Allocating DC Fast Charging Stations for Battery Electric Vehicles

OVERVIEW

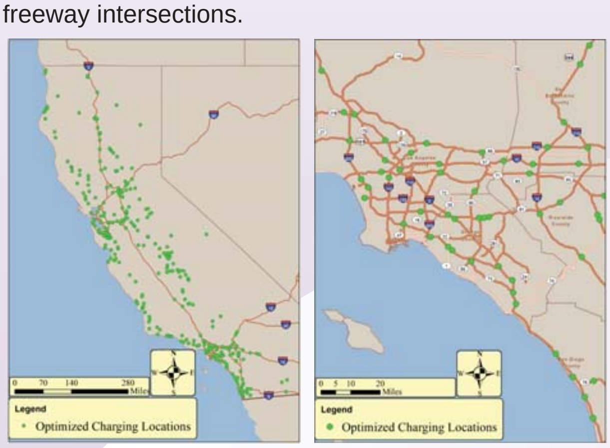
Battery electric vehicles (BEVs) are important for reducing fuel consumption and vehicle operating cost. However, the range limits and long recharging times serve as obstacles for the mass deployment of BEVs. Well Planned Level 3 DC fast charging stations may be a solution to satisfy long distance travel demand instead of a large scale Level 2 non-home charging infrastructure. This work identifies candidate charging routes and uses freeway exits and highway intersections as approximate candidate charging locations, and consequently solves a set covering problem to minimize the number of charging stations. Results show that 290 locations are required for the State of California based on travel data from the 2000 California Travel Survey. With this optimized station network, electric light duty vehicle miles travelled (VMT) can reach 92% and BEVs can be used by 98% of drivers. Congestion at several stations suggests extra chargers at those locations. A reservation system can benefit both the BEV drivers and station operators by reducing the number of waiting events and wait times, decreasing the extra chargers needed, and more evenly utilizing all the stations.

GOALS

Optimize the locations of DC fast charging stations in California and evaluate the BEV feasibility and the temporal utilization of charging stations based on different station selection strategies.

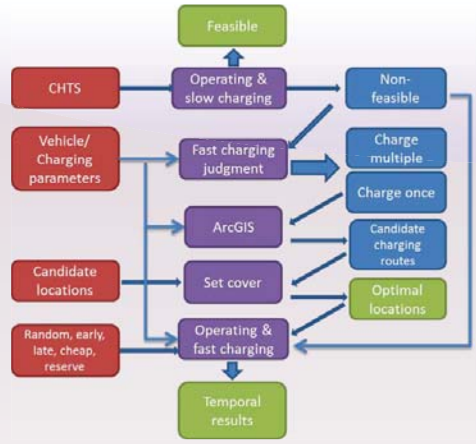
RESULTS

290 sites are required to cover BEVs with 60 miles range demanding one time fast charging during a whole day. Most locations are distributed in the most populated areas, such as greater Los Angeles, San Diego, San Francisco Bay area, and Sacramento. And, most of them are close to freeway intersections.

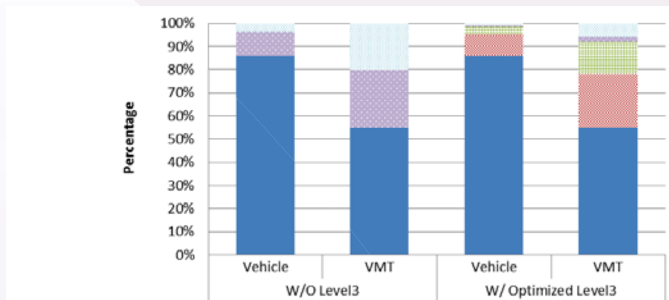


Optimized charging locations for California and Los Angeles region.

The optimized station network provides good coverage such that BEV feasibility is 88% and 98% for long distance driving and all driving, respectively. And, this network increases the feasible VMT to 92%.



BEV Level 3 fast charging station allocation optimization model.



	W/O Level3 Vehicle	W/O Level3 VMT	W/ Optimized Level3 Vehicle	W/ Optimized Level3 VMT
Infeasible (Charge More)	3.95%	20.05%	0.98%	5.75%
Infeasible (Charge Once)	10.09%	25.04%	0.75%	2.12%
Charge More	0.00%	0.00%	2.97%	14.30%
Charge Once	0.00%	0.00%	9.34%	22.91%
No Need	85.96%	54.91%	85.96%	54.91%

BEV and VMT feasibility with and without the optimized fast charging station network.

Wait events exist for all of the strategies with late charging having the most, followed by early, cheap, and random charging. A reservation system makes the average wait time at least 70% shorter than any other scenario. It can also decrease the maximum waiting time dramatically to less than 1 hour. Furthermore, it helps to distribute charging events more evenly to different locations.

	Average Wait Time for 1,467 Vehicles (minutes)	Average Wait Time for Wait Events (minutes)	Maximum Wait Events at any Station	Maximum Accumulated Wait Time at any Station (minutes)	Electricity Cost per Charge (dollar)	Average Charges / Station	Standard Deviation of Charging Distribution
Random	0.81	9.15	9.7	184.28	1.75	5.06	0.91
Late	1.51	11.08	15	415.17	2.10	5.06	1.48
Early	1.14	9.59	12	150.54	1.38	5.06	1.27
Cheap	1.00	8.71	12	150.54	1.35	5.06	1.24
Reserve	0.21	6.81	3	47.49	1.45	5.06	0.47

Wait time, wait event, electricity cost, and station operating status for different station selection strategies.

RECENT PUBLICATIONS/PAPERS

L. Zhang, T. Brown, G.S. Samuelsen (2013). The optimization of DC fast charging deployment in California. Energy Policy, under review.

PERSONNEL

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