Impact of battery electric vehicle initial conditions on ultra-fast charging events

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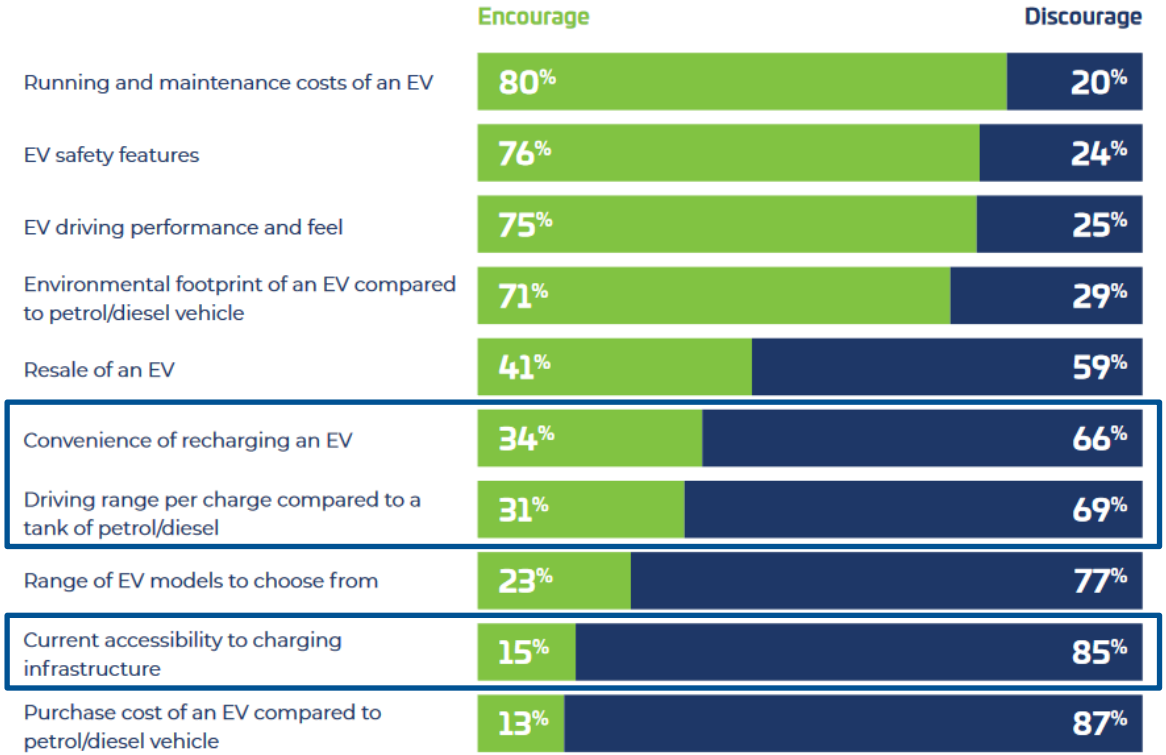
Agenda

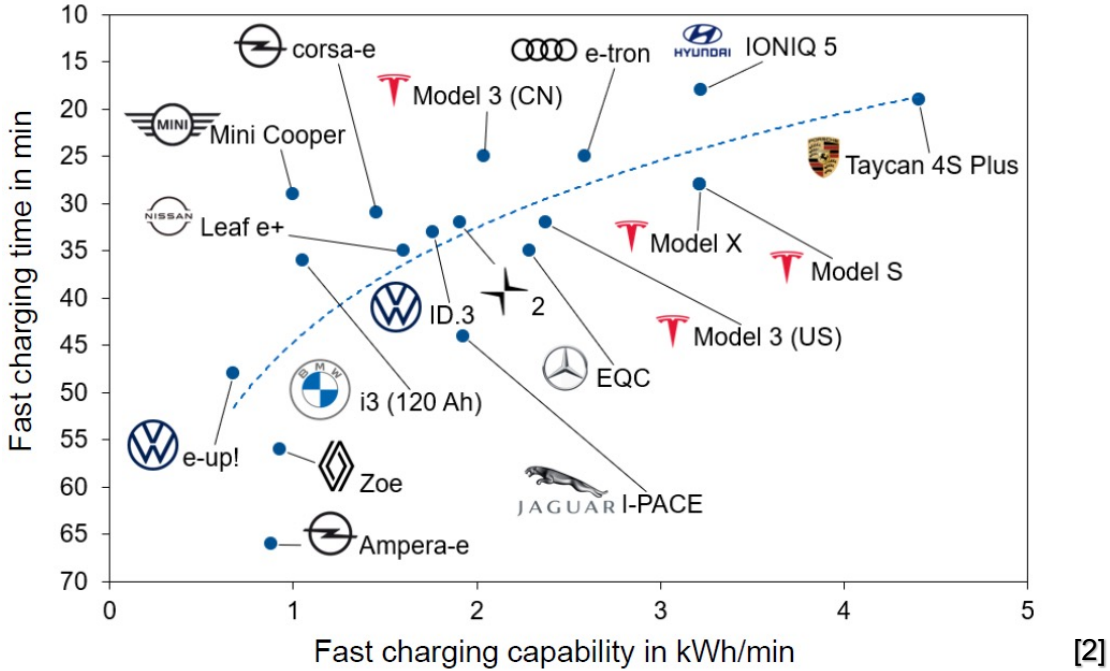
- Current Barriers for Electric Mobility
- Challenges of Ultra-Fast Charging
- Model-Based Fast Charging
- Influence of Initial and Ambient Conditions
- Perspectives for Future Fast Charging Operation Strategies

What is holding electric mobility back?



Electric Vehicle Council (Australia): Consumer Attitudes Survey 2021 [1]

The trend goes towards increasing fast charging capability



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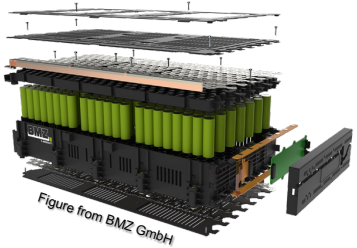
Fast charging remains a challenge

Cell Level

lithium-plating,
mech. stress,
electrolyte decomposition,…

Module Level



balancing, cell spread,
temperature gradients,
thermal management,…

Vehicle Level

user friendliness, cost,
ambient conditions,
infrastructure, route planning,…

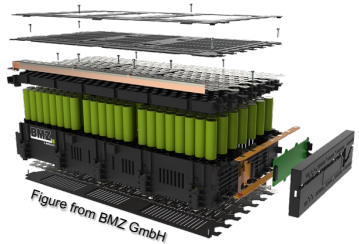
Time ⟷ **Aging**

New fast charging solutions are required

Cell Level

cell chemistry,
cell design,
new manufacturing methods,…

Module Level

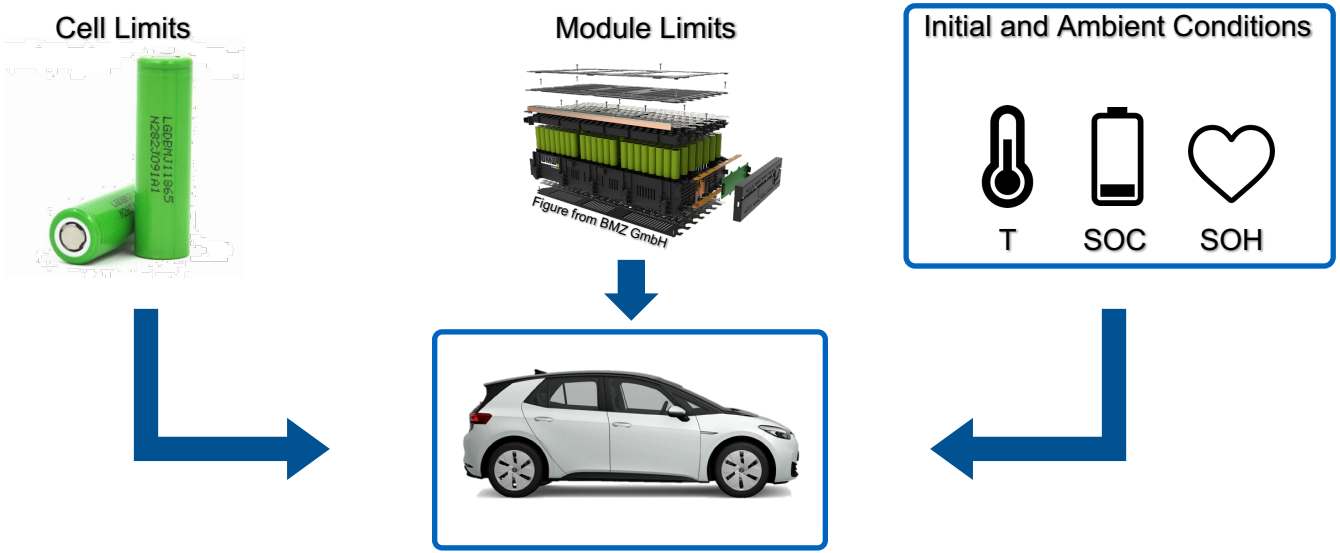


optimized charging methods,
model-based charging,
optimized assembly,
new BMS and thermal management concepts,…

Vehicle Level

?

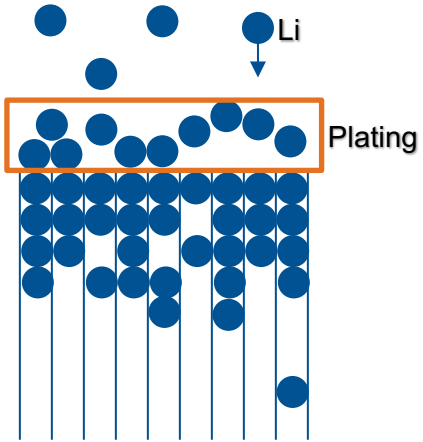
Optimized vehicle operation for fast charging?



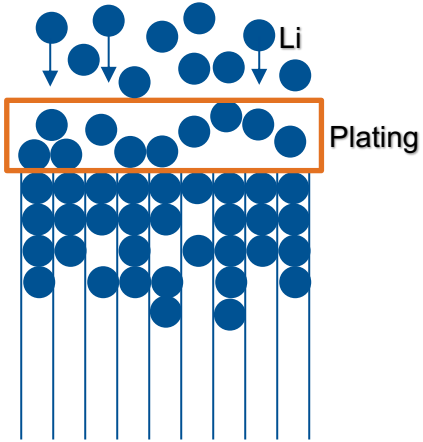
How should electric vehicles ideally be operated for ultra-fast charging times below 15min?

Dominant Aging Mechanism: Lithium Plating

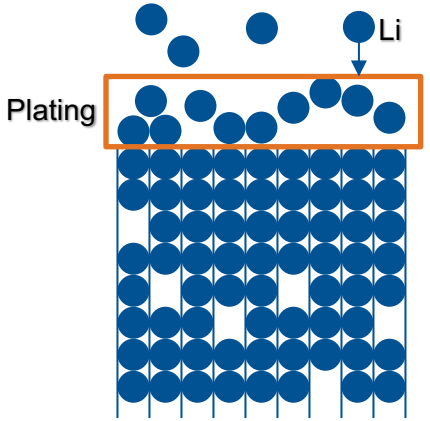
Low Temperatures



High Charging Currents



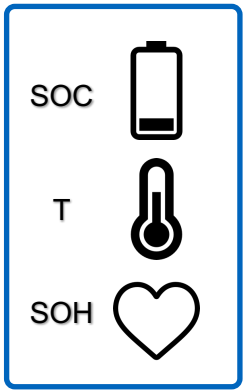
High State-of-Charge



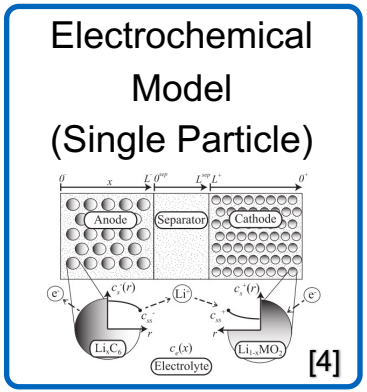
Lithium plating occurs at negative anode potentials!

[3]

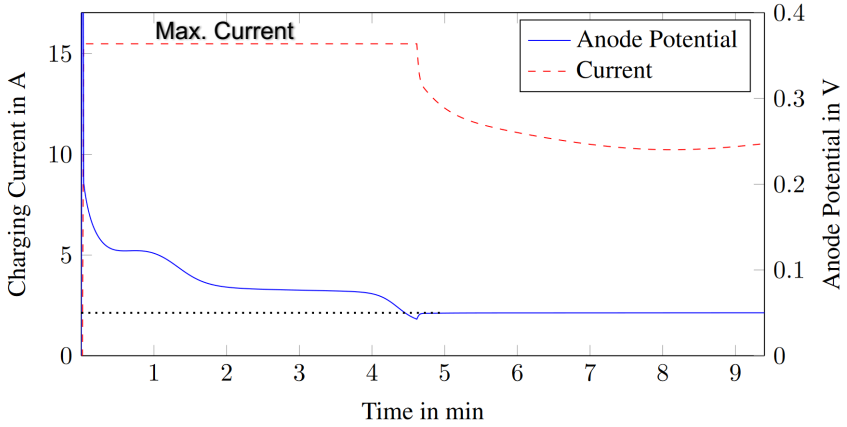
Model-based Charging



Initial and Ambient Conditions



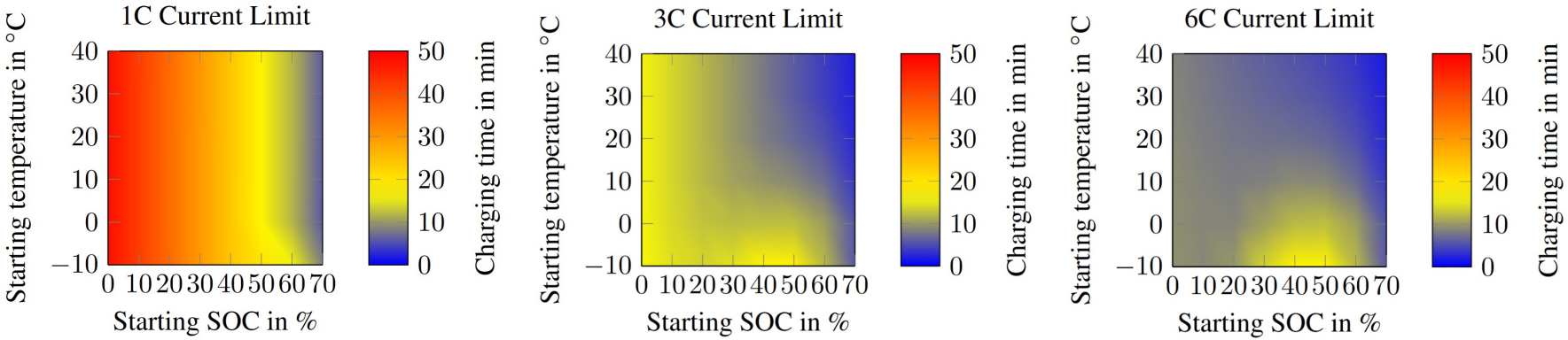
Model-based charging controller



Anode potential is kept above reserve to prevent lithium plating

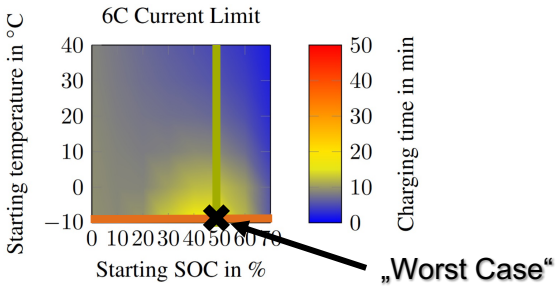
How long does a charging process take, depending on initial SOC and temperature?

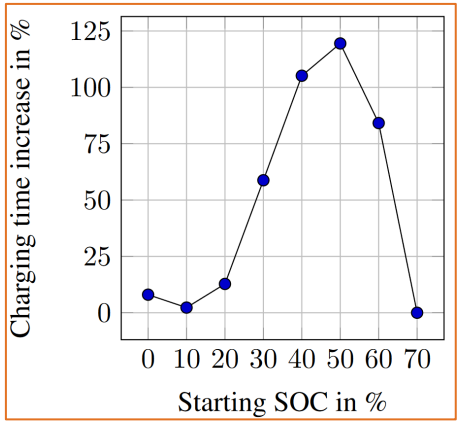
Low temperatures and medium SOCs critical

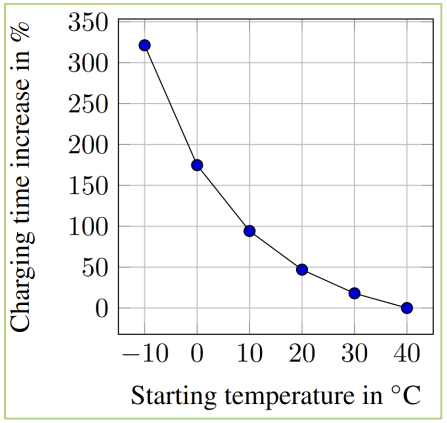


- Timing of fast charge event strongly influences charging duration
- Low temperatures: anode potential reaches 0V earlier
- Medium SOCs: current is reduced before the cell can heat up from charging

Up to threefold increase of charging duration

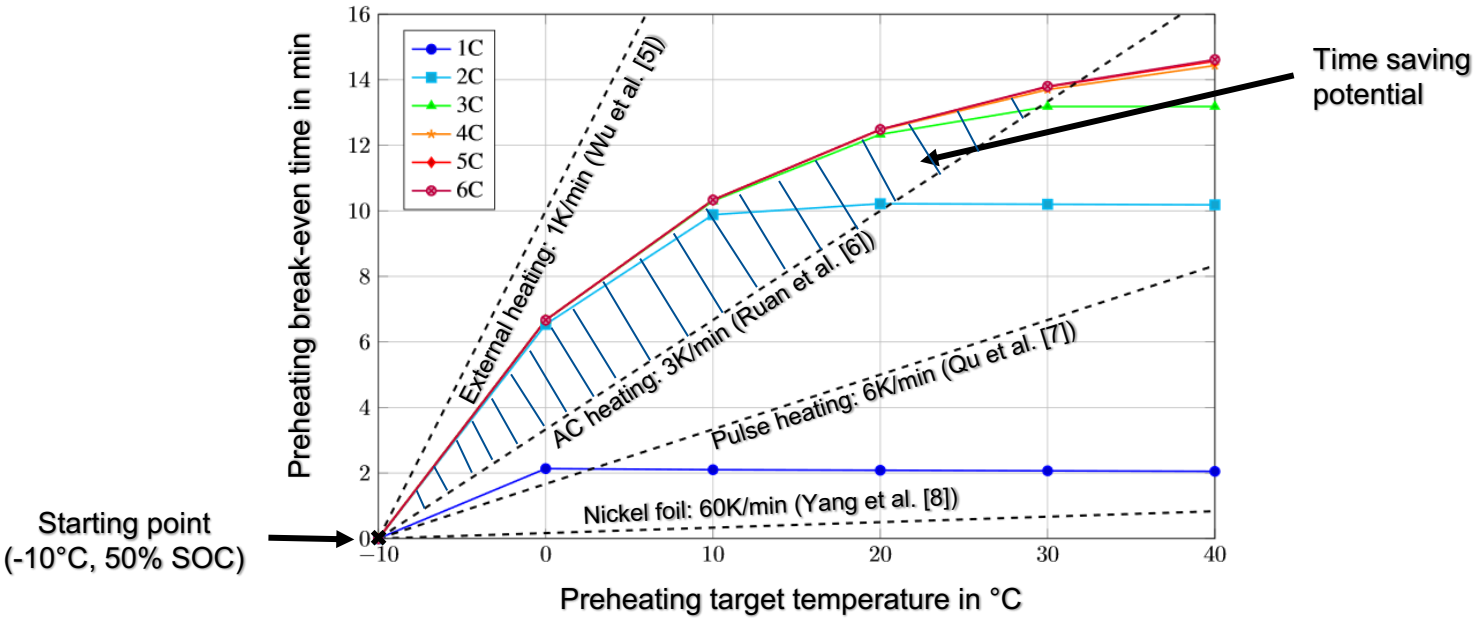






Solution: Charge planning optimization and thermal management?

Preconditioning is increasingly used to save time



Preconditioning already implemented in state-of-the-art vehicles

Key Takeaways

- Fast charging cabability strongly depends on initial conditions
- Fast charging at medium SOCs and low temperatures is critical
- Fast charge timing at low SOCs can save time
- Preconditioning with sufficient speed can save time

Future Questions

- Potential of optimized charge-scheduling strategies
- Interplay of charge-scheduling and thermal management
- Consideration of battery aging
- Influence of cell format and chemistry
- Relevance for different applications and vehicle concepts
- User-friendliness

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