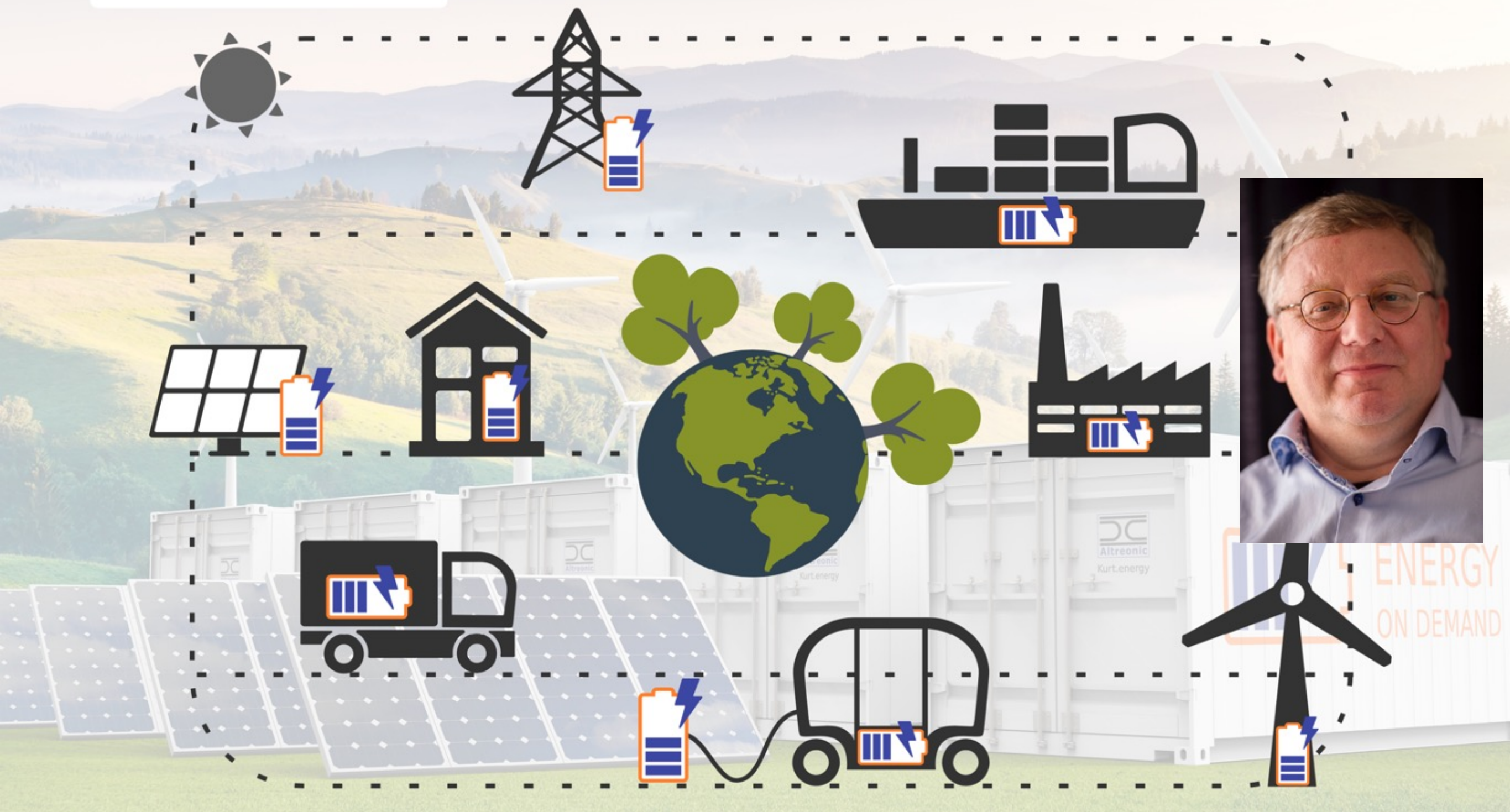




www.kurt.energy

ENERGY FOR LIFE, BLUE CELL POWER



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Eric Verhulst,
CEO/CTO

The shift to clean energy needs better batteries NOW

Altreonic- Kurt.energy

Company and technology profile



Altreonic NV - previously Eonic Systems NV

- **30 years safety-critical embedded software**

- Experience in trustworthy systems engineering
- ESA: Virtuoso RTOS in Rosetta mission



Today:

- ***5Gen unique fault tolerant VirtuosoNext RTOS***
- *GoedelWorks: Systems Engineering portal for certification*
- *KURT.mobi: Light Electric Vehicle for urban use (inactive)*
- **KURT.energy:**
 - Batteries based on hybrid Carbon-based supercaps



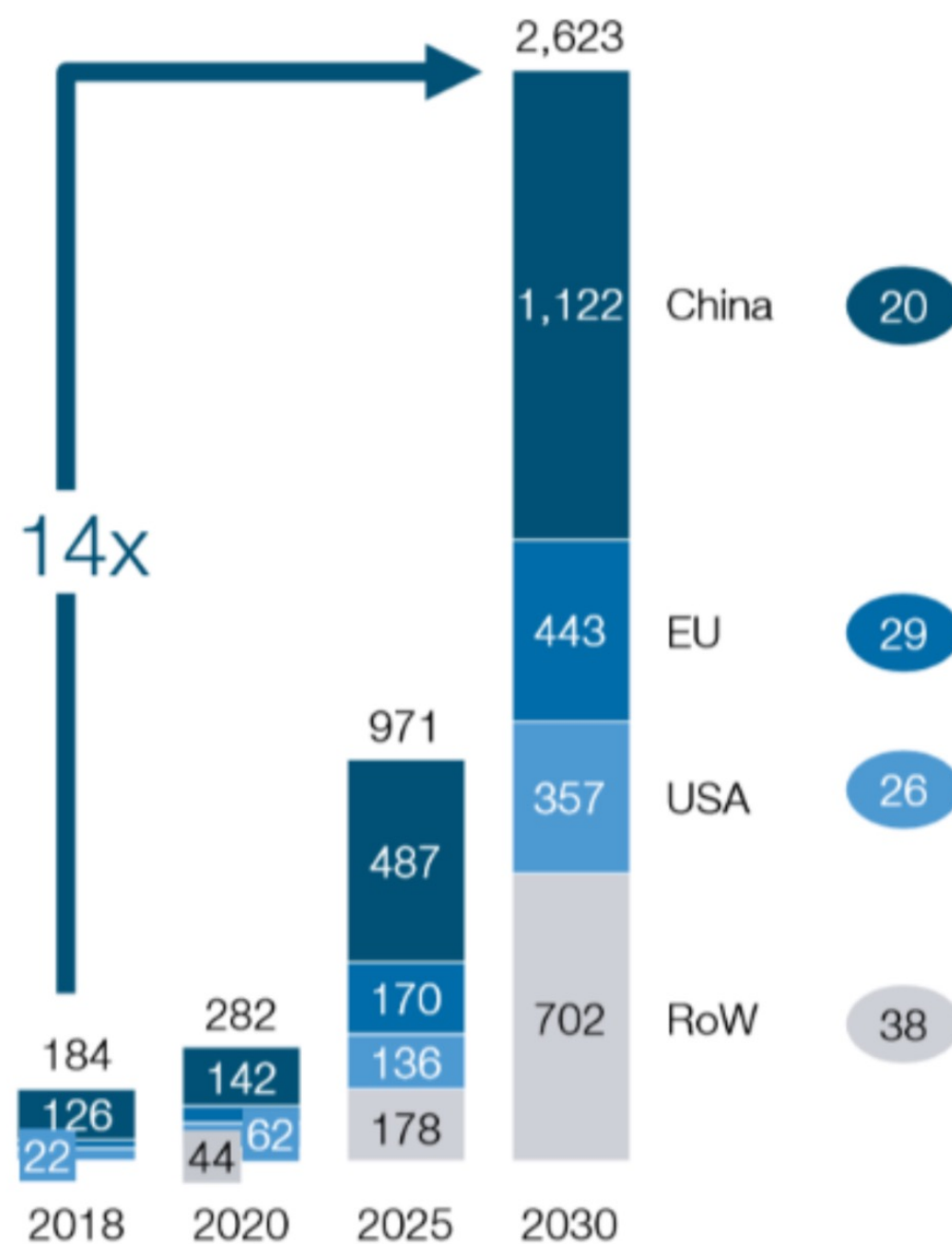
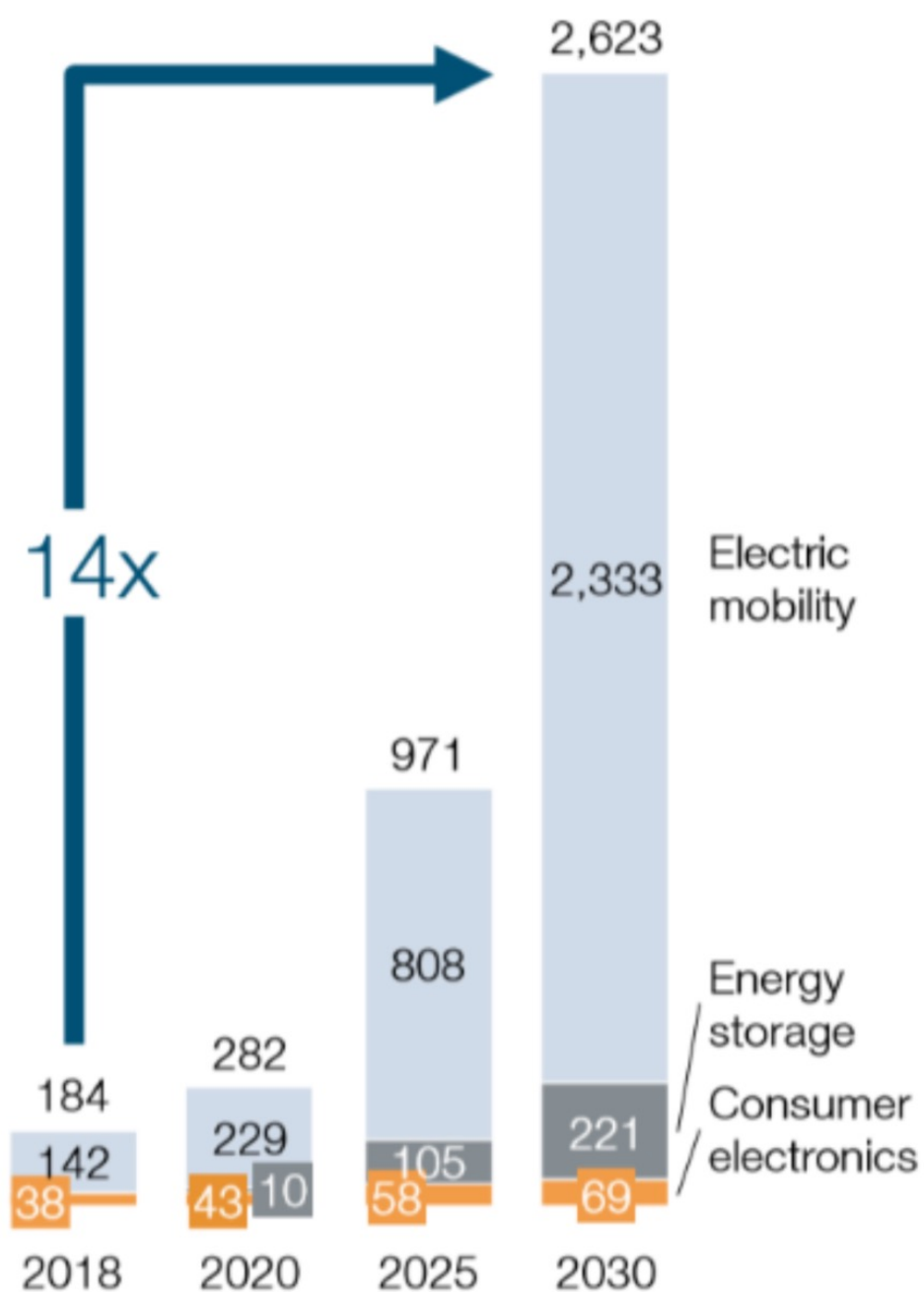
Battery demand (src: Battery 2030, EU)

Global battery demand by application
GWh in 2030, base case

CAGR,
% p.a.

Global battery demand by region
GWh in 2030, base case

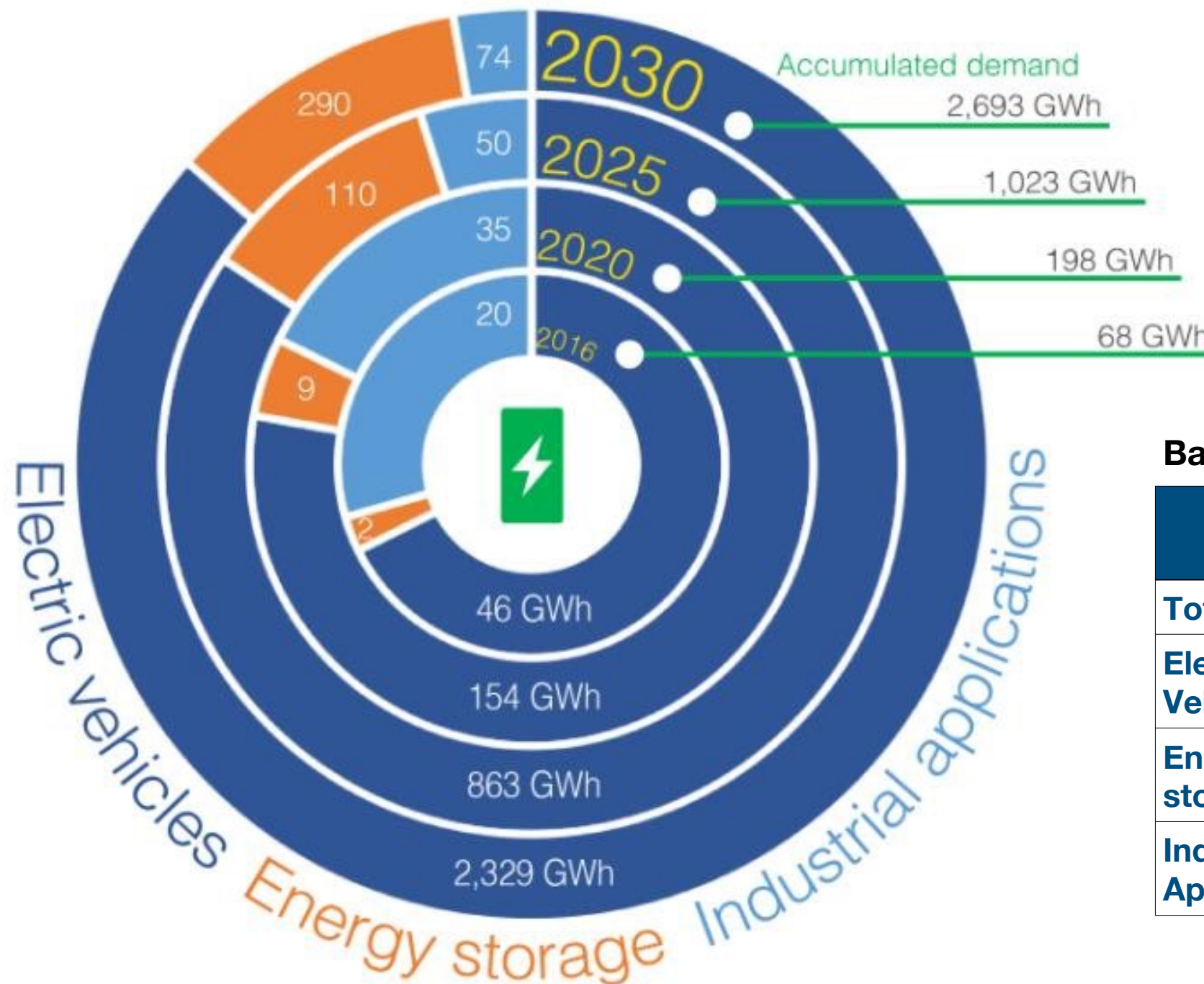
CAGR,
% p.a.



Growing Battery demand in GWh

Battery demand by sector, 2016-2030

Source: EU Commission
Joint Research Center



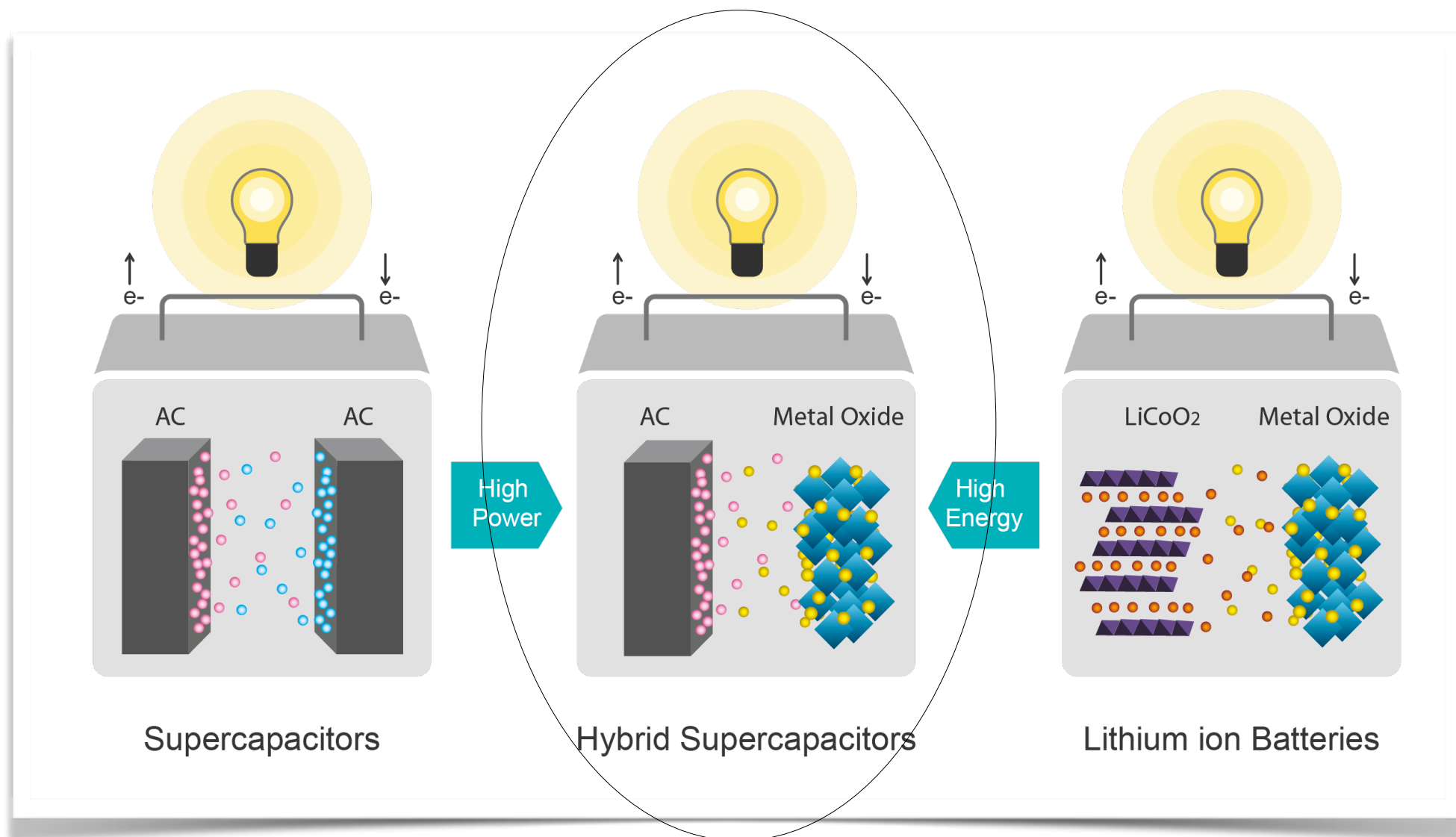
Battery demand in GWh

	2016	2020	2025	2030
Total	68	198	1.023	2.693
Electric Vehicles	46	154	863	2.329
Energy storage	2	9	110	290
Industrial Applications	20	35	50	74



The step beyond Lithium-ion batteries

- Hannover Messe May 2018
- Unique carbon based hybrid super capacitors with energy of Li-ion
- After intensive verification: MOU for JV agreement with Tomen in Dec 2018
- Roadmap JV and own production in execution



Game changing hybrid carbon-based powercapacitors

Li-ion

Kurt.energy Hybrid Power/Energy Capacitors

Fire risk

NO fire risk

Complex to use

Very simple and robust

Short time limited power

Sustained high power capability (upto 20x)

Limited temperature range

Works from -40°C to +80°C

Fast charging is problematic

Can charge to 75% in 5 min

Lifetime too short

1 mio km or 30 years and more

Sustainable?

10 to 20X less environmental footprint

Cost efficient

Lowest life cycle cost

Many announcements

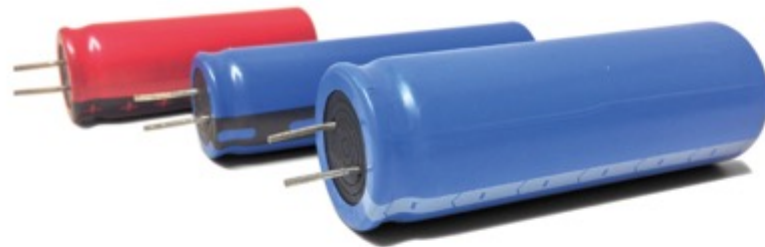
In production

**High energy density + high power density + safety + long lifetime
+ no BMS + no active thermal management
= a game-changing opportunity**



Small cells, enabling a high potential

CARBON BASED POWER CAPACITORS

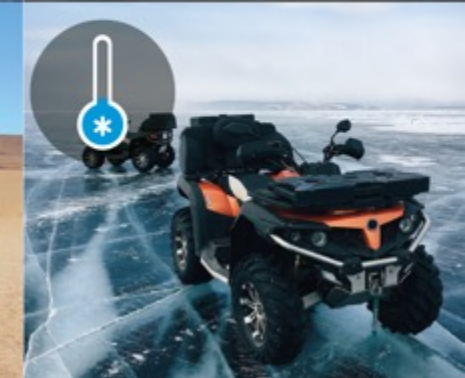


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*Hybrid
vehicles
application*



*Extreme
temperature,
lifetime
and power
requirements*



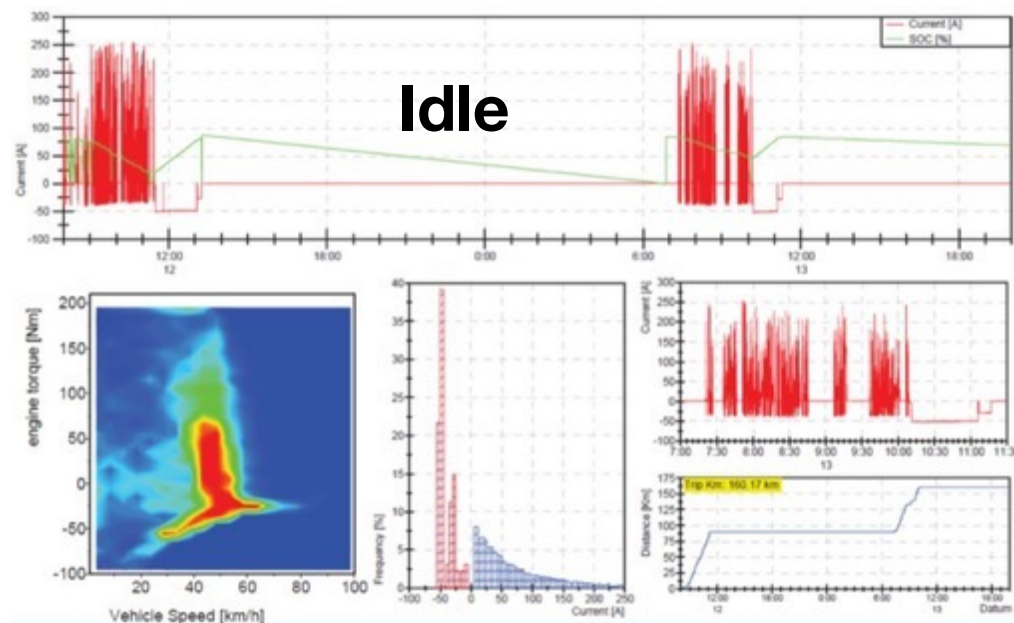
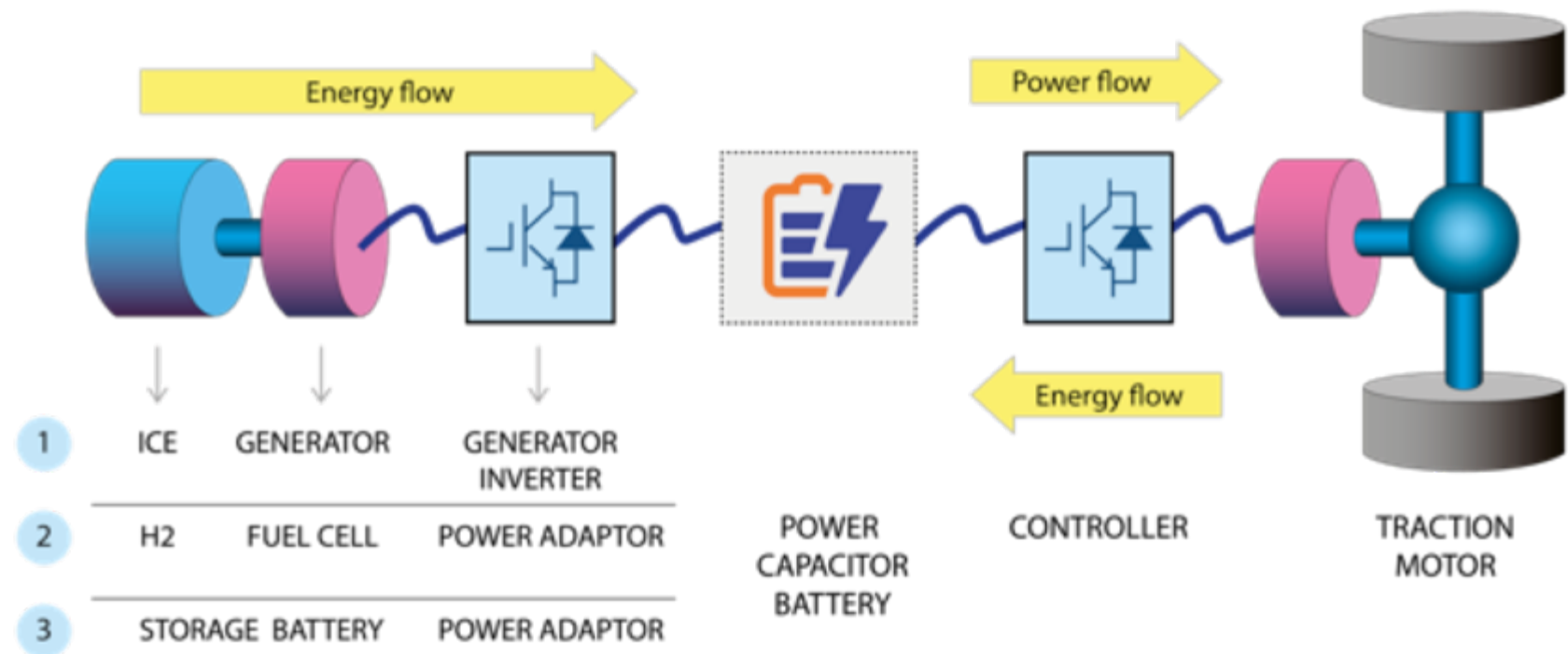
Hybrid carbon-based power and energy capacitors



Power capacitor = energy + power

charging
+
regen
braking

Pull-up



Unbeatable benefits in hybrid propulsion:

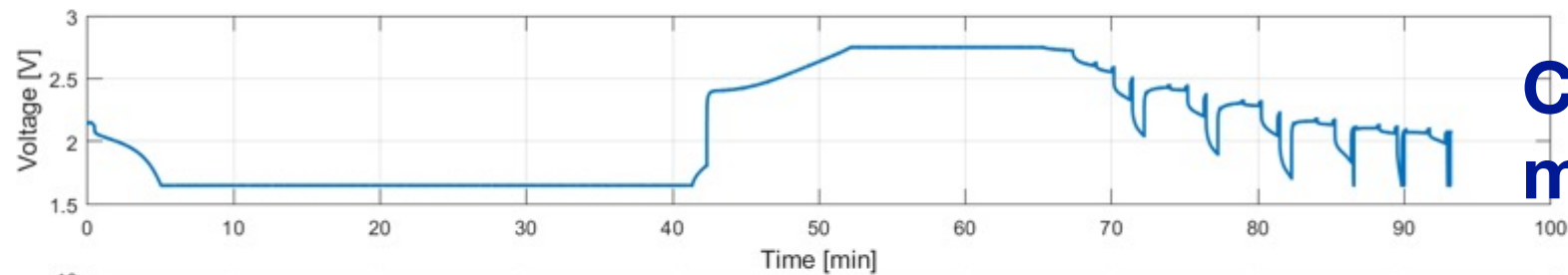
- Safe (H2 fuel cells!)
- Power (upto 10C and more)
- Simple: no BMS, no active cooling
- Works from -40 to +80°C
- Lifetime: unto 30 years

Power needs happen in bursts: the killer for Li-ion

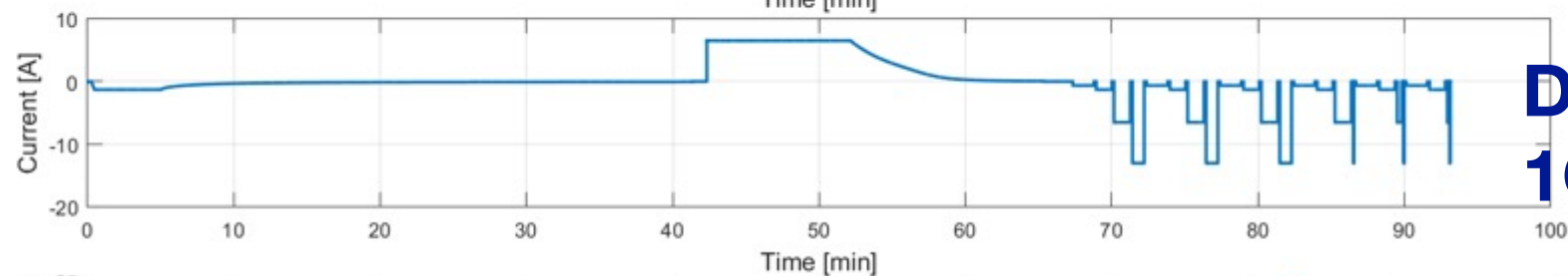


Verified and stress tested

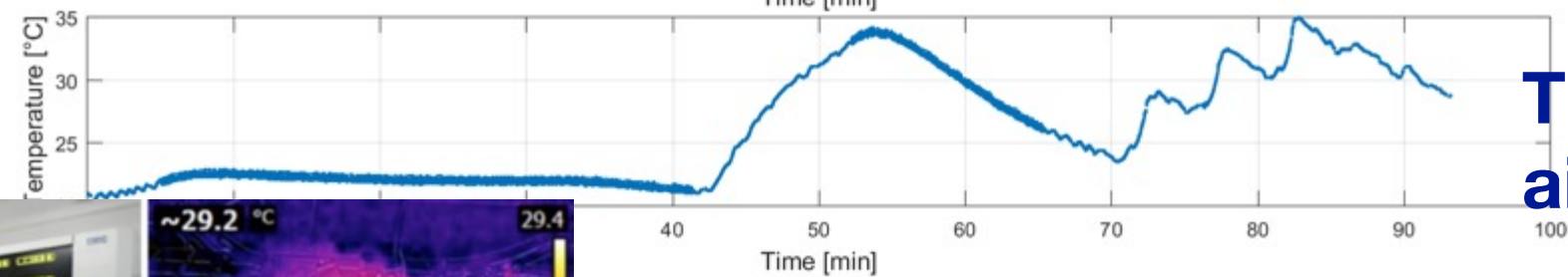
Test 4773 | 18650 | Cell 22 | WLTP test



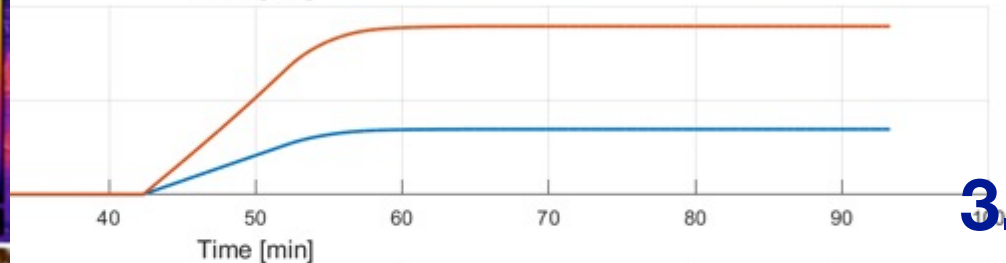
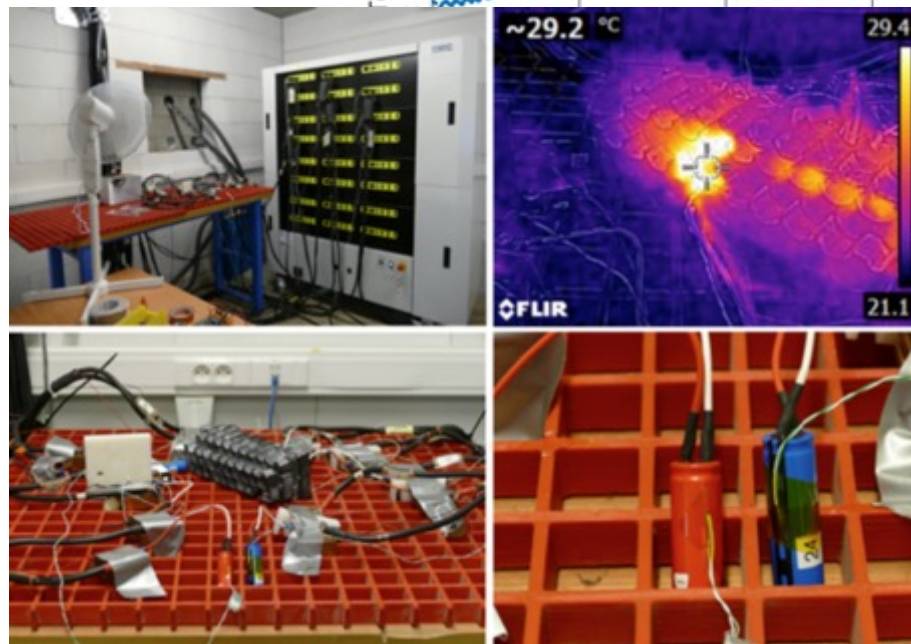
Charging in 5 minutes to 75%



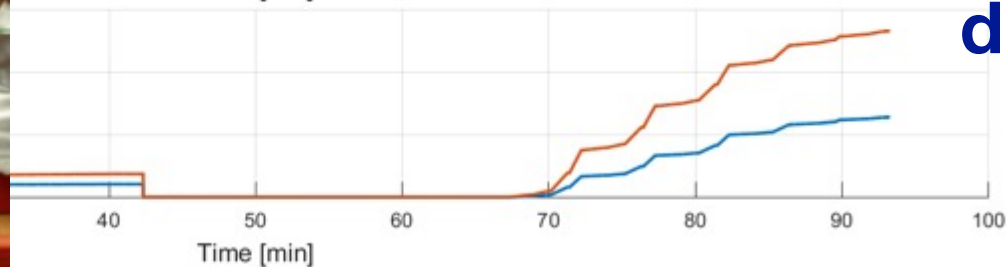
Discharging at 0.5, 1C, 5C, 10C



$T < 35^{\circ}\text{C}$ in ambient air



3.4 Wh charged & discharged



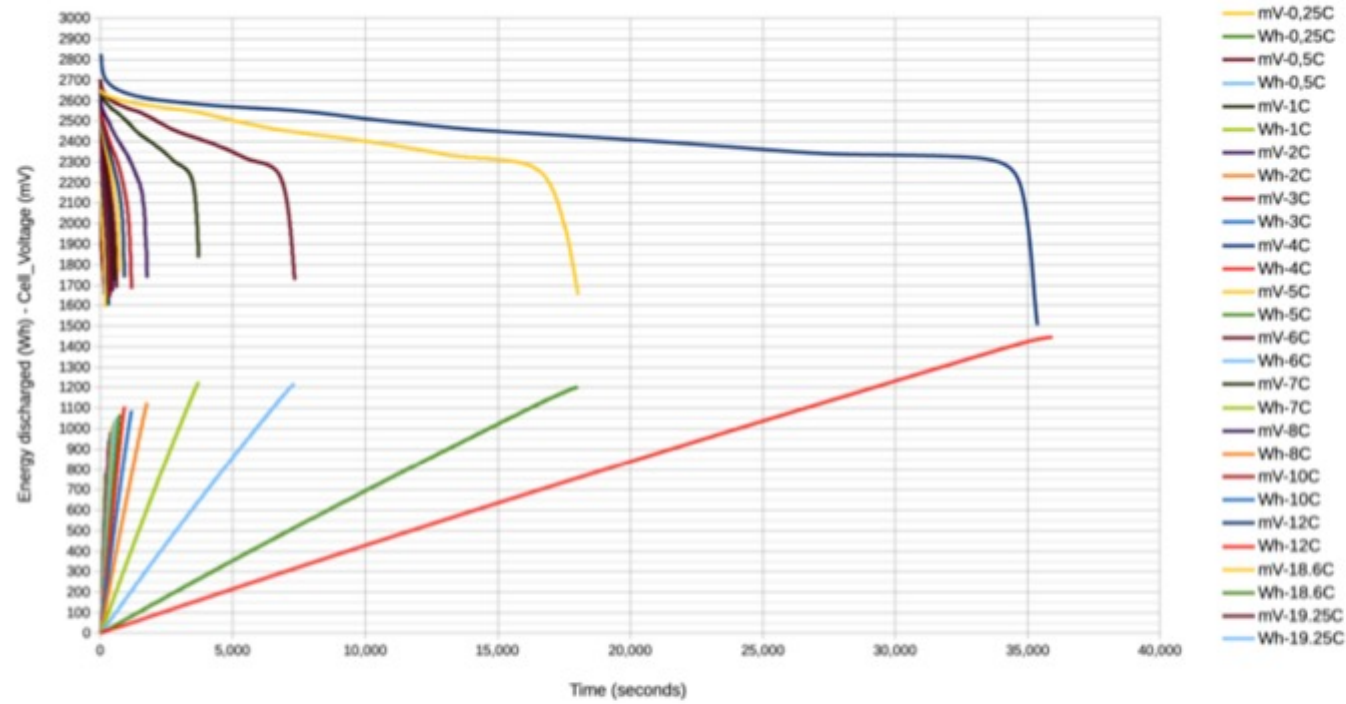
Charging at 5C (6.5 A), discharging at 0.5C, 1C, 5C, 10C, simulating WLTP cycle



From 3A to 488A on a non-cooled battery

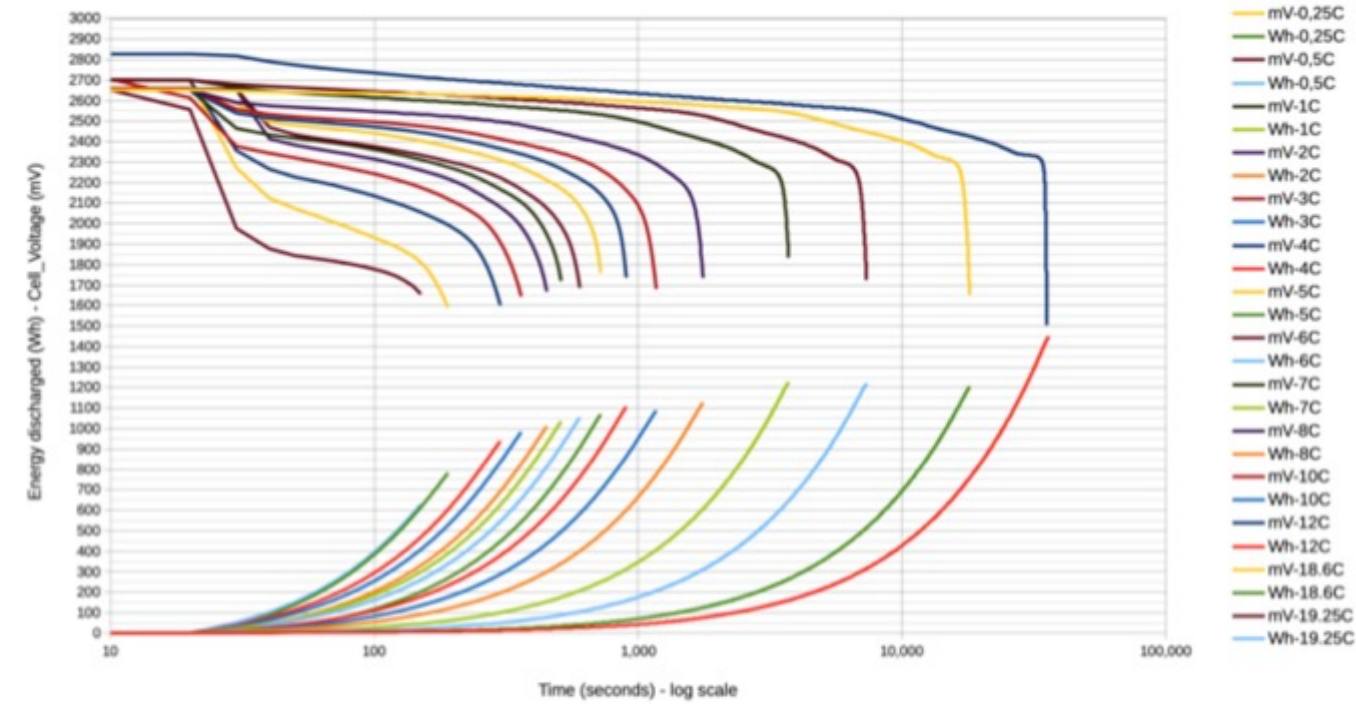
20Sx20P 18650 Powerpack (25Ah/50V)

Discharging curves 0.1C-19.5C (3A - 488A) (linear scale)



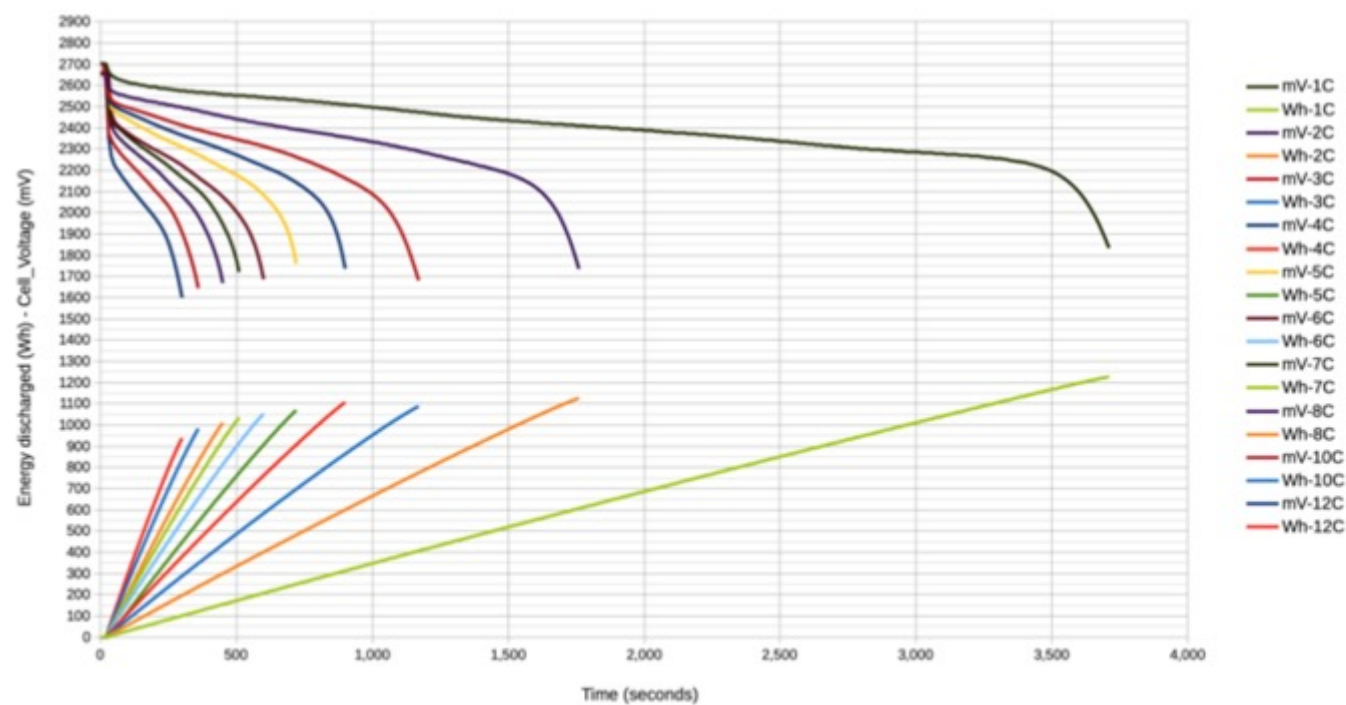
20Sx20P 18650 Powerpack (25Ah/50V)

Discharging curves 0.1C-19.5C (3A-488A) (Log scale)



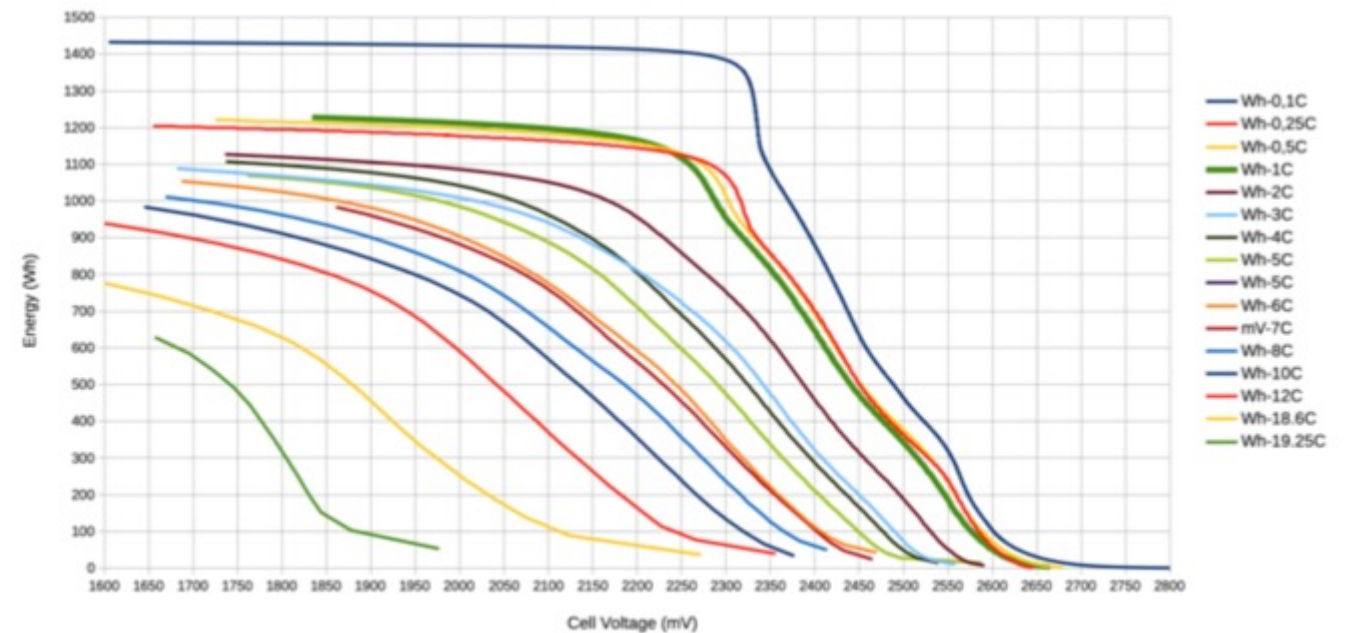
20Sx20P 18650 Powerpack (25Ah/50V)

Discharging curves 1C-12C (25A - 300A) (linear scale)

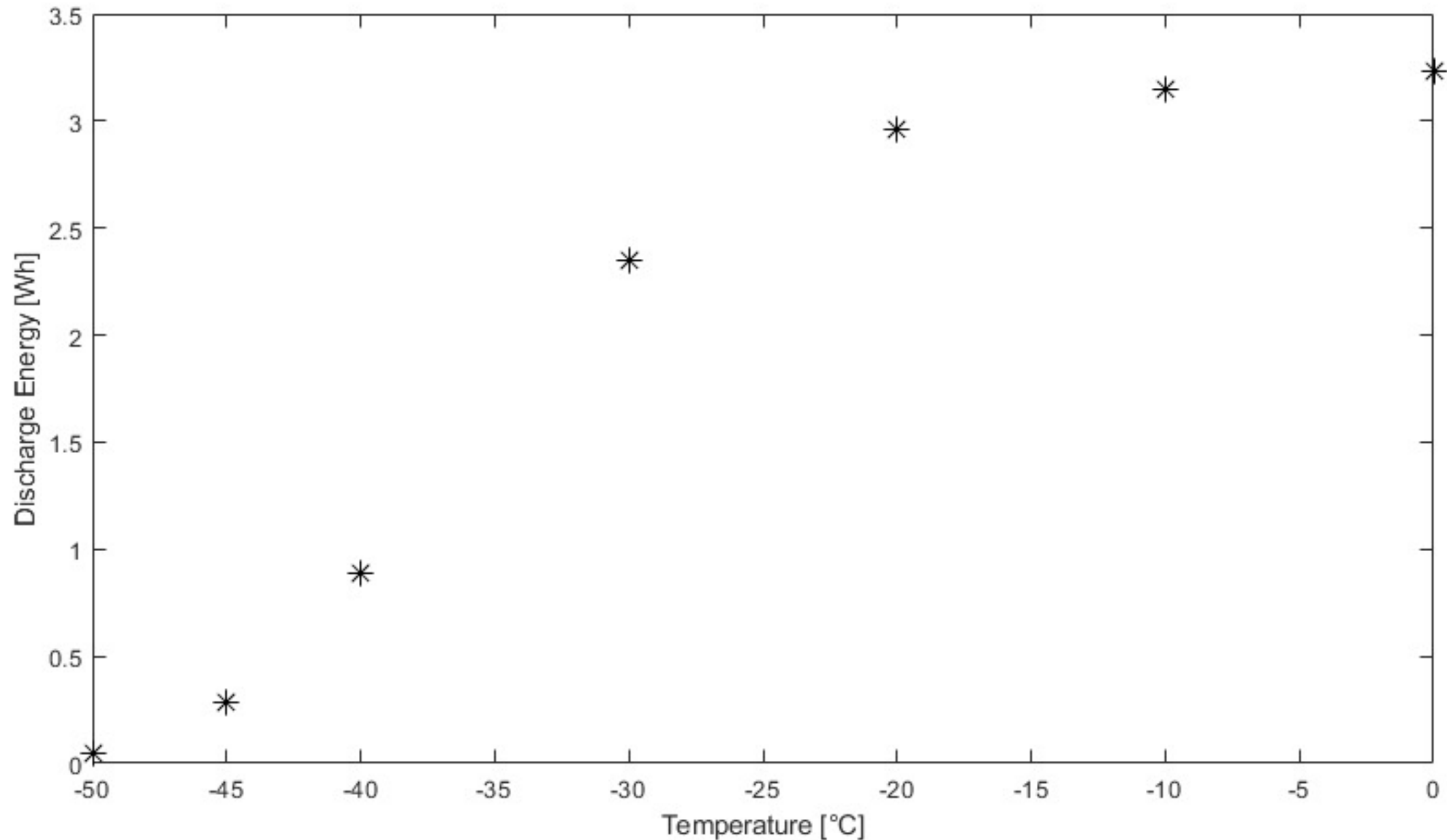


20Sx20P 18650 powerpack (25Ah/50V)

Energy discharged (Wh) vs. Voltage at 0.1C to 19.5C



Third party test: T.U.Munich (Raumfarth



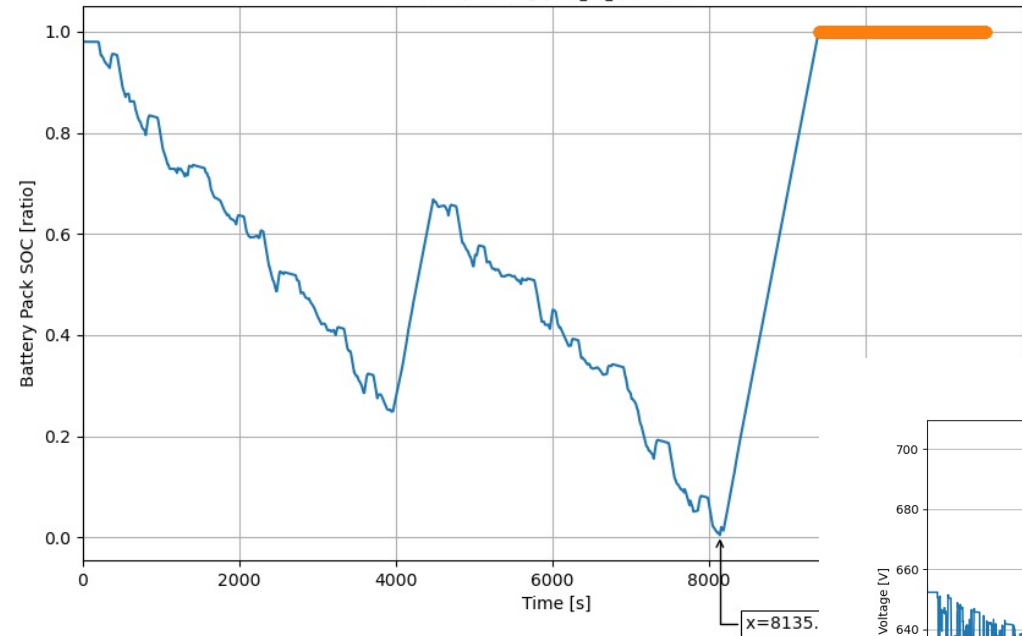
- Testing at very low temperature: very low capacity loss upto -30°C



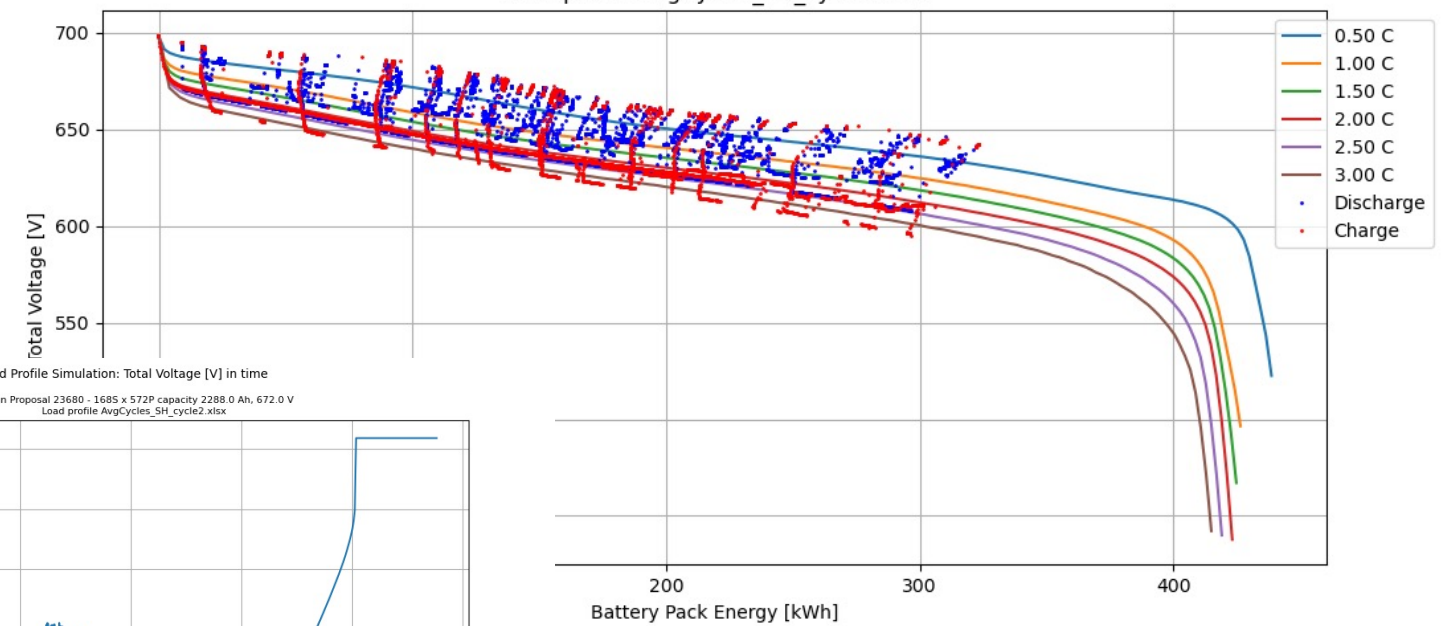
Simulations (single cell type)

Load Profile Simulation: Battery Pack SOC [ratio] in time

Design Proposal 18650 - 268S x 432P capacity 540.0 Ah, 670.0 V
Load profile AvgCycles_SH_cycle2.xlsx

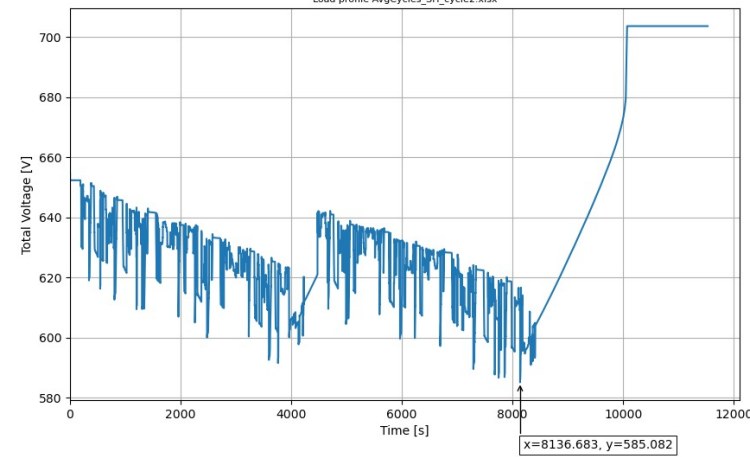


Load Profile Simulation
Design Proposal 18650 - 268S x 576P capacity 720.0 Ah, 670.0 V -- interpolated
Load profile AvgCycles_SH_cycle2.xlsx



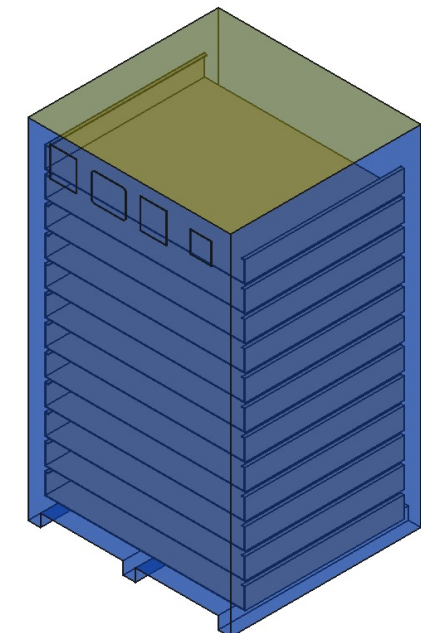
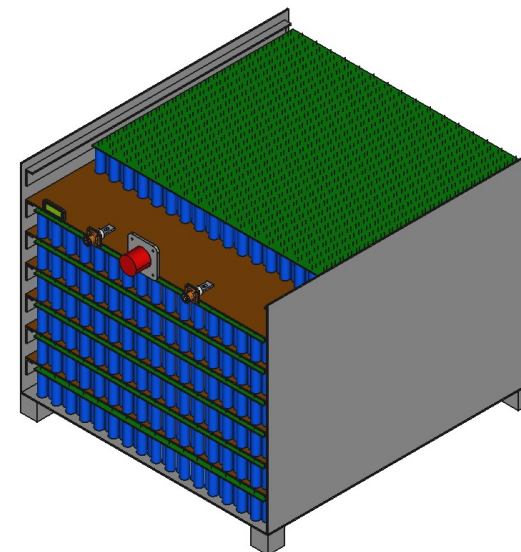
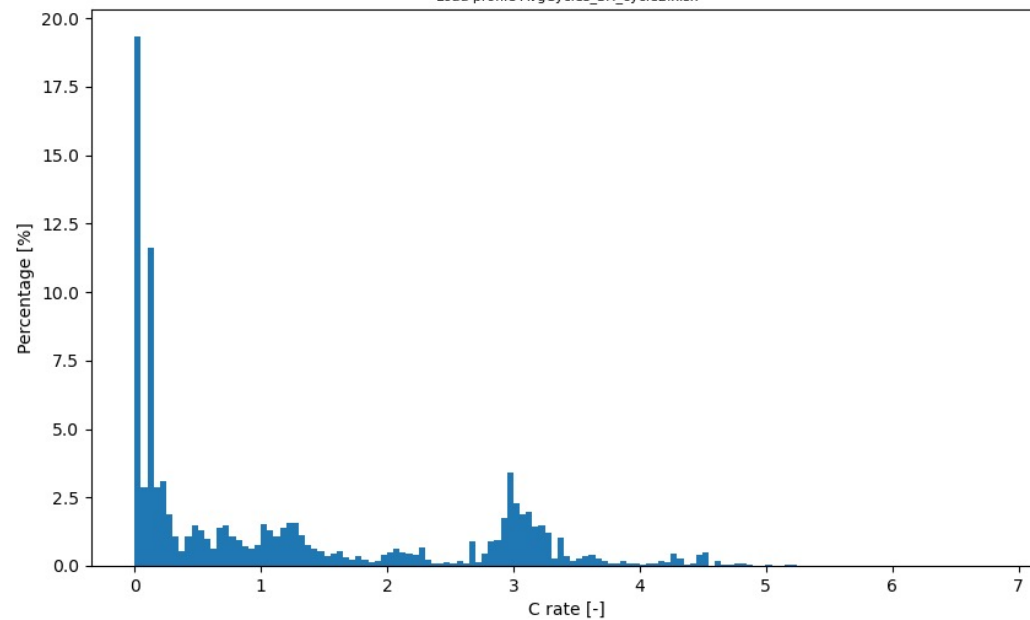
Load Profile Simulation: Total Voltage [V] in time

Design Proposal 23680 - 168S x 572P capacity 2288.0 Ah, 672.0 V
Load profile AvgCycles_SH_cycle2.xlsx

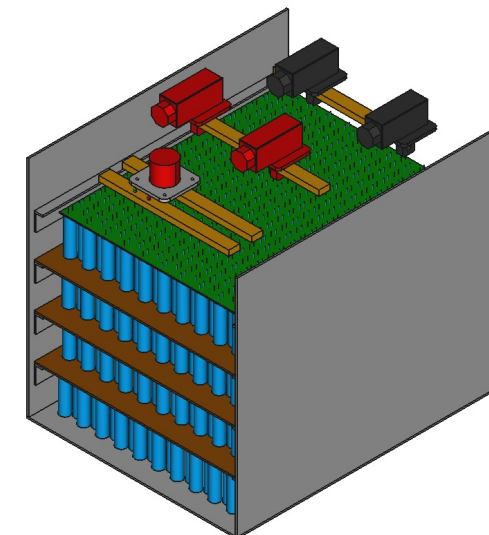
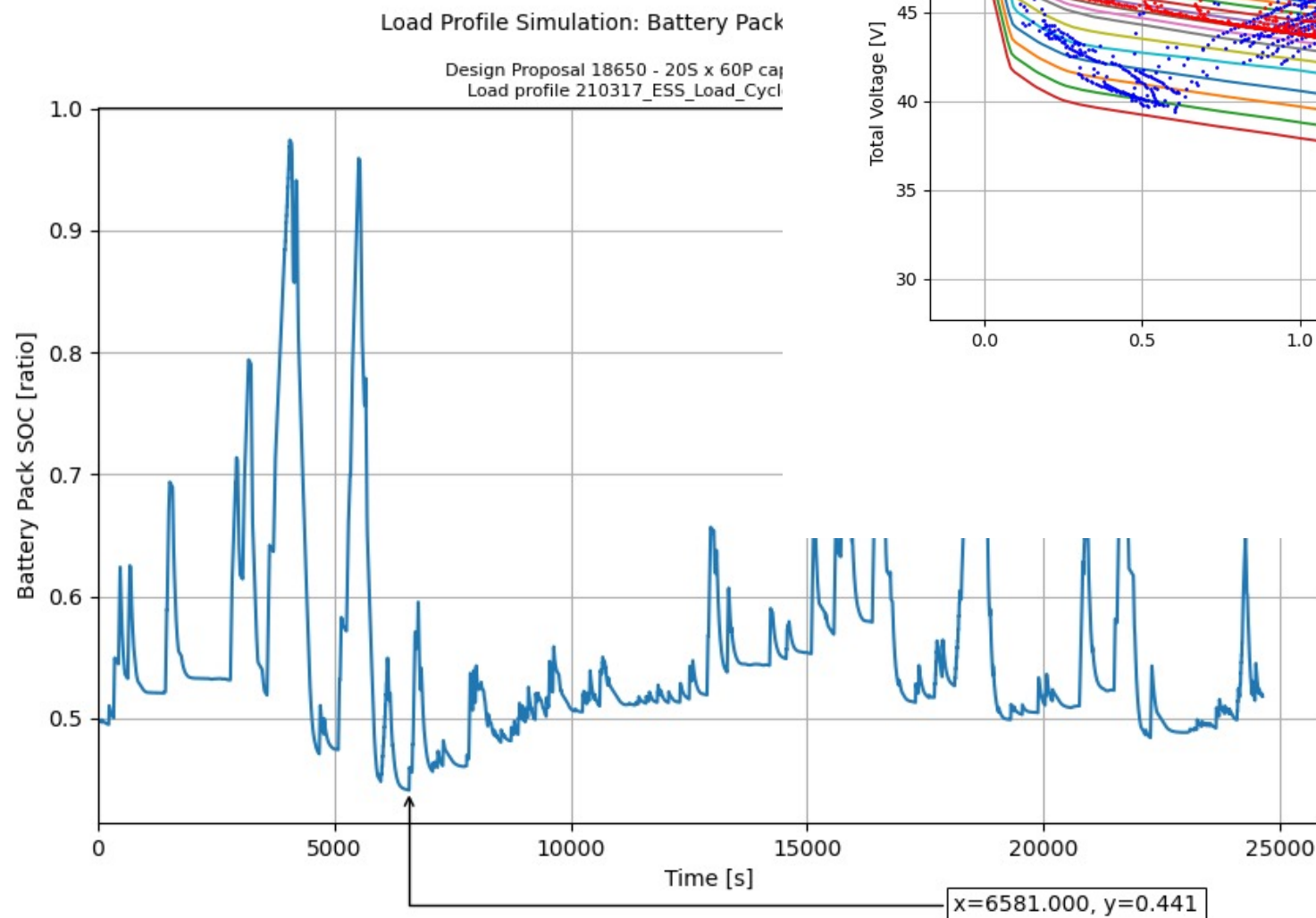
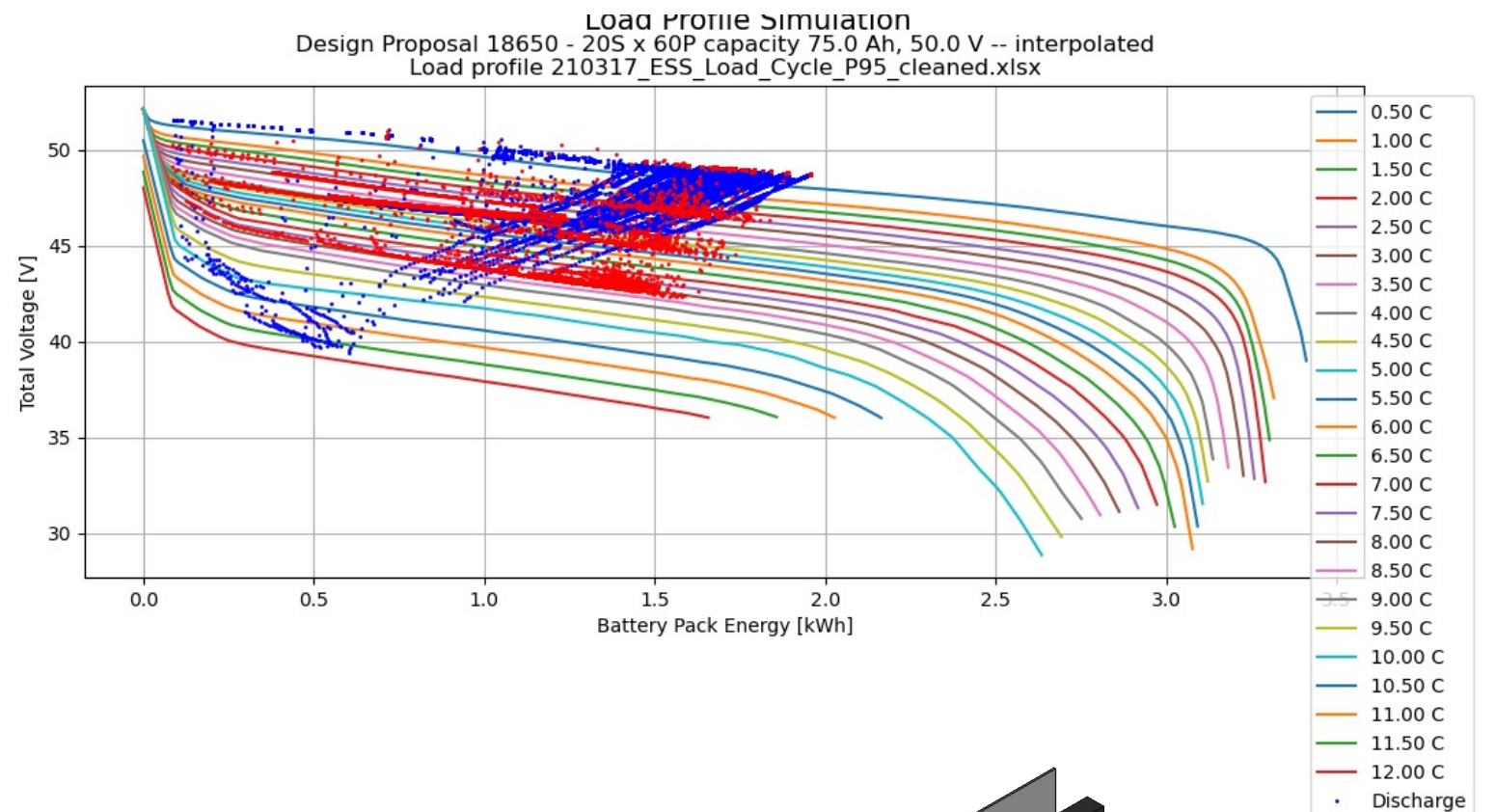
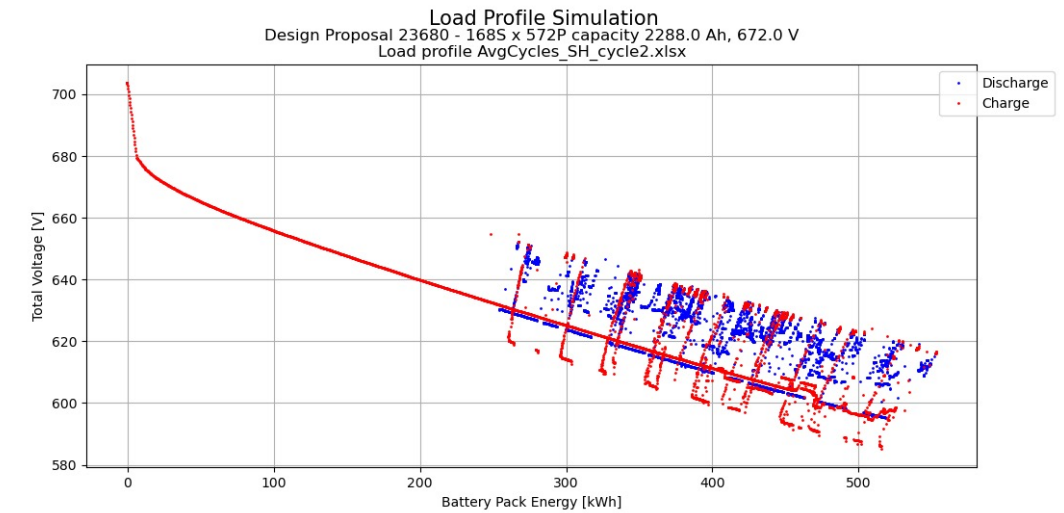
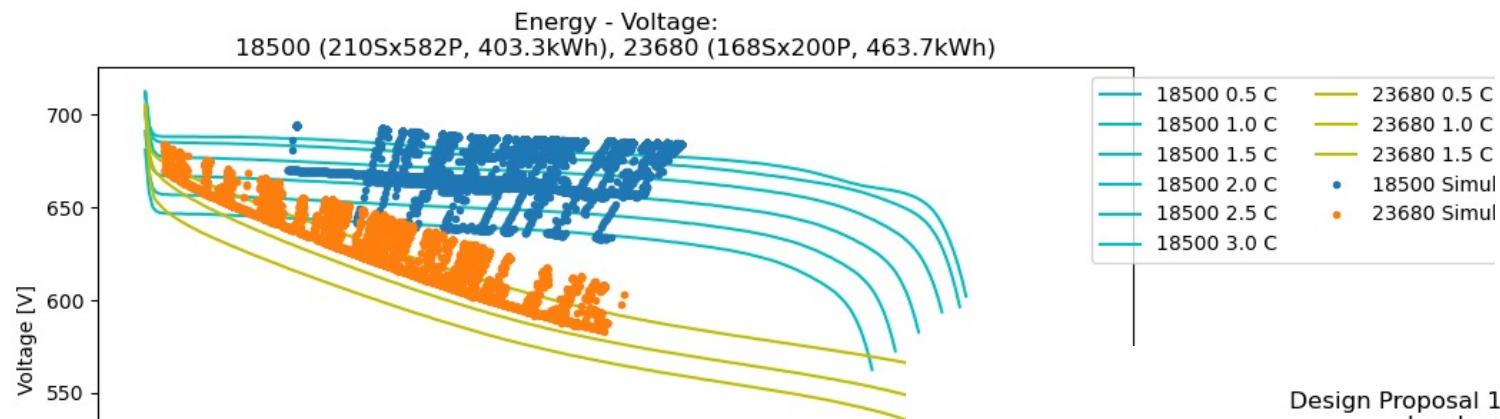


Load Profile Simulation: C rate occurrence

Design Proposal 18650 - 268S x 432P capacity 540.0 Ah, 670.0 V
Load profile AvgCycles_SH_cycle2.xlsx



Simulations (hybrids)



Seal of Excellence → pilot battery assembly line

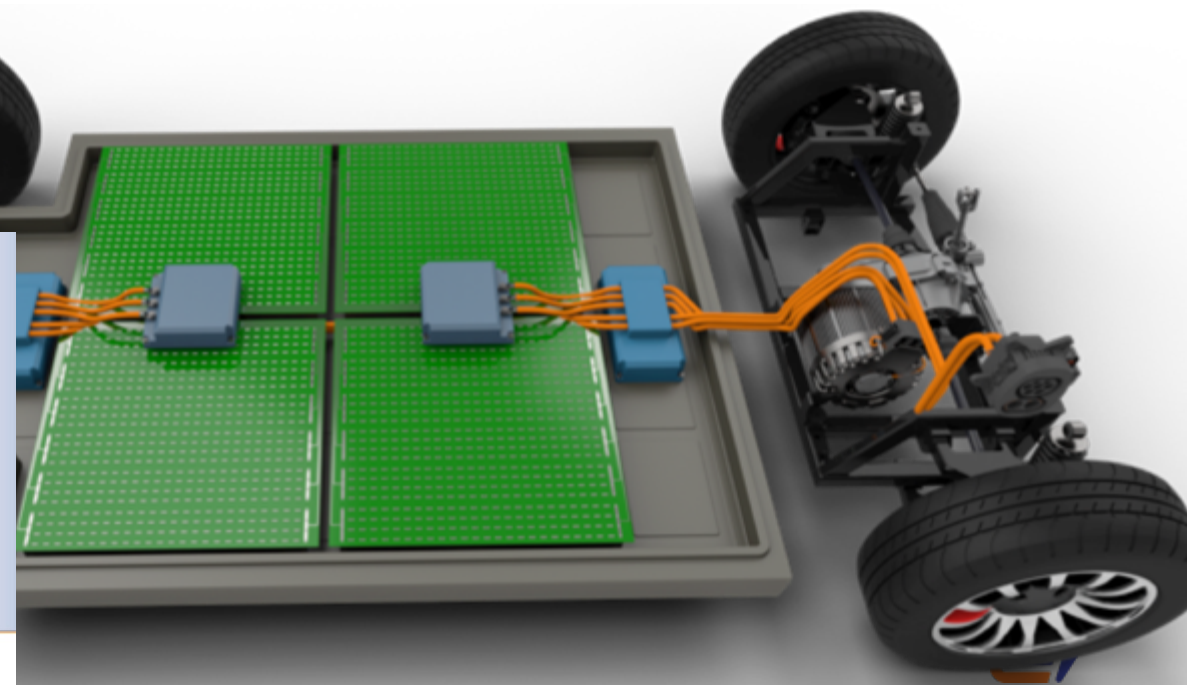
Evaluation by external experts:

- Business development plan
- Pilot battery assembly line

Partner in Multi-Moby H2020 project to bring to market a novel approach to modular and autonomous urban class e-vehicles.

Visit: <https://www.multi-moby.eu/>

**Charging in 5 minutes
(from another power capacitor pack!)**



Some pics



**From small UPS to MWh hybrid, BEVs and energy storage worldwide
Medical, satellites, vehicles, trains, ferries, solar energy farms**



Kurt.energy division of Altreonic

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