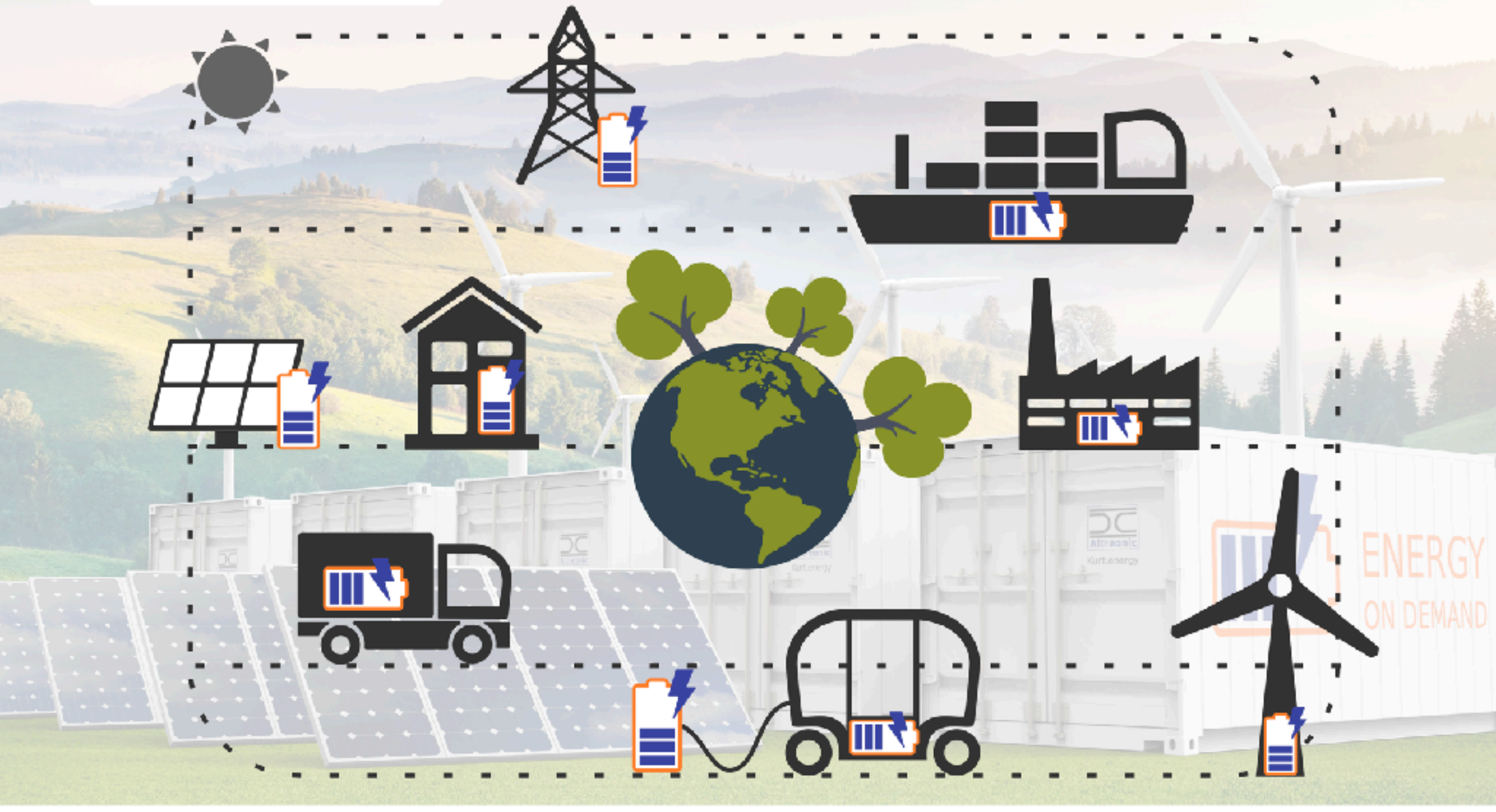
www.kurt.energy

ENERGY FOR LIFE, BLUE CELL POWER



Kurt Energy

The shift to green energy needs better batteries NOW

Company background

Altreonic NV - previously Eonic Systems NV

30 years safety-critical embedded software

- Experience in trustworthy systems engineering
- ESA: Virtuoso RTOS in Rosetta mission
- International company with 45 people WW
- Sold to Wind River Systems in 2001

Today:

- *5Gen unique fault tolerant VirtuosoNext RTOS used in KURT*
- *GoedelWorks: Systems Engineering portal for certification*
- *KURT.mobi: Light Electric Vehicle for urban use*
- **KURT.energy: Novel type of batteries based on C-supercaps**
- Electric Clean Energy is the new economic vector

Applying technology: Kurt.mobi

KURT for urban mobility: one scalable concept

City-KURT:

Small yet powerful

Last mile delivery

Shuttle-KURT:

the only L7-shuttle below 450 kg

Cost-efficient yet robust

Optimal e-consumption

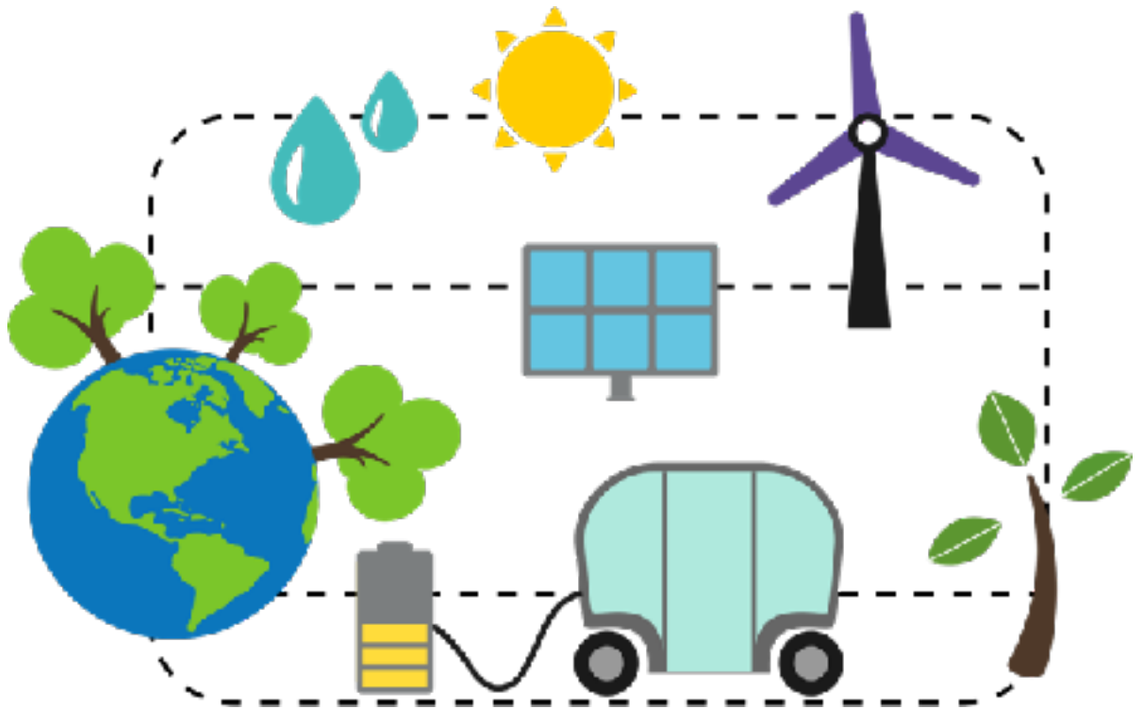
Very fast e-charging

Multi-purpose & modular

Safety & Reliability

Designed with autonomous driving in mind

Kurt.energy:
Tackling the battery and energy issue



Game changing hybrid carbon based power capacitors

Similar energy density like lithium-ion batteries with the benefits of supercapacitors.

1. **Can burn** => Carbon power capacitors **DO NOT BURN**
2. **Too heavy** => Carbon power capacitor pack can be 1/3 smaller
3. **Short peak power capacity** => Sustained **high peak capacity (5-20X)**
4. **Made with problematic rare metals** => Few rare metals
5. **Loss of power in cold environments** => Works -40°C/+80°C
6. **Need powerchargers to charge rapidly** => smaller fast chargers
7. **Need lots of cells and electronics (hence higher cost)** => Same performance with 1/3 size, no BMS, no active thermal management

Combination of high energy density, high power density and safety provides a game-changing opportunity

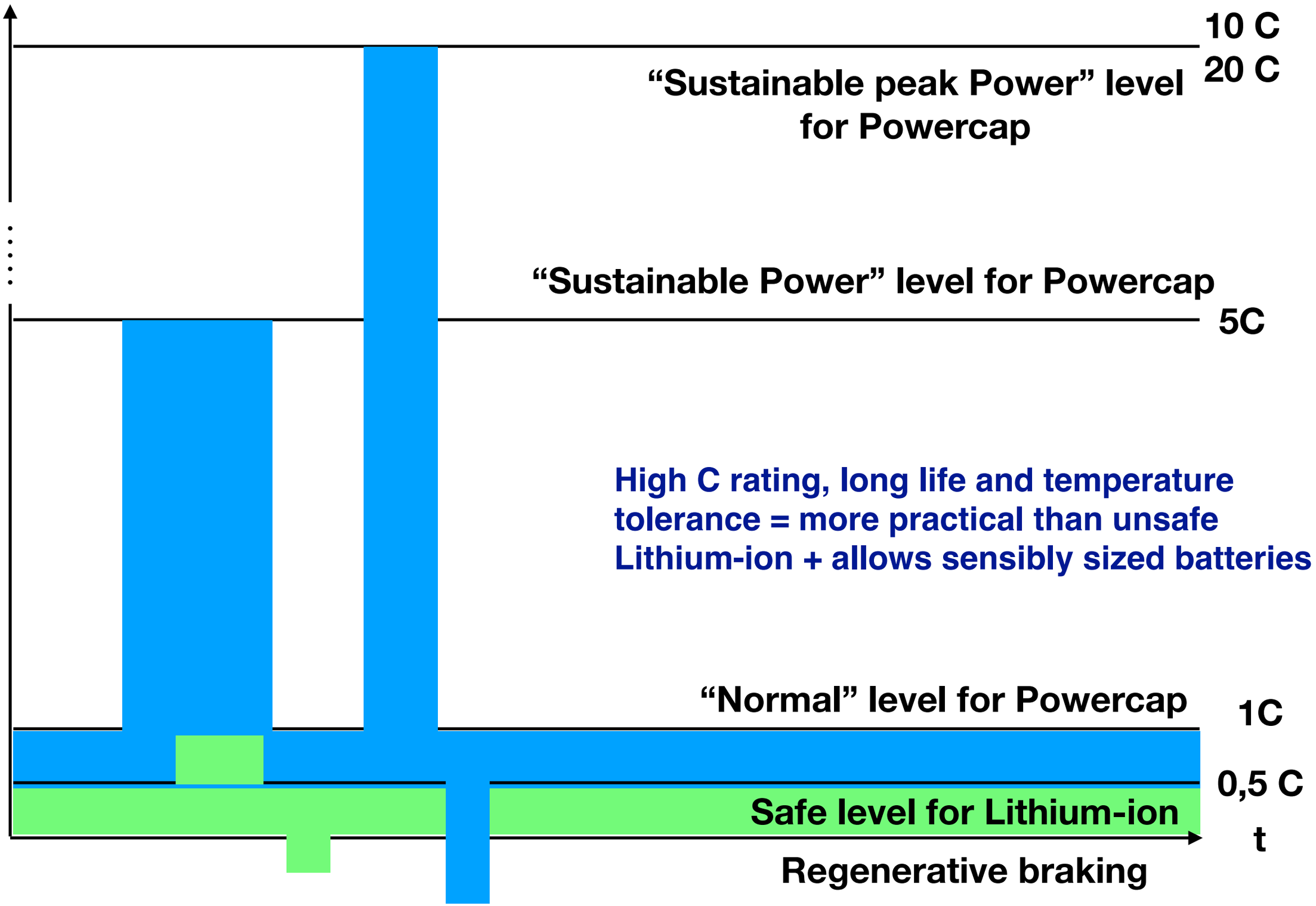
Research on Lithium based batteries promises better and safe batteries but are they in production? **Our carbon power capacitors are in production**.

The total cost of the solution is lower than with Li-supercapacitors. The price will be comparable to Lithium based batteries when independent volume production begins. Lifecycle cost already significantly lower.

Comparison of batteries and C-powercaps

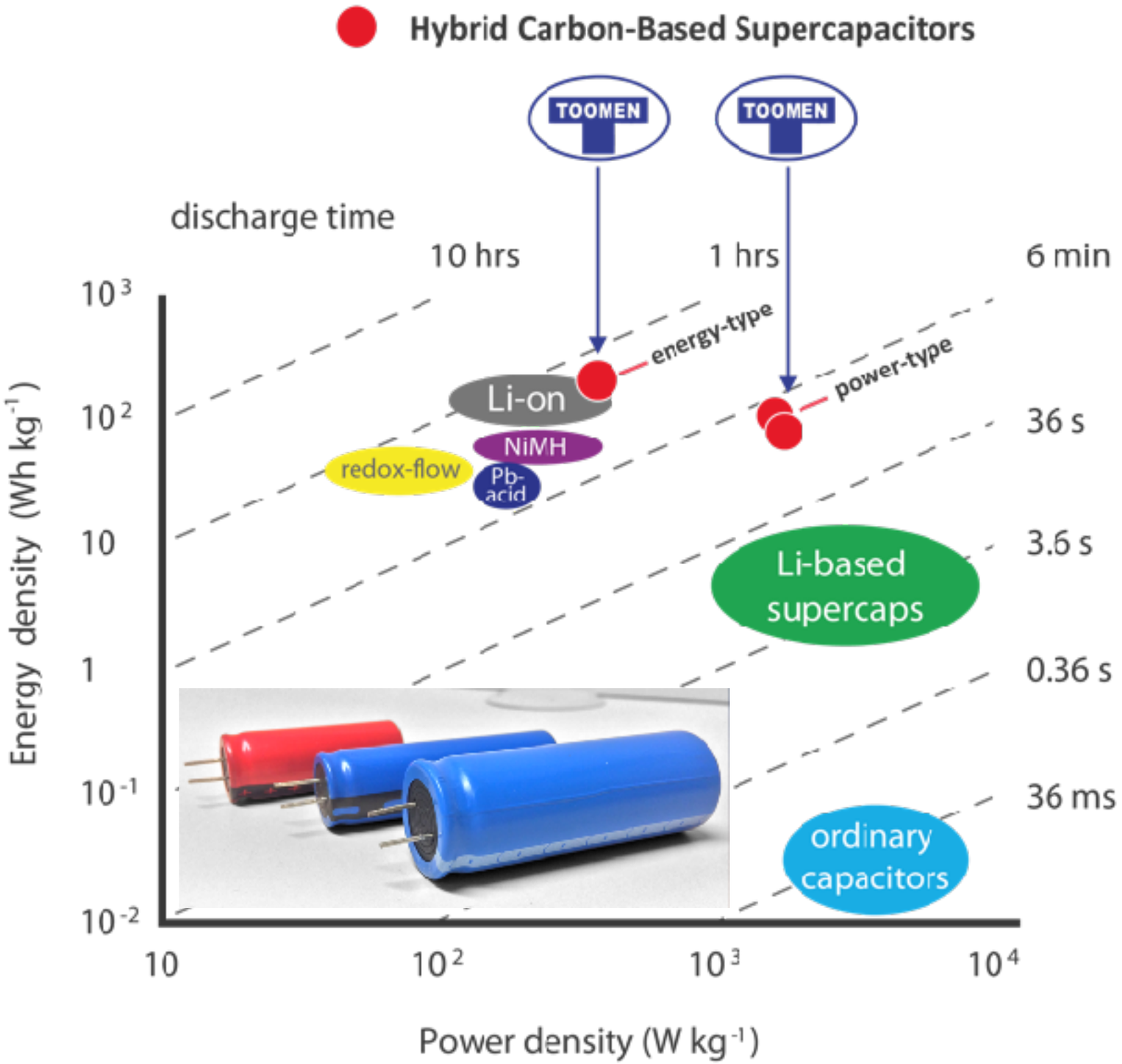
	Lithium iron phosphate battery	NMC lithium battery	Lithium titanate battery	Lithium based super capacitor	Power-type C-powercap	Energy-type C-powercap
Energy density (Wh/kg)	90 - 150	180 - 250	70 - 95	4 - 6	**80 - 100**	**180 - 230**
Power density (kW/kg)	0.1 - 0.2	0.1 - 0.5	0.5 - 1	5 - 7	**1 - 1.5**	**0.3 - 0.5**
Typical charging/ discharging rates	1.0 C	0.7 - 1.0 C	1.0 - 5.0 C	100.0 - 200.0 C	**10.0 - 20.0 C**	**1.0 - 1.25 C**
Working temperature (℃)	-10 ~ 55	-20 ~ 45	-40 ~ 60	-40 ~ 65	**-20 / -40 ~ +80**	**-20 / -40 ~ +80**
Cycle life (times)	2000	2000	5000	> 500000	**> 20000**	**> 10000**
Safety	acceptable	not good	good	excellent	**excellent**	**excellent**
Complexity	Medium: BMS needed	High: BMS needed + thermal mgt	Medium: BMS	Low: no BMS, passive cooling	**Low: no BMS, passive cooling**	**Low: no BMS, passive cooling**

Power capacitor = energy + power



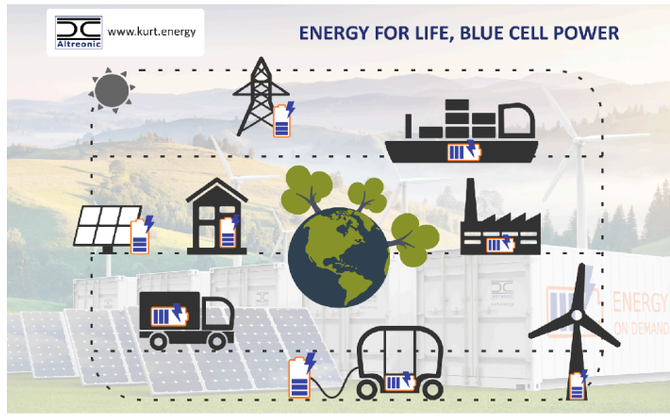
High C rating, long life and temperature tolerance = more practical than unsafe Lithium-ion + allows sensibly sized batteries

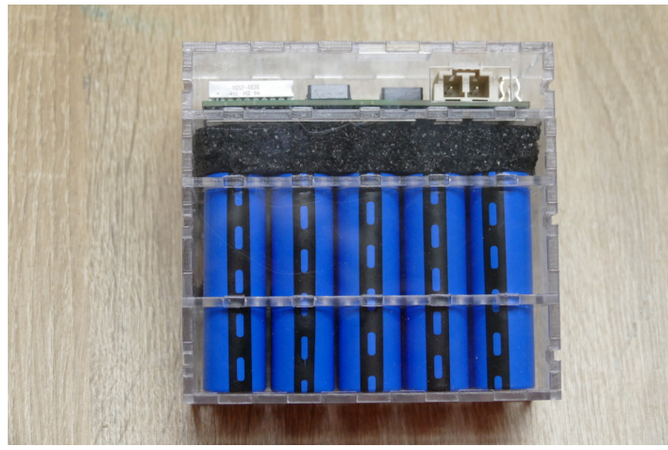
Argone chart: comparison

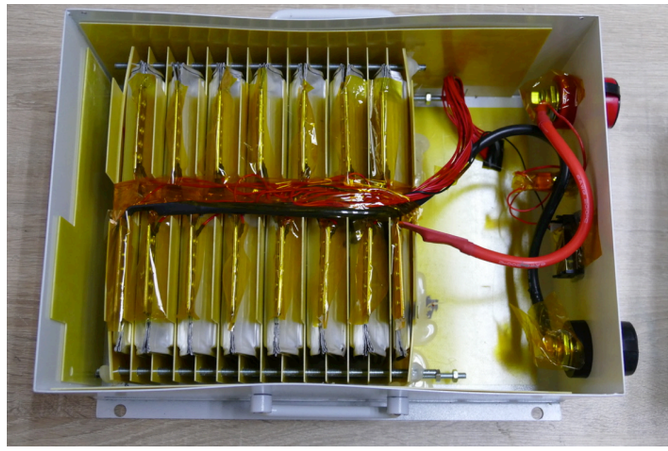


Go to market strategy Europe 2019

1. Kurt.energy has an exclusive agreement to develop the market for the cell manufacturer in China
2. China focuses on cell production and China/SE-Asia market
3. Kurt.energy focuses on:
   - Business development EU and worldwide
   - System level design and local assembly
   - Roadmap for assembly and production in Europe
4. Focus first on premium market segments:
   - High Power requirements
   - High safety, reliability and lifetime requirements
   - Fast charging
5. Focus markets:
   - Hybrid drives
   - Wind turbines
   - Emergency Power Supplies (UPS)







First application: car battery

<u>Advantages:</u>

- No lead inside
- Lighter
- Fuel consumption (-2 to -5 %)
- No issues @ -20°C
- Longer lifetime
- Constant capacity over lifetime

Proven applications

- Developed and tested in China:
- Premium car battery (CUSCO JP, Subaru). Reduces fuel consumption up to 8%
- Windmill blade trimming and pitch control: 2x cheaper and 3x better than Li-supercaps
- Serial hybrid city vehicles:
  - Battery reduced from 2 ton to 300 kg
  - Fuel consumption 2l/100km/ton vehicle
  - Better energy recuperation (braking)
  - No need for charging infrastructure
- Grid stabilisation:
  - Much smaller battery needed
- Fork lifts / heavy tractors:
  - Smaller batteries
  - but fast recharging

Applications


Space


Heavy mining vehicles


Hybrid trucks


E-bike battery

Old-timer electrification


Energy storage


Grid stabilization


Street lighting


Car batteries


AGVs & forklifts


Hybrid vehicles


Trains

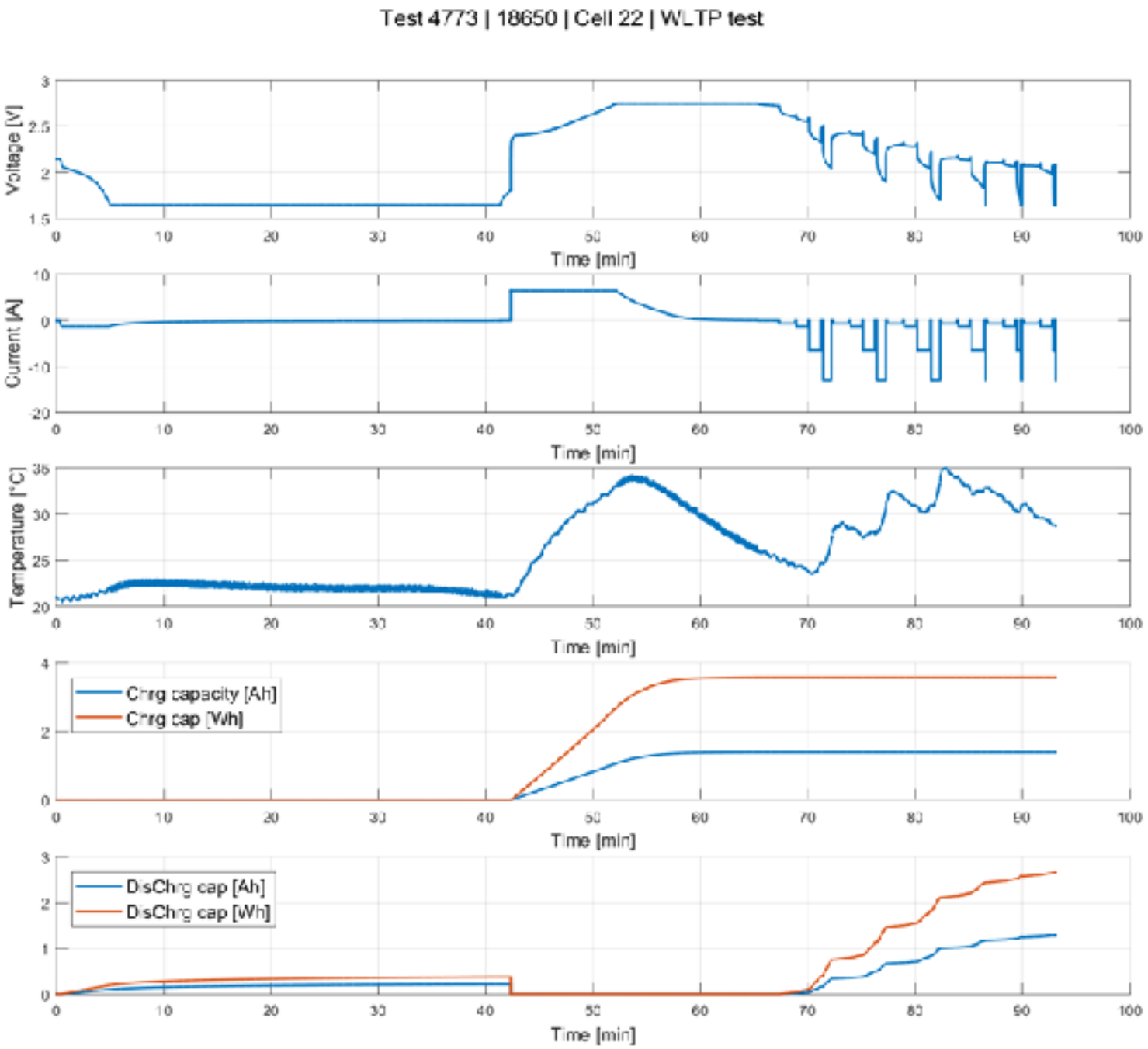

Welding equipment


Hand-held power tools


Home energy system


Power mills

Confirmed by external test & stress & abuse tests



Charging in 10 minutes to 75%

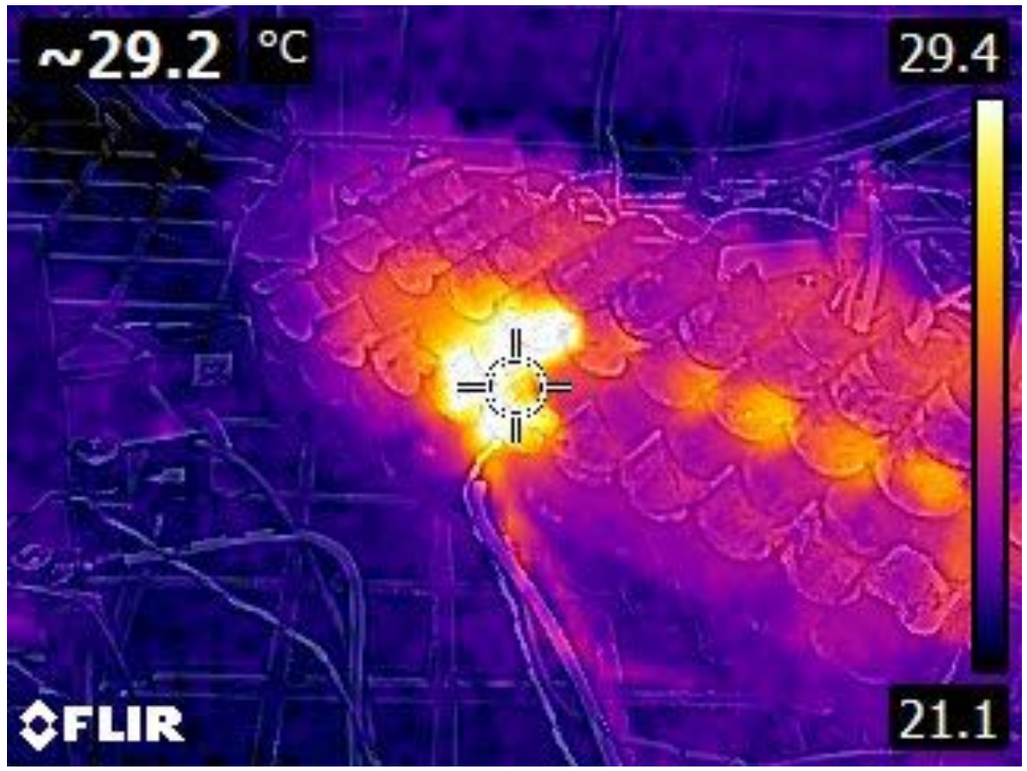
Discharging at 0.5, 1C, 5C, 10C

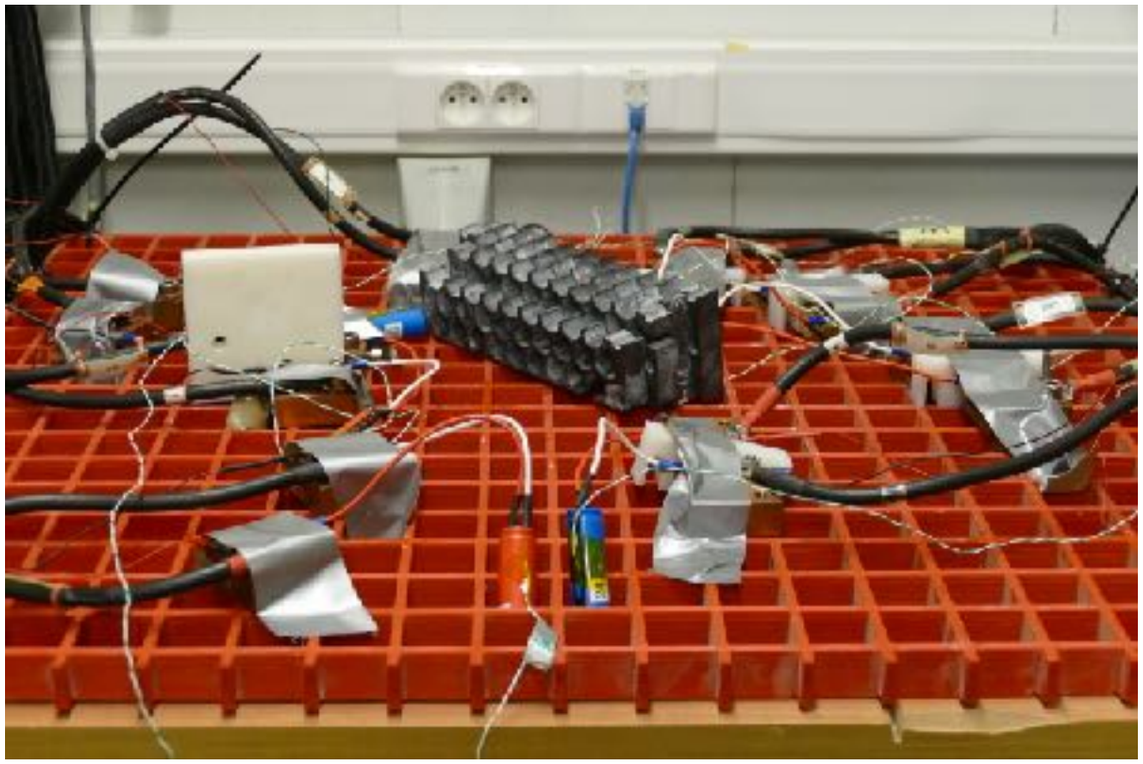
T < 35 °C in ambient air

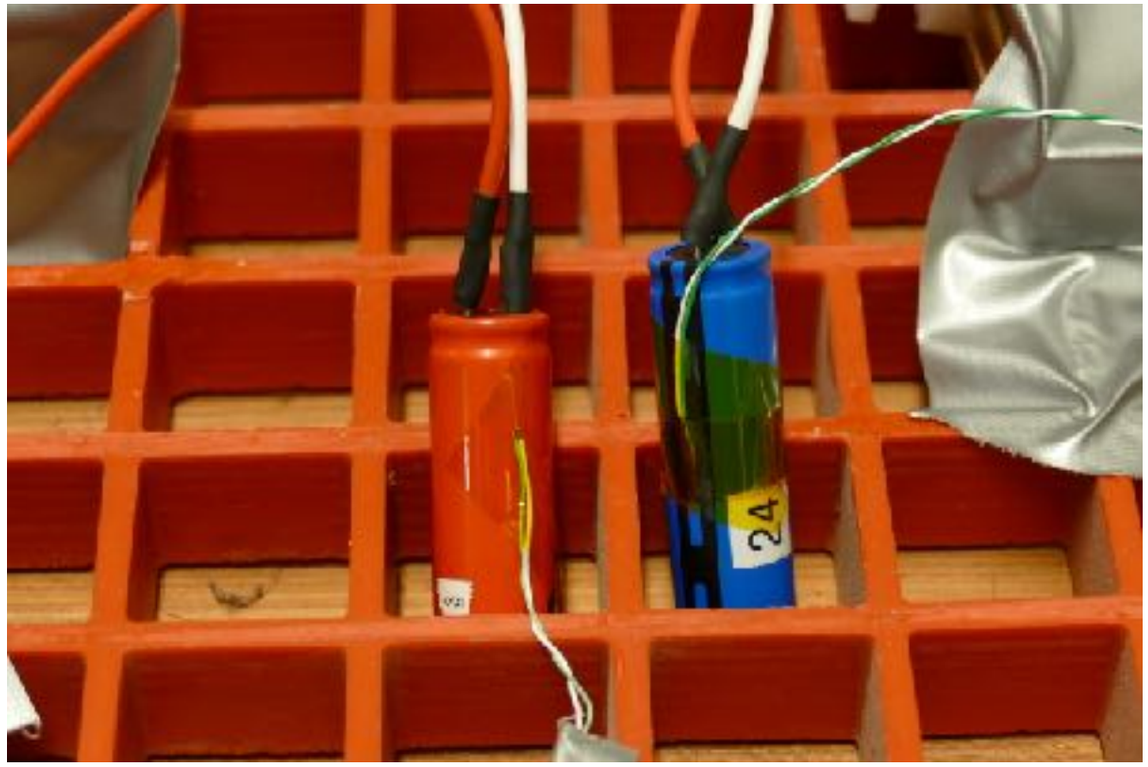
3.4 Wh charged & discharged

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

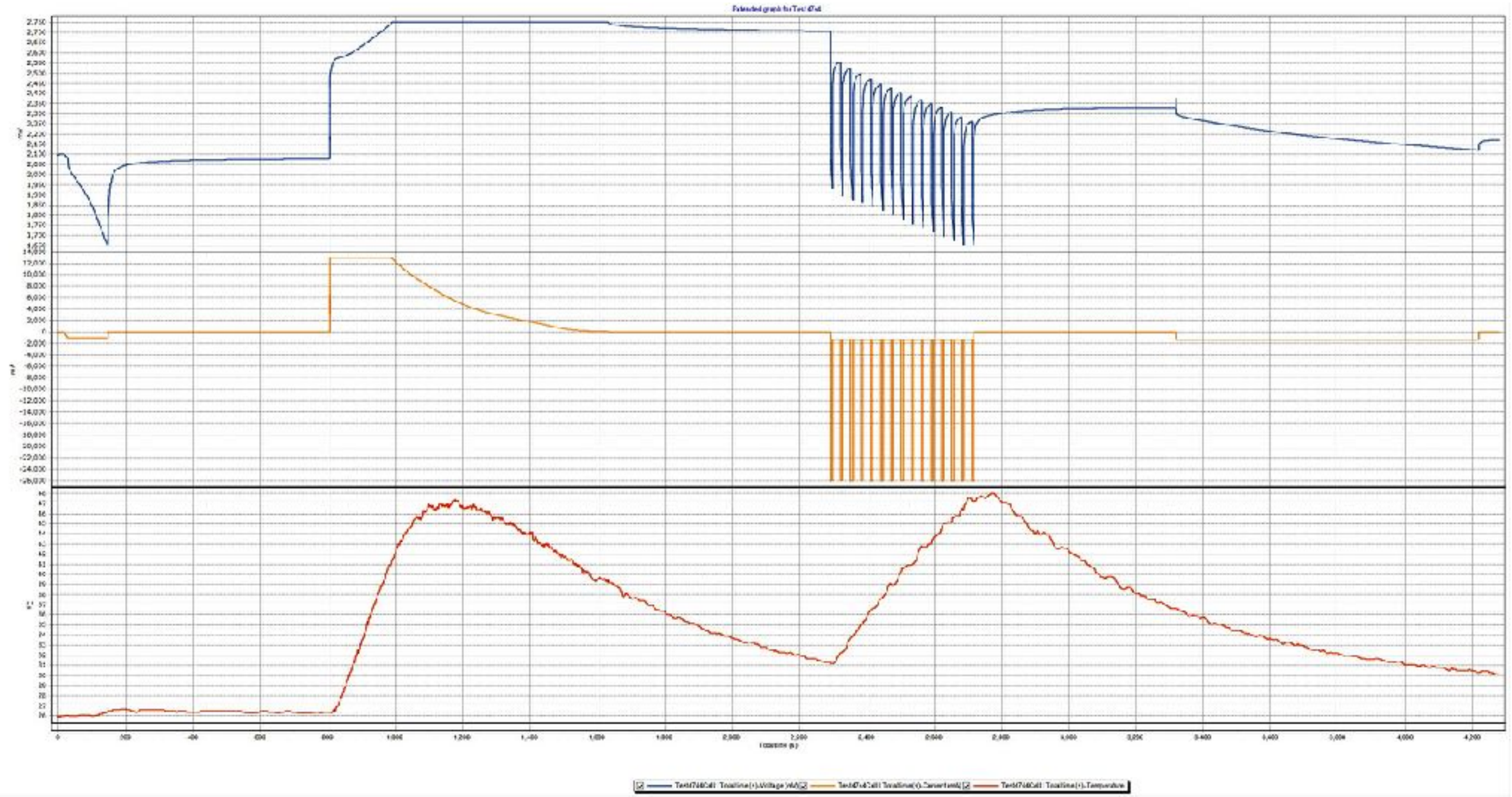
Tests at FlandersMake Lommel

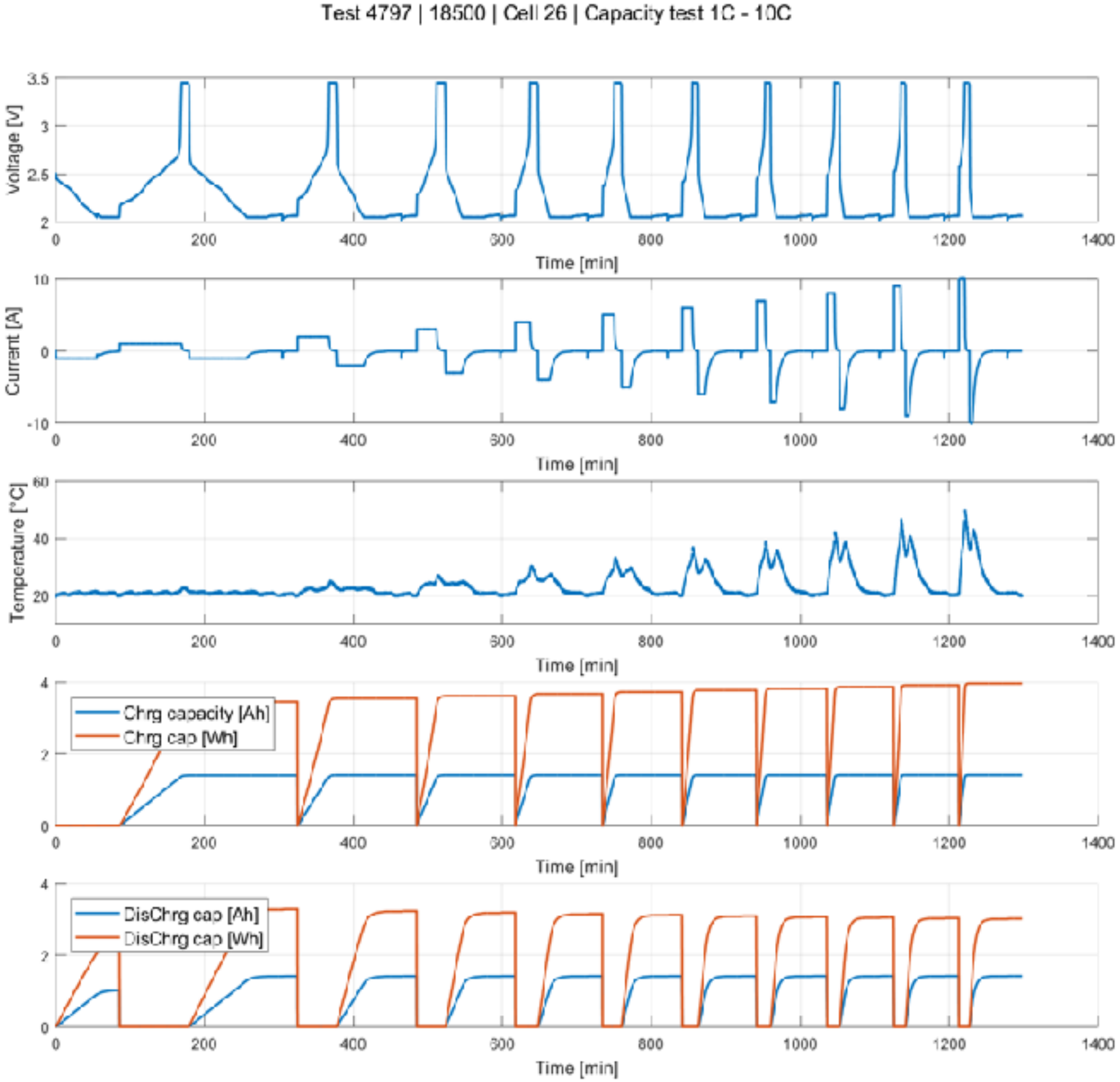






Stress test at 20C (26A)



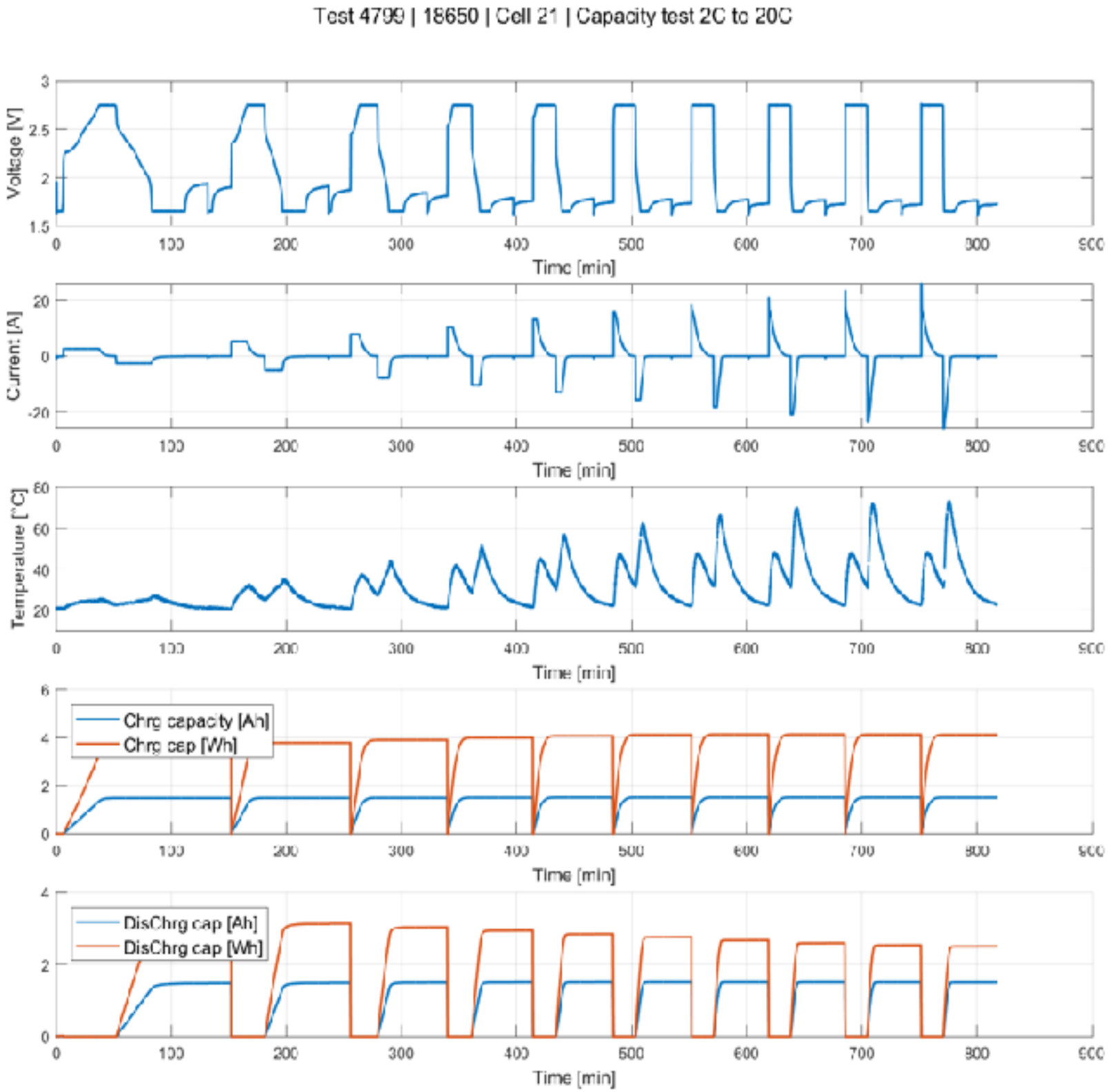


Charging in 22 minutes to 75%

Charging and discharging with 1.C (1.0 A) upto 10C (10.0 A)

Temperature peaks at 55°C remains below 30°C up to 5C

3,2 Wh charged & discharged

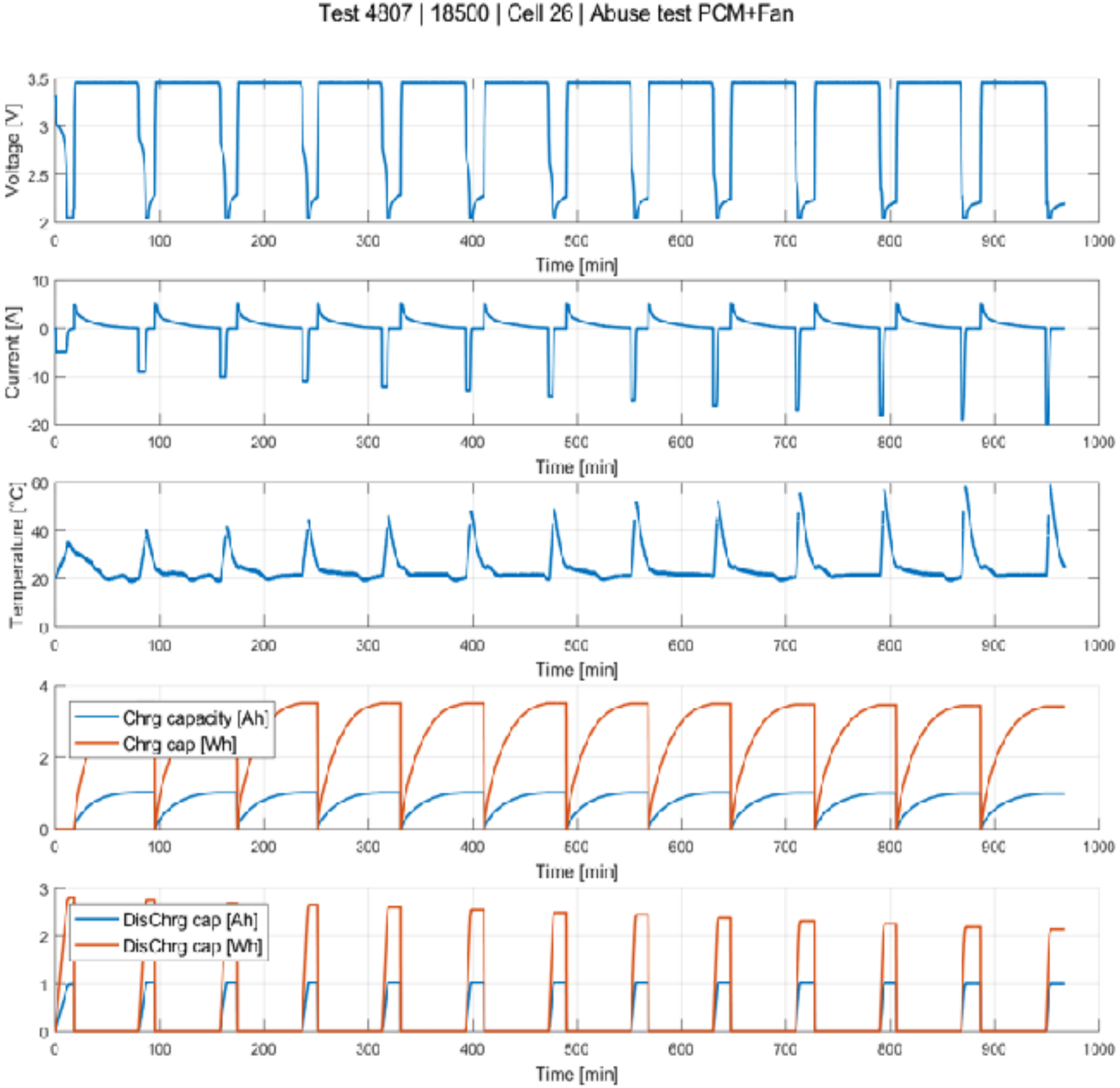


Charging in
5 minutes
to 75%

Charging and
discharging
with 1C (1.3 A)
upto 20C (26.0 A)

Temperature
peaks at 75°C
remains below
60°C up to 10C

3,5 Wh
charged &
discharged

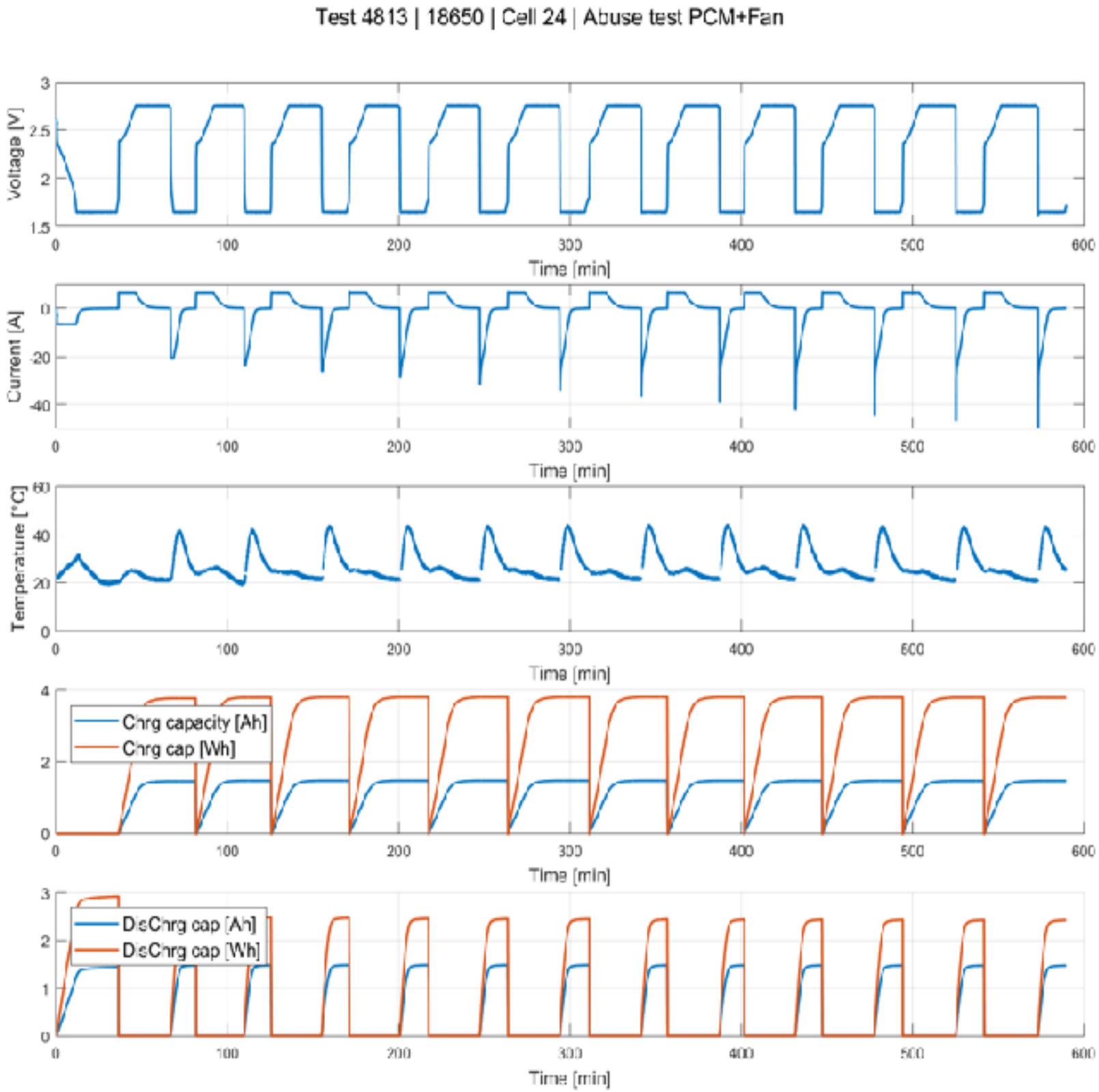


Charging at 5C in 22 minutes to 75%

Discharging from 9C (9.0 A) upto 20C (20.0 A)

Temperature peaks at 60°., Remains below 40°C till 10C

Charge capacity unaffected

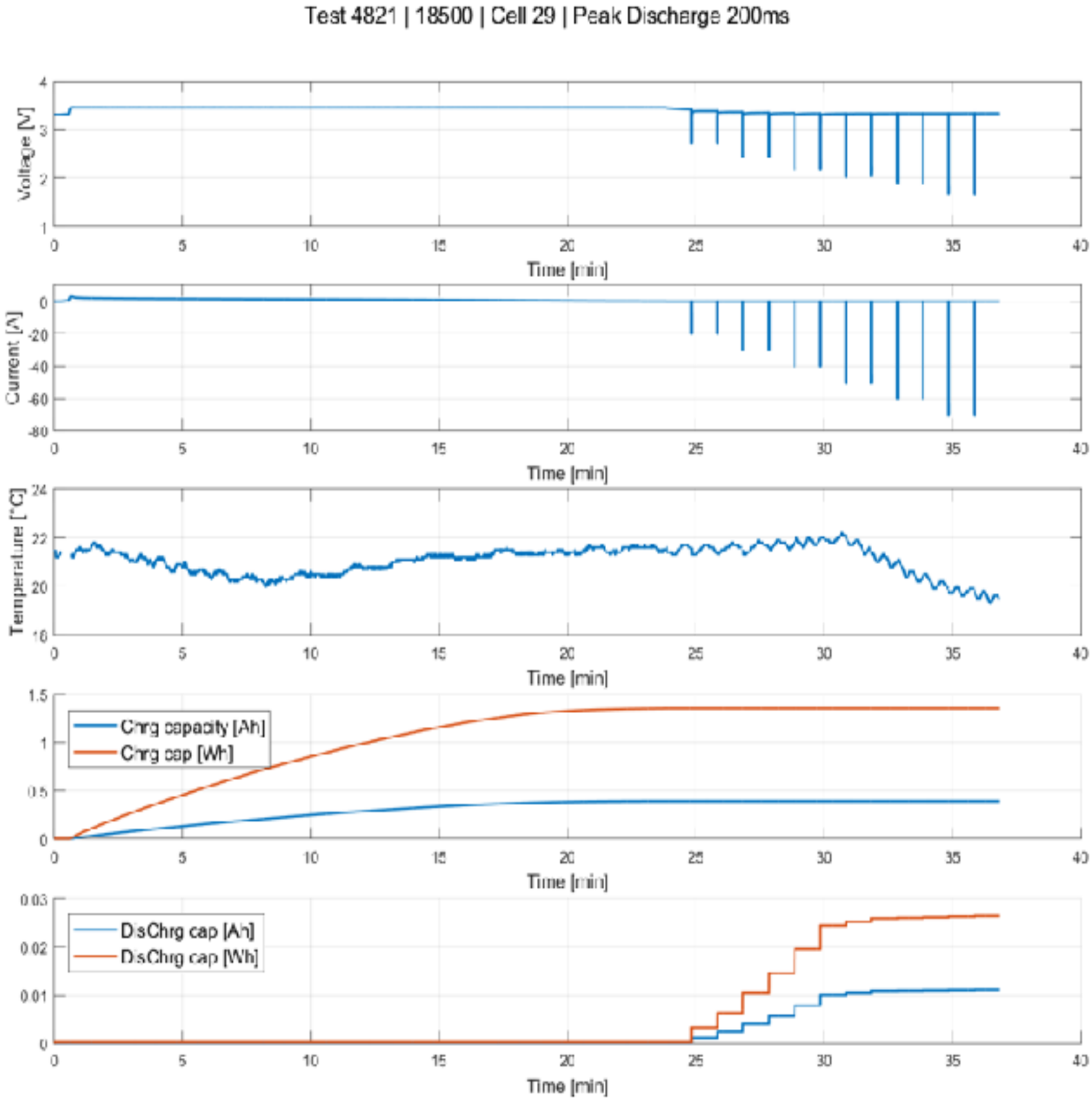


Charging at 5C in 5 minutes to 75%

Discharging from 16C (20.8 A) upto 38C (49.4 A)

Temperature peaks at 42°C, remains below 40°C upto 16C

Charge capacity unaffected



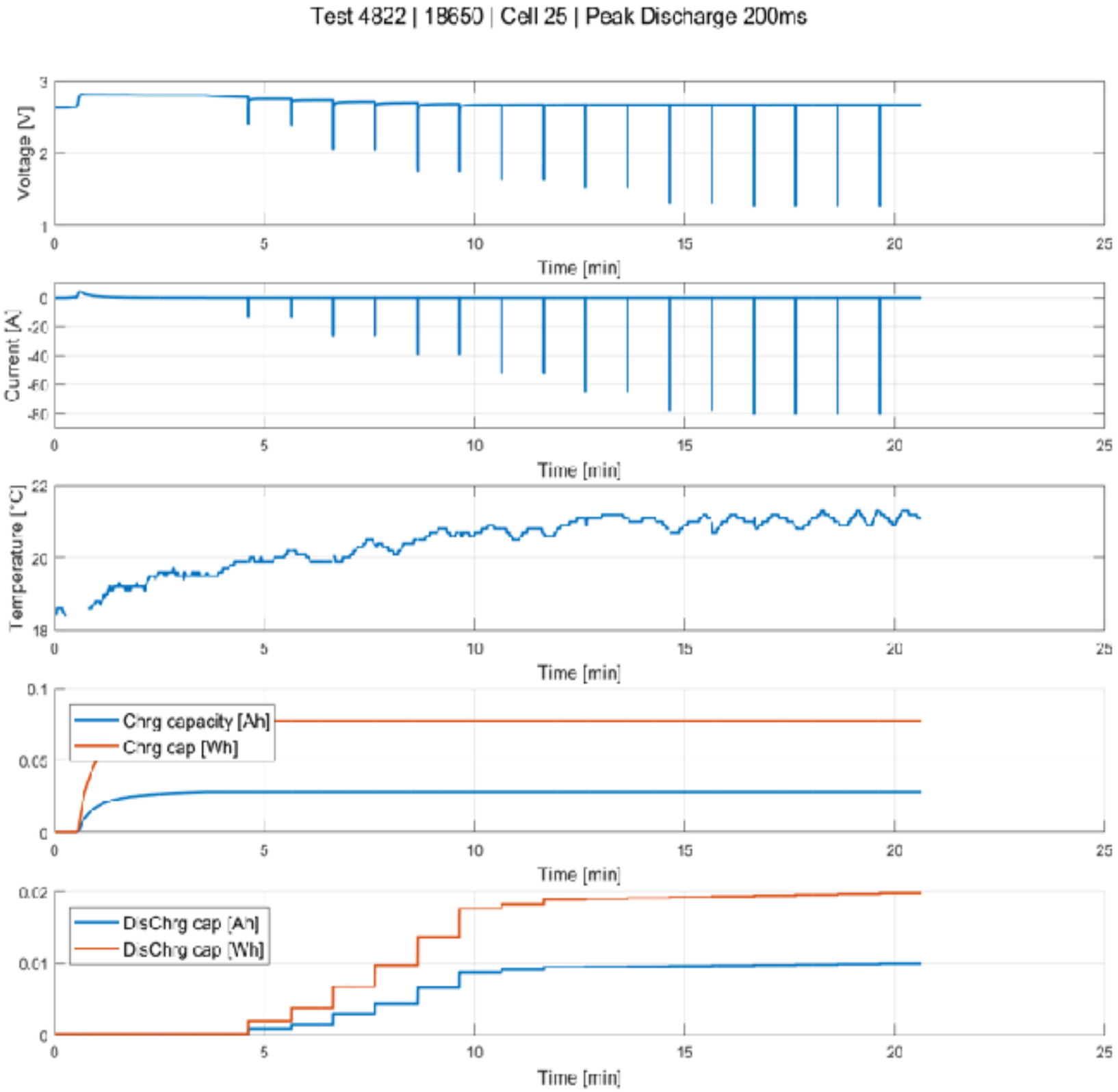
Charging at 3C in 25 minutes to 50%

2X Pulse (200 ms) discharging from 20C (20 A) upto 70C (70 A)

No measurable temperature increase

Discharge capacity not affected

Note: tester limit 80A



Charging at 3C in 5 minutes to 75%

2X Pulse (200 ms) discharging from 10C (13 A) upto 60C (78 A)

No measurable temperature increase

Discharge capacity not affected

Note: tester limit 80A

Why no BMS?

No Active balancing needed:

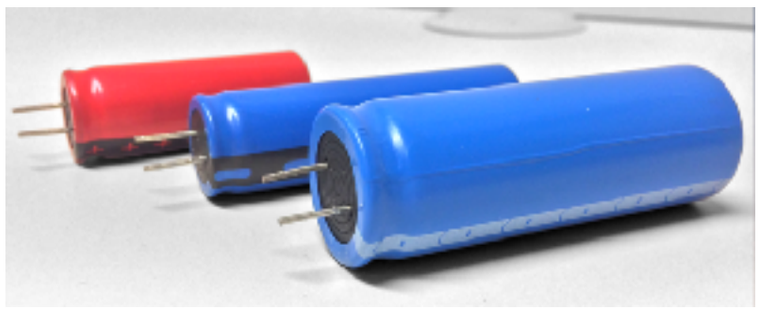
- **Cells are matched at assembly time**
- **Connected in “rectangular” S xP mesh**
- **Hence, no need for active balancing**
- **Benefits:**
  - **Much simpler, better use of space**
  - **Robustness: BMS has many parts that can fail and age**
- **Less “extra” weight**
- **If a cell fails:**
  - **(unlikely, only when penetrated or short circuit)**
  - **Fails as an open circuit**
  - **Battery remains operational**

Why no active thermal management system?

Powercapacitors remain cool

- **Low internal resistance**
- **Can tolerate low and high temperatures**
  - **(high temperatures will affect lifetime, as for any technology)**
  - **No risk of thermal runaway**
- **Good design practice:**
  - **Keep C-rate < 5C for 18500, < 10C for 18650**
  - **Occasional higher rates are not a problem**
  - **Keep things “cooled” => enclose in heat absorbing package**
- **Benefits:**
  - **Save a lot of complexity**
  - **Save a lot of weight**

Construction of a power capacitor pack



Safety standards

- EMC test report
- EN 62133-2
- MSDS
- ROHS
- REACH
- Full certification package available

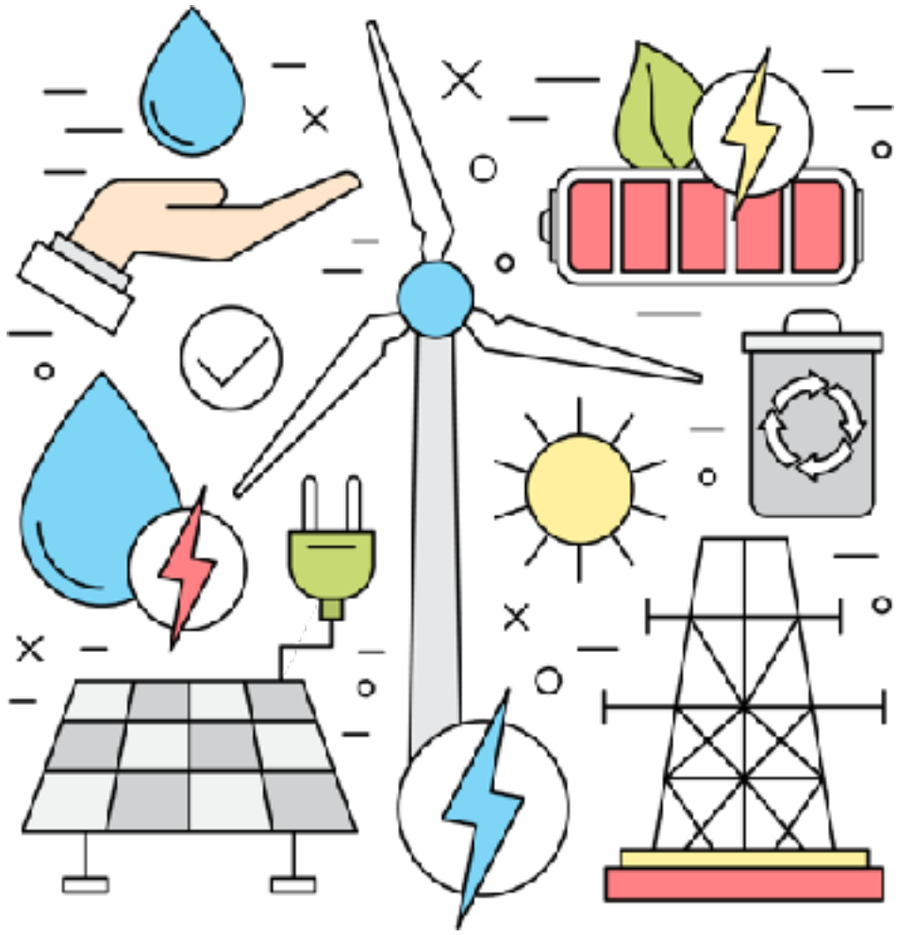
A catalyser in clean energy

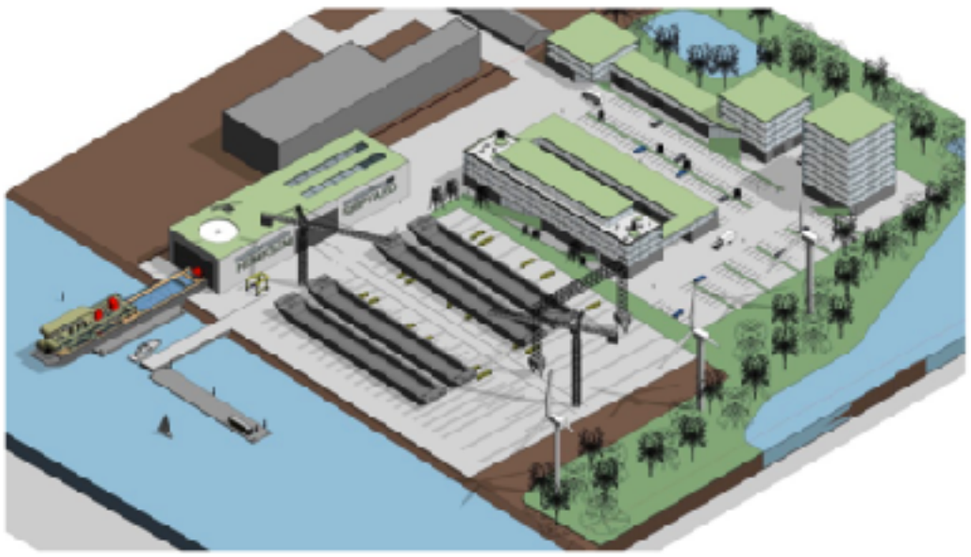
Applications of C-based supercaps

- Powerbanks (charging in 10 min): internal development
- Starter batteries (for ICE vehicles)
- Hybrid batteries
- Serial hybrid vehicle drives
- Vehicle batteries:
  - First customer (agricultural vehicles)
  - Heavy duty vehicles (e.g. mining)
- Fast charging vehicle batteries:
  - Potential project for airport cargo tractors
- Energy buffering storage: see Energy Site
- Frequency grid adjustment: see Energy Site
- Building energy system: initial prospects discussions

Roadmap: Total clean energy production and storage

Clean Energy Site: linking transport





- Clean energy = diversity + buffering + unstable grid
- MWh container batteries
- Higher efficiency through:
  - EMS (Energy Mgt Sys)
  - Rotating batteries
    - Buffer (when energy is cheap)
    - H2
    - Grid stabilisation
    - Swapping: for electrified inland shipping

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