# Supplemental Information on HEV Batteries

SIG #2@Stockholm
Jan 2024

# Contents

Background

Supplementary information

- Comparison of Maximum temp during TR by nail penetration between HEV and BEV cell

- Battery specification for HEV

 -Total energy of REESS vs cell capacity

- Comparison of test results between HEV and BEV cell

-Energy needed from heater for TR

- SOC influence on TR by external heating of HEV cell

Summary

| # | Title | Related paragraphs | Issue description | Action plan |
|---|---|---|---|---|
| 6 | NOVC-HEV | 6.15.3 | So far, the consideration of the thermal propagation requirement is focusing on BEV (high energy REESS).<br>The typical feature of NOVC-HEV;<br>(a) The capacity of cell and REESS are much smaller than REESS for BEV;<br>(b) The SOC of the REESS is controlled at medium level and is rarely used at high level.<br>With those feature, the risk of thermal runaway due to internal short and its propagation are considered as much lower than the BEVs. Therefore industry requested to allow simplified assessment for NOVC-HEV.<br>JPN requested to see the largest cell capacity for HEV (e.g. for HDV.) | Industry provides further information about the cell size or other reference information. |

OICA proposal in WD2

6.15.3.1. Step 1: Initial documentation submission

If the REESS is designed not to have coupling system for charging the Rechargeable Electrical Energy Storage System (REESS), the risk management analysis according to paragraph 6.15.4. shall be performed.

Additional information on HEV battery is provided.

# Typical Specification of Battery Pack and Cell for xEV

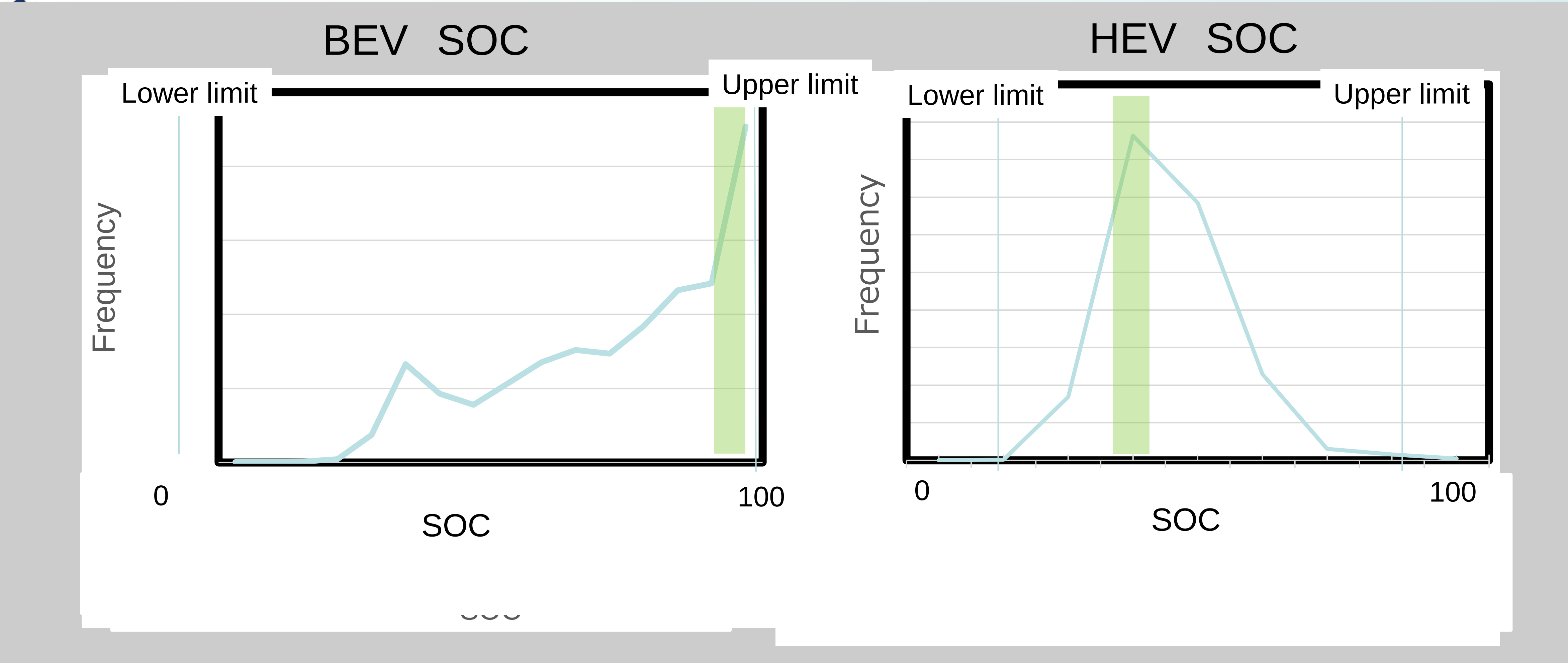
shared at the last meeting

| | BEV/PHEV | HEV | |
|---|---|---|---|
| Cell capacity（Ah) | 50- 200 | 3-5 | Cell capacity and specific energy is much less than one of BEV/PHEV. |
| Cell specific energy（Wh/kg) | ＞200 | <100 | |
| Battery pack energy（kWh) | 10 ～ 120 | 0.5～1.5 | Battery pack energy of HEV is extremely low compared to one of BEV/PHEV. |
| Weight（kg) | 100～600 | 20～50 | |
| External charging | Applied | Not Applied | |

- In addition to the large differences in the specific energy and total energy of cells and packs, there is also difference in the presence or absence of external charging.

shared at the last meeting

# Example of SOC frequency of BEV and HEV




BEV: higher frequency of high SOC condition in real usage conditions.
HEV: higher frequency of middle range of SOC condition in real usage conditions.

# Design Principle of HEV System

- HEV without external charging is essentially intended to improve fuel economy.

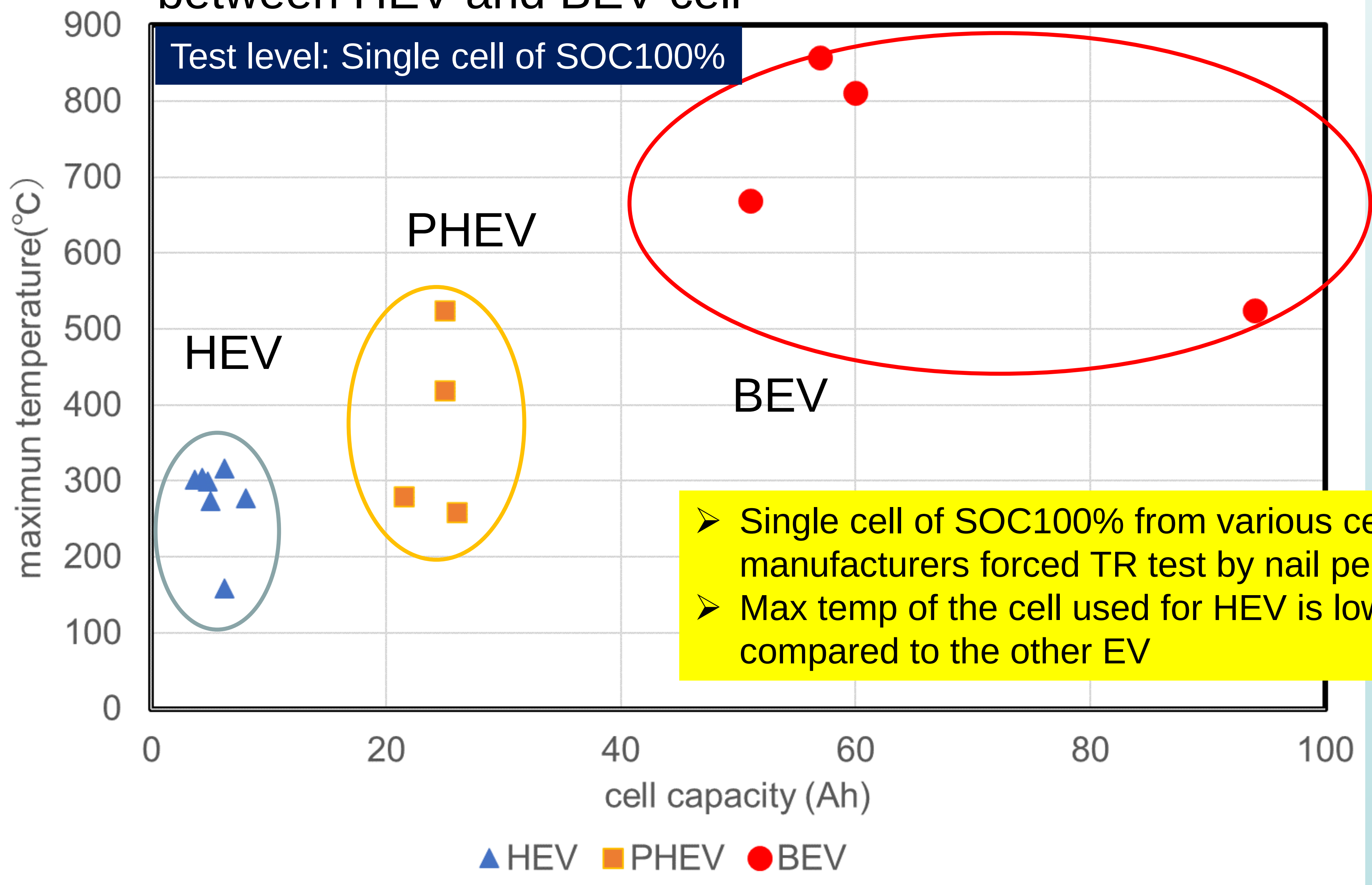
- In general, HEV battery recuperates the energy during deceleration and provide propulsion energy to support acceleration. Therefore, short-term regenerative input power and propulsion output power are required.

→ The high voltage system is preferable. Small capacity cells with high power capability are connected in series to achieve required voltage.

- The main propulsion energy source is the internal combustion engine, so there is no need for batteries with high energy. Further, SOC is controlled to be intermediate range so as to satisfy the above conditions.
  (In a high SOC, regenerative energy cannot be stored, resulting in energy loss)

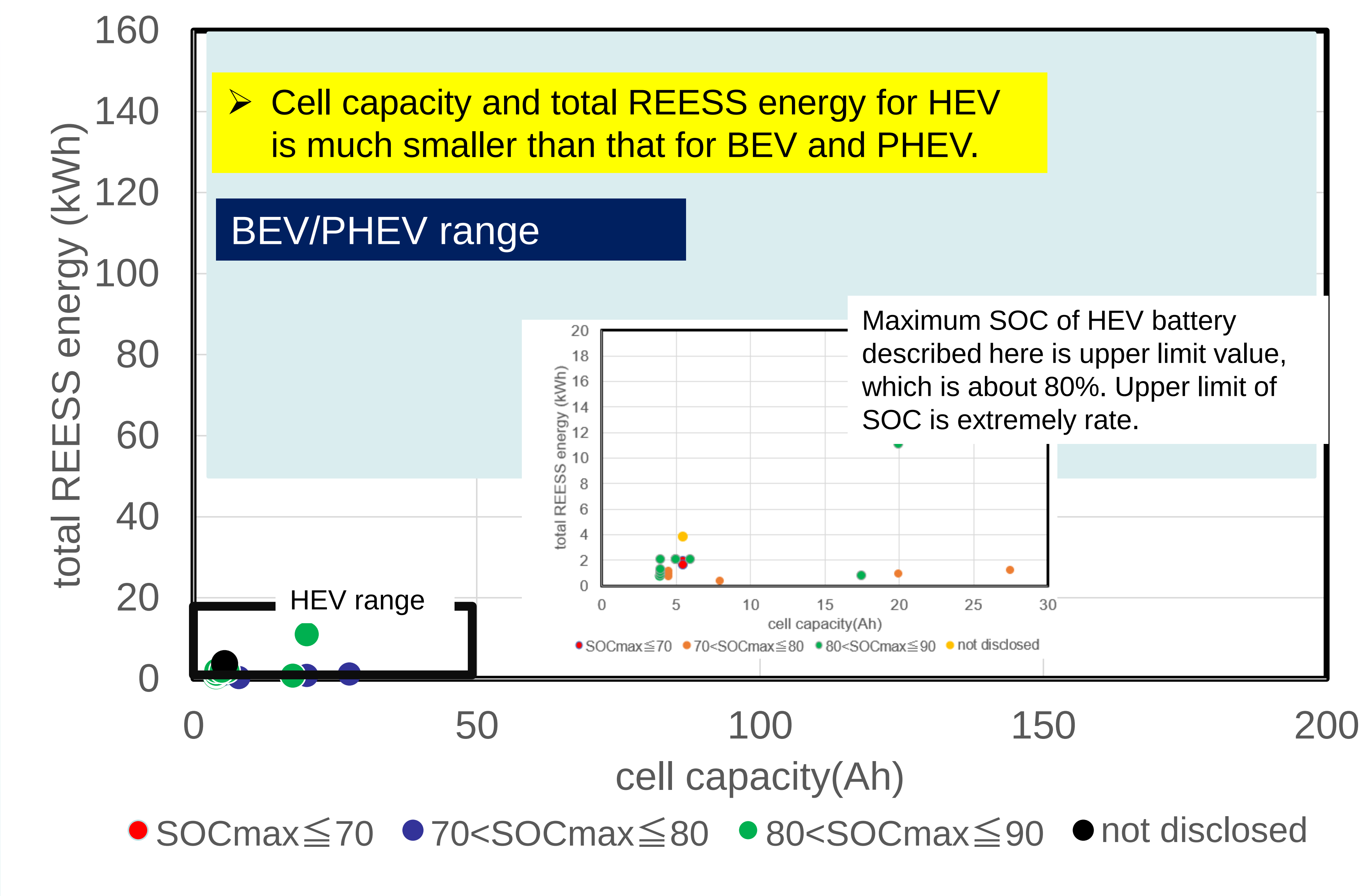
**No reported thermal incident in HEV batteries even in the nearly 15 years history**

# Comparison of Maximum temp during TR by nail penetration between HEV and BEV cell

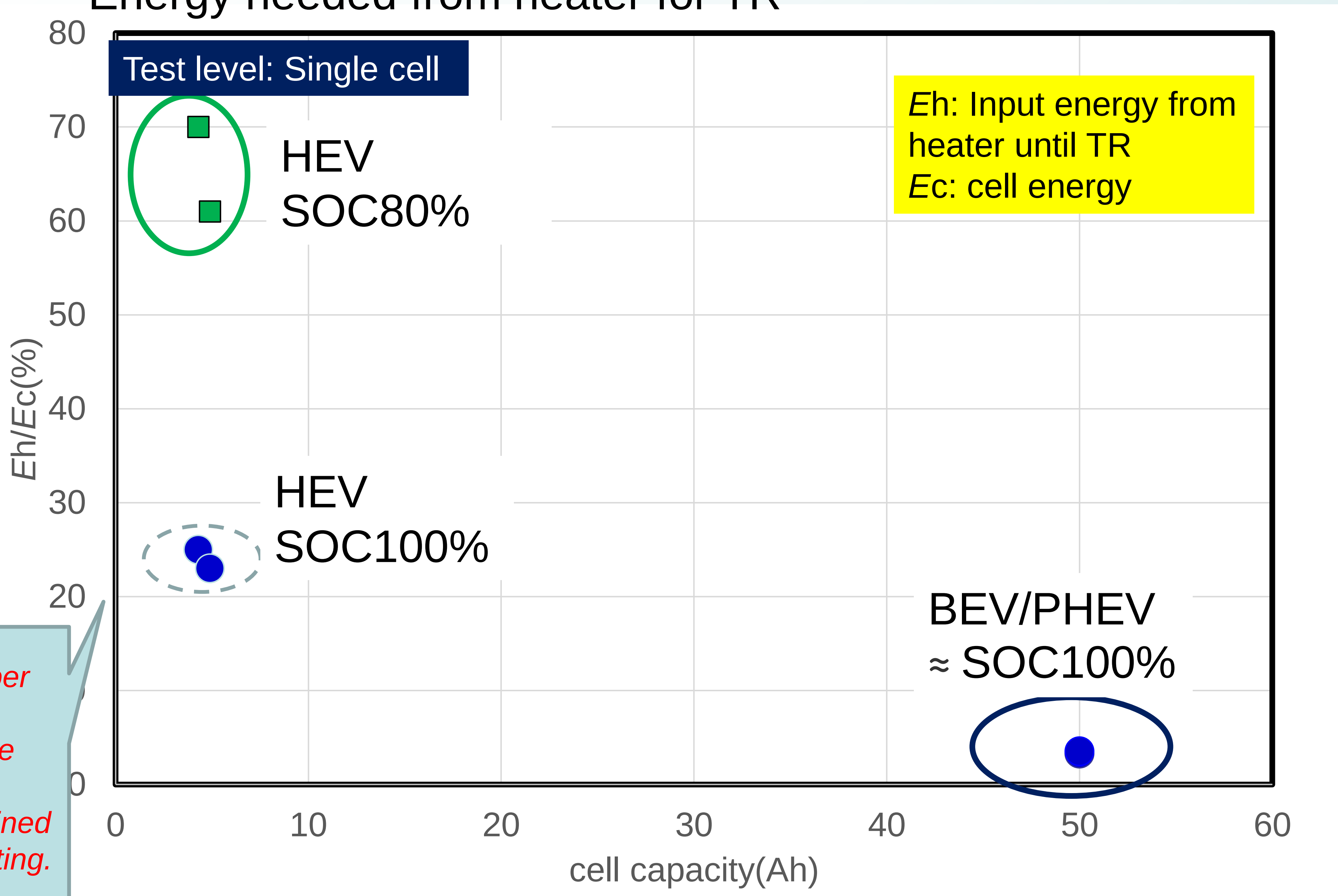



- Single cell of SOC100% from various cell manufacturers forced TR test by nail penetration
- Max temp of the cell used for HEV is low compared to the other EV

# Specification of the battery system for HEV (1)
# REESS energy –cell capacity

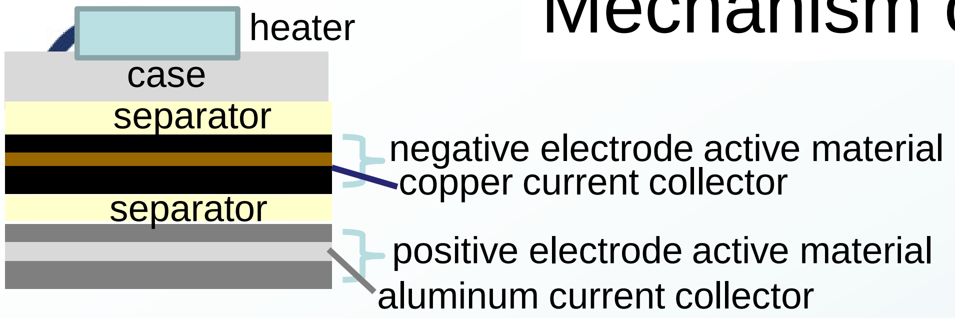


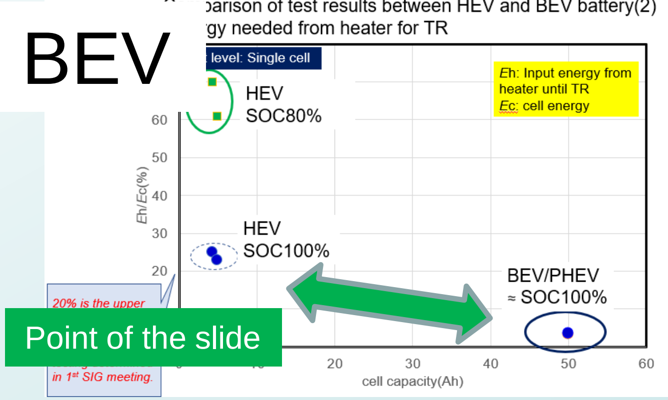
# Comparison of test results between HEV and BEV battery(2)
## Energy needed from heater for TR



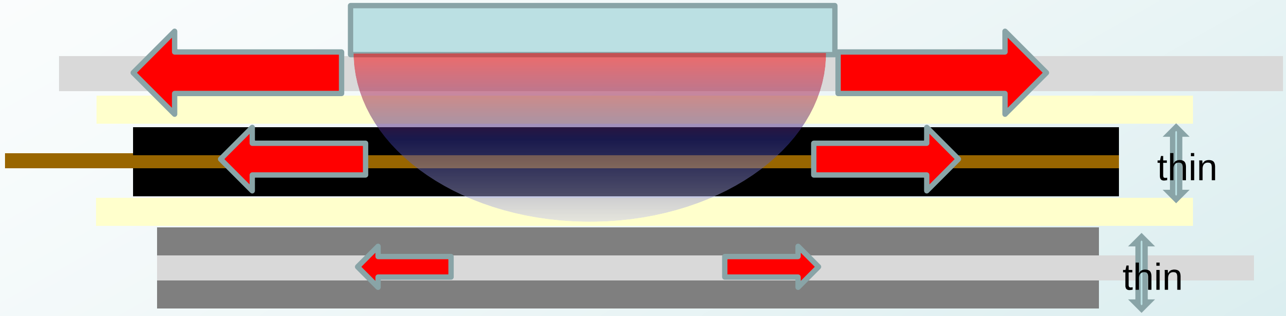

*20% is the upper limit of input energy from the heater in TP testing determined in 1st SIG meeting.*

# Mechanism of TR in the cell for HEV and BEV

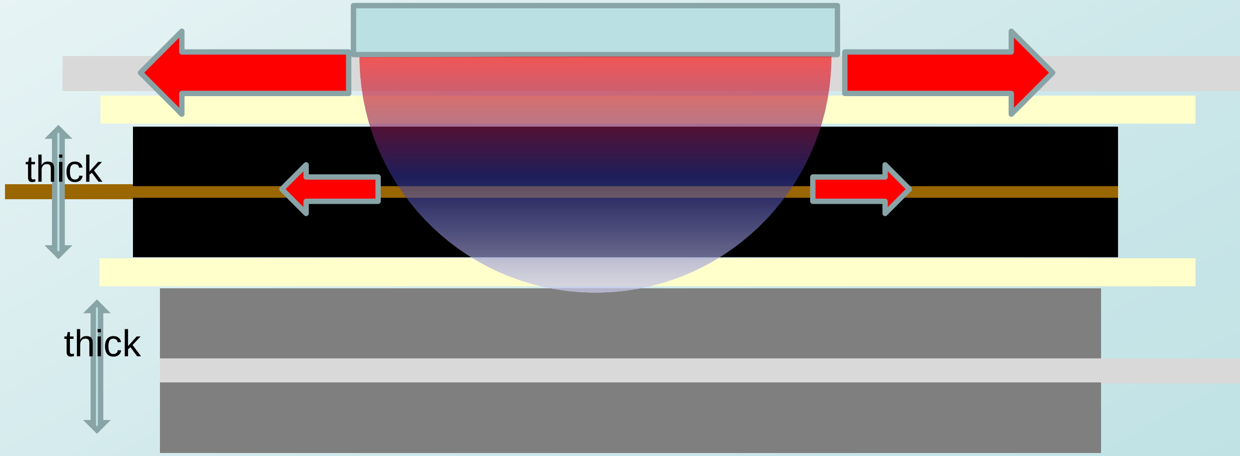



## Schematic description of the cell for HEV




## Schematic description of the cell for BEV



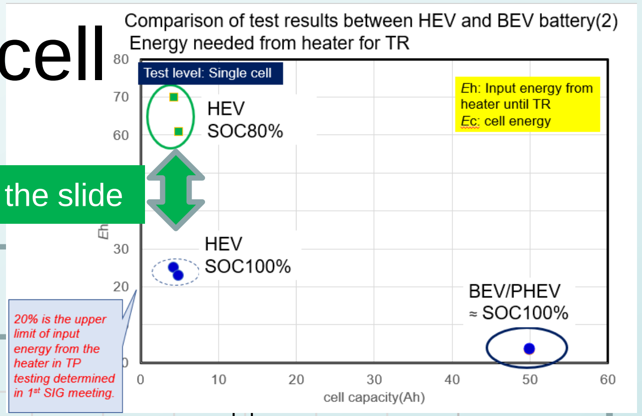

In LIB for HEV, **heat that enters from the outside is easily transferred to the current collector** through the thin active material layer compared to LIB for BEV.
It is difficult for the temperature to rise in the local specific area, which means it is not so likely to lead to TR.

**LIB for BEV has a thicker active material layer** than LIB for HEV, and heat that enters from the outside is difficult to transfer to the current collector than the active material.
Temperature increase in the local specific area occur, which can easily lead to TR.

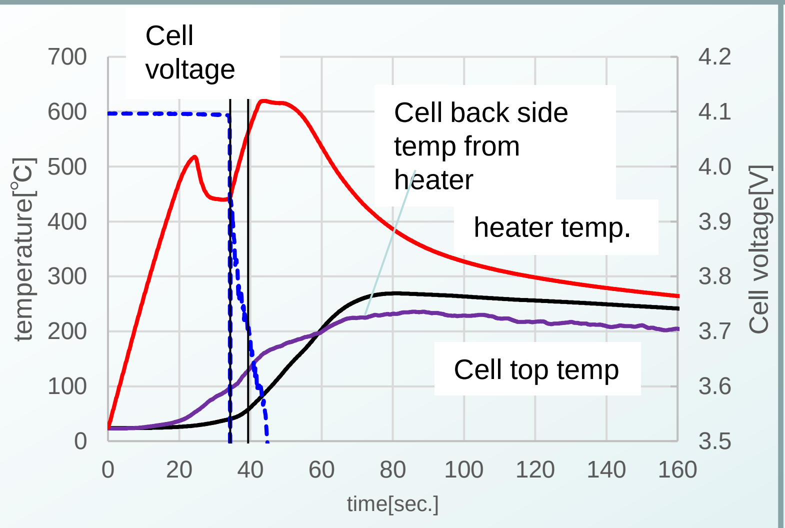
# SOC influence on TR by external heating of HEV cell

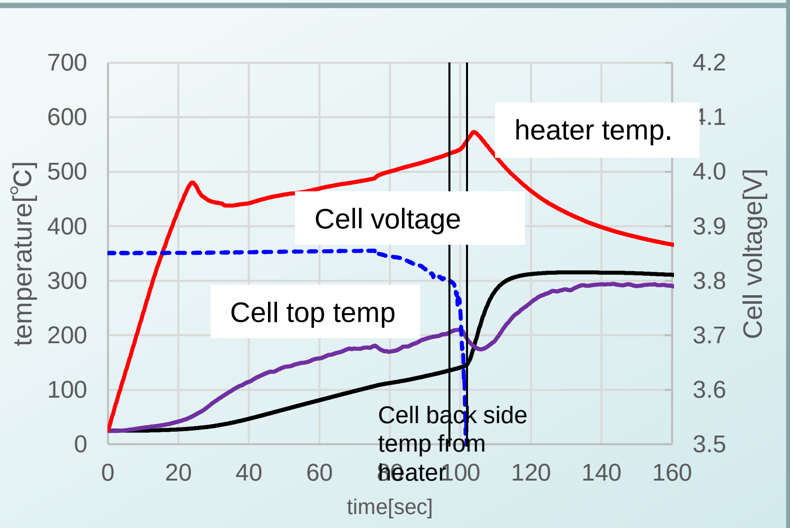
Test level: Single cell

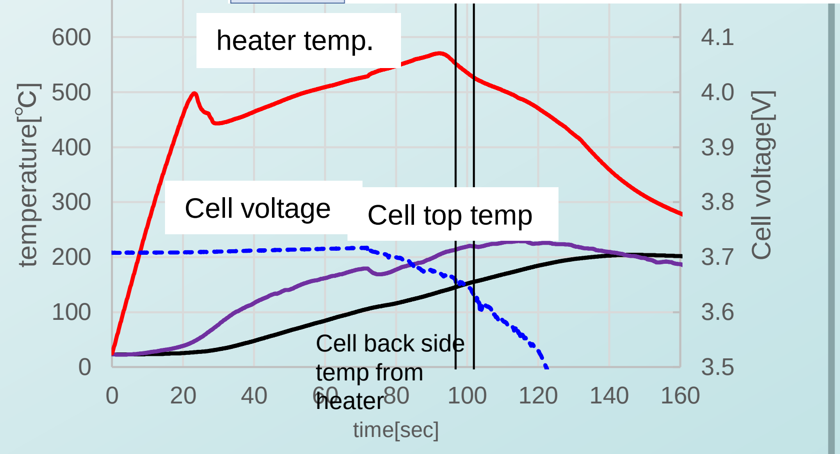
Point of the slide




| SOC100% | SOC80% | SOC60% |
|---|---|---|
| TR at about 35sec | TR at about 100sec | No distinguished TR |
| *Eh* / *Ec* (%) 25% | *Eh* / *Ec* (%) 87% | (No distinguished TR) |




The lower the SOC, the more energy is required for TR.
When the SOC is further lower, TR is not recognized.

# Summary

- **The max temp of HEV** cell during TR is **lower than that of BEV cell**. HEV cells have low energy density and are less likely to cause thermal propagation(TP) even if TR occurs.

- HEV battery specifications :**Cell capacity and REESS energy are lower than those for BEV batteries. SOC80-90%** is the extreme upper limit in existing HEV system.

- In case TR occurs by local heating at SOC100%, **BEV cells** need **less than 10%** of their own energy, while **HEV cells** need **more than 20%**. This is because **the internal structure** of HEV cells makes it difficult for local temperatures to rise.

- In actual use, **more energy is needed in at SOC 80%** to lead to TR in the currently proposed procedures. Lower energy state such as SOC80% is relatively stable and less likely to exceed the transition state compared with SOC100%, which means TR is less likely to occur.

TR and TP are far less likely to occur in HEV batteries than in BEV batteries, and it is difficult to lead to TR in HEV batteries using currently proposed test methods.

Therefore, it is reasonable to **require risk assessment documentation for HEV battery.**

Thank you for your kind attention!