred}}$$

- Aggregator (1 meter)



$$\sum_{t=1}^{T}(\rho_t^{\text{imp}} P_t^{\text{imp}} - \rho_t^{\text{exp}} P_t^{\text{exp}})\,\Delta t$$

$$P_{i,t}^{\text{net}} = P_{i,t}^{\text{load}} - P_{i,t}^{\text{dis}} + P_{i,t}^{\text{ch}} - P_{i,t}^{\text{pv}}$$

$$\sum_{i=1}^{3} P_{i,t}^{\text{net}} = P_t^{\text{imp}} - P_t^{\text{exp}}$$

$$0 \le P_t^{\text{imp}} \le M$$

$$0 \le P_t^{\text{exp}} \le M$$

$$E_{i,t} = E_{i,t-1} + (\eta P_{i,t}^{\text{ch}} - \frac{P_{i,t}^{\text{dis}}}{\eta})\,\Delta t$$

$$E_i^{\text{rate}} * SOC^{\min} \le E_{i,t} \le E_i^{\text{rate}} * SOC^{\max}$$

$$E_{i,T} = SOC^{\text{ini}} * E_i^{\text{rate}}$$

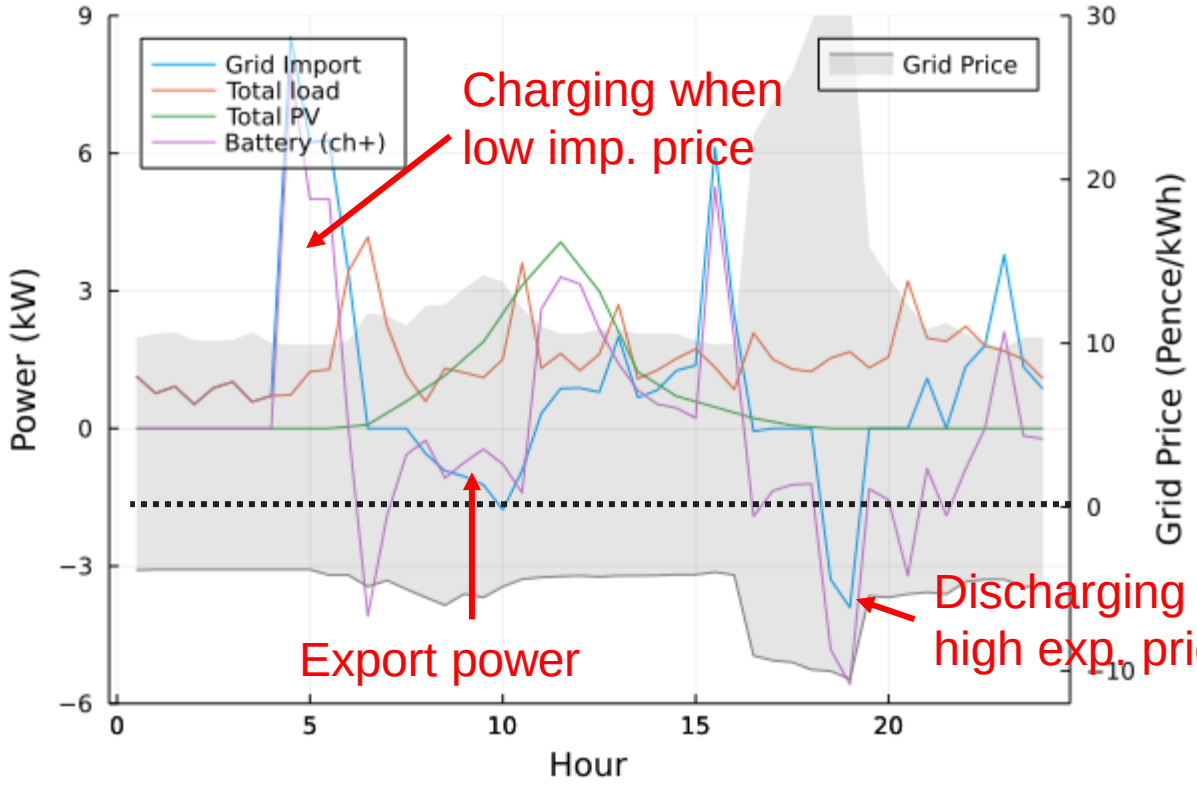
$$0 \le P_{i,t}^{\text{ch}} \le P_i^{\max}$$

$$0 \le P_{i,t}^{\text{dis}} \le P_i^{\max}$$

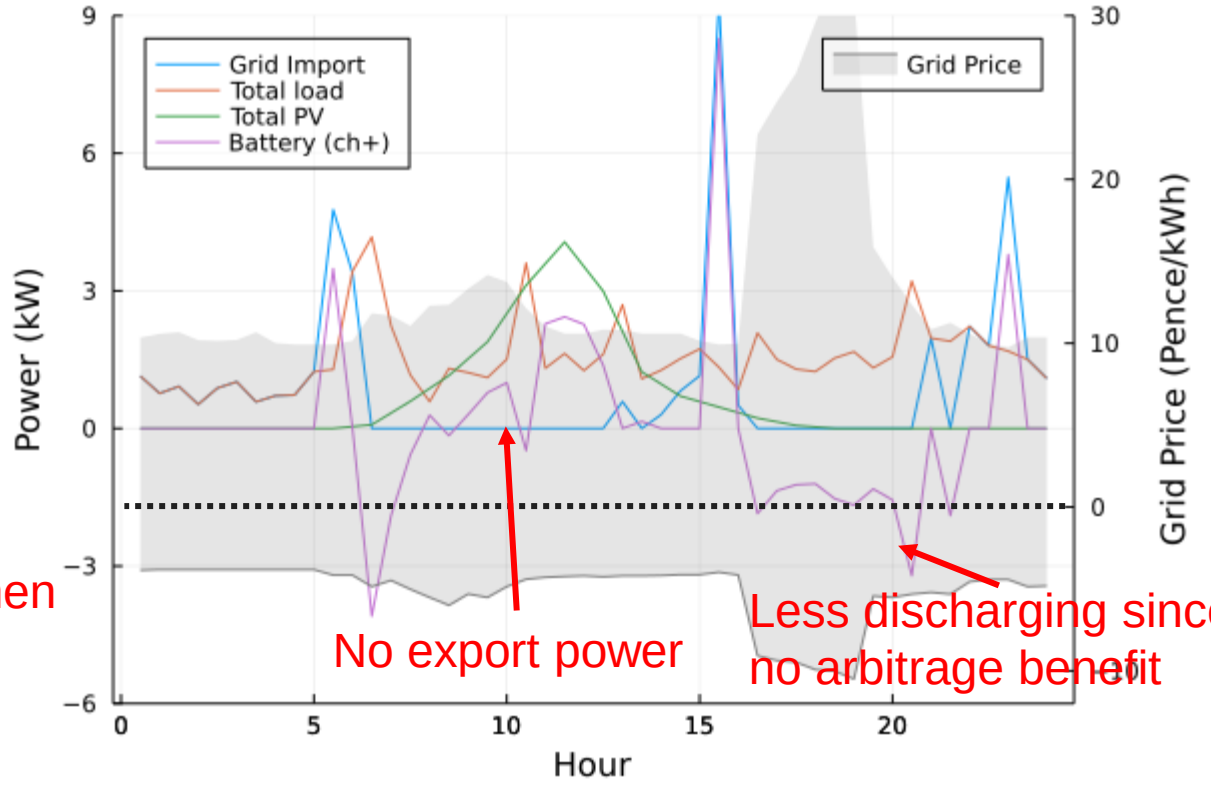
$$0 \le P_{i,t}^{\text{pv}} \le P_{i,t}^{\text{pv\_pred}}$$

Results: Total Power

Single



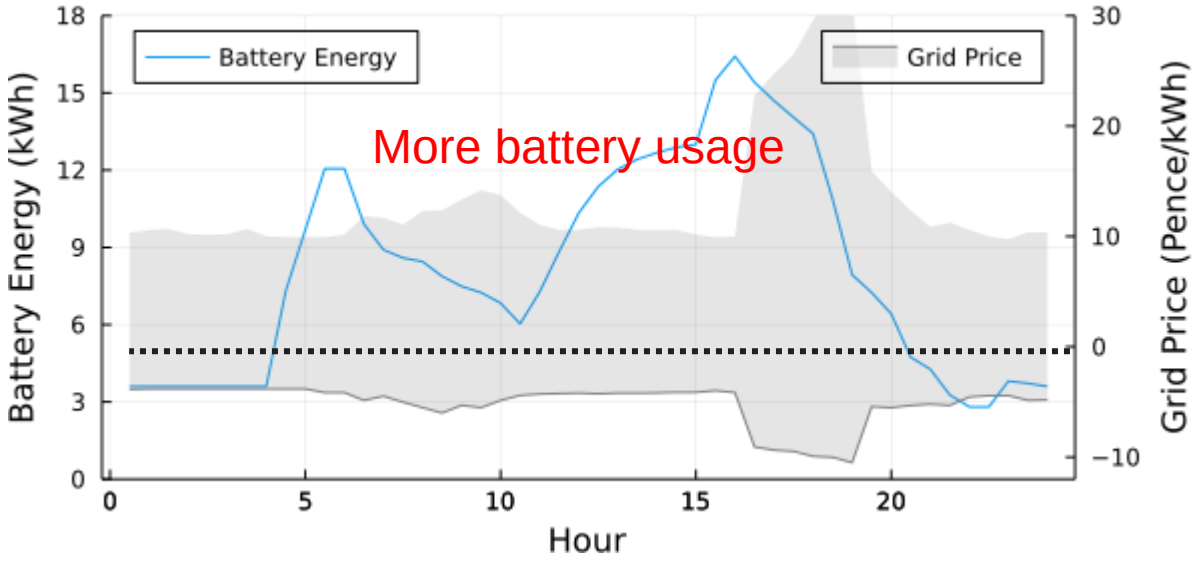
Aggregator



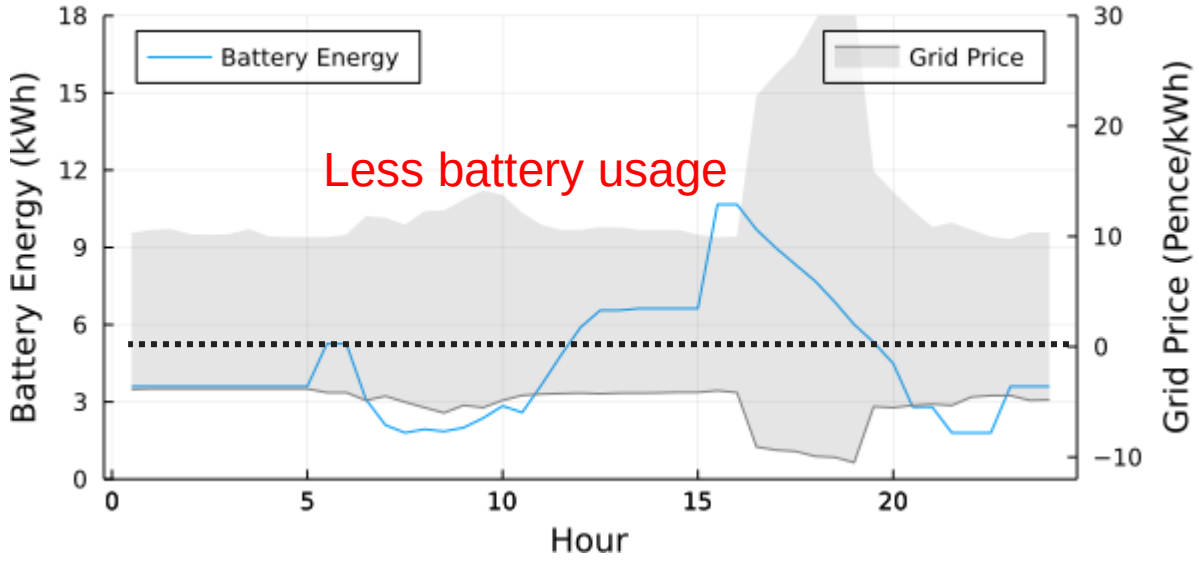
- House-level operation
  - More grid interaction
- Aggregation
  - No export power, less discharging

Results: Total Battery Usage

Single



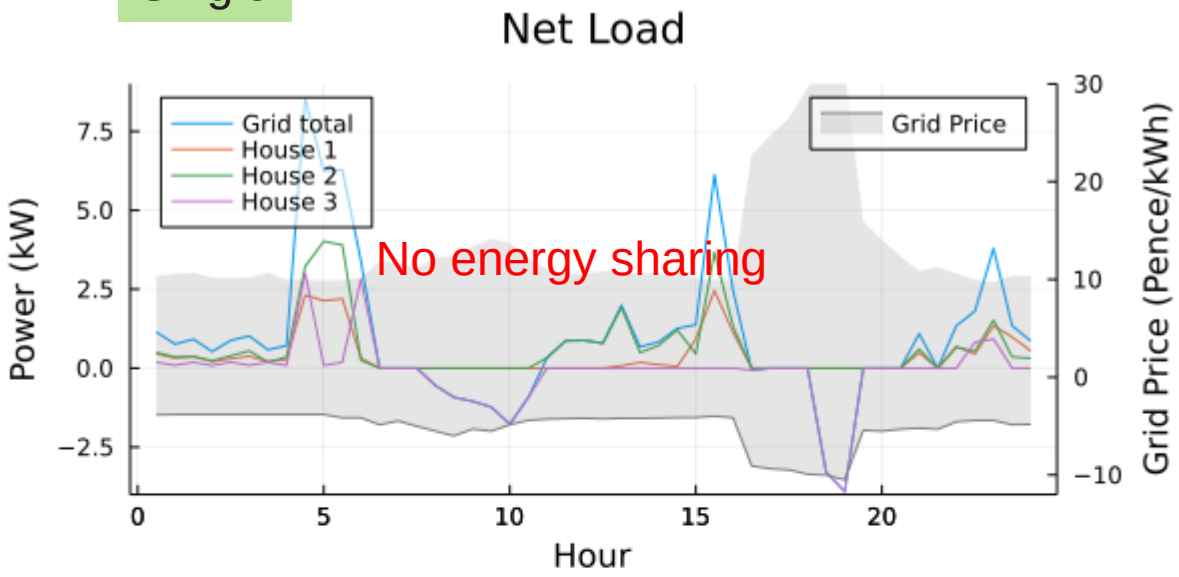
Aggregator

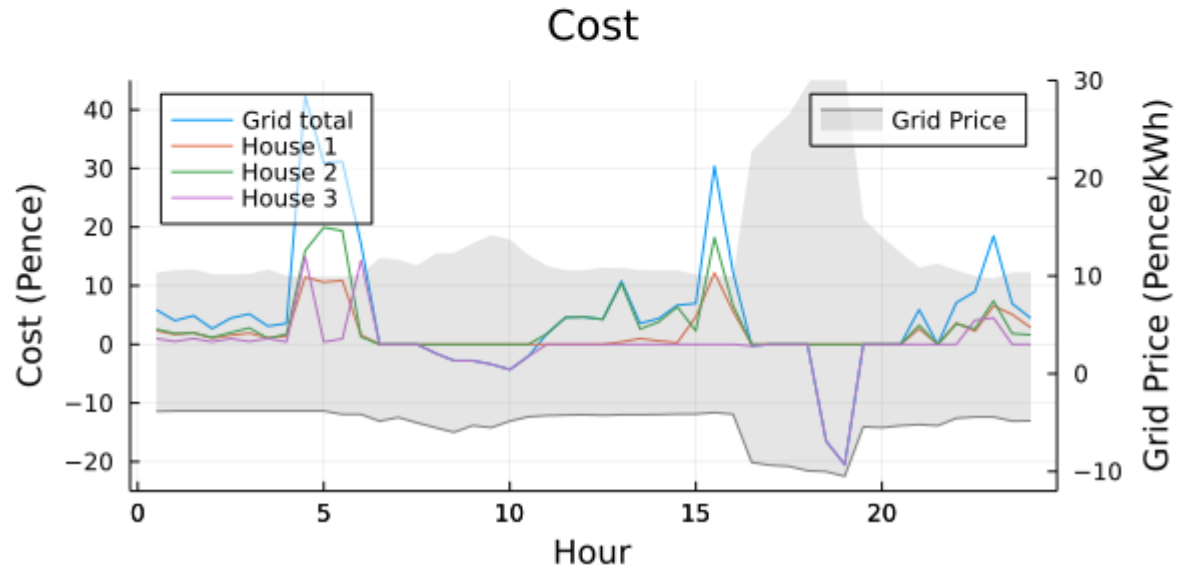


- House-level operation
  - More battery usage for cost saving
- Aggregation
  - Less battery usage since the price scheme has no energy arbitrage price scheme

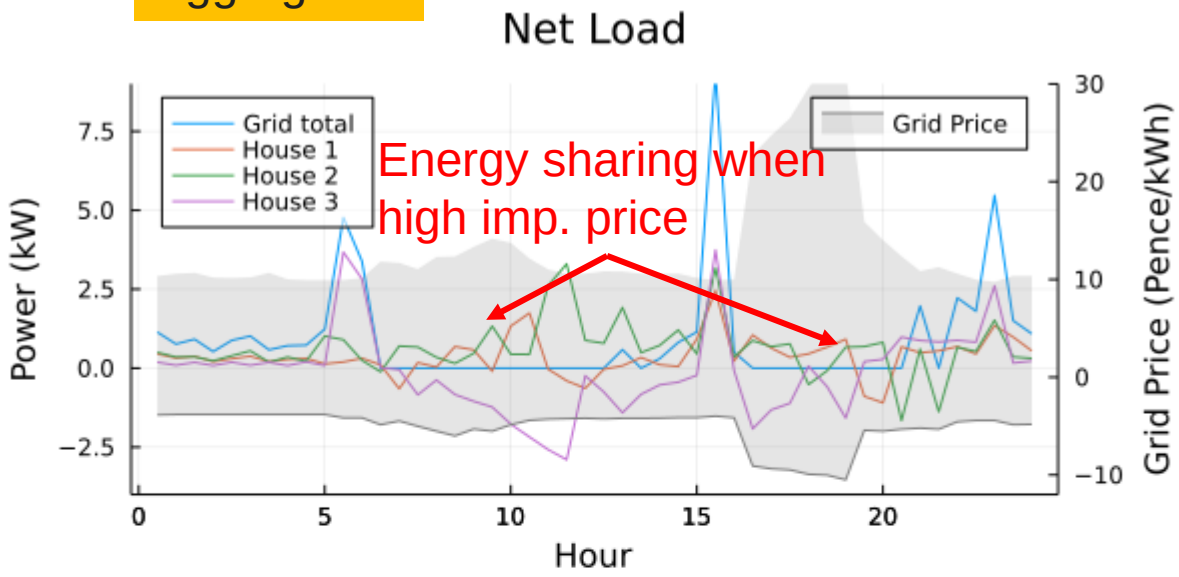
Results: House Net load

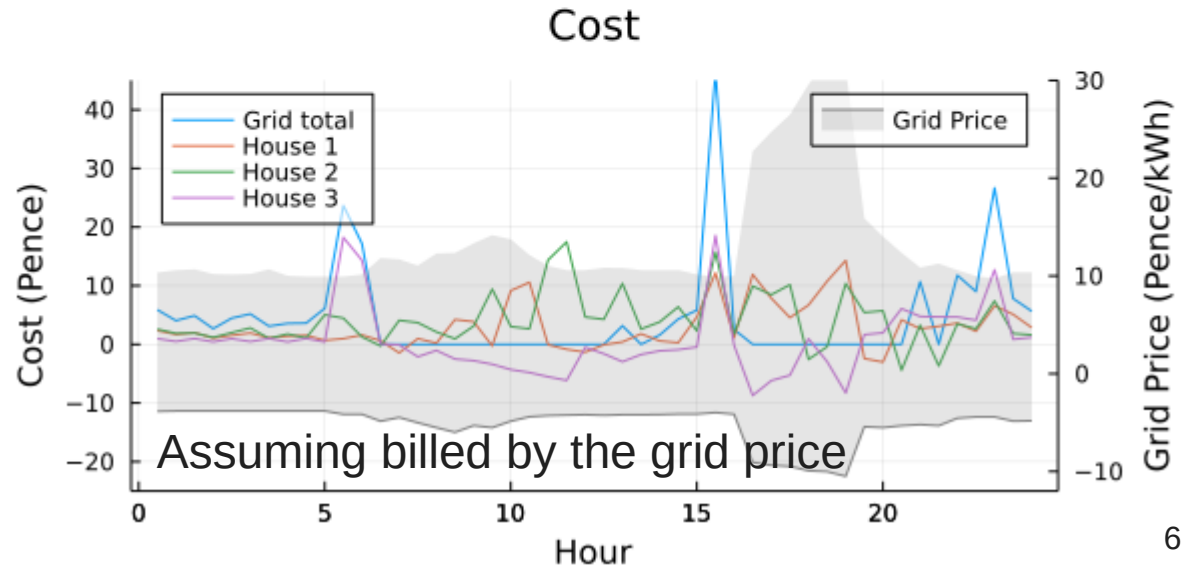
Single





Aggregator





Comparison and Summary

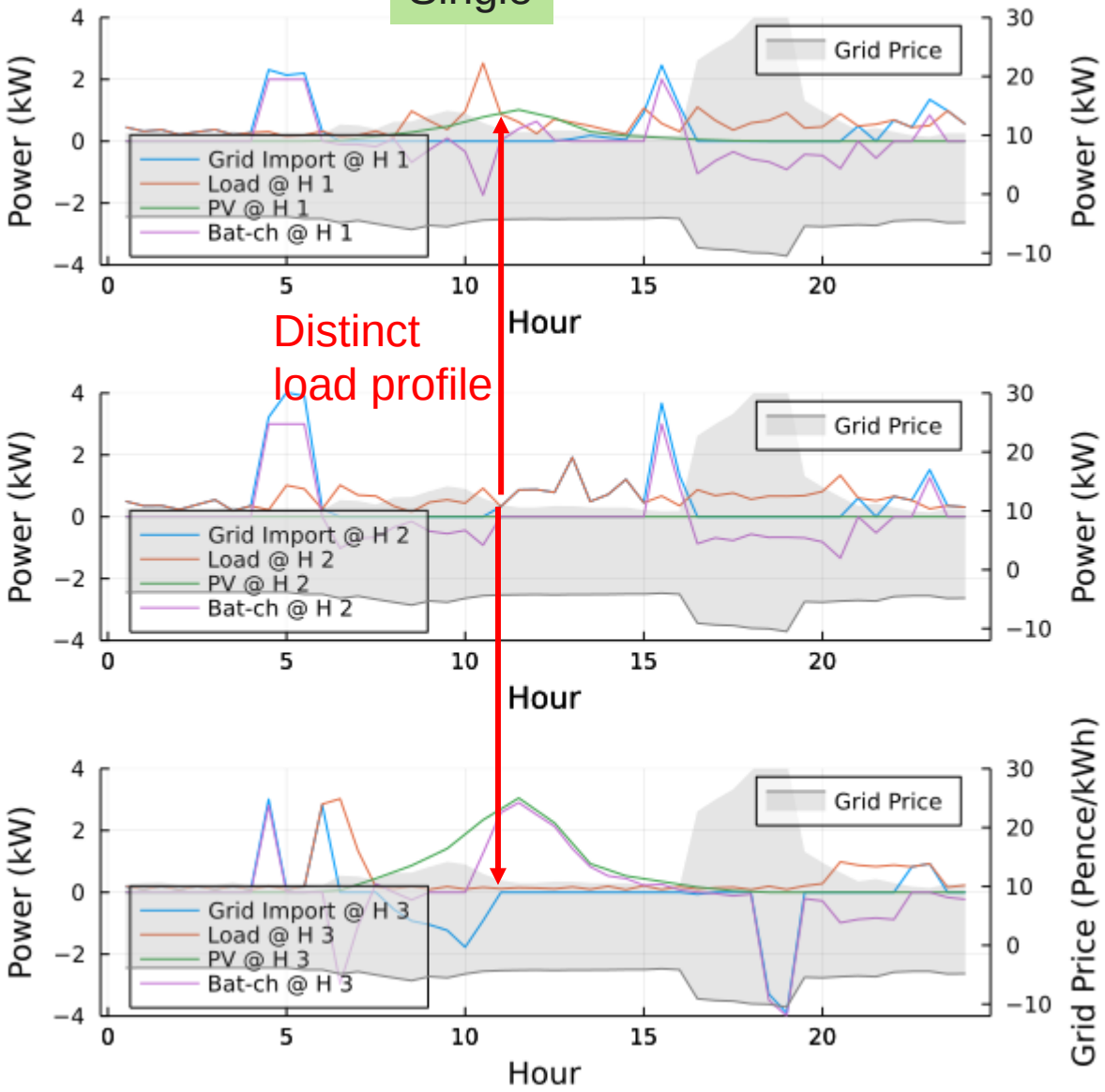
Scenario	Grid Energy (kWh)			House cost (pence) (assuming billed by the grid price)				Total cost (pence)
	Import	Export	net	House 1	House 2	House 3	Total	
Single	29.39	**6.86**	22.536	95.276	157.503	-9.219	243.56	**243.56**
Aggregated	21.72	0	**21.72**	145.264	198.722	28.187	372.17	**219.76**

Scenario	House Consumption (kWh)								
	House 1			House 2			House 3		
	Import	Export	net	Import	Export	net	Import	Export	net
Single	9.448	0	9.448	15.472	0	15.472	4.474	6.856	-2.382
Aggregated	11.043	**1.918**	9.125	17.106	**1.877**	15.229	9.787	**12.426**	-2.639

- House-level operation
  - More cost / grid interaction and more battery usage (degradation cost)
- Aggregation
  - **Energy share** among houses → reduced total **net load and cost**
  - Could optimize (reduce) the **battery capacity**
  - Challenge: how to share the cost and allocate the benefit (Shapley…)

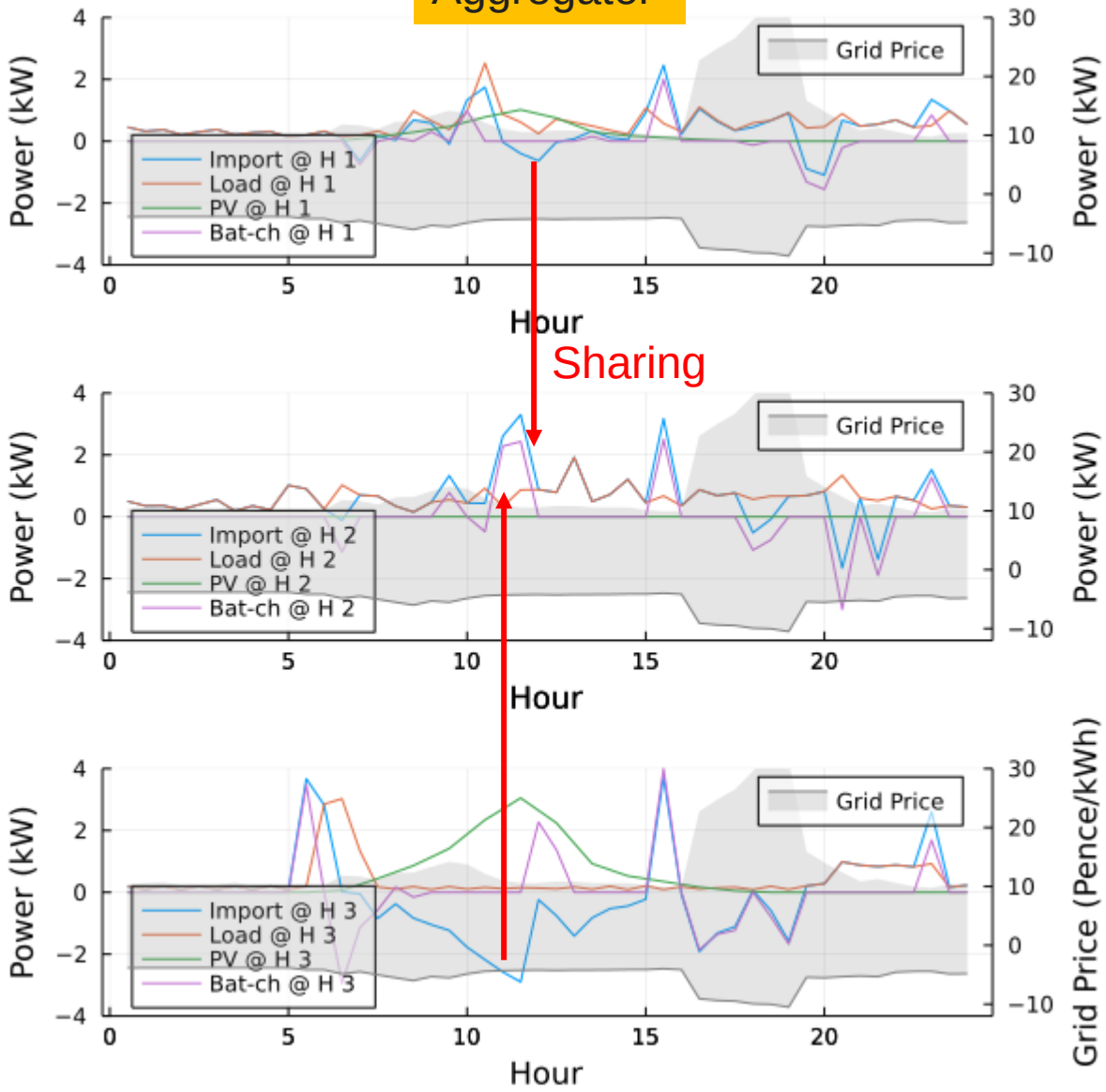
Results: House Power

Single



Distinct load profile

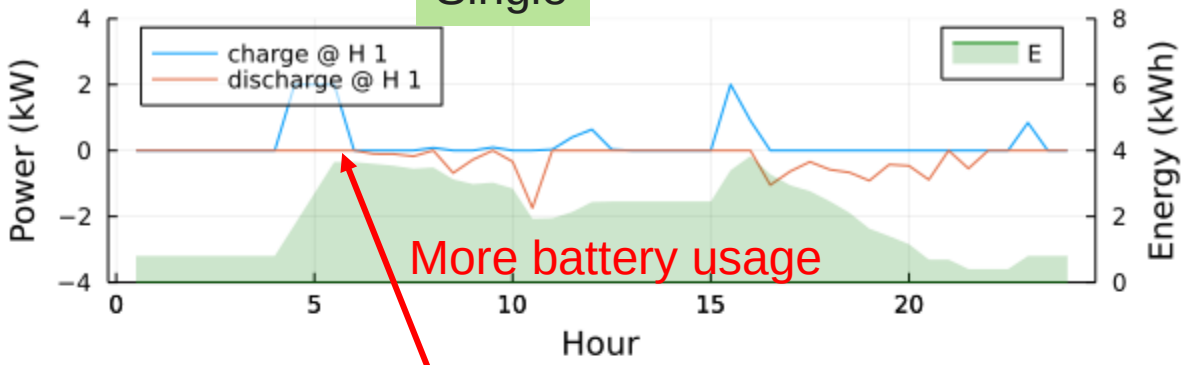
Aggregator



Sharing

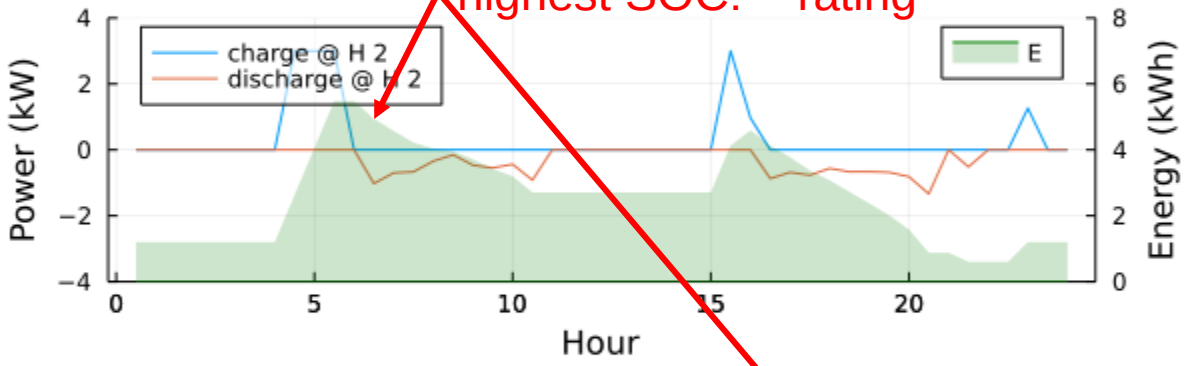
Results: House Battery

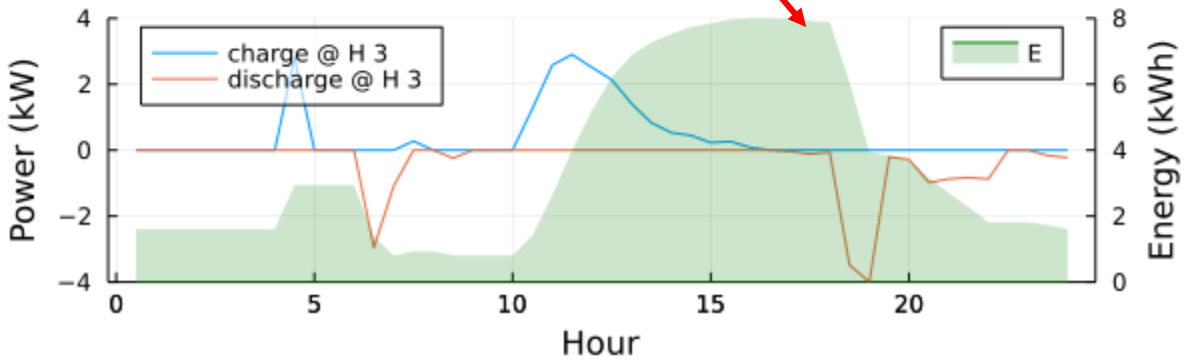
Single



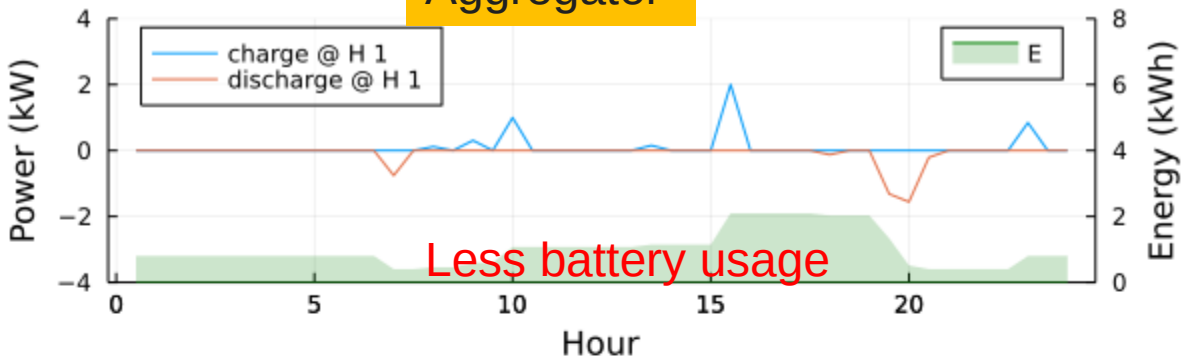
More battery usage

highest SOC: ~ rating





Aggregator



Less battery usage

highest SOC: ~50%