

skeleton+

# Skeleton Technologies: Company Intro

Providing Mission-critical high-power Energy Storage Solutions

Certified



9001:2015



14001:2015



IATF 16949

# Part I:

Company Overview &  
Products



**SkelCap**  
supercapacitor

# Skeleton Technologies – Company Overview

Products proven in the field with blue-chip customers

## Key facts & figures

 **€95bn**

addressable market opportunity for short duration, high power energy storage<sup>1</sup> across different end markets

 **17 years**

years of R&D investments in proprietary material technology and products, protected through 74 active or pending patent families

 **360**

employees worldwide, with more than 120 staff members in engineering & development

 **€9bn**

Commercial agreements with blue chip clients, across applications.

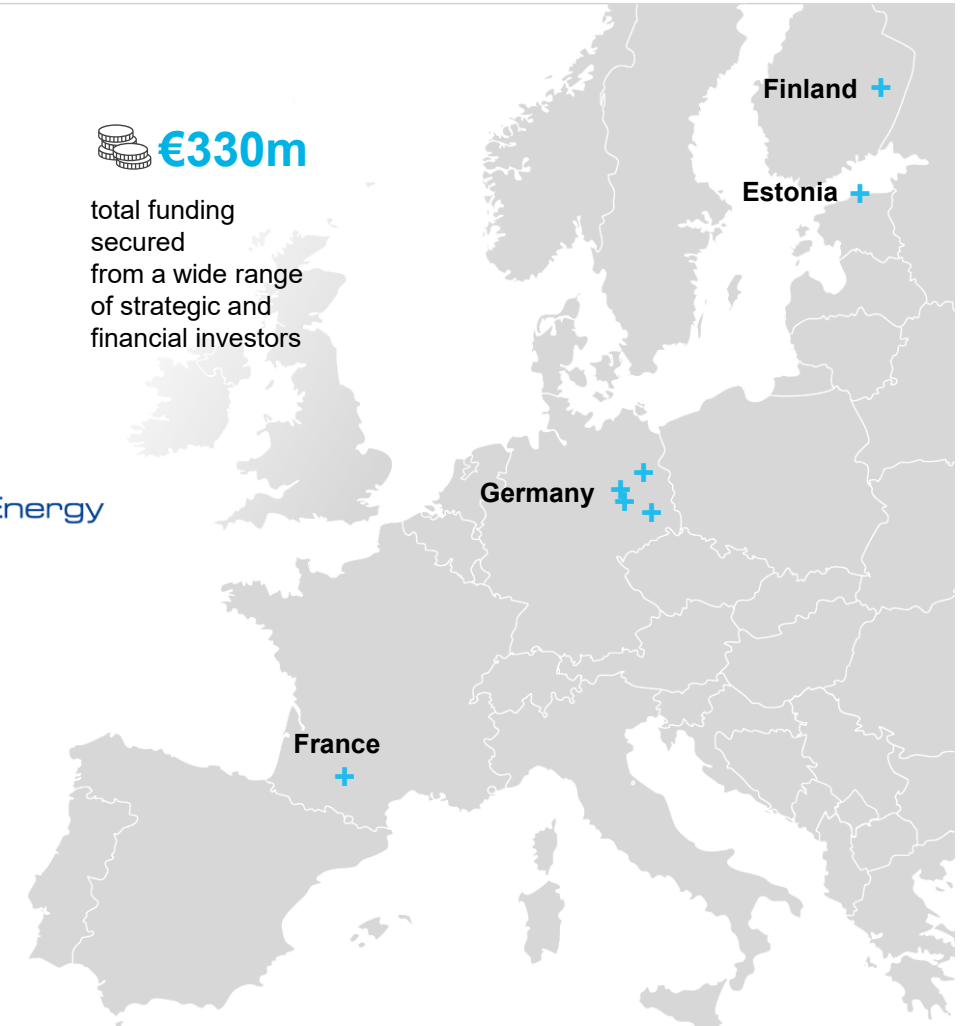
 **€330m**

total funding secured from a wide range of strategic and financial investors

## Selected existing investors



## Selected existing customers



# From Single Cells to Full Energy Storage Systems

The only full value-chain manufacturer on the market

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## Raw Material

Curved Graphene



## Single Cells

SuperCapacitors  
SuperBatteries



## Industrial Modules

From low to high voltage needs  
Supercapacitor modules with smart  
balancing and management systems



## Systems

MWs of immediate power  
Modular, supercapacitor-based  
energy storage systems

# Technological Advantage Through Superior Carbon Raw Material

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Backed by the largest R&D team in the industry



## Li-ion Batteries

use a chemical reaction to store energy



Slow



## Supercapacitors

use an electric field to store energy



Fast



## SuperBattery

Based on supercapacitor technology



Fast

- + Limited power density (0.5 kW/kg)
- + **High energy density** (250 Wh/kg)
- + Limited cycle life (<6000)
- + Slow charge rate (3 C)
- + Safety concerns
- + Utilizes critical raw materials (Li, Graphite, Co)

- + **High power density** (up to 60 kW/kg)
- + Limited energy density (up to 16 Wh/kg)
- + Extreme cycle life (>1 million)
- + Extremely fast charge rate (2000 C)
- + High inherent safety
- + No rare metals

- + High power density (4 kW/kg)
- + **Increased energy density** (65 Wh/kg)
- + Long cycle life (50,000)
- + Fast charge (<60s)
- + Extreme power (20 C continuous, 100C peak)
- + High inherent safety
- + High recyclability and sustainability
- + No Graphite, no Co, <5% Li

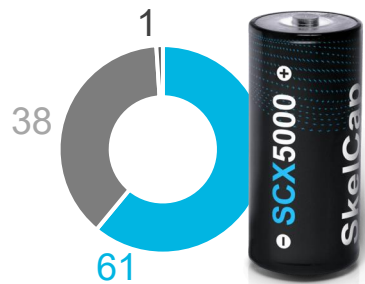
# Increased Safety & Sustainability Compared to Lithium-ion Batteries

Lower cost due to Curved Graphene and abundance of other raw materials



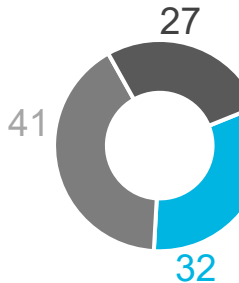
## Curved Graphene

- Proprietary carbon, produced without any rare earth materials
- Synthesis byproducts re-usable – zero waste created



## Supercapacitor

- Mostly carbon and aluminum, easy to recycle
- Contains no heavy metals



● Organic components   ● Aluminum   ● Other



## Little to no rare earth metals used

- ✓ The only metal content in supercapacitors is aluminum
- ✓ SuperBattery uses no graphite, nickel or cobalt, and very little lithium (<5% of weight)



## Easy and affordable to recycle

- ✓ Carbon and aluminum are easy to recycle
- ✓ Products use lower cost elements than in Li-ion



## Sustainable production and processing

- ✓ Skeleton uses water-based process for coating and recycling
- ✓ Products are safer to handle than li-ion batteries due to no lithiated graphite or lithium plating

# Filling the Gap with SuperBattery

High power from sub-second to up to 45 minutes duration

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**Supercapacitors**



<1s to 60s

**SuperBattery**



Fast charging

1-5 min

1-45 min

**Lithium-Ion batteries**



>45 min

# Part II:

## Technology



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use a chemical reaction to store energy



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# Batteries & Energy Storage Cost-down Requires New Materials

Curved graphene is a cost-effective active material made in Germany

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- + Skeleton has developed a proprietary material, **Curved Graphene**, which is a microporous carbon material with exceptional conductivity
- + Curved graphene improves high power properties of Super-Capacitors, SuperBatteries, Solid-State and Lithium-Ion Batteries
- + Skeleton is currently building a curved graphene mass production plant in the Bitterfeld-Wolfen chemical park, Germany
- + 4 out of 5 products are produced inside the chemical park, and curved graphene doesn't require any rare earth material
- + The inventors of curved graphene, who are co-founders of Skeleton, were awarded the European Inventor Award (2022) by the European Patent office

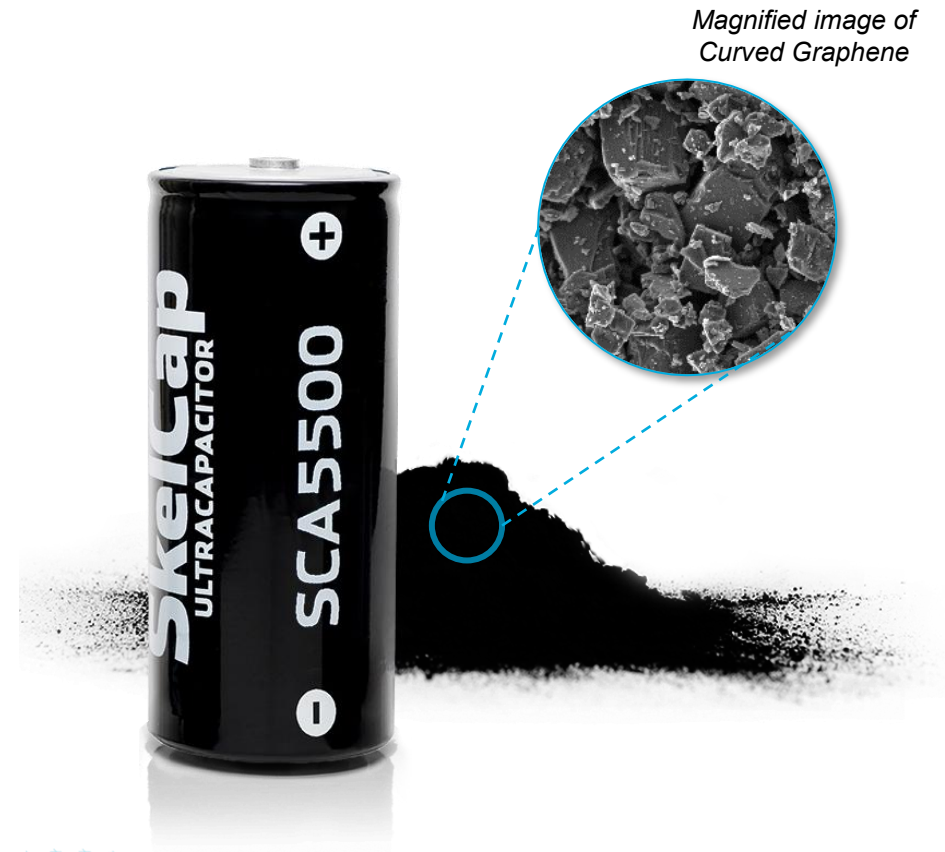


**Dr. Anti Perkson**

**Dr. Jaan Leis**

**Inventors of curved graphene,  
co-founders of Skeleton Technologies**

- + 20+ year experience in materials science and energy storage
- + Winners of the European Inventor Award in 2022



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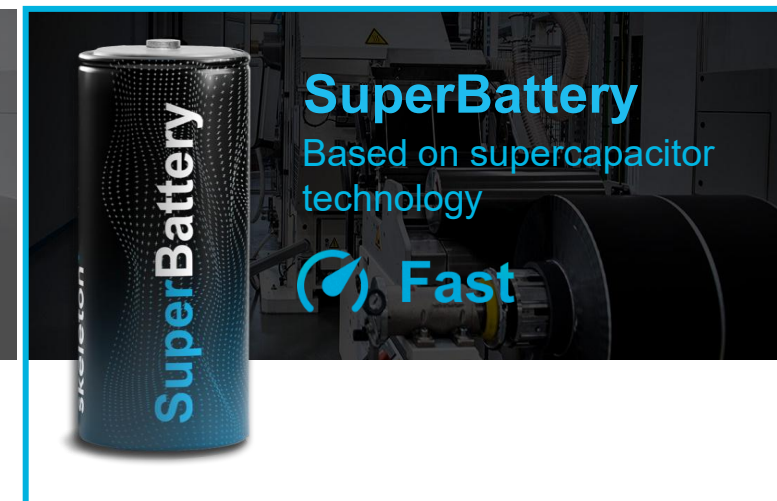
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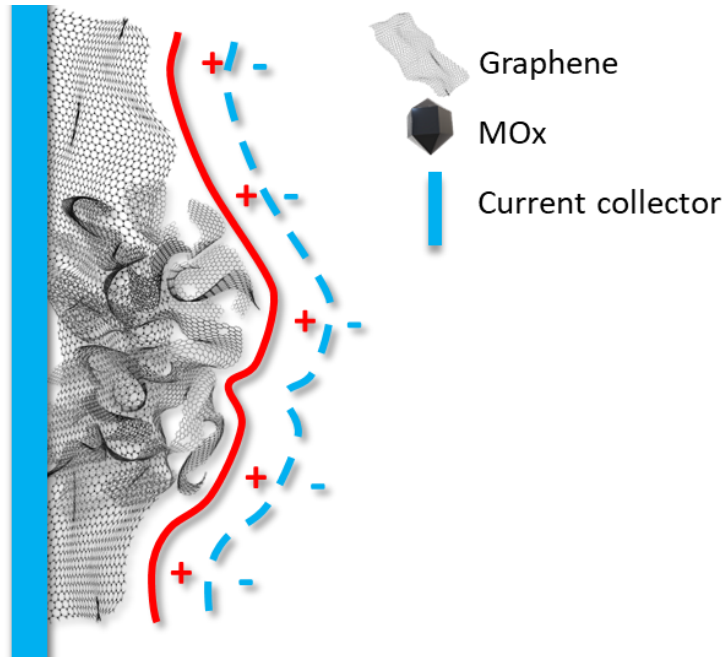
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# SuperBattery: A hybrid charge-storage device

Combining the best of two worlds

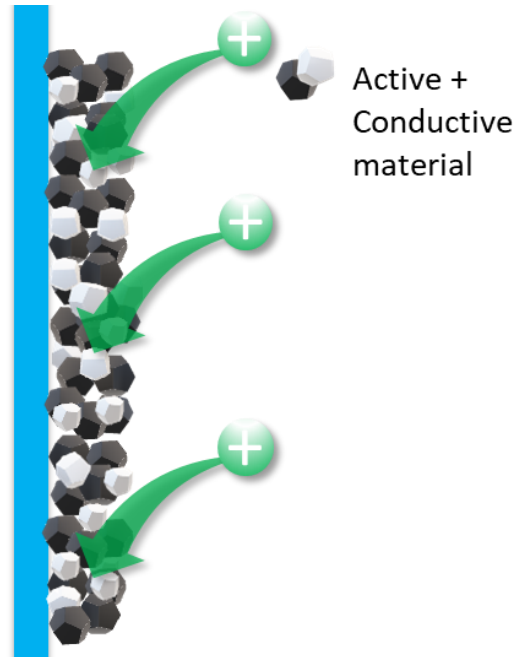
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## Classic EDLC



- ✓ Electrochemical double layer
- ✓ Capacitance-based energy storage
- ✓ Energy limited by available surface charge

## LIBs



- ✓ Intercalation + redox reactions
- ✓ Power limited by charge intercalation through bulk material

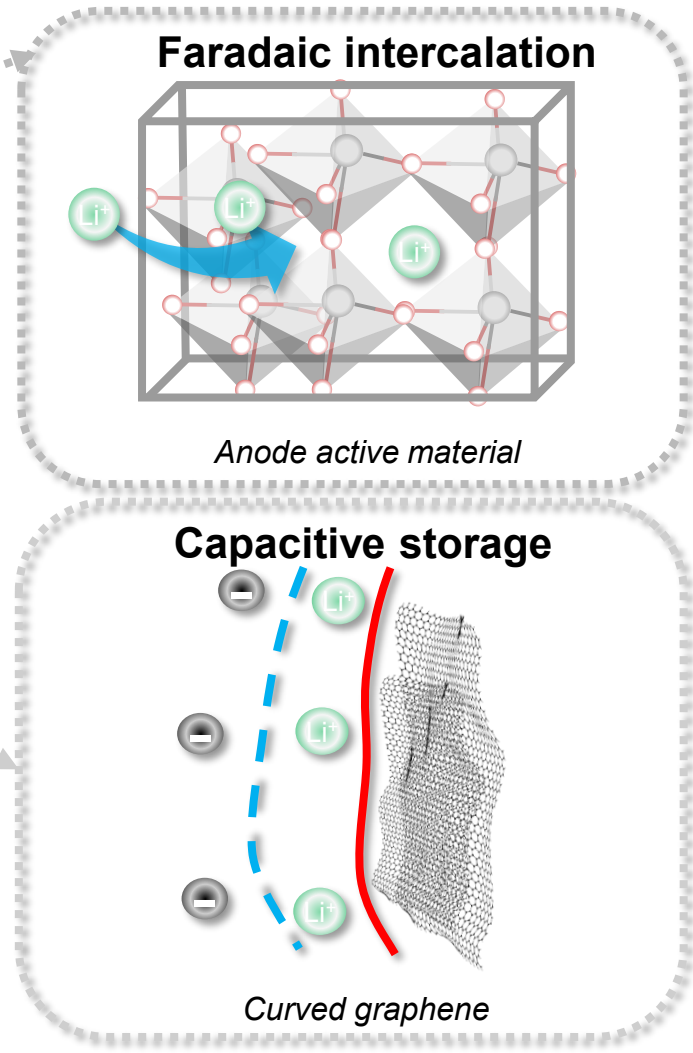
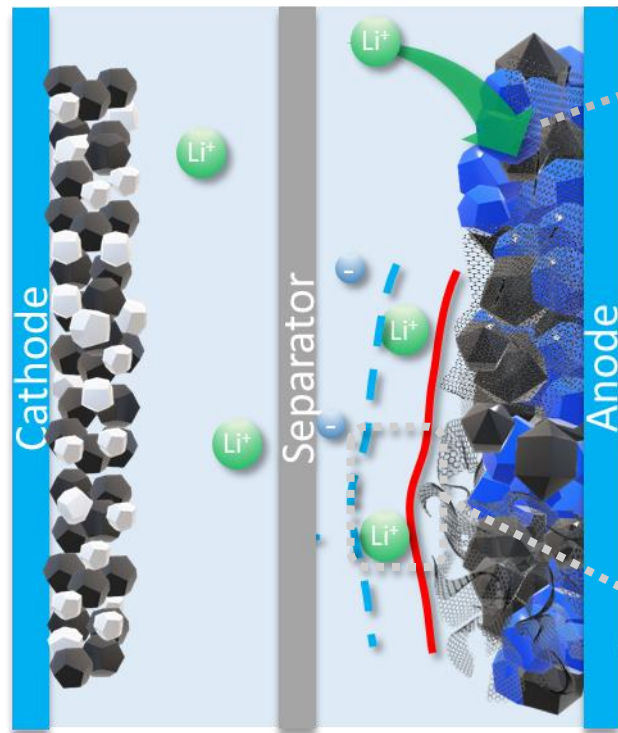
## SuperBattery





# SuperBattery: A hybrid charge-storage device

SuperBattery concept



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## Cathode

-  Cathode active material
-  Conductive material

## Anode

-  Anode active material
-  Curved graphene

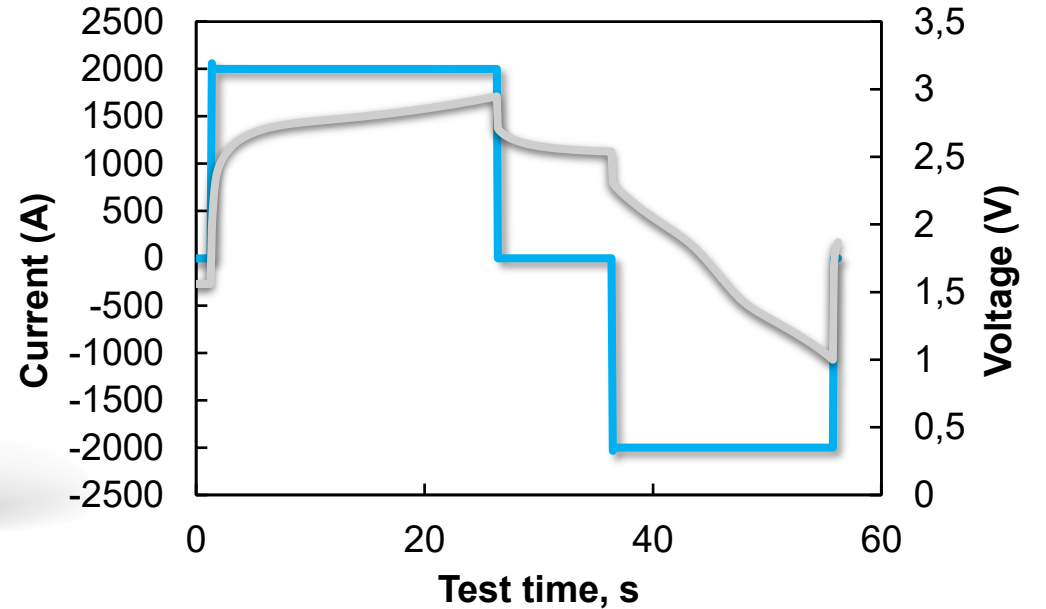
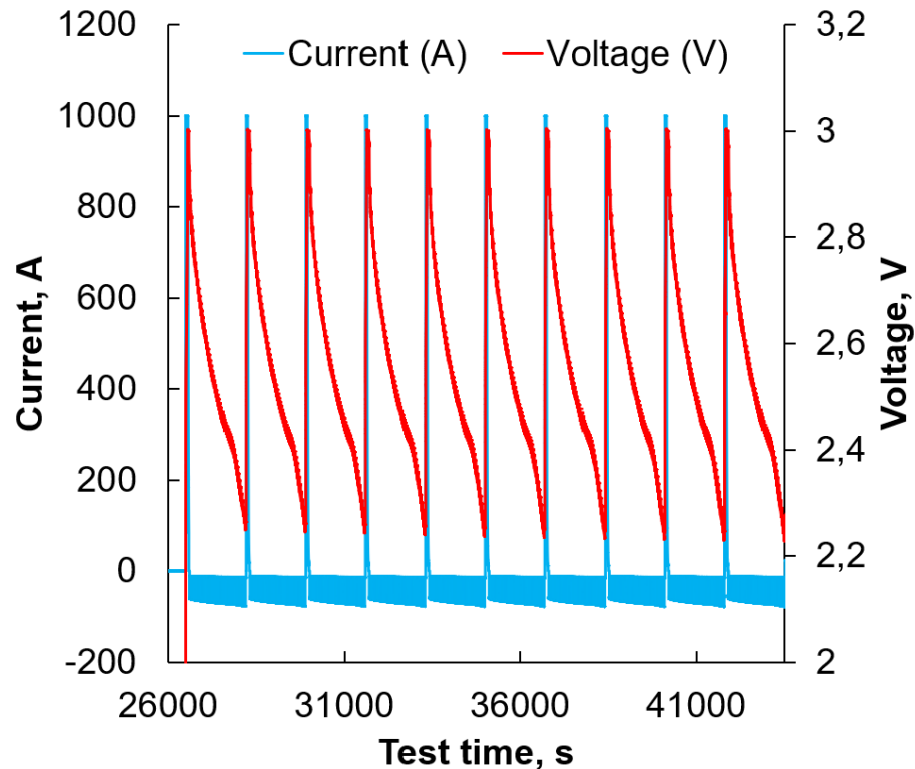
## SuperBattery



# SuperBattery: 2000 A peak with 23 Ah cell

Spotlight on high power and ESR performance

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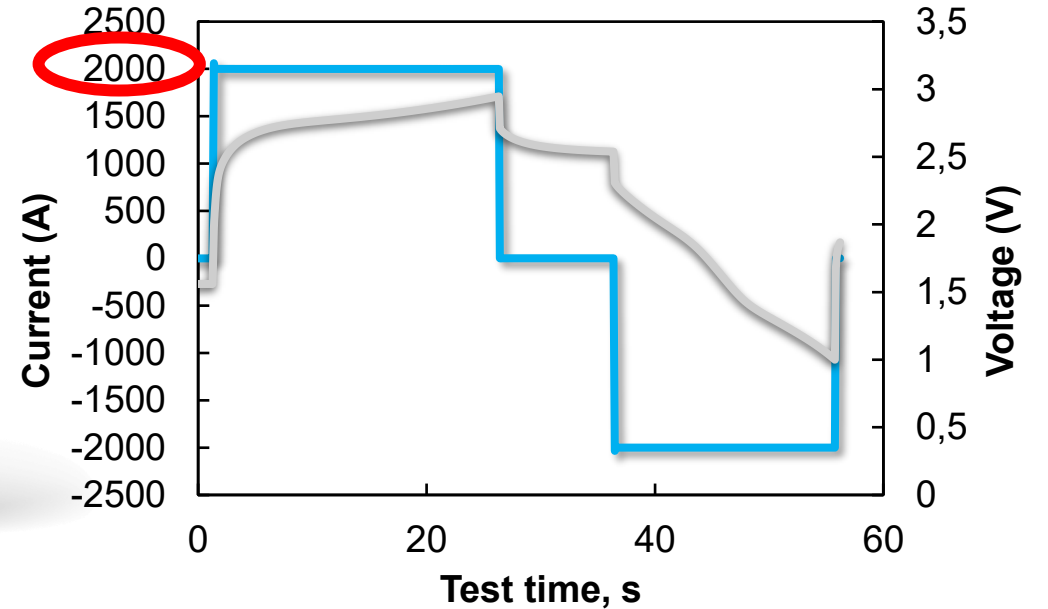
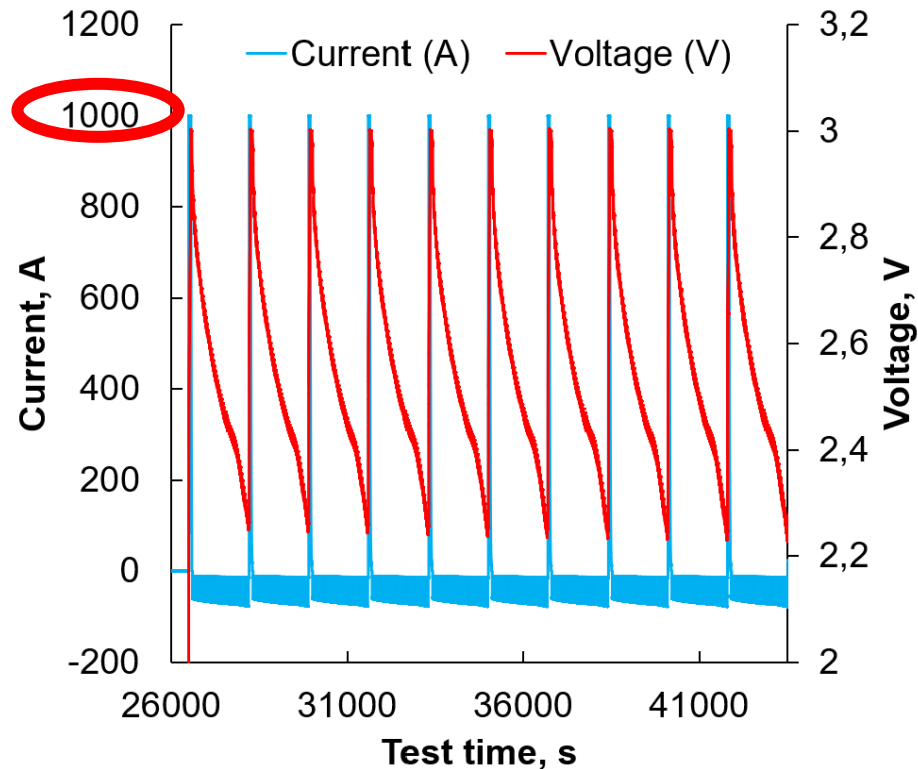
- + High C rates at ultra fast charging 10 cycles with 50 C charge rates

- + **2000 A** charge/and discharge pulse on **single cell level**
  - best in class behavior reduce significantly the effort for cooling and increase the lifetime
- + High power test reveals **> 4.8 kW/kg and 10 kW/L**

# SuperBattery: 2000 A peak with 23 Ah cell

Spotlight on high power and ESR performance

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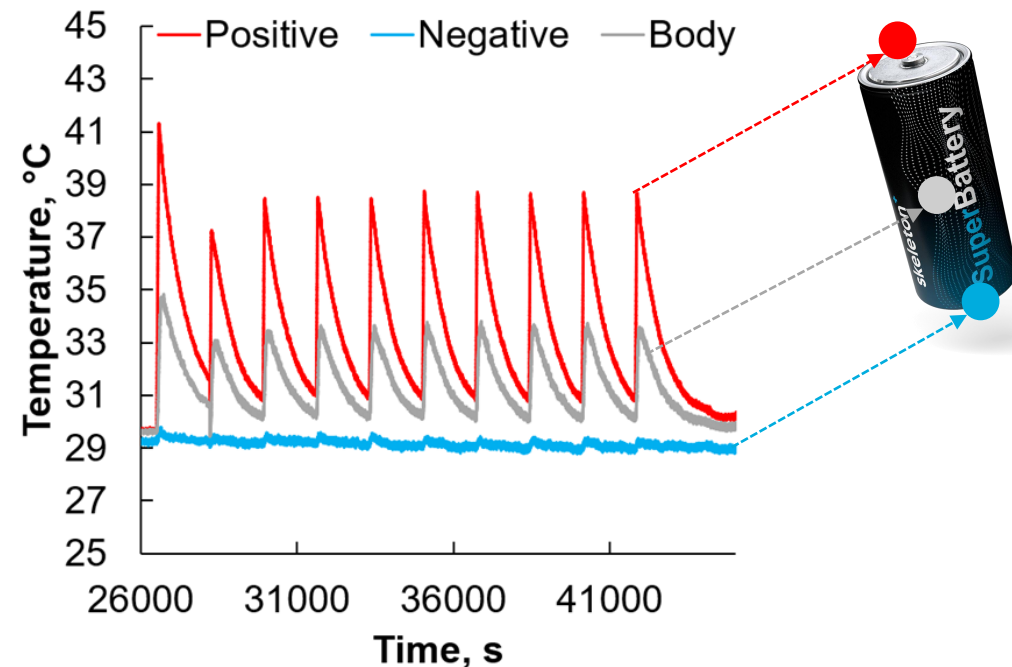
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# SuperBattery: A Sustainable Energy Storage Product

Spotlight on high power and ESR performance

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- + The Skeleton 162V SuperBattery module is among others used in grid, heavy duty and transport applications

- + Low temperature development during cycling with 1000 A.

# SuperBattery: Safest battery technology

Industrial D60 cells

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## Overheating

- + Fully charged (3.0V) D40L85 cell heated to 250 °C in oven
- + Safety valve opened at 135 °C with maximum cell terminal temperature 363 °C
- + No fire or explosion
- + **Key Achievements:**
  - + No thermal runaway – higher safety

## Nail penetration and crushing

- + Fully charged (3.0V) D40L85 cell penetrated with a rod or crushed by a cylinder
  - + **Nail penetration key achievements:**
    - + Nail completely penetrated, no safety risks
  - + **Crushing key achievements:**
    - + No safety risk during complete deformation of cell

## Cell overcharge

- + D40L85 cell charged to 6V (+200% Rated voltage)
- + **Key Achievements:**
  - + No fire or explosion at 6V

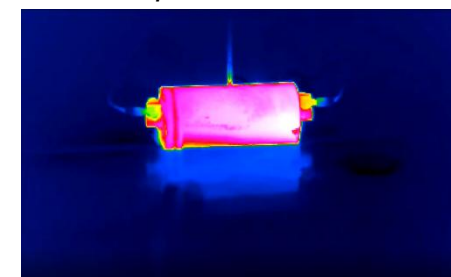
Cell before the test



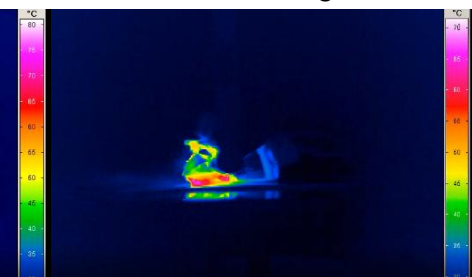
Safety valve after overheating



Nail penetration



Crushing



Cell vented during test



Cell cleaned after venting

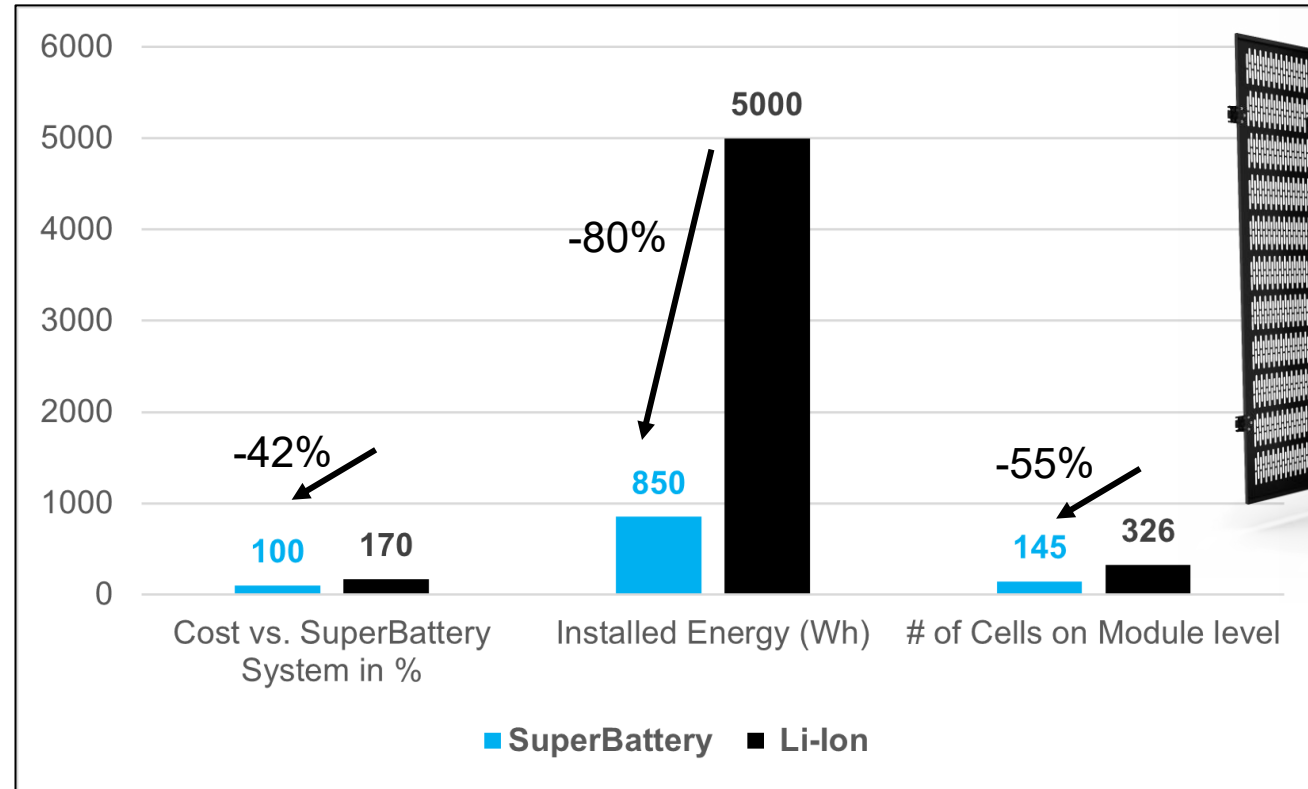


# SuperBattery as MWs Energy Storage

Enabling advanced Battery Backup Units

Discharge Power	10.00 kW
Discharge time	300 s
Energy Accessibility	98%
Energy of the pulse	833 Wh
Discharges per year	365

SuperBattery systems provide the lowest System-level footprint and longest cycle life.





## Part III: Applications

**We're in  
the MWs  
business**

# Multi-Niche Approach

Skeleton of every energy storage system

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- Data center peak shaving
- Data center backup power bridging
- Backup power



- Virtual inertia / Grid forming in STATCOMs
- Microgrid power back-up and quality
- Backup for medical equipment



- 48V active suspension
- KERS / Push-to-pass
- 12V board net stabilization & back-up solutions
- Fuel cell support



- Engine start
- Mild hybrid bus energy storage
- Fuel cell power support solutions for truck and bus transportation



# Millions Of Units In The Field With An Excellent Track Record

Unrivalled quality and reliability in mission-critical applications from aerospace and power grids to mobility

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## Mission-critical power you can bet your business on from rockets to national grids

Certified to international quality and safety standards



**100+ MWs** installed in grid and industrial sites worldwide



**10,000+** systems and modules operating today



Delivering products to customers **10+ years**



**SIEMENS**

 **Hitachi Energy**

 **ŠKODA**

 **Danfoss**

 **HONDA**

 **esa**

+ global truck and passenger car OEMs

+ global aerospace and defence primes

# A Qualified Supplier & System Provider to Industry Leaders

To grid, data centers, transportation, and industrial companies, OEMs & Tier 1s

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## Hyperscaler-validated GrapheneGPU turning hundred-megawatt spikes into steady power

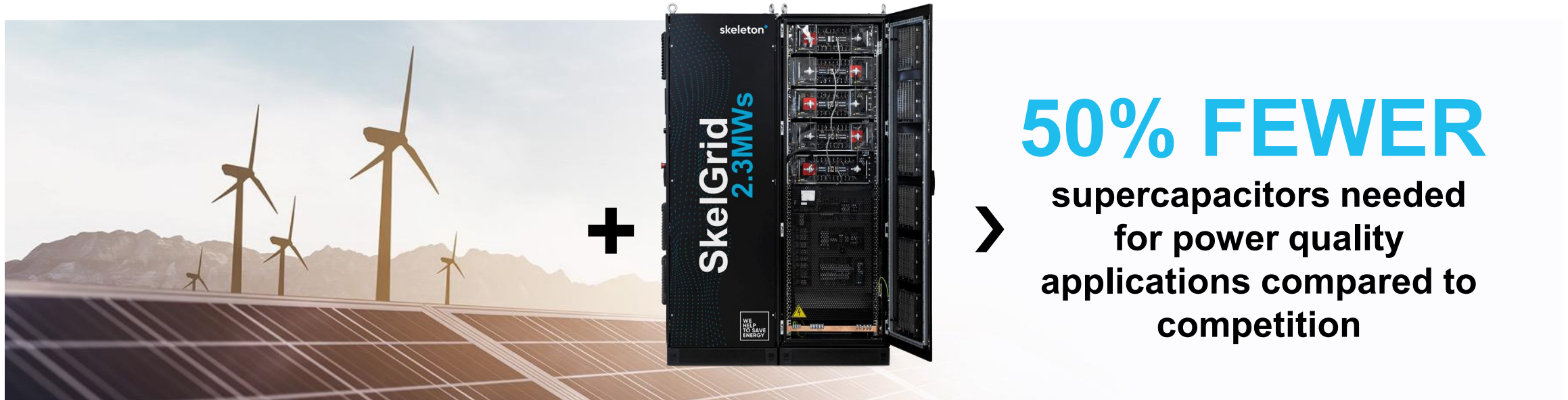
- + **Increase in computing capabilities (FLOPS) up to 40%** by allowing GPUs to operate at their full capacity by reducing thermal de-rating.
- + **Reduced grid connection size by up to 45%** due to GrapheneGPU handling power peaks.
- + **Energy use decreased by up to 40%** by eliminating dummy or artificial loads used to stabilize power demand.



# Enabling Higher Penetration of Renewable Energy & Stabilizing Power Grids

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MWs not, kWh business – 50 MW solution delivered



**50% FEWER**  
supercapacitors needed  
for power quality  
applications compared to  
competition



“Most competitive supercapacitor-based ESS for grid applications.”  
(Virtual Inertia)

# Supercapacitors Electrifying Trams Across Europe

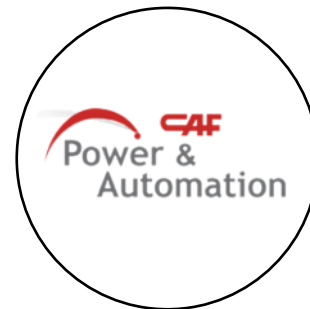
Kinetic energy recovery reduces costs and protects infrastructure

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“Skeleton Technologies brings the necessary quality mindset to critical applications. **The highest power density and efficiency in the industry provides us with a very clear competitive advantage.**”

Stanislaw Wizur  
Škoda Electric



“**Skeleton’s cells are a perfect fit to the rail and tram industry.** Adding them to our energy storage systems will greatly benefit our existing and future customers, **allowing to maximize energy efficiency at an unprecedented level.**”

CAF Power & Automation

# Supercapacitors & SuperBattery Kickstarting Fusion Reactors

Enabling technology to create clean energy

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**120 MW**  
For 3s, enabling plasma  
to be heated to  
**100 million degrees Celsius**



Supercapacitors are used to provide **20 MW of power for each gram of hydrogen to be heated in less than 1 second**. Skeleton is supplying a **global leader in fusion energy**.

TRANSPORTATION &  
HEAVY MACHINERY

## Eliminating downtime and increasing battery lifetime

Skeleton is supplying North  
American truck OEMs with  
supercapacitor-powered  
engine starting solutions and  
SuperBattery-powered e-  
catalyst heating solutions



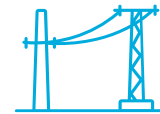
# Key Benefits

To working with us

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IATF-certified & the **largest supercapacitor factory** in Europe



**100+ MWs** of grid & industrial installations, **10 000+** systems & modules in the field



Unique technology & product roadmap with **Curved Graphene**, protected by 70 patent families



World-class team of **300+ professionals** with vast experience in energy storage development & production

**skeleton+**

# Thank you!

For more information  
contact us:  
[www.skeletontech.com](http://www.skeletontech.com)

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