

# Skeleton Technologies

## The Role of Next-Generation Supercapacitor Energy Storage in Zero-Emissions Urban Transportation

On 15 March, ACEA, the European Automobile Manufacturers' Association released the latest statistics for the European bus market, showing a big increase in registration numbers for electric buses, growing from 2,210 in 2020 to 3,282 in 2021.

For 2021, electric buses already represent 10.6% of all bus registrations within the EU. Add to that the 10.1% for hybrid-electric buses, and together the hybrids and full electric buses represent over a fifth of all new registrations in the EU.

Sure, Europe is still far behind for example the Chinese market, where the city of Shenzhen alone has a fleet of 16,000 electric buses, but the future is electric. In Europe, battery manufacturers are heavily scaling up production to meet the demand from both the passenger

car market and the transportation sector. Electric buses are the key to efficient, zero-emissions public transportation.

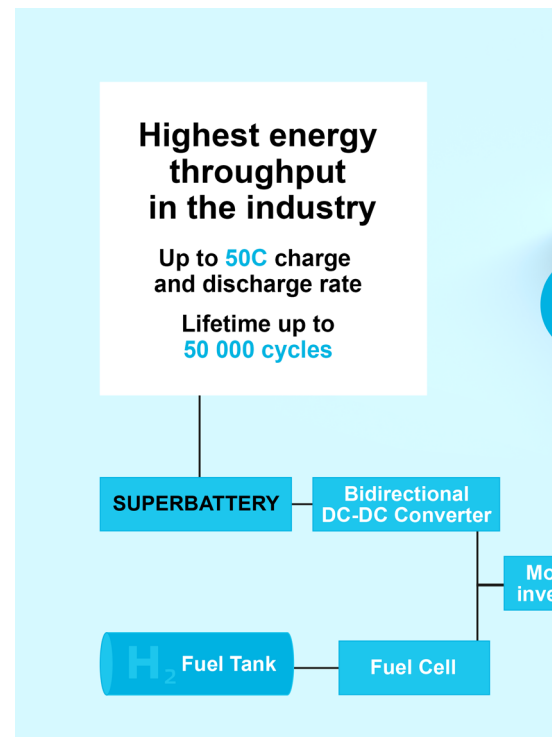
Fuel-cell electric buses represent a new and rapidly growing sub-category of zero emission buses. For example, one of the European market leaders, Solaris, has sold a promising 54 hydrogen buses in 2021 after first launching the model in 2019.

### Supercapacitor-Based Technologies Ready for Mass-Adoption

Skeleton Technologies, the global leader in supercapacitor energy storage technologies, is working with a number of customers on fuel-cell electric bus applications, where the current challenges include the comparatively slow response time of batteries and the oversizing of the battery pack – both are currently required to reach

the necessary power to support the fuel cells. Oversizing leads to increased costs, and unnecessary increase in weight and volume of the battery pack.

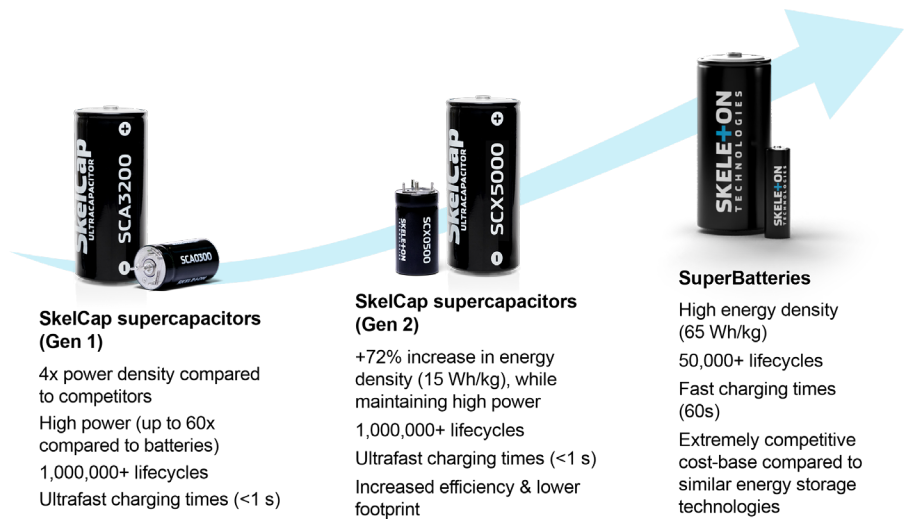
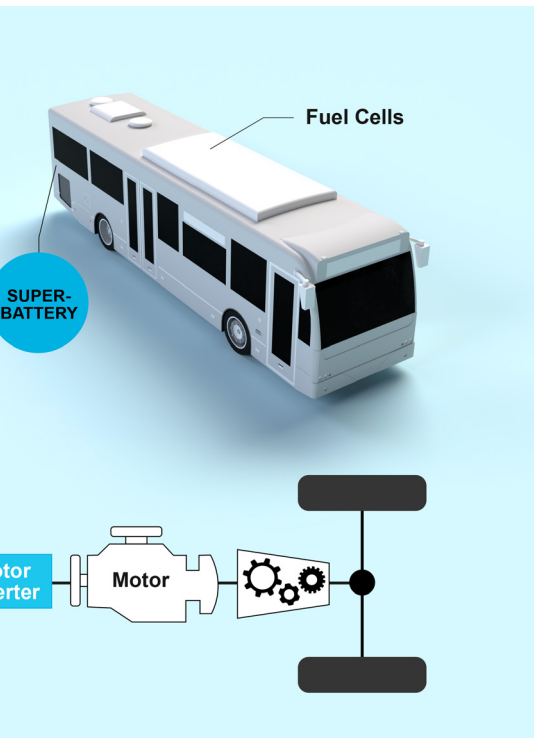
Skeleton's upcoming SuperBattery technology fills the gap in the market between traditional



supercapacitors (max. 30 sec application time) and lithium-ion batteries, eliminating the need to size the battery packs on power requirements.

SuperBatteries are the key enabling technology for fuel cell buses, by enabling quick response time and power boost, and decreasing the power demand from the fuel cells. They also offer a 10-fold increase in energy density compared to current state-of-the-art supercapacitors on the market, while maintaining long lifetimes and much higher power than lithium-ion batteries.

SuperBatteries can withstand a much higher number of charge-discharge cycles than lithium-ion batteries and therefore can serve throughout the lifetime of the bus without the need of a replacement. It is also an inherently safer technology than conventional lithium-ion batteries and is not subject to a risk of fire, which is even more important for a vehicle with a hydrogen tank.



**SkelCap supercapacitors (Gen 1)**

4x power density compared to competitors  
High power (up to 60x compared to batteries)  
1,000,000+ lifecycles  
Ultrafast charging times (<1 s)

**SkelCap supercapacitors (Gen 2)**

+72% increase in energy density (15 Wh/kg), while maintaining high power  
1,000,000+ lifecycles  
Ultrafast charging times (<1 s)  
Increased efficiency & lower footprint

**SuperBatteries**

High energy density (65 Wh/kg)  
50,000+ lifecycles  
Fast charging times (60s)  
Extremely competitive cost-base compared to similar energy storage technologies

Electrification & Power

A combination of fuel cells and SuperBatteries is the most cost-effective solution for fuel cell electric buses because of:

- Reduced size requirements compared to li-ion batteries partnered with fuel cells
- Lower initial cost due to eliminating the need for an oversized battery pack to match the power requirements
- Increased lifetime – SuperBatteries last for the entire lifetime of a vehicle
- Inherent safety – no risk of fires
- Enabling regenerative braking at maximum motor power

SuperBatteries are also a more sustainable technology compared to batteries, using no cobalt and only a fraction of the lithium used in lithium-ion batteries.

**On-Going Projects with Bus OEMs**

Skeleton Technologies is working with a number of bus OEMs on the implementation of supercapacitor-based energy storage solutions. One such project is underway with

Wrightbus, one of the leaders in the development of hydrogen fuel cell-powered buses for both long-range and urban transportation.

Skeleton’s Sales Director for the transportation sector, Tobias Ragnarsson, comments on the future of the bus industry: *“While China is a clear leader in e-bus adoption, the trend in Europe is also very clear: the adoption of battery electric and fuel cell buses is increasing fast and the market is realising the potential of supercapacitor energy storage. We’re in talks with a number of companies with ambitious plans for their electric bus technologies and fleets, so the future of zero-emissions transportation looks promising and at Skeleton, we’re delighted to be a part of the solution and the fight against climate change.”*

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**SKELE+ON**  
TECHNOLOGIES

# SuperBatteries - cost-effective energy storage for fuel cell electric buses

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**Highest energy throughput in the industry**

Lifetime up to **50 000 cycles** & charge/discharge rate up to **50C**



**WE  
HELP  
TO SAVE  
ENERGY**

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