

## Battery modeling

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Simulation Research

Learning by Simulation

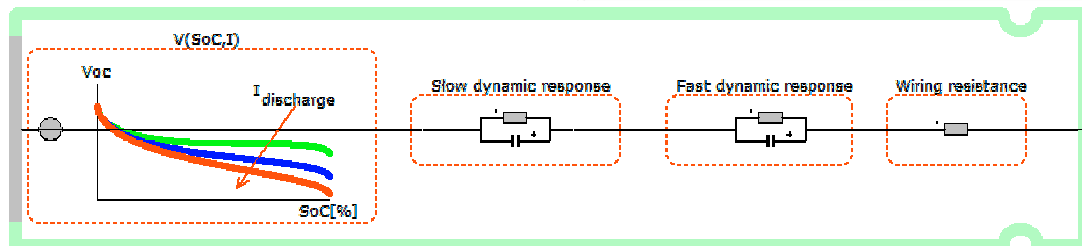
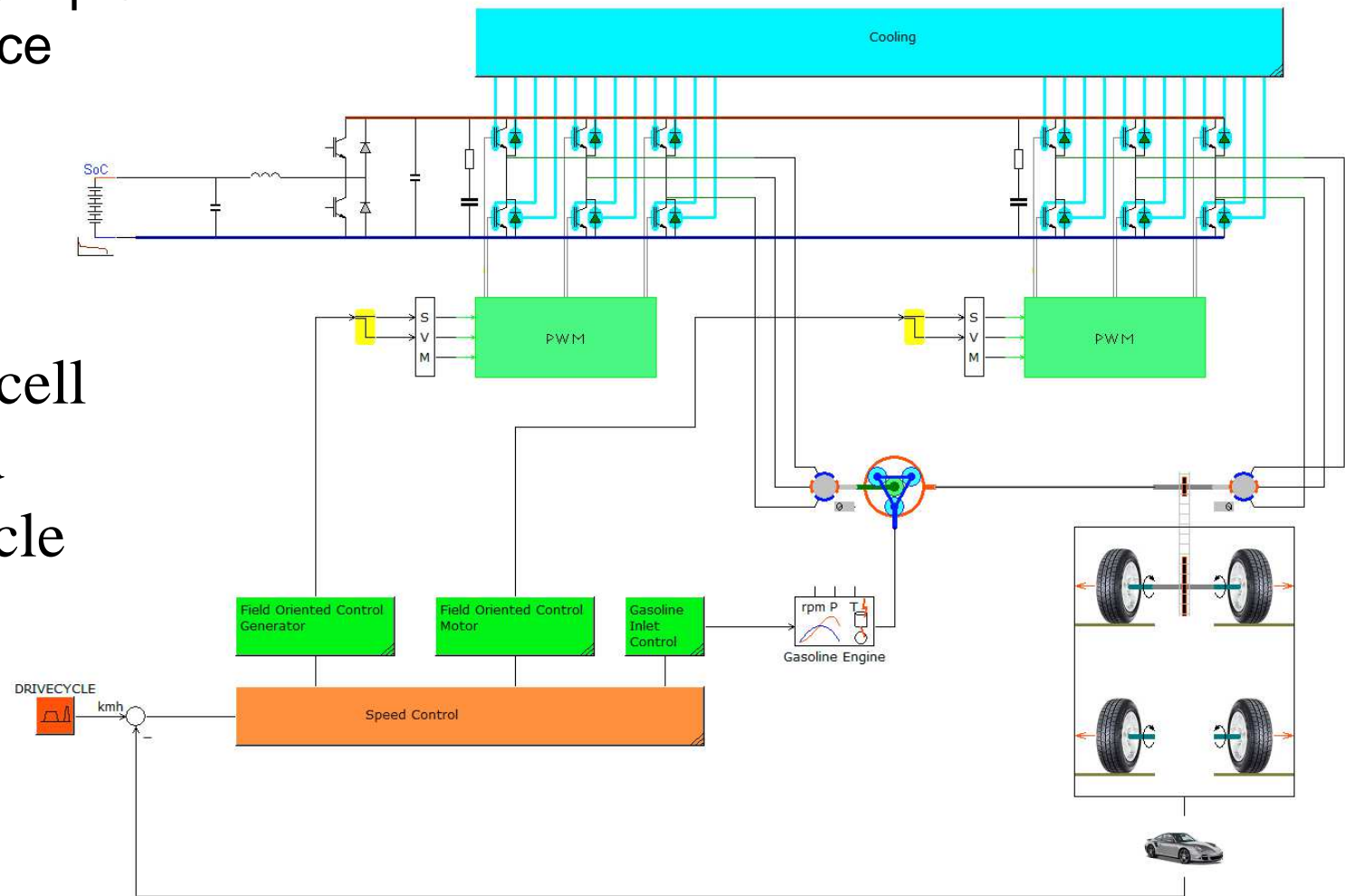


- Secondary Cell
  - Construction
  - Materials
  - Electrical

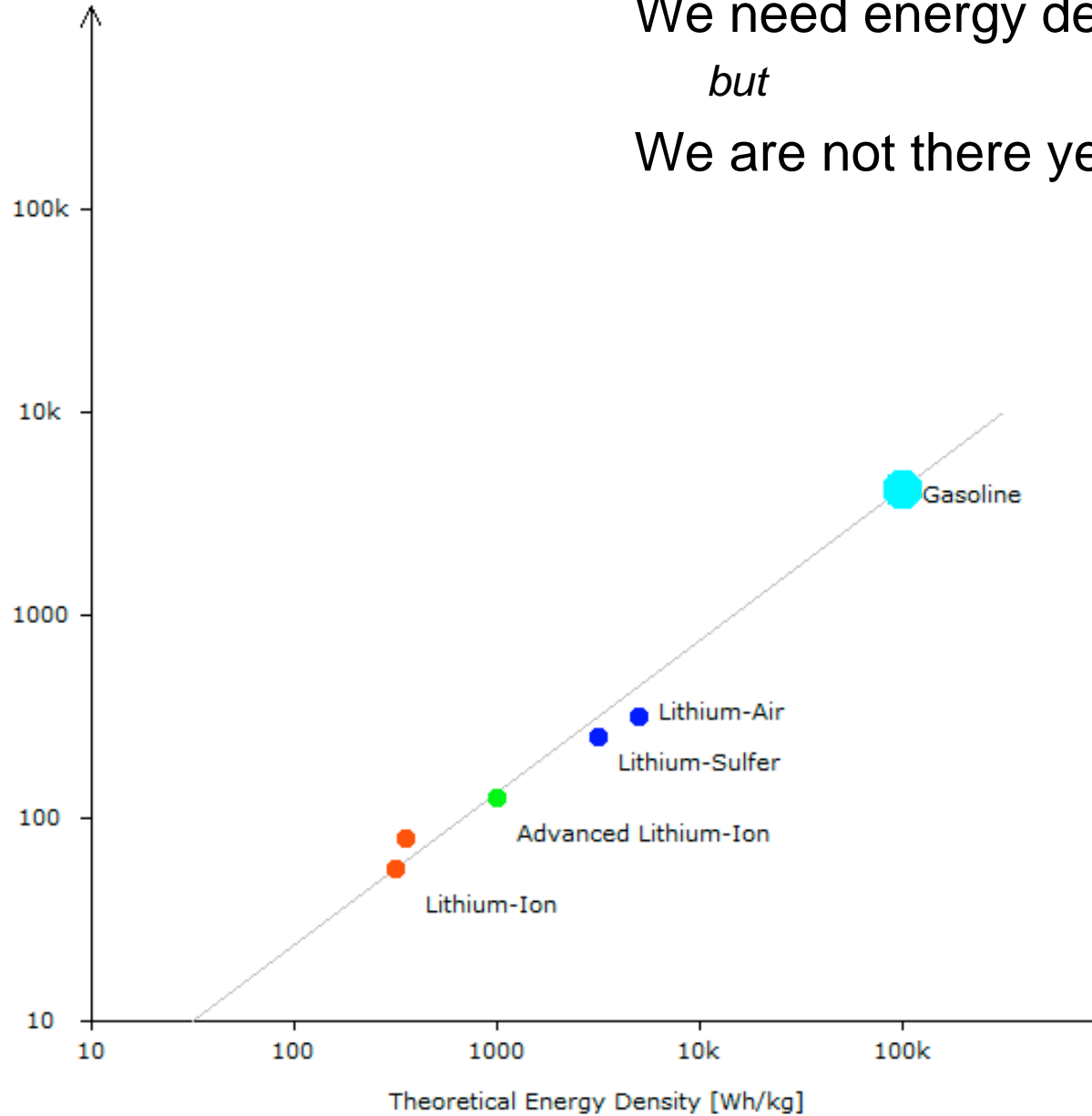


A battery is **not** a simple voltage source

Rechargeable cell  
in a Hybrid  
Electric Vehicle

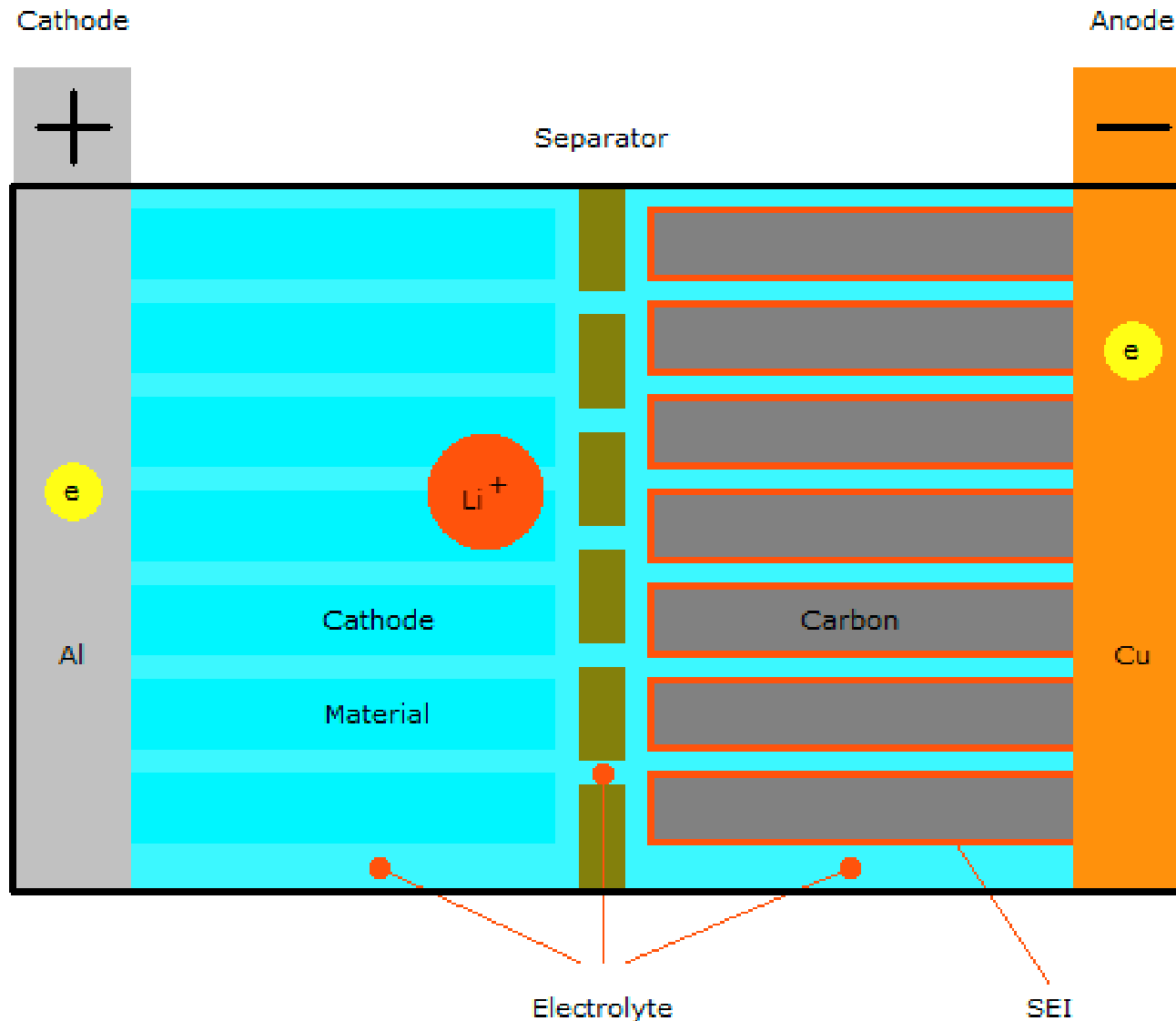


Practical Energy Density [Wh/kg]

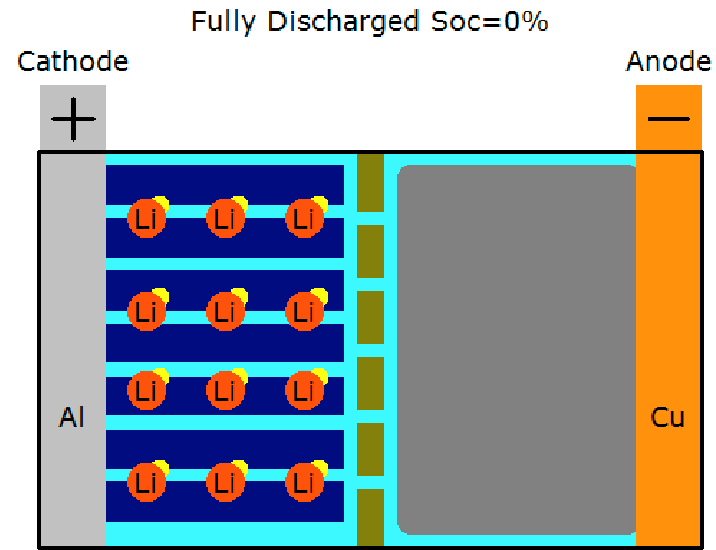
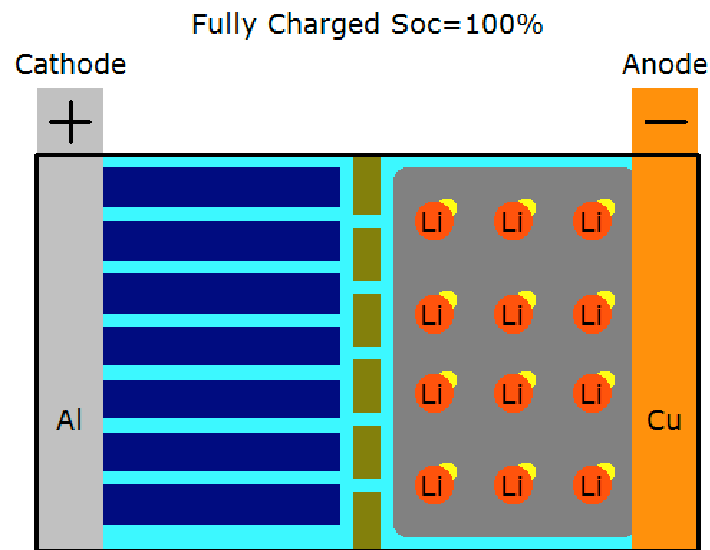
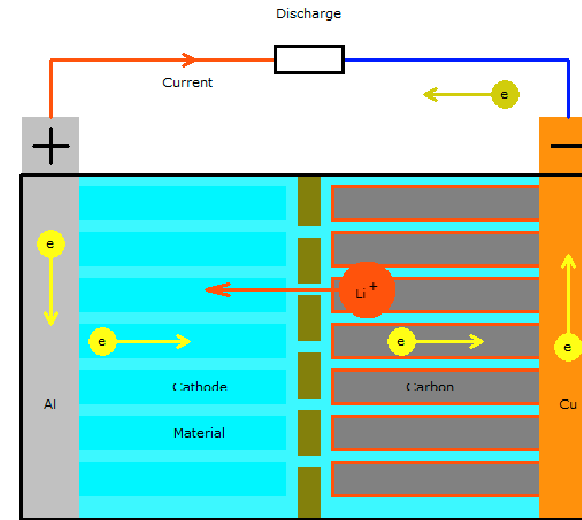
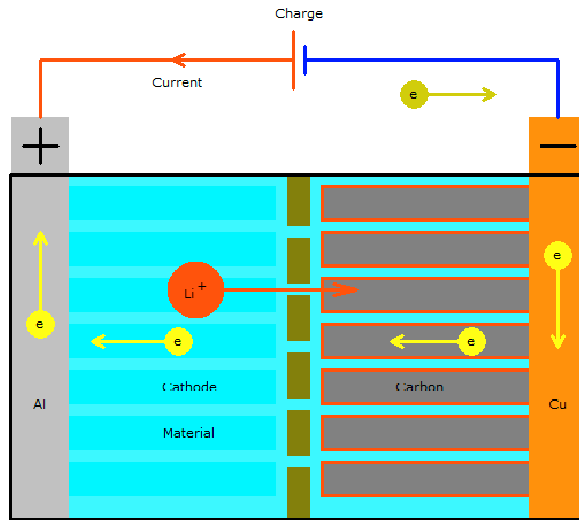


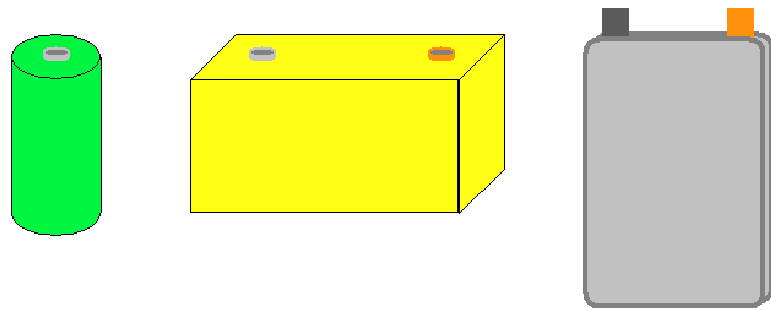
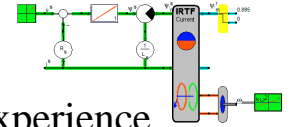
We need energy density like Gasoline  
*but*  
We are not there....

Lithium Ions are moving in a lithium polymer or liquid Electrolyte

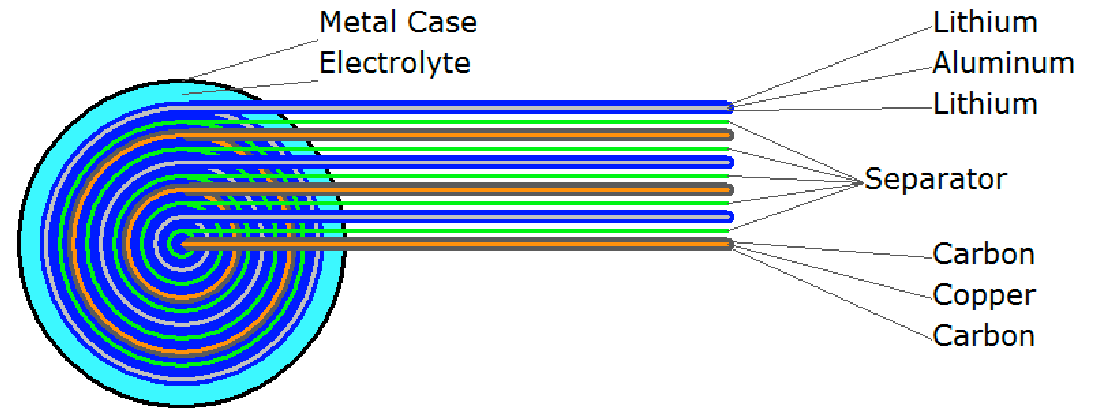


# Charge and Discharge

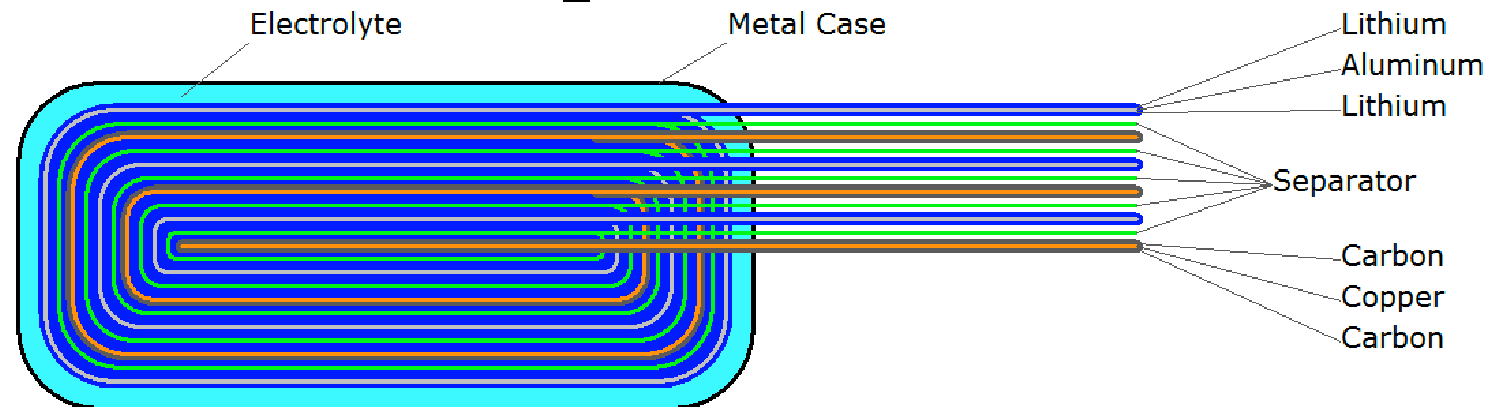




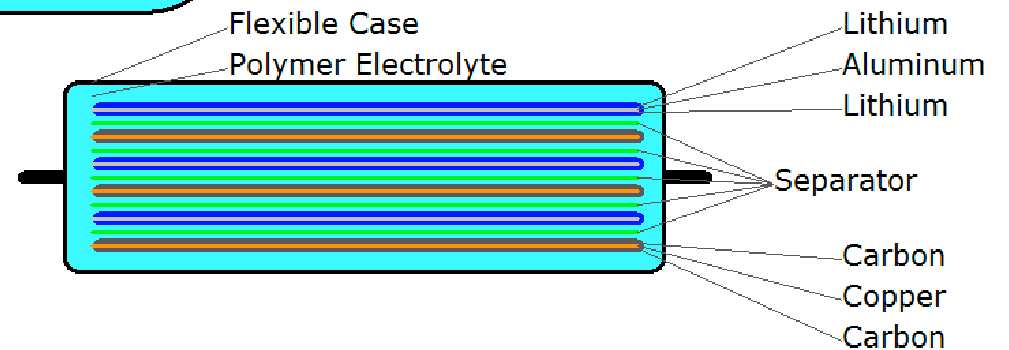
## ■ Cylindrical



## ■ Prismatic



## ■ Pouch

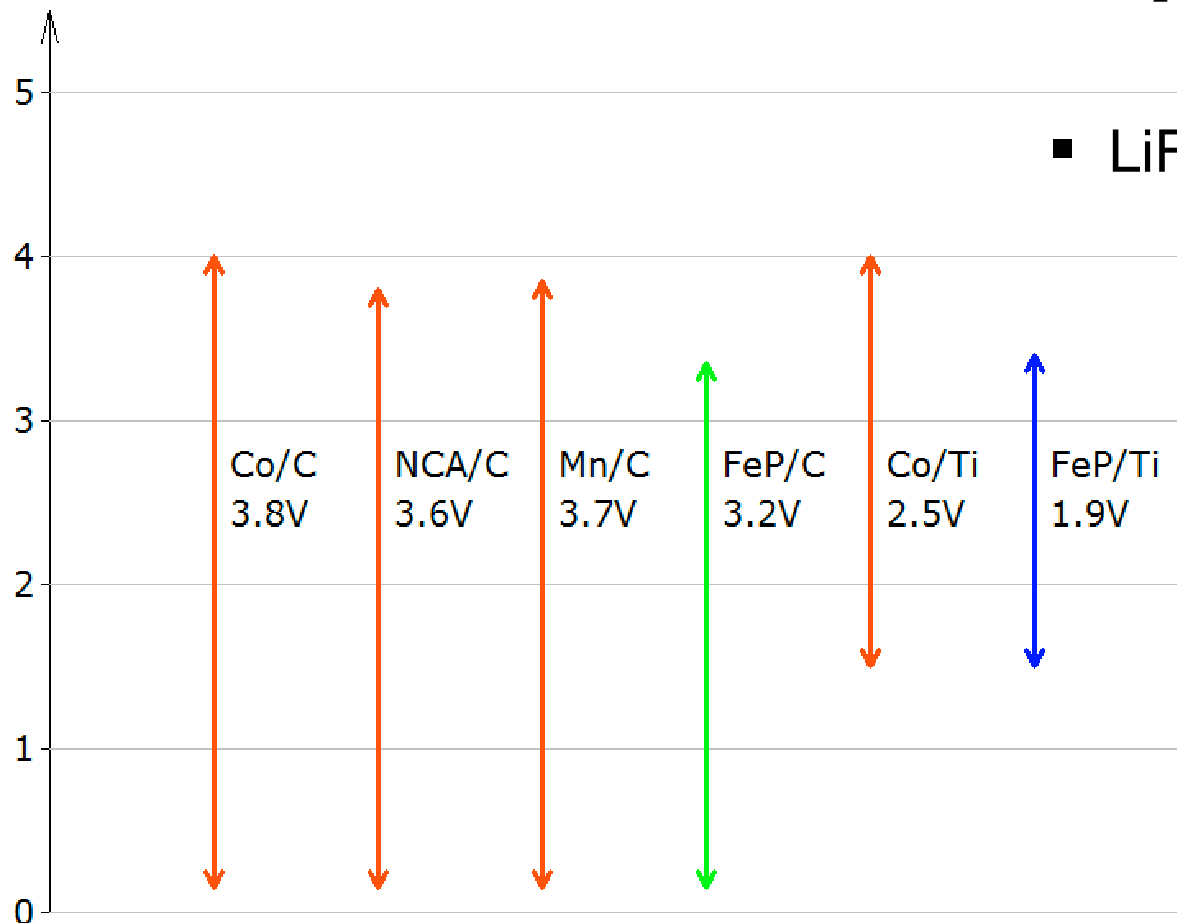


- Cobalt has high energy density

▪ but

- LiFePO is more safe

Voc[V] (SoC=50%)

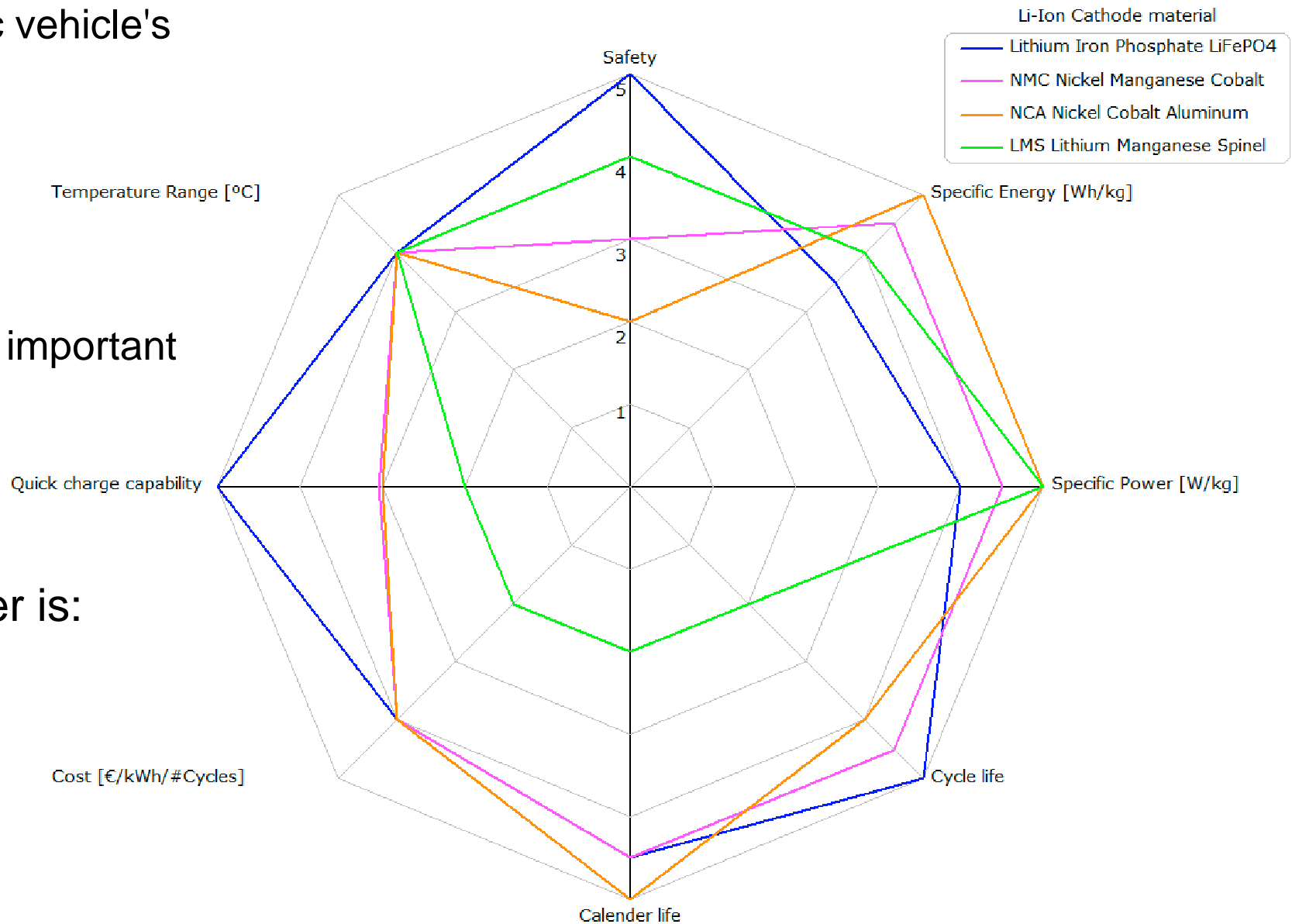


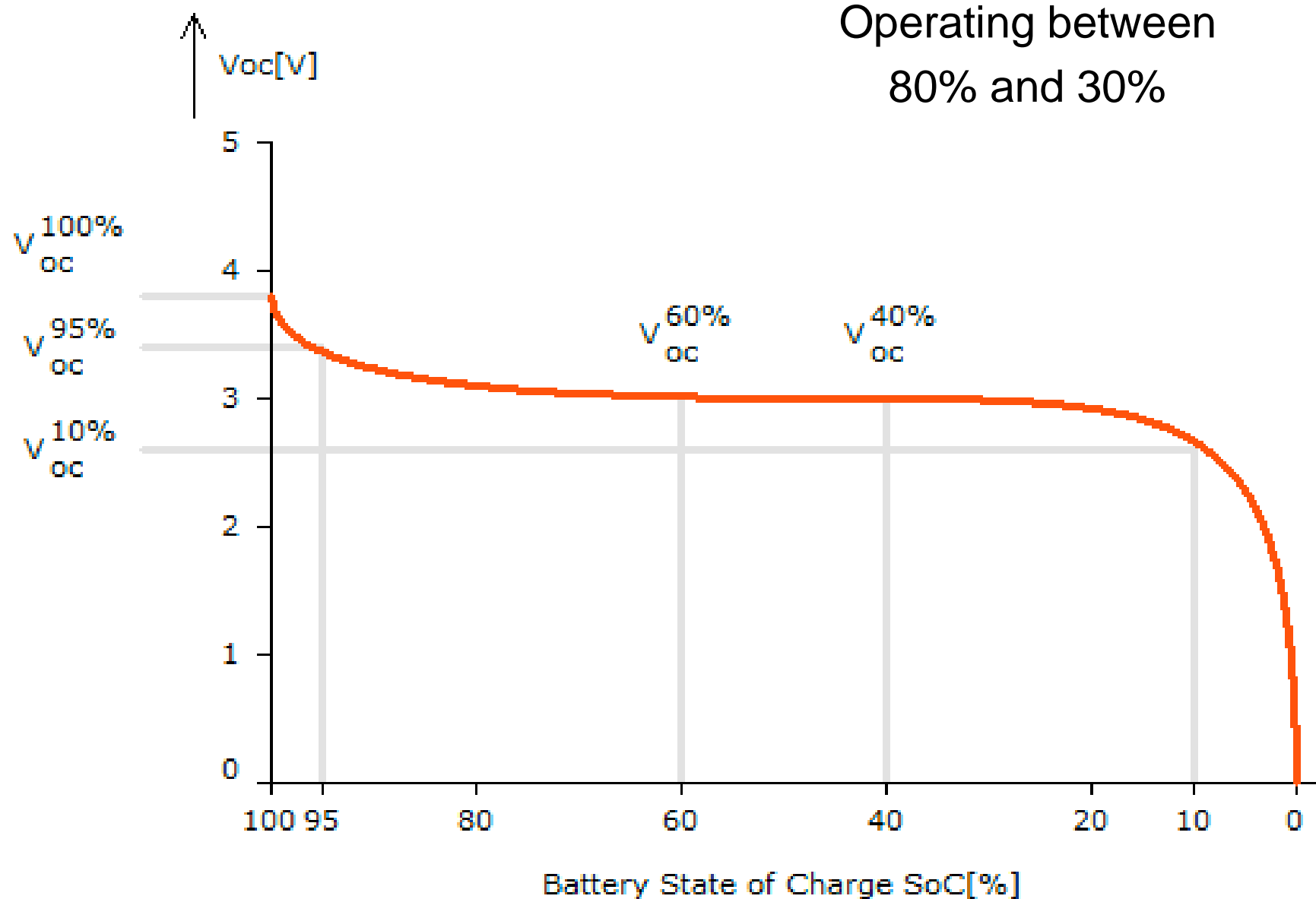


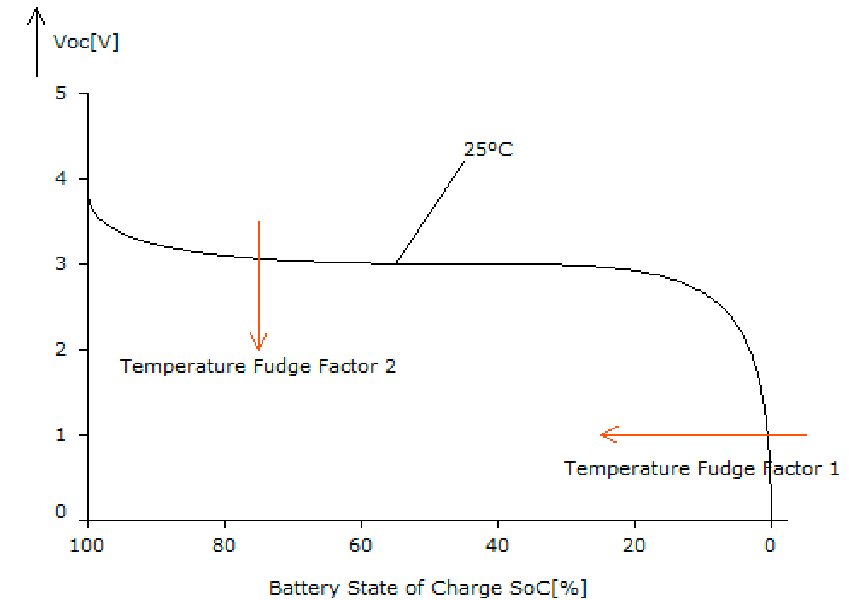
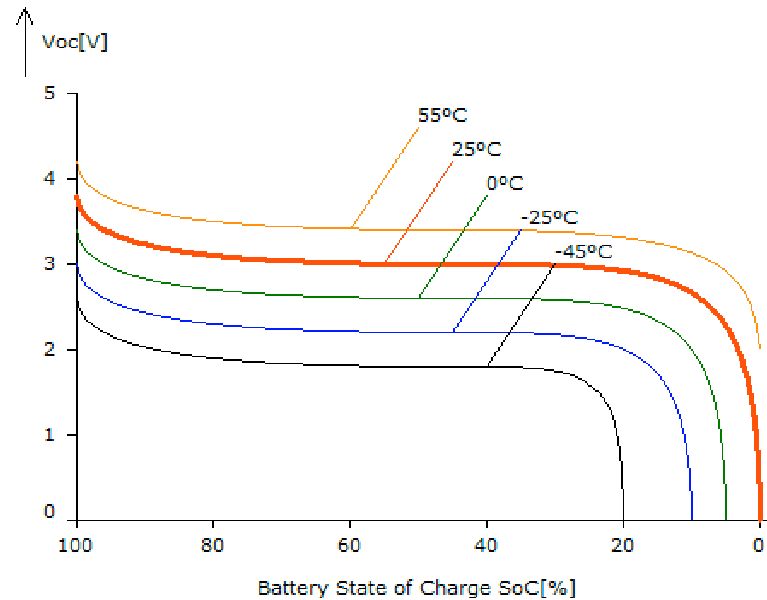
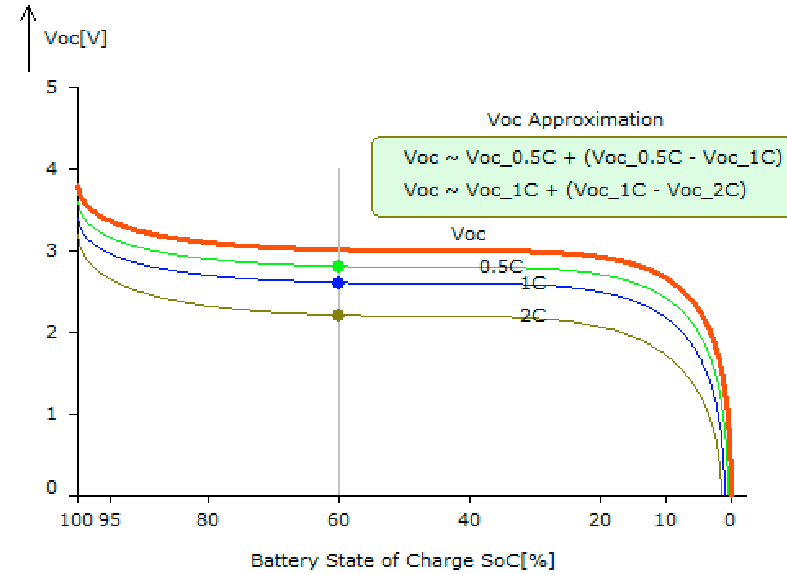
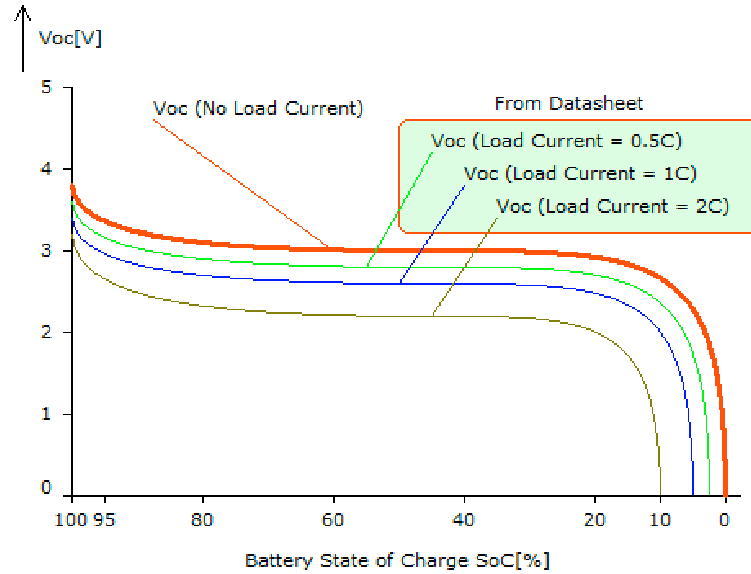
- Safety first in
  - electric vehicle's

- Cycle life
  - second important

- The winner is:
  - LiFePO

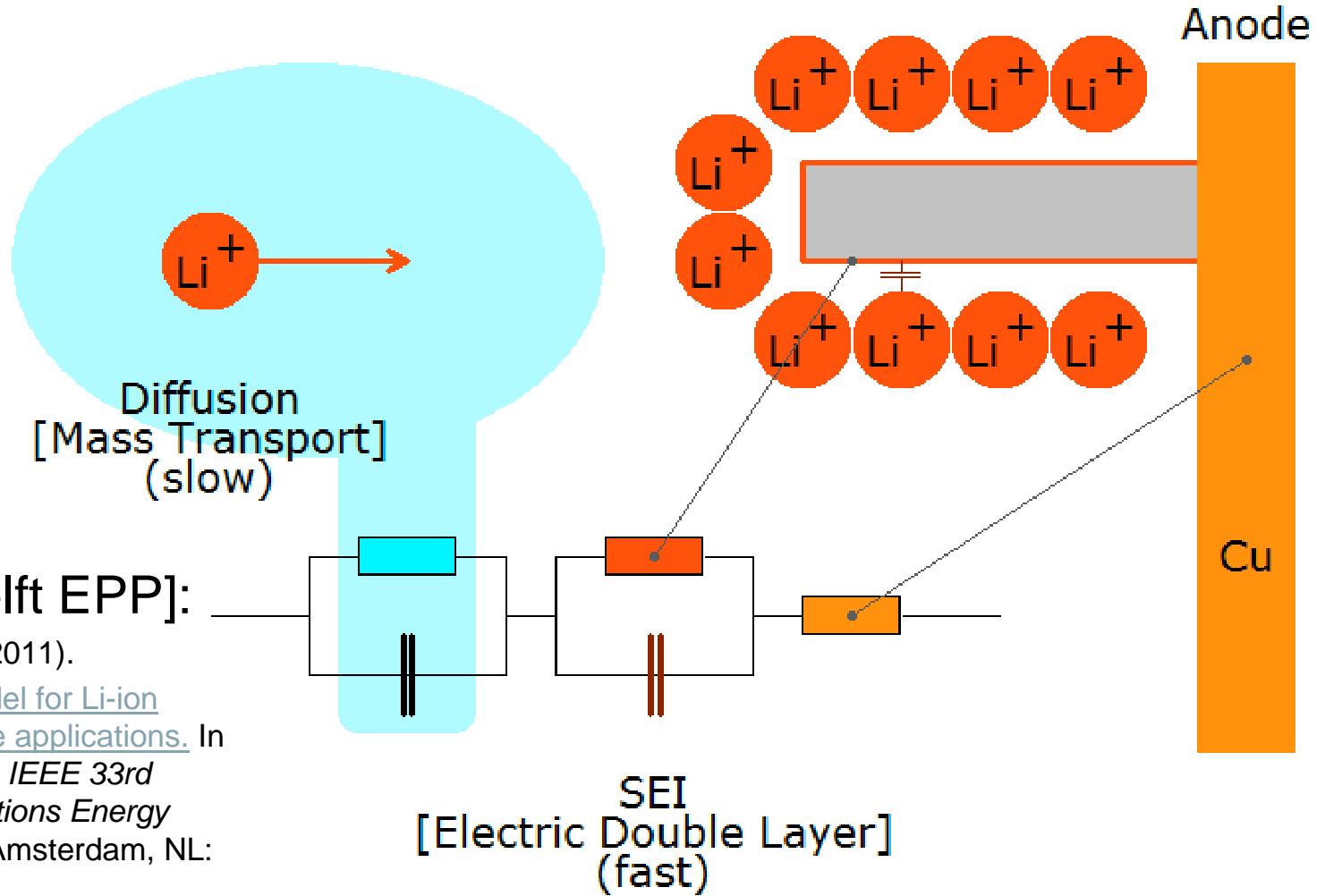






## Modeling:

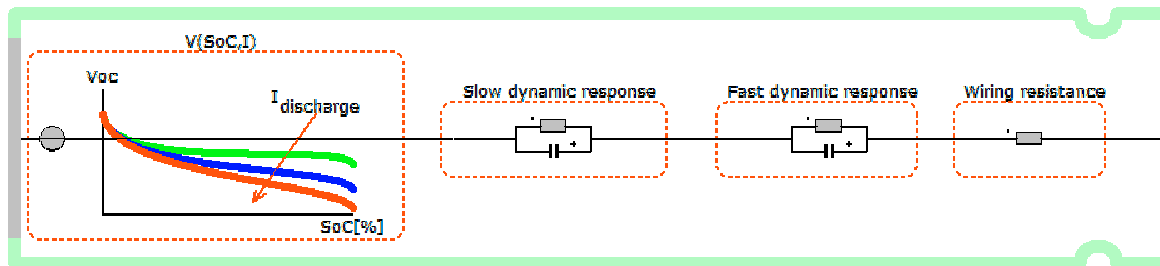
Physics inside the Cell has a large impact on the model



## More details [TU Delft EPP]:

Lam, L, Bauer, P & Kelder, EM (2011).

- [A practical circuit-based model for Li-ion battery cells in electric vehicle applications.](#) In s.n. (Ed.), *Proceedings of the IEEE 33rd International Telecommunications Energy Conference, 2011* (pp. 1-9). Amsterdam, NL: IEEE.



- BMS is required in high power Li-Ion batteries
- Balancing cell voltages
- Identifying broken cells

Cell with limited capacity

