Community Charging Hubs in Multi-Unit Dwellings: Electric Vehicle Charging Management and Technoeconomic Assessment

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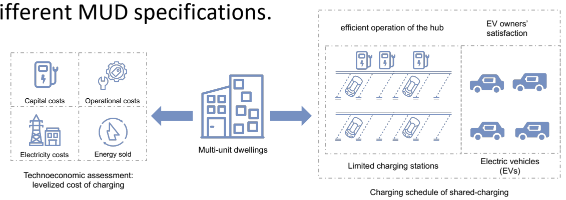
Introduction

- Residential EV charging is the most prevalent and convenient option. However, less than 50% of household vehicles have access to dedicated parking (Traut et al., 2013). Therefore, multi-unit dwelling (MUD) residents have limited access to residential charging, leading to higher operating costs and less flexibility.
- We formulate a modified job shop scheduling problem to optimize EV charging sessions' scheduling. We apply our model, measure the charging hub's performance and evaluate the levelized cost of charging through a techno-economic assessment in three numerical experiments in Chicago, New York City, and Los Angeles, with different MUD specifications.

Figure 1



Methods

- We propose a rule-based heuristic approach to optimize the charging scheduling problem. Technoeconomic assessment is used to quantify the levelized cost of charging. The methods are depicted in the schema in Figure 2.

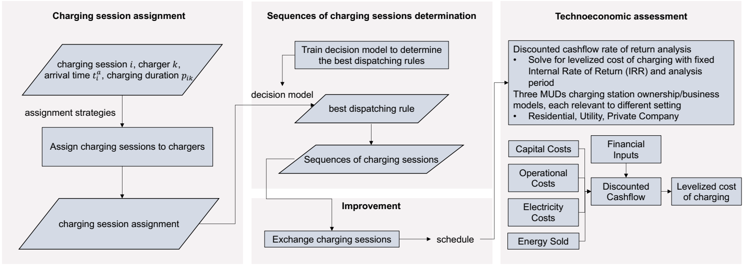


Figure 2

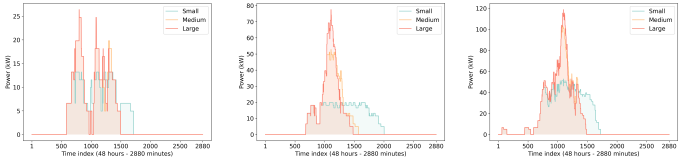
Research Highlights

- Our research framework evaluates the viability of community charging hubs for MUDs, proposes algorithms for centrally shared charging session scheduling, and conducts the MUD community charging hub's techno-economic assessment.
- The rule-based heuristic algorithm proposed to solve this management problem provides high-quality charging schedule solutions and improves the waiting time by 71.4% on average when compared to an unmanaged FCFS charging scheme.
- The cost and performance metrics of the small, medium, and large charging hubs and their load profiles are presented for three scenarios. The large charging hubs usually have a higher maximum power than the small and medium ones but have a shorter operating period. As charging hub size increases, the total waiting time decreases, and the levelized cost of charging increases.
- We uncover tradeoffs between the charging hub's performance and its levelized cost of charging. As additional charging stations are installed, the total waiting time is often reduced, but the levelized cost of charging rises. Installing DCFC stations often costs more than adding level-2 chargers but reduces waiting times more drastically.
- Equivalent charger setups based on levelized cost of charging and total waiting time are provided, which can satisfy various stakeholders' goals.

Results

- The cost and performance metrics of the small, medium, and large charging hubs (Table 1) and their average 48-hour load profiles (Figure 3) of the small, medium, and large charging hubs for three scenarios: Chicago, Los Angeles, and New York City (left, center, and right columns, respectively) with level-2 charging stations

Figure 3



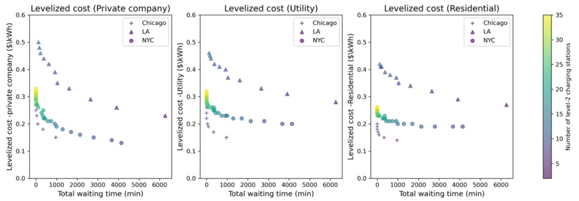
Study area	Charging hub size	Number of level-2 chargers	Total waiting time (min)	Levelized cost of charging ($/kWh)		
				Private company	Utility	Residential
Chicago	Small	2	1853	0.15	0.15	0.14
	Medium	5	46	0.24	0.21	0.17
	Large	8	0	0.3	0.26	0.21
New York City	Small	8	4147	0.13	0.19	0.18
	Medium	21	271	0.25	0.25	0.22
	Large	35	0	0.34	0.31	0.26
Los Angeles	Small	3	6270	0.24	0.28	0.27
	Medium	8	927	0.39	0.40	0.38
	Large	13	123	0.51	0.47	0.43

Table 1

Discussion and Conclusion

- Tradeoffs between levelized cost of charging and total waiting time (when only level-2 charging stations are installed in the MUD charging hub)

Figure 4



- The map of equivalence, considering either equivalent performance (total waiting time) or cost (private company levelized charging cost) for the scenarios pertinent to NYC

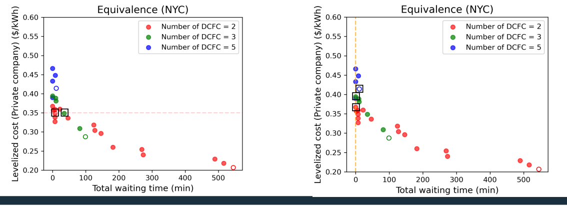


Figure 5