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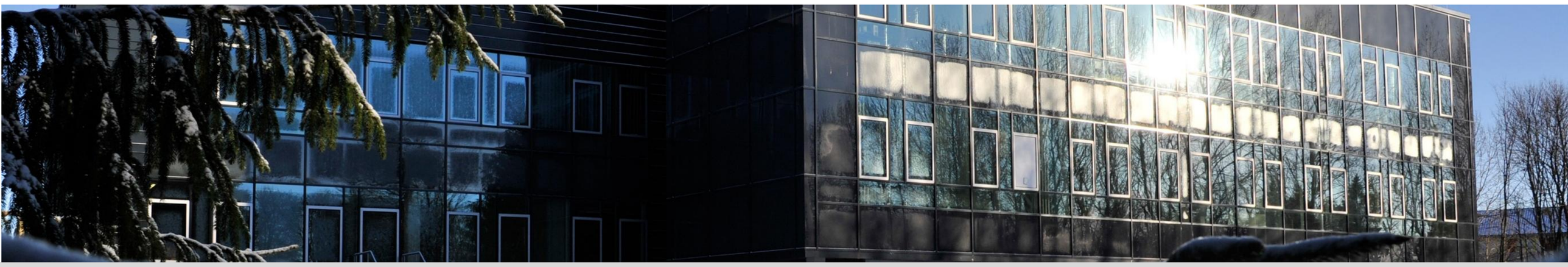

Improving battery development by leveraging representative and dynamic load profiles derived from customer data

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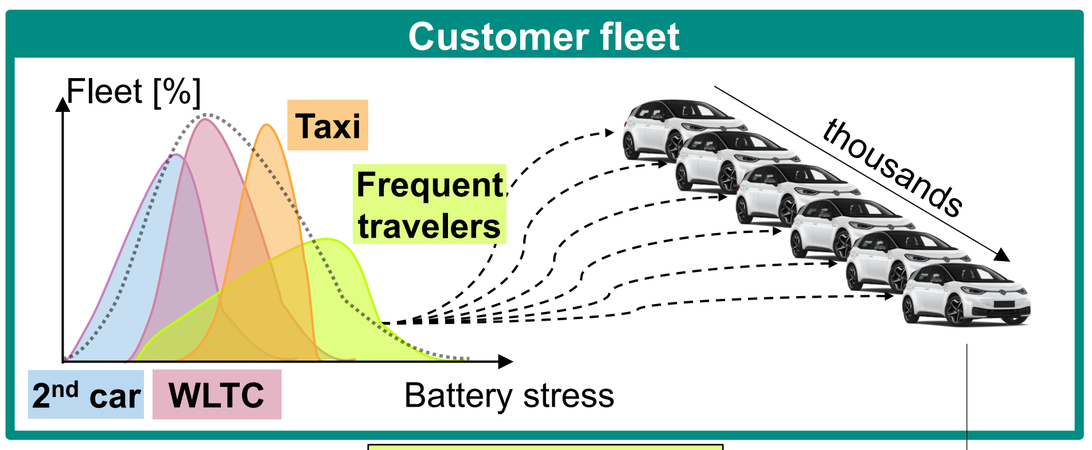
During simulation of vehicle batteries, load profile choice greatly influences system behavior

We propose a framework to calculate representative load profiles from large data pools.

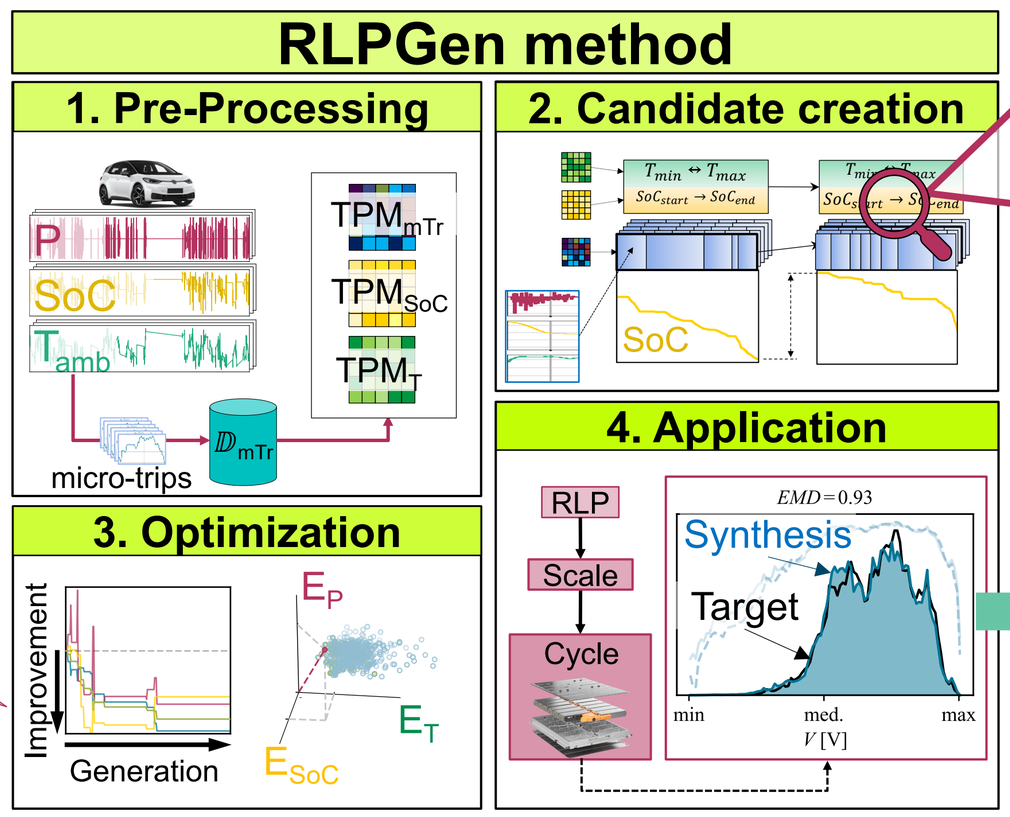
<u>Complication</u>: Batteries evince heterogeneous reactions induced by their concurrent states of I, T, and SoC [1,2]. However, available input profile synthetization methods fail to represent simultaneous thermo-electrical usage dynamics [3-5]. Furthermore, investigations on sensitivity between modeling assumptions and effective battery behavior need to be conducted.

<u>Solution</u>: Using our novel method, we create several load profiles that incorporate dynamic power, state-of-charge, and temperature. We then statistically assess their replicative ability of downstream reactions through industry-level simulation models. [6]

<u>Results</u>: Our profiles mimic statistical system states with high-fidelity with up to 100% accuracy of achieved FCE, SoH_R, or service life at SoH_C= 70 %. We point out the urgency of including dynamic voltage exploitation into representative load profiles.



<u>Synthetization process</u>:
1) **Statistical aggregation** of similar usage profiles
2) **MCMC simulation** derives several SoC discharge stroke phases
3) **A genetic algorithm** discovers profiles with best statistical match
4) **Cycling** determines missing dimensions (Input: {P,T_{amb},$\widehat{SoC}$} → Output: {V, I,T_{bat},SoC}).



Data-driven component engineering is the key to finding Pareto-optimal settings for both product cost and user experience.

References
[1] Vermeer et al. (10.1109/TTE.2021.3138357)
[2] Birkl et al. (10.1016/j.jpowsour.2016.12.011)
[3] Zhang et al. (10.1109/TVT.2018.2887063)
[4] Zhao et al. (10.1007/s11356-018-3541-6)
[5] Ben-Marzouk et al. (10.1109/TVT.2021.3077671)
[6] Katzschke et al. (10.1016/j.etran.2025.100419)

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