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Shared Charging Hubs May Help Reduce Greenhouse Gas Emissions and Peak Power Demand

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Issue

The public and private sectors are making significant investments in electric vehicle charging infrastructure, however, the design, planning, and rollout of charging infrastructure tends to be siloed by mode (i.e., charging needs for passenger vehicles, transit buses, trucks, e-scooters, and other modes are not considered together). Given the ever-increasing interactions among these electrified transportation modes, there is growing interest in how to better integrate the design and delivery of charging infrastructure, such as through shared charging hubs.

To help policy makers and transportation agencies make more informed decisions regarding the planning and design of charging infrastructure, UC Riverside researchers developed a model for determining the optimal location, configuration (i.e., number of chargers, power capacities), and charging schedules for shared charging hubs serving cars and transit buses with the goal of reducing greenhouse gas (GHG) emissions. The model was then applied using Contra Costa County in California as a case study.

Key Research Findings

Shared charging hubs are more cost-effective compared to charging stations dedicated to a single transportation mode. The planning framework used to site and design shared charging hubs optimizes the allocation of budget between the bus and passenger car sectors. Charging stations dedicated to a single transportation mode do not have this flexibility. Also, shared charging can reduce peak power demand through coordinated charging across transportation modes, the initial capital investment for power equipment is reduced immediately. Additionally, the electricity bills are also reduced because of the lower demand charges, which implies profound benefit in the long run.

Considering the carbon intensity of electricity (ECI), which varies throughout the day, and enabling vehicle-to-grid (V2G) technology can reduce GHG emissions even further. A case study in the research shows that a considerable improvement of GHG reduction is observed when the carbon intensity of electricity is considered in terms of scheduling when cars and buses should charge. Further enabling the V2G results in an even more significant improvement as V2G technology allows buses and cars to send power back to the grid, which is especially meaningful when the carbon intensity of electricity is high.

The Contra Costa County case study revealed phased development patterns for charging hubs. Using cost-benefit analysis, the research assessed a five-phase infrastructure rollout plan with increasing annual budgets, as detailed in the following table. Due to the high costs of electric buses, Phase 1 prioritizes establishing charging hubs and providing chargers for cars with high potential

	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Annual Budget ($ million)	0 - 2	2 - 8	8 - 34	34 - 40	40 and above
GHG reduction ($mTCO_2e$/day)	0 - 6.4	6.4 - 23.2	23.2 - 61.7	61.7 - 62.6	62.6
Average GHG reduction per $million investment	3.2	2.8	1.5	0.15	0.0
Key feature	Kick-off in car sector	Switching to bus sector	Dominant by bus sector	Pre-saturated	Saturated

Table 1. GHG reductions and budget for a hypothetical 5-phased EV charging infrastructure rollout plan.

to utilize low-ECI electricity. With the hubs in place, Phase 2 shifts focus to the bus sector, targeting buses with high daily GHG emissions for electrification. In Phase 3, most of the budget is allocated to the bus sector. Phases 4 and 5 see diminishing marginal benefits of investment. It is important to note that these phased development patterns can change based on different cost factors. See Table 1.

The optimization model can be easily customized to other areas. Designed in a flexible way, the proposed optimization model can be easily customized for other regions by integrating local data, including potential charging hub locations, transit schedules, patterns of passenger car usage, and cost factors.

Further Reading and More Information

This policy brief is drawn from the report "Charging Hub for Electrified Mobility" prepared by Ran Wei with the University of California, Riverside. The report can be found here: www.ucits.org/research-project/2021-47. For more information about findings presented in this brief, please contact Ran Wei at ran.wei@ucr.edu.

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