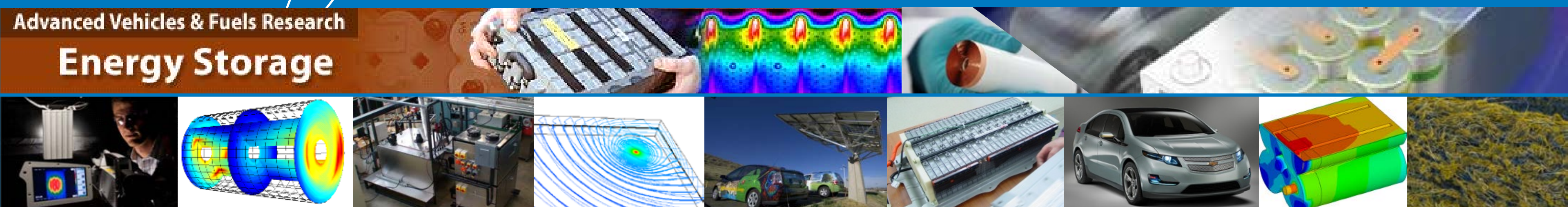
A Techno-Economic Analysis of BEV Service Providers Offering Battery Swapping Services



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Sponsored by DOE VTP
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NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Motivation

- Battery electric vehicles (BEVs) could significantly reduce the nation’s gasoline consumption and greenhouse gas emissions rates.

- However, both the upfront cost and the limited range of the vehicle are perceived to be deterrents to the widespread adoption of BEVs.

- A service provider approach to marketing BEVs, coupled with a battery swapping infrastructure deployment could address both issues and accelerate BEV adoption, **but does it make financial sense to the consumer?**

Outline

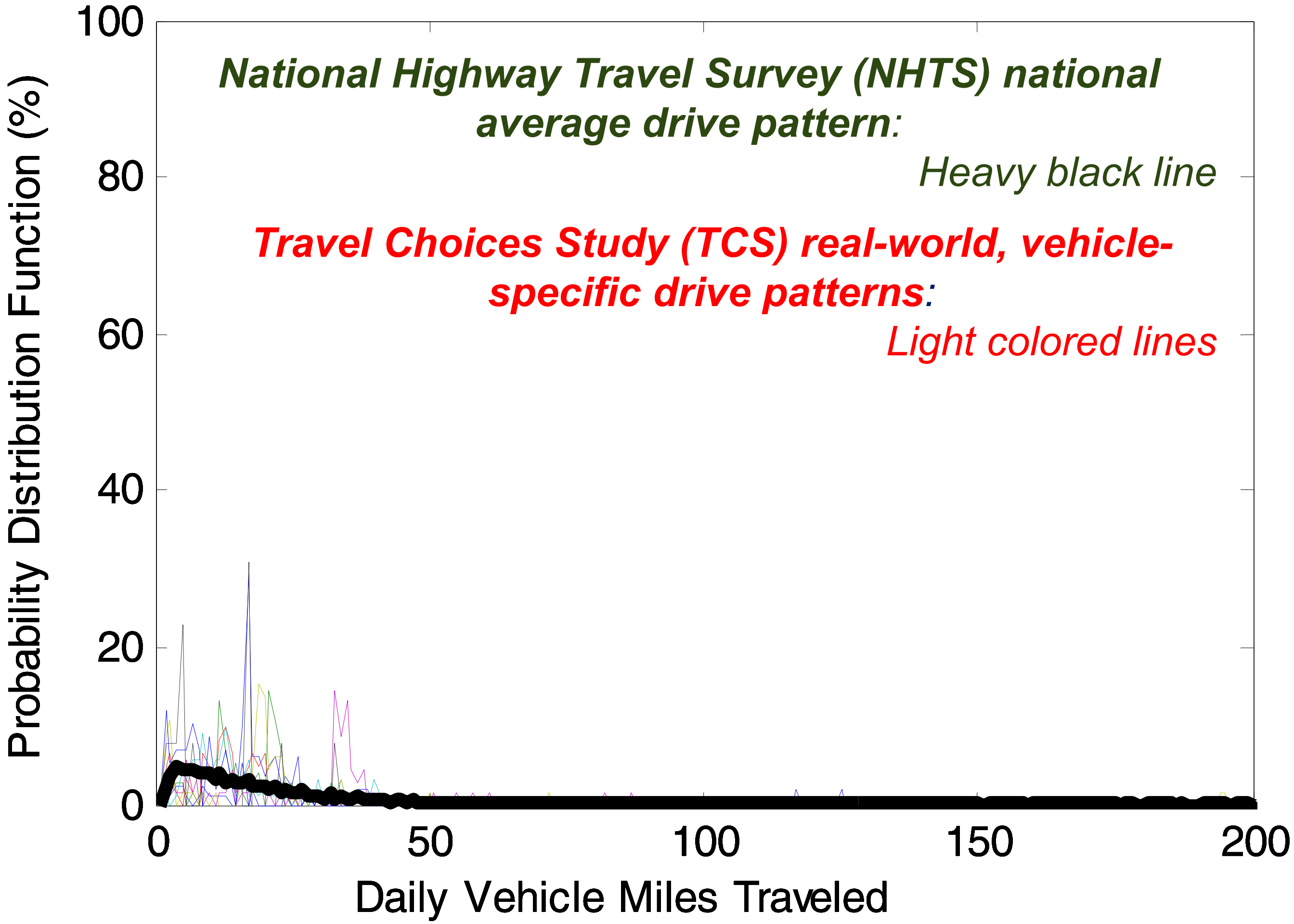
- Customer Selection
- Service Usage Statistics
- Service Plan Fees
- Driver Economics

Customer Selection: Unachievable Travel

- Our studies have shown that how a driver completes travel not achievable with a BEV (e.g., day trips longer than the range of the vehicle) strongly impacts economics.
- If you can complete unachievable travel at low marginal cost (e.g. use another CV owned by the household), battery swapping is unlikely to be cost-effective.
- However if unachievable travel is expensive (e.g. a rental car is required), then battery swapping may be an attractive option. Thus we restrict our study to this scenario.

Customer Selection: Drive Pattern Data

- Not all drivers are well suited to a battery swapping service plan, and no battery swapping service provider would target the entirety of the vehicle market.



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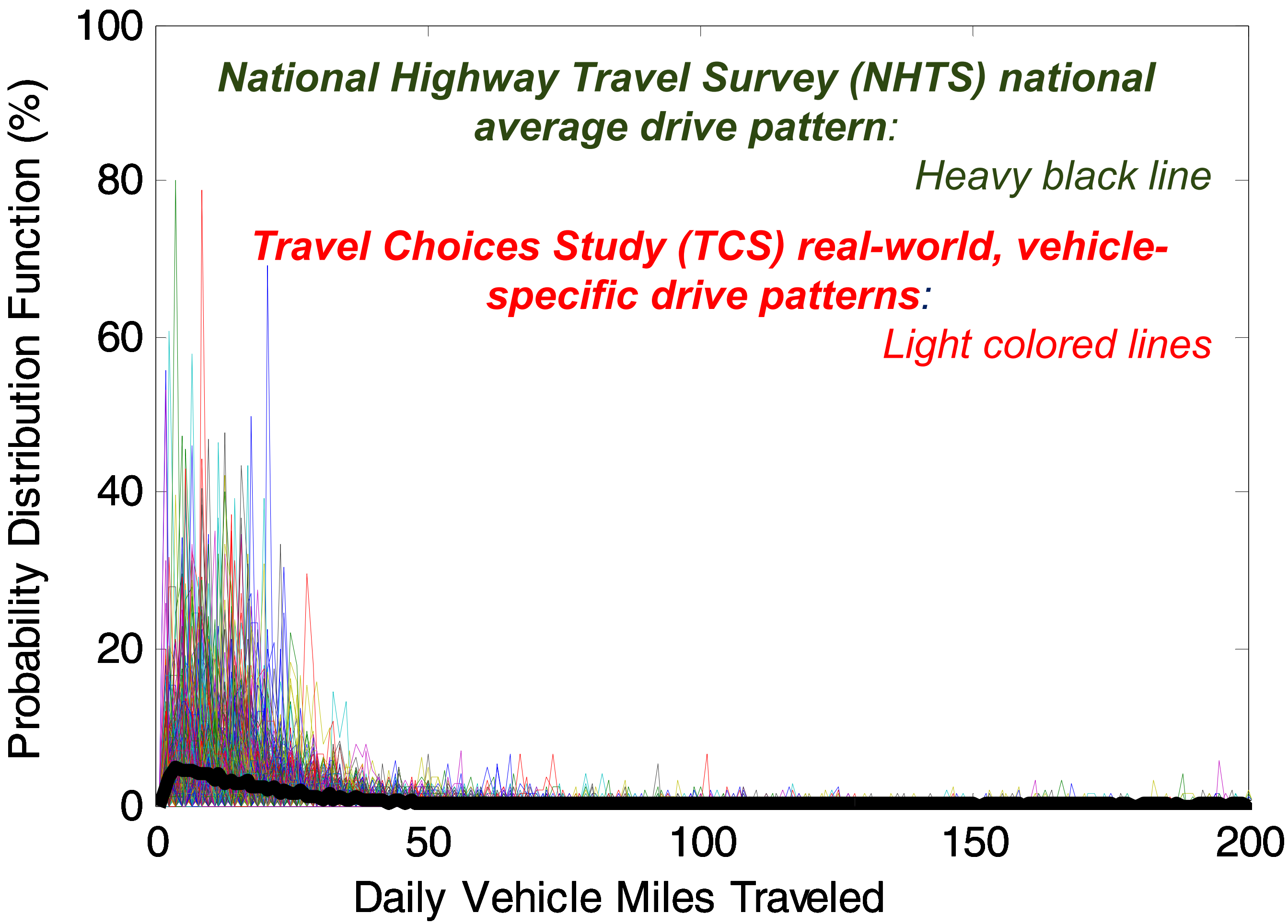
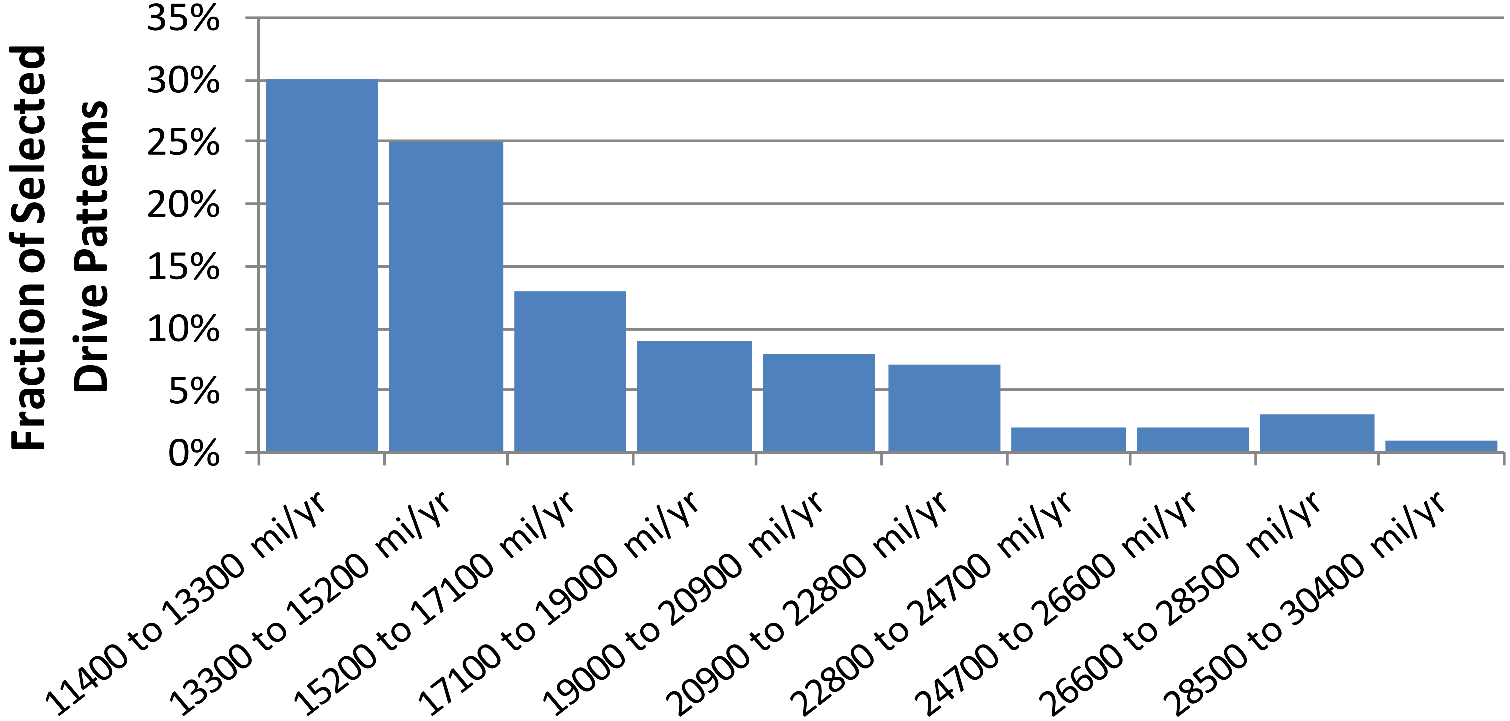


Customer Selection: Drive Patterns

- We down-select 100 drive patterns (~25% of the complete TCS set) that show the best potential cost effectiveness relative to directly-owned conventional vehicle (CV) and BEV alternatives using a simplified TCO analysis.

- We find that annual VMT is the single most important factor driving our down-selection



Service Usage Statistics: Approach

- To calculate service plan fees, we need to know infrastructure requirements and operating expenses.

- Approach: Apply the Battery Ownership Model (BOM) to calculate electricity usage, battery swapping frequency, battery life, and vehicle utility factor for each combination of 100 drive patterns, three vehicle ranges, three maximum battery SOCs, and two fast charge wear factors.

  – Note we apply a limit of four battery swaps per day (max) to account for temporal and spatial restriction on swapping availability, as well as a driver's willingness to change behavior.

Service Usage Statistics: Results

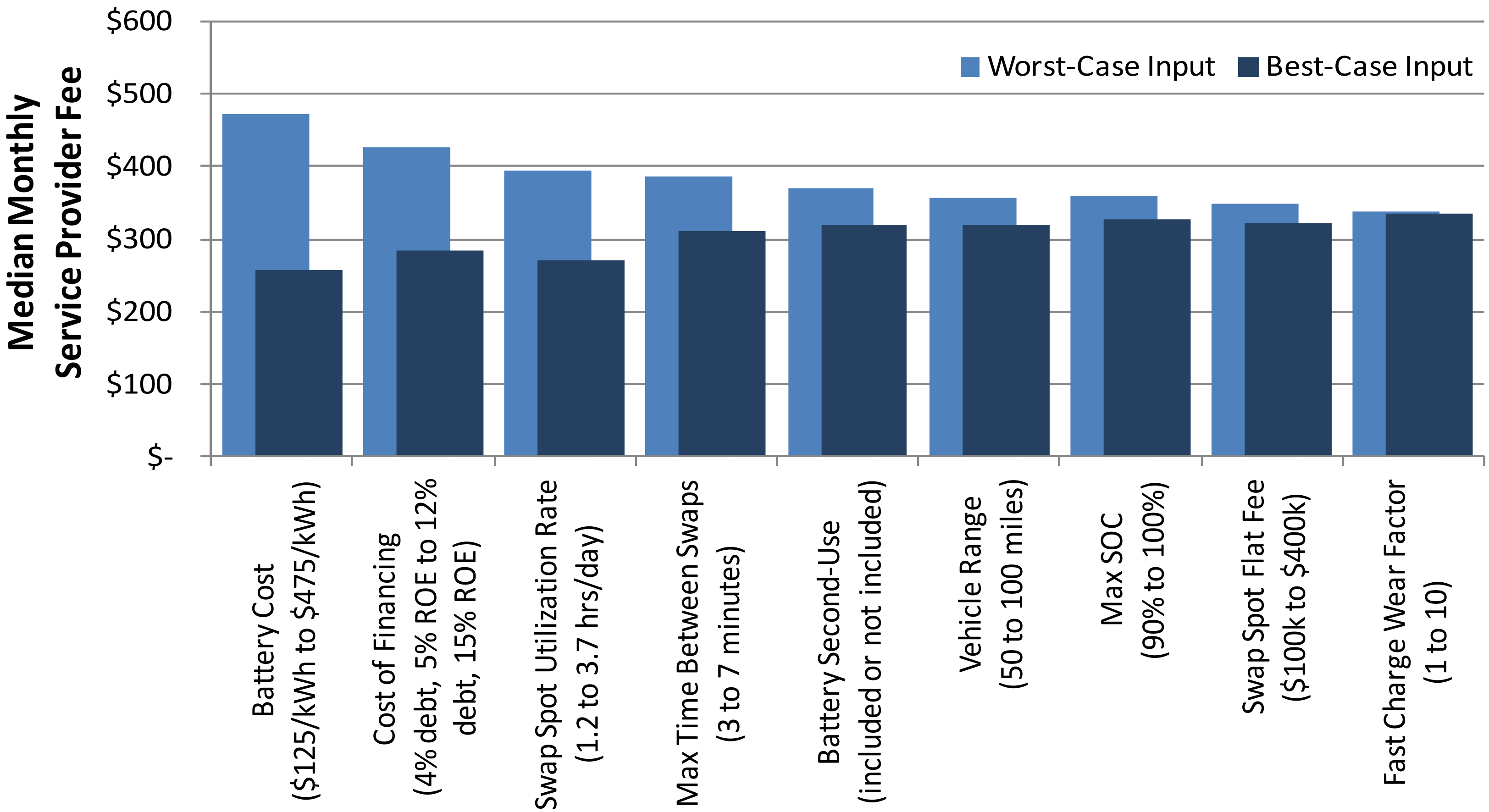
Range	Max SOC	Fast Charge Wear Factor	Battery Life (yrs)	Annual Electricity (kWh)	Swaps per Year (No.)	Utility Factor
50 mi	100%	1	8.4	5684	158.4	86%
		10	6.6	5673	157.9	85%
	95%	1	11.1	5681	152.7	85%
		10	8.6	5675	150.8	85%
	90%	1	14.2	5670	150.1	85%
		10	11.6	5672	147.3	85%
75 mi	100%	1	9.0	6059	71.8	89%
		10	8.9	6055	71.8	89%
	95%	1	12.3	6059	70.5	89%
		10	12.1	6066	70.4	89%
	90%	1	14.7	6066	66.3	89%
		10	14.6	6072	66.5	89%
100 mi	100%	1	8.4	6572	43.2	94%
		10	8.4	6572	43.2	94%
	95%	1	11.5	6596	41.9	94%
		10	11.5	6597	41.9	94%
	90%	1	14.4	6600	39.8	94%
		10	14.4	6600	39.8	94%

- BEV50: high battery swapping frequency, battery life sensitive to fast charge effects, good utility factor
- BEV100: low battery swapping frequency, negligible sensitivity to fast charge effects, utility factor approaching 100%.

Service Plan Fee: Approach

- Input service usage statistics.
- Calculate swap spot infrastructure requirements.
  - Utilization rate (hrs/day) drives number of customers per swap spot (1.2 hrs/day for typical U.S. gas pump).
  - Max time between swaps (minutes) drives number of chargers and batteries at swap spots, and determines customer wait time.
- Account for all swap spot infrastructure, battery, home charger, electricity costs, and operating expenses.
- Calculate service plan fee using a detailed business model to meet return-on-equity (ROE) requirement.
  - Build infrastructure in year zero for 10,000 subscribers using 50/50 equity/debt financing.
  - Remaining working capital following all expenses, taxes, and debt payments is applied to build new infrastructure each year, thereby determining increase in subscribers.
  - Service plan fee is calculated such that the value of the company at year 15 is equal to the initial equity investment had it grown at the prescribed ROE.

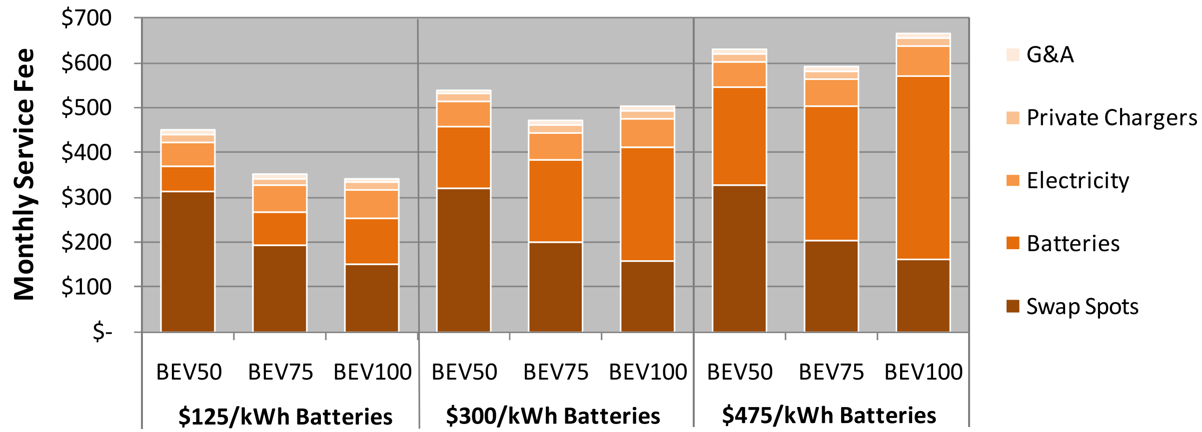
Service Plan Fee: Input Sensitivity



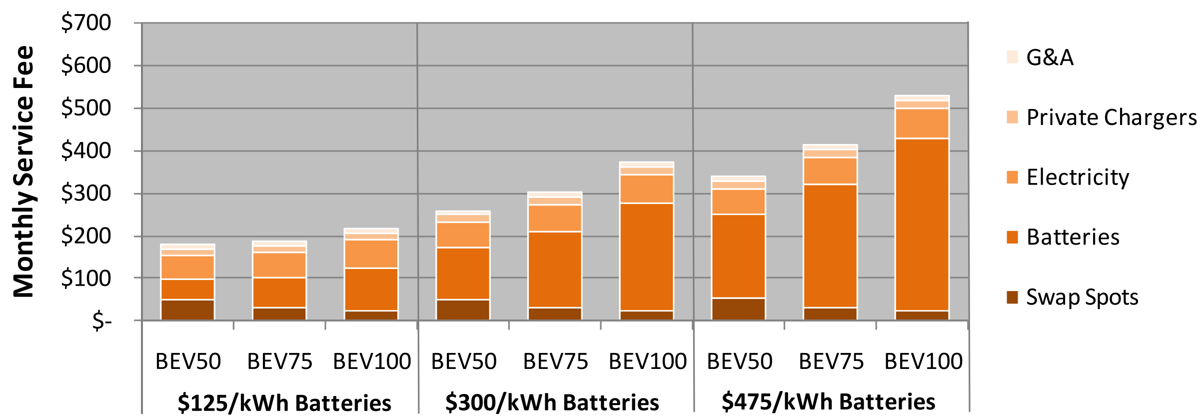
- Battery cost and cost of financing are the two highest impact factors.
- Swap spot service variables combine to have a large impact too.
- Fast charge wear factor has a negligible impact.

Service Plan Fee: Cost Breakdown

High Service, High Cost Battery Swapping

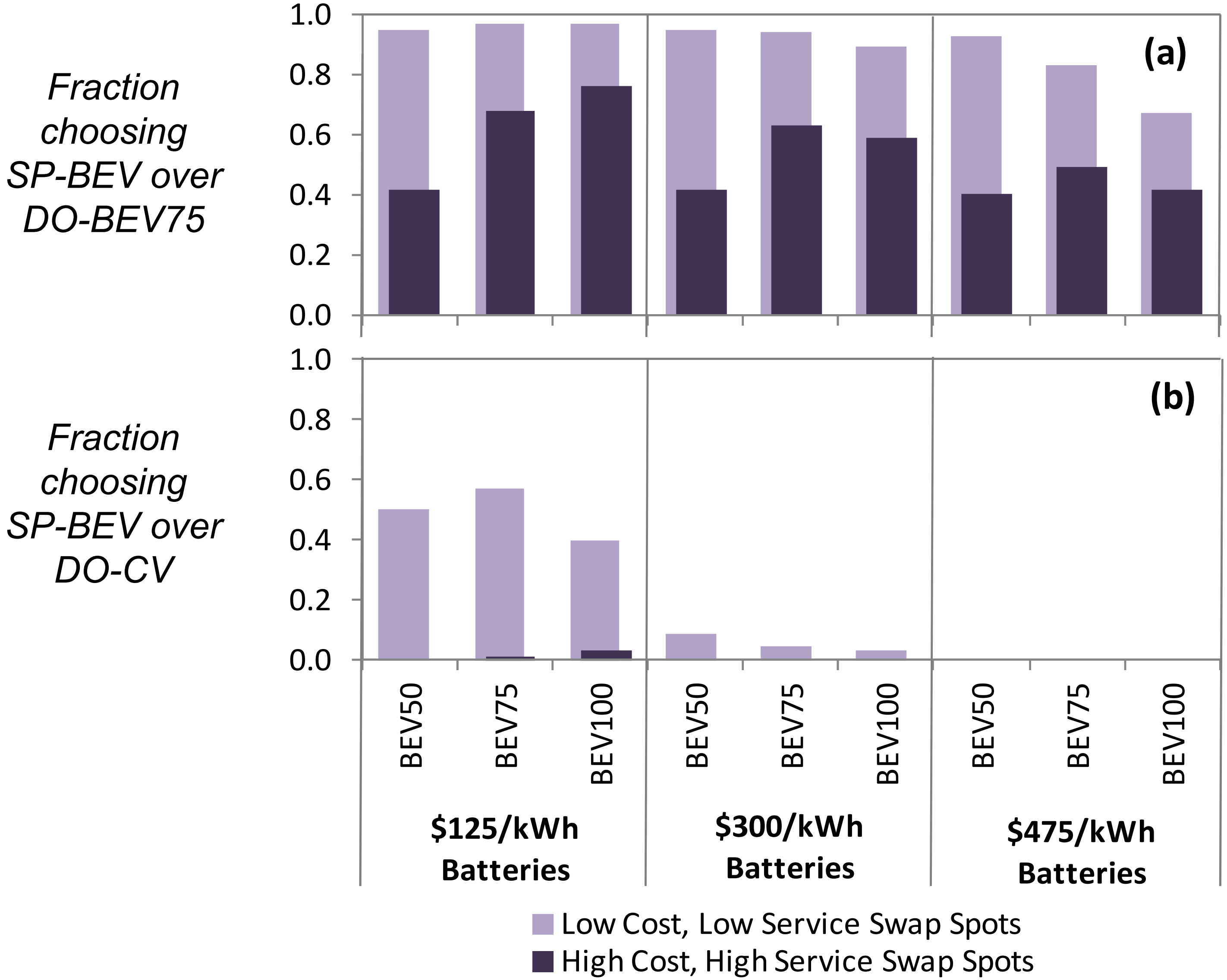


Low Service, Low Cost Battery Swapping



- Batteries are a major cost component in nearly every scenario.
- Swap spot infrastructure costs can vary from insignificant to the largest single cost element.

Individual Driver Economics



Remaining Questions

- How big is the applicable high mileage, high cost of unachievable VMT market?
- How much of a premium is this market willing to pay over a CV?
- What level of convenience will be necessary?
- How will temporal and spatial factors impact necessary infrastructure deployments?
- What other consumer-choice factors will have a strong impact on adoption of a battery swapping service plan?

Presumably, the answer to many or all of these questions is not supportive of a battery swapping service in the US.

Feb 5, 2013, 2:58pm PST | **UPDATED:** Feb 5, 2013, 3:31pm PST

BetterPlace will cease US operations, close Palo Alto office

Lindsay Riddell
Reporter-
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Better Place, the once-hot electric vehicle startup that raised $750 million in investment, said it is shutting down operations in the U.S. and Australia to focus on the markets where its made the most progress: Israel and Denmark.

BetterPlace is closing its North American and Australian

http://www.bizjournals.com/sanfrancisco/blog/2013/02/betterplace-will-cease-us-operations.html?page=all

Conclusions

- It is unlikely that a battery swapping service plan will be more cost-effective than ownership of a conventional vehicle.
- A battery swapping service plan may be a more cost-effective solution than a directly owned BEV for some single-vehicle, high-mileage consumers.
- However, other factors not considered in this analysis could decrease the viability of such a service.


Thanks!
Questions?