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Electric Vehicle Symposium & Exhibition

June 19-22, 2016 | du 19 au 22 juin 2016

Montréal, Québec, Canada

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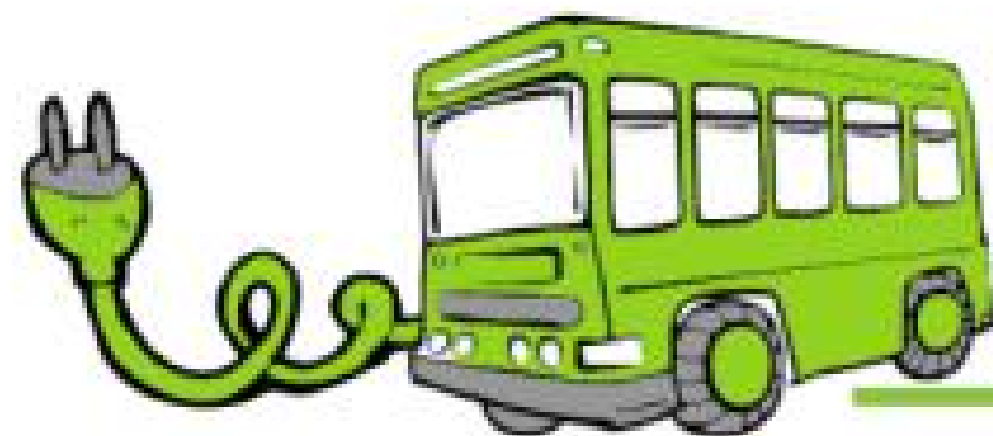
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LTO based modular battery system with thermal management for fast charging application in electric buses



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About Impact Clean Power Technology S.A.

- Development and manufacturing of customized Battery Pack for electric buses and trucks
- Laser welding centre for li-ion batteries
- System design and engineering office (40 engineers)
- Battery Packs manufacturing line
- Advanced Battery Electronics, Software and System Integration
- 11 years on the market
- More than 600 battery packs in various vehicles on the roads





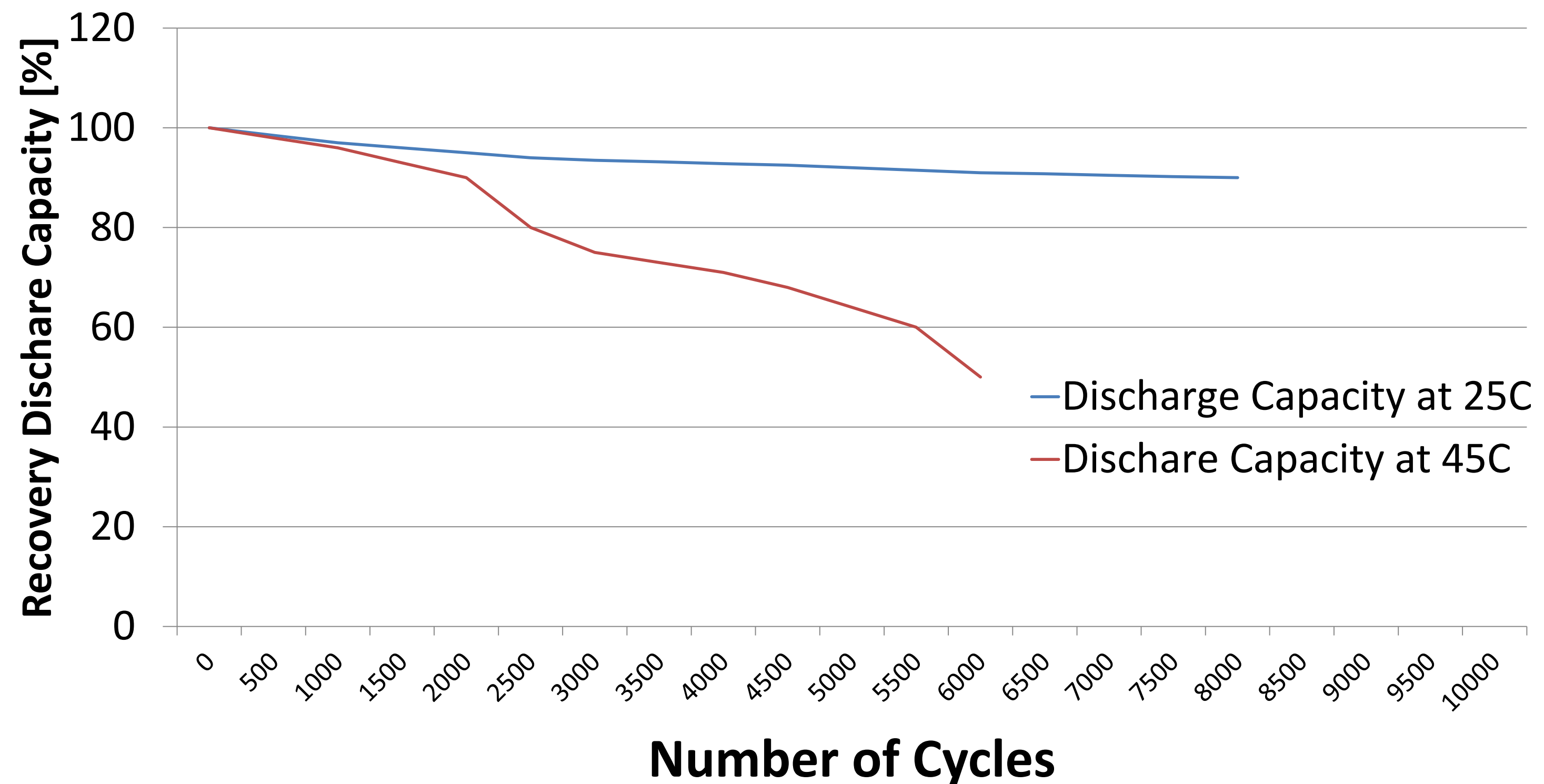
LTO Technology – candidate for modern e-bus battery

- High charge currents – typically 5C continuous
- High discharge currents – practically the same as in charging
- Large number of cycles – more than 12000 full cycles – to certain lifetime, cycles are not affecting ageing of the cell
- Very good performance (both charging and discharging) in subzero temperatures to -30°C
- High current is not affecting lifetime of the cell

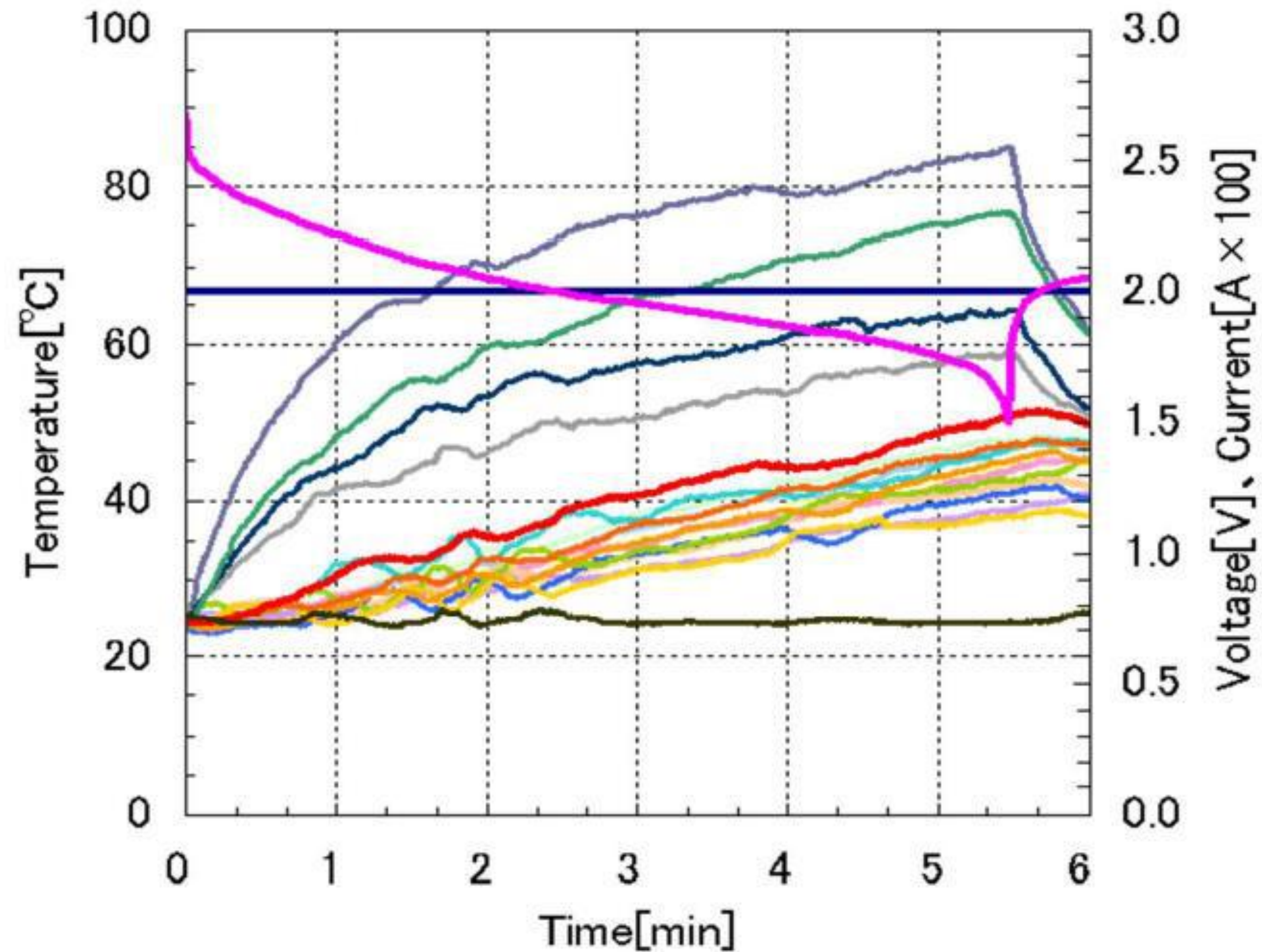


LTO Technology – some drawbacks

- Very low specific energy – at a level of 90Wh/kg today
- High influence of elevated temperature on lifetime and performance !!



LTO Technology – Temperature rise with 200A from single cell



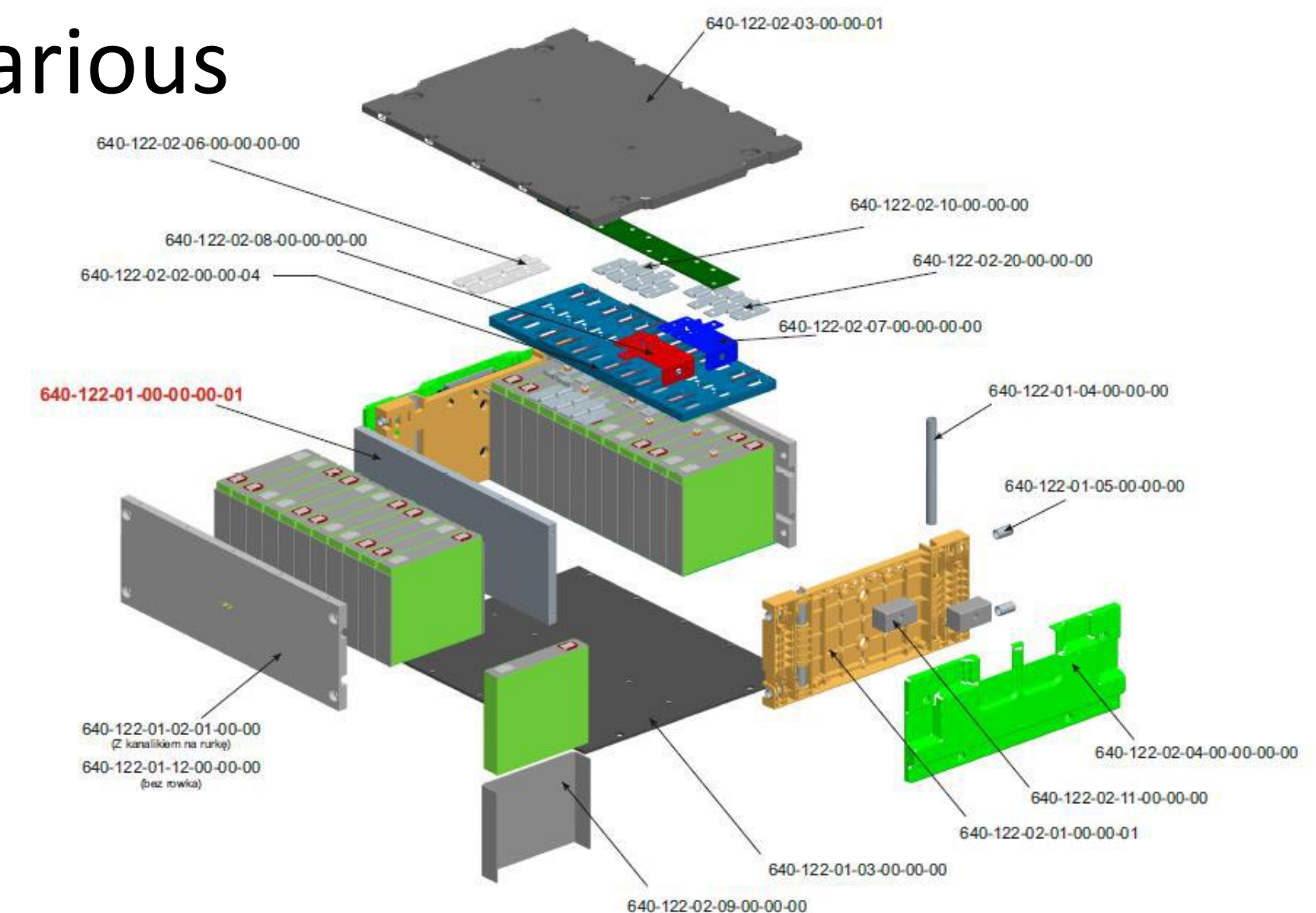
- Cooling is necessary
- Module special design is required to provide good thermal management
- Laser welding of cell terminals is required to minimize connection losses



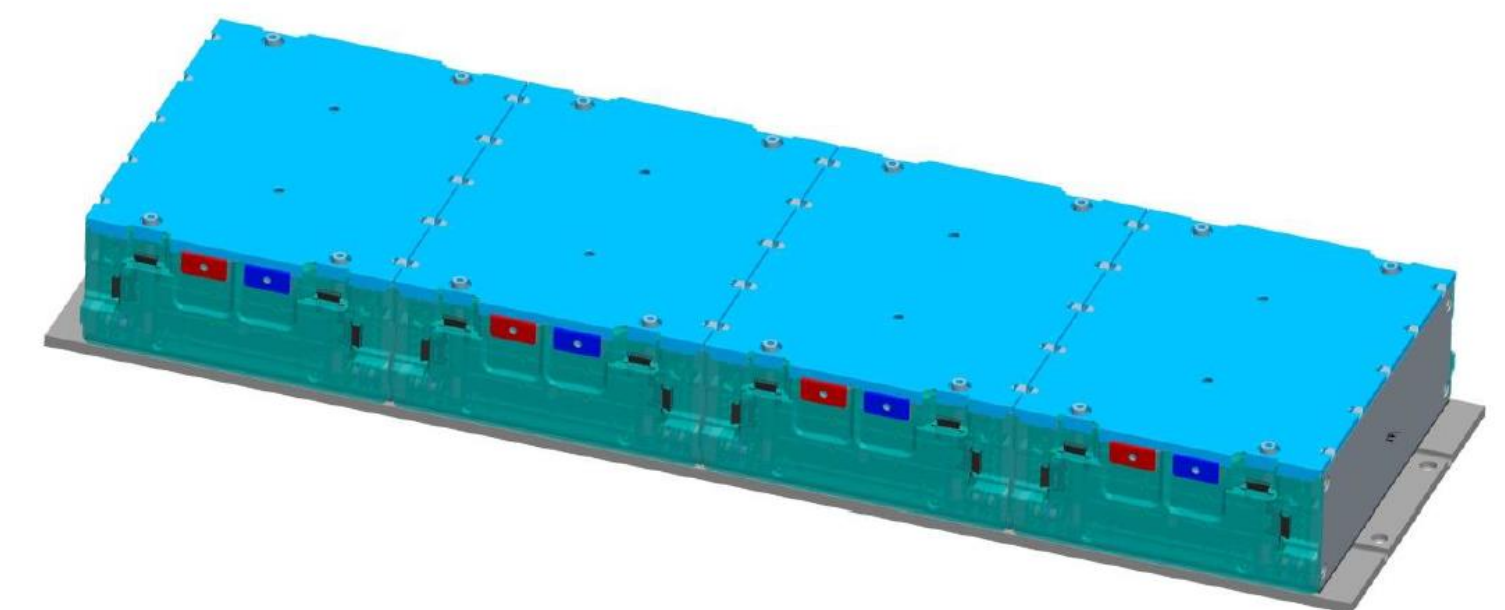
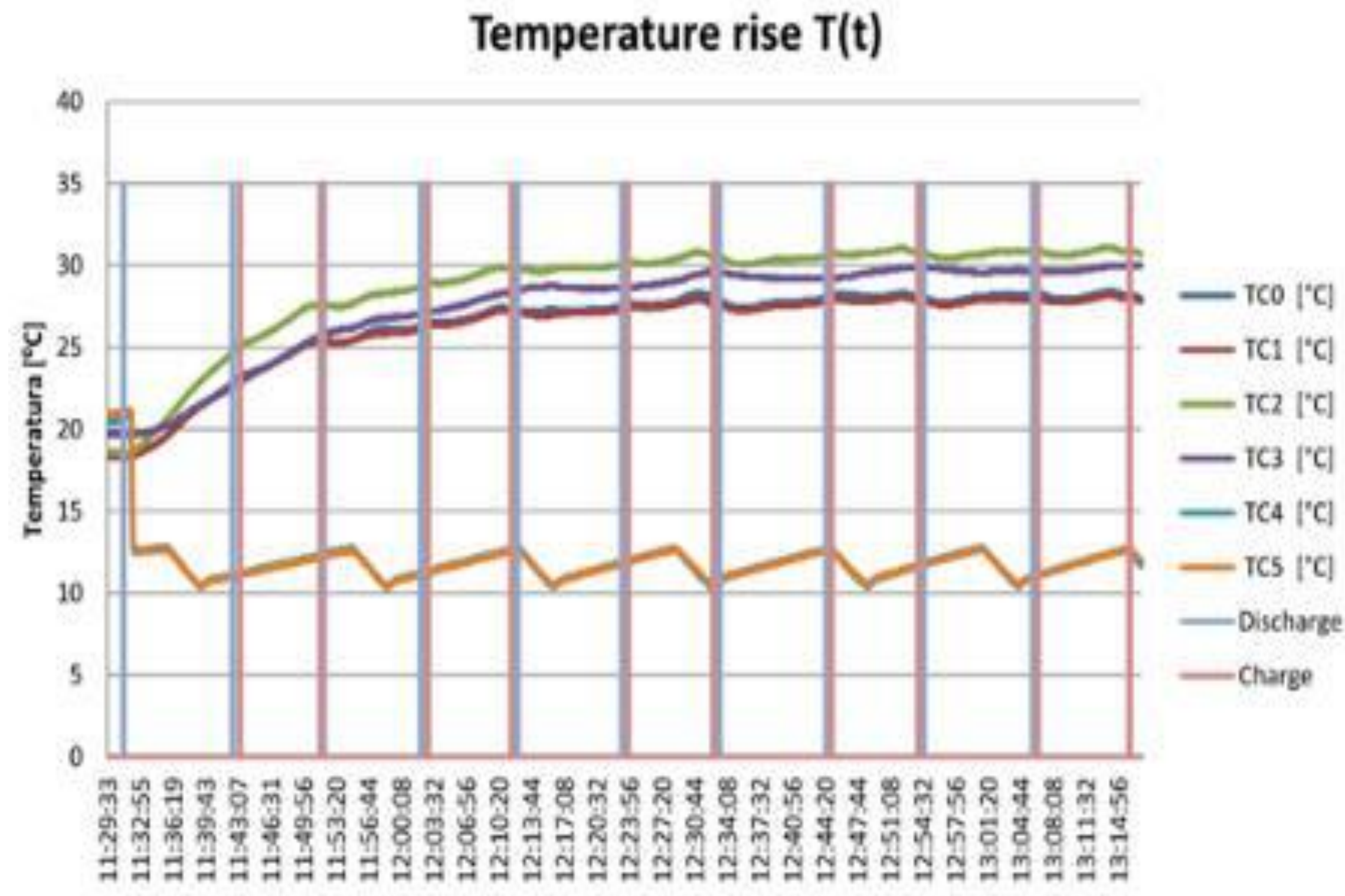
LTO Technology – Modular approach to better control thermal management of the cells

BP design is based on relatively small 24-cells modules, the advantages are:

- Individual thermal management on module level – water heat exchangers as part of design
- Flexibility for battery pack design with various customized shapes
- Easy assembly for laser welding process
- Easy maintenance and assembly

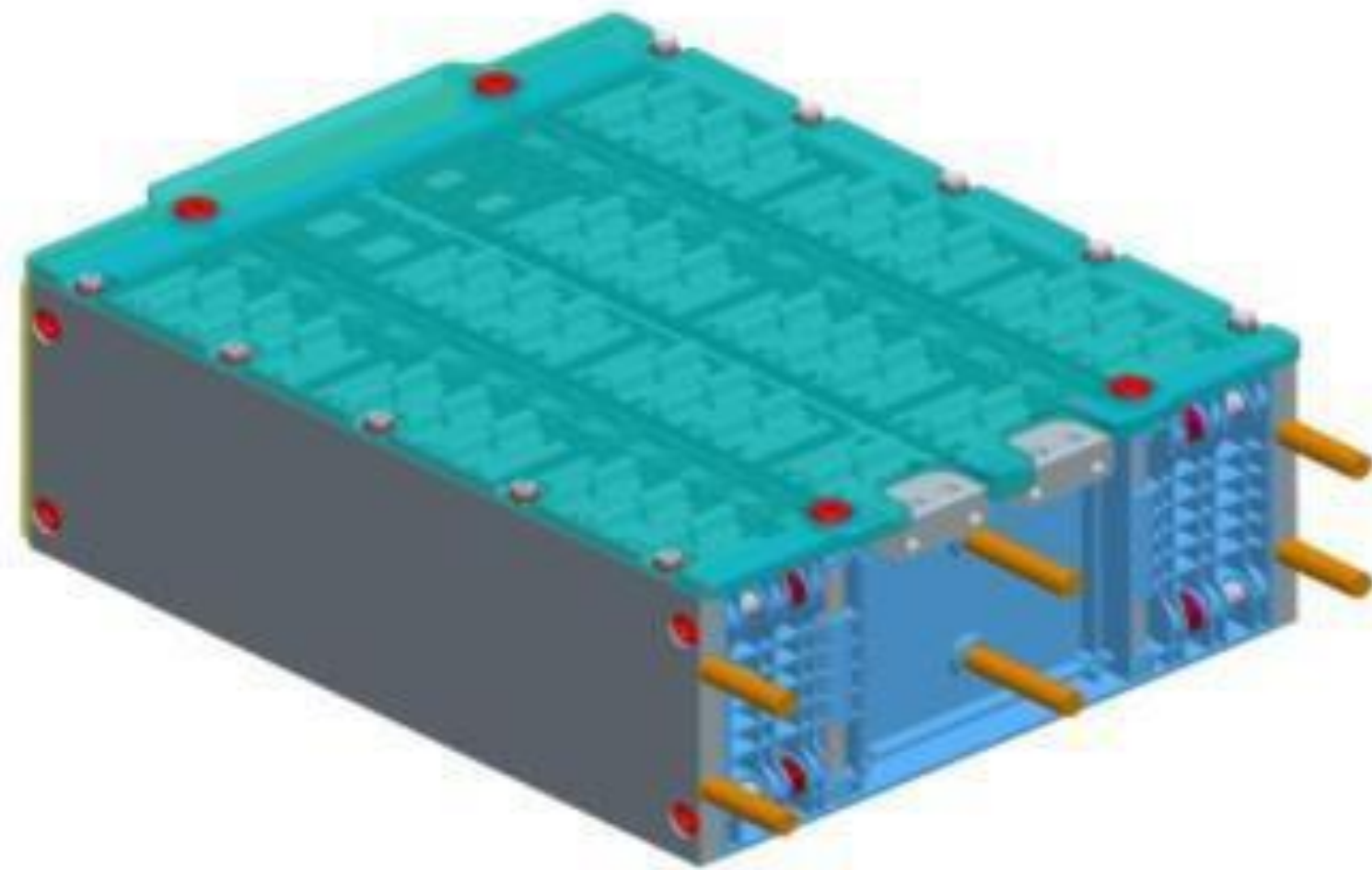


LTO Technology – Thermal management implementation



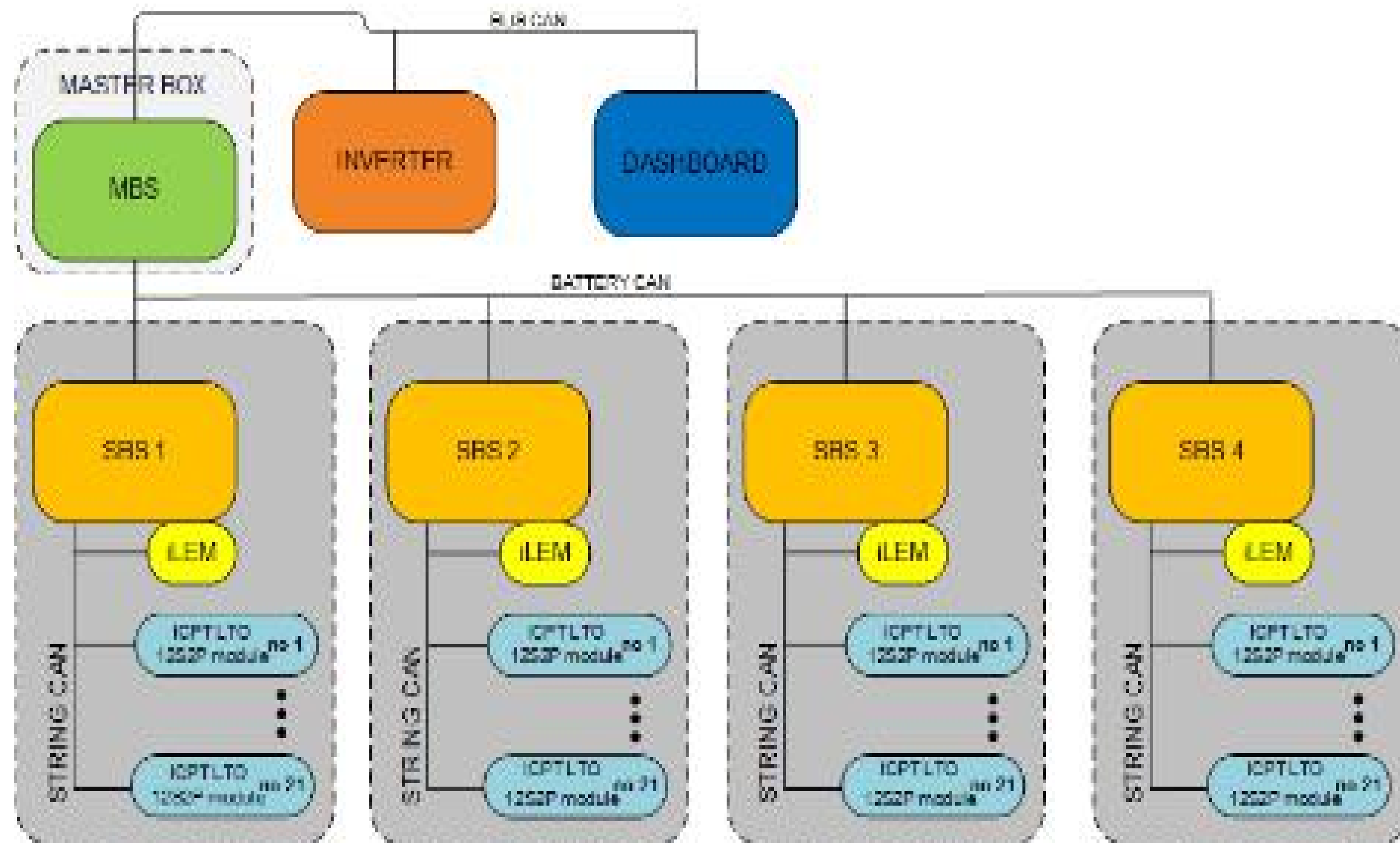
- Water radiator added to the module design
- Standard lightweight module has 5C charge / 4C discharge tested capability

Heavy duty design



- For special applications with up to 10C charge/discharge demand
- Much more complicated heat exchanger design
- Heavier solution

LTO Technology – Complete Battery Pack for E-Bus design



- LTO modules connected in series are creating separate packs
- Parallel operation of several packs to increase capacity
- 3 – level protection system
- Safety controller in MasterBox
- Dedicated Cooling Unit



Advantages of thermally managed LTO battery packs for electric buses

- Ultra Fast Charging complete implementation for electric bus
- Flexible battery pack mechanical design allowing easy integration with bus body and drivetrain
- Pantograph or wireless fast charging capability
- Very short recharging times at bus line end shorter than 15 minutes
- Relatively small Battery Pack capacity
- **Virtually unlimited range of electric bus in the city allowing 24-hour continues operation with 10-12 years+ lifetime**

Successful LTO implementation – Solaris Urbino Electric



- Solaris Urbino Electric 12m and 18m buses
- LTO battery capacities: from 75kWh to 127kWh
- Fast charging through pantograph with up to 450kW charger power
- 12 buses already delivered to Barcelona, Hannover, pending Hamburg and Tampere



Conclusions

- LTO technology can change completely approach to E-Bus market
- Technology is mature and if properly managed, it can provide 10+ years lifetime with practically unlimited number of cycles
- Thermal management is a key to the proper LTO Battery Pack design

Technology has been developed with the help of funds received from KIC InnoEnergy