Supercapacitors Markets


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- Subscriptions
- Consultancy
- Global Events
- Web Journals
- Webinars

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ELECTRIC VEHICLES & ENERGY STORAGE TECHNOLOGIES INSIGHT
Covering the current and future markets and technologies of electric vehicles & energy storage

NOVEMBER 20 - 21, 2019
SANTA CLARA CONVENTION CENTER, CA, USA

What to Expect

+ Forthcoming energy independent vehicles (EIVs)
+ Totally new energy storage and other components
+ Merging of systems and structural electronics
+ New manufacturing techniques
+ Promising materials for emerging battery technologies
+ Integration with other components - displays & energy harvesters

CO-LOCATED CONFERENCES WITH A SHARED EXHIBITION ON THE HOTTEST TOPICS.

### December 3-5, 2019 | Stuttgart, Germany

www.IDTechEx.com/Stuttgart

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<td>2. Smart Materials Roadmap: Massless Energy, Smart Glass &amp; Beyond</td>
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- Technology assessment
- Market forecasts
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- Key players
- Industry structure
- Value chain & opportunities
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The report details how breakthroughs are leading to the two primary limitations to wider adoption of supercapacitors - energy density and price - will be largely overcome. It finds that market trends to fastest charging, providing pulse power, safe transport, no expensive materials and no issues of disposal are increasingly favouring supercapacitors over batteries.
A capacitor is an electrostatic device: it relies on static charge. It works like a spring.

**When compressed, it can store then shoot out energy** –

**spring**: pop gun

**capacitor**: rail gun, research on taming the H bomb, pulse welding.

**Absorbs vibrations** –

**spring**: vehicle suspension

**capacitor**: smoothing spiky electricity so it becomes useful eg electricity from a device making electricity from vibrations.

**Delayed action/ phase change** –

**spring** in a clock

**capacitor** in an electronic circuit, electric motor starter, fluorescent light.

A battery stores more but fills and empties more slowly – rather like a bucket of water
Device active structures and gaps in the market

**Hybrid electrolytic capacitor-supercapacitor**

Gap in the market – aluminium electrolytic-EDLC hybrid for general purpose use in electronics

**Supercapacitor = EDLC usually optimised for its double layer capacitance but sometimes for its pseudocapacitance**

Gaps in the market: 120Hz, more affordable versions, acceptable pseudocapacitors, etc.

**Hybrid supercapacitor – battery**

Gap in the market: more affordable versions, less often the worst of both worlds

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![Diagram](image-url)

**Tantalum electrolytic-EDLC hybrid**

- Activated carbon EDL electrode
- Sintered porous tantalum with oxide grown on

**Electric Double Layer Capacitor**

- Electrolyte
- C1, C2
- \( \frac{1}{C_{EC}} \approx \frac{1}{C_1} + \frac{1}{C_2} \)

*(Activated Carbons as Electrodes)*

**Lithium ion battery - EDLC hybrid**

- Electrolyte
- C1, C2
- C_{EC} \approx C_1

*(Activated Carbons + Battery Type as Electrodes)*

**Boost pseudocapacitance or boost hybrid capacity**
Improvements promising major impact

The most important performance improvement in supercapacitors that will sharply increase market potential are energy density and lower cost.

There are several development routes to 100Wh/kg, where lithium-ion batteries were 10-15 years ago.
Even better batteries and supercapacitors a real prospect

The red edged box is where future advances are expected

- **EDLC**: Electric double layer capacitors/supercapacitors with double layer capacitance dominant
- **CSH**: Capacitor-supercapacitor hybrid
- **Pseudo**: EDLC with pseudocapacitance dominant
- **BSH**: Battery-supercapacitor hybrid eg LIC

**Supercapacitors and their derivatives 2019**

- Electrolytic capacitors are around 0.003 Wh/kg
- Li-ion and Li metal batteries 2030

**Power Density (W/kg)**

**Energy Density (Wh/kg)**

0.01 0.1 1 10 100 1000
Three main market segments

**Consumer**
- Burst Power
- Battery Life Extension
- Quick Charge

**Industrial**
- Burst Power
- Regenerative Power
- Back up Power

**Transportation**
- Burst power, backup and primary power
- Regenerative power
- Fuel cell & battery protection
The future of supercapacitors is in vehicles

Supercapacitor value market 2019-2030
Energy Independent Vehicle (EIEV) is propelled entirely by electricity created on-board from wind (when parked), sun, heat etc. It may or may not have energy storage. There are currently EIEV cars, planes, boats.

**Powertrain options**

- **Micro hybrid**: conventional that switches off the engine whenever it stops. Some regenerative braking. Not an electric vehicle.

- **Mild hybrid**: electric torque assist permits smaller engine, regen braking. 50-75% cheaper than full hybrid. 20-30kW versions will be possible. Only an electric vehicle in later forms driving wheels electrically some of the time.

- **Full hybrid**: has propulsion by electric motor part of the time. Full regenerative braking. Some plug in for extra electricity/electric range.

- **Pure electric vehicle**: has no fuelled engine and always propels itself by electric motor.

- **Electric Vehicle**: 50 – 90 kW

**Electrification**

- **Typical range of electric power**
- **CO₂ reduction in European Drivecycle**

- **Supercapacitors**
  - Used by Anhui, CRRC, Higer, Sinaute.
  - Used by Lamborghini, PSA, GM, Mercedes
  - Used by Geely (peak shaving) and Ford soon

- **Levels of Powertrain Electrification**

- **IDTechEx Research**

- **Over 4.5 million cars with start-stop systems are powered by Maxwell’s supercapacitors.**

- **The new 48V mild hybrid cars and trucks cycle the battery violently and client loads need surges of power. First orders for supercapacitor protection came in 2018 for peak shaving using 30-100Wh, replacing a complete 0.5-1.5 kWh 48V lithium-ion battery being, as yet, uneconomic.** See IDTechEx report, “48V Mild Hybrid Vehicles 2019-2029”. 

- **Downloaded by Rachel Eggington - rachel.eggington@zapgo.com 04 Jun 2019 12:36:50**
Supercapacitors in the Automotive Sector

Vehicle Electrification driving Ultracapacitor Adoption in Automotive

- **Reducing emissions** of internal combustion engine requires **fast response** energy capture & delivery
- Variety of solutions – **engine downsizing, braking regeneration & power assist** - are essential
- **Next gen automotive architectures** to accelerate adoption & increase system content
Supercapacitors are used in the automotive sector for powertrains but also for other purposes such as guaranteeing that bus doors can be opened after an accident and a back up braking system will operate.

<table>
<thead>
<tr>
<th>Supercapacitors in the automotive sector: examples</th>
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<tbody>
<tr>
<td>Continental Automotive Systems' Maxwell-powered voltage stabilization system (VSS) was a standard feature on 2016 Cadillac ATS and CTS sedans and ATS coupes. GM uses supercapacitors on many microhybrids for better regen and fit-and-forget.</td>
</tr>
<tr>
<td>Peugeot 308 and other diesel platforms use supercapacitors in stop start systems for better regen and fit-and-forget.</td>
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<tr>
<td>BOSCH Supercaps have become the cheapest high power energy storage technology for power discharges below 13 seconds and below 25°C, that means all sports cars and cold weather countries.</td>
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<td>Toyota’s TS040 winner racing car integrates supercapacitor technology.</td>
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<td>BMW-Toyota sports car partnership may integrate the technology in the future.</td>
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<tr>
<td>Honda developed a supercapacitor system to buffer high power in their FCX fuel cell car platform and they used one in an early mild hybrid.</td>
</tr>
<tr>
<td>Mazda uses supercapacitors in their i-Eloop energy recovery system.</td>
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<tr>
<td>Automobili Lamborghini S.p.A., incorporated use supercaps in a stop-start idle-elimination system in all Lamborghini's Aventador cars or better regen and fit-and-forget. It has specified supercapacitor bodywork for its Terzo Millennio concept supercar right for 10 minute charging and greater acceleration, saving weight..</td>
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<tr>
<td>April 2019, Geely signed a collaboration with Tesla subsidiary Maxwell to source peak shaving supercapacitors for its Volvo and other 48V mild hybrid and full hybrid vehicles.</td>
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Supercapacitor manufacturers

There are about 100 serious manufacturers of supercapacitors. The 12 leaders were responsible for about $320 million sales in 2018 and the rest about $90 million, giving a market of around $410 million, down from about $600 million in 2015. The drop was due to the Chinese Government effectively banning the main user – HEV buses, something it has now reversed. With a roadmap of many new applications becoming cost effective over the coming years, we anticipate renewed market growth of 3% yearly, an important driver of this being the Chinese (SPS) credibly promising 30% price and cost cut over the coming three years. If certain potentially very large applications kick in then this growth will easily double. Future number one may be CRRC.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Country</th>
<th>2018 $M</th>
<th>Small versions</th>
<th>Large versions &gt;1000F</th>
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<tbody>
<tr>
<td>1 TESLA bought Maxwell inc Nesscap</td>
<td>USA, Korea</td>
<td>90</td>
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<td>2 Nippon Chemicon</td>
<td>Japan</td>
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<tr>
<td>2 LSMtron</td>
<td>Korea</td>
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<td>SPS</td>
<td>China</td>
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<td>Ioxus</td>
<td>USA</td>
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<tr>
<td>Murata</td>
<td>Japan</td>
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<td>LIC &amp; SC</td>
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<td>CapXX</td>
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<td>LIC</td>
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<td>Panasonic</td>
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<td>Taiyo Yuden</td>
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Energy recovery and peak shaving – Mild Hybrid

Efficient energy accumulation thanks to quick charging in seconds
Electric vehicles and hybrid cars, which will become mainstream in the 21st century, are designed to use energy efficiently, and reuse the energy generated and accumulated during automobile deceleration. The time period for this energy generation is very short, meaning that batteries can recover only 30% of the energy, yet supercapacitors can recover approximately 80% of this energy.

Peak shaving
Batteries cannot cope with many extra loads at once – active suspension, superchargers, servos ……..


![Automobile Energy Recovery at Deceleration](image)

Energy generation recovery at braking
Decelerating Charging
Super capacitor
Battery
Motor / Electricity generation unit
Engine
Supercapacitor buses

Chinese supercapacitor pure-electric vehicles are spreading worldwide in small numbers – about 1000 supercapacitor buses, one supercap. ferry boat, some drayage trucks in eight countries. In 2016, the bus below claimed the world record for charging speed. The limitation to further deployment is price and the need to recharge every 8 km or so. IDTechEx continues to visit researchers and we believe that the necessary 60-100 Wh/kg will be achieved with so supercapacitor buses will only need to recharge at depot on 30 km routes.

See IDTechEx report, “Electric Buses 2019-2029”
Longer term: structural supercapacitors ZapGo, Lamborghini Terzo Millennio and others

Technology Demonstrator – Boot lid Design

13kg
5.2kg

and it stores energy!!
Performance enhancement and multi-purposing


In the E-Home camper van shown above, battery performance is improved by supercapacitors for faster recharge and delivery of the electrical energy.
Progress in new applications

In conferences and interviews across the world, IDTechEx is seeing a strong pattern of supercapacitors and their derivatives being adopted in more and more industrial electric vehicles, Airborne Wind Energy AWE and small wind turbines.

For example Huddig, Volvo, Komatsu and others making wheel loaders, carriers and excavators sometimes have regeneration when tools drop or rotate so a surge of electricity is captured. Some must create surges of energy to provide a powerful task such as vectored traction when loaded and again supercapacitors are seen as a good solution.

Kahlsruhe Institute of Technology optimises supercapacitors and hybrid supercapacitors with small wind turbines: extra energy storage. See IDTechEx reports on distributed energy, off grid etc.

KiteNRG of Italy is developing its AWE to 500kW and they told us supercapacitors are needed in an island configuration to accept the surges of power created. See IDTechEx report, “Airborne Wind Energy 2018-2028”.

Seabased of Sweden has orders for up to $200 million each for farms of wave harvesters up to 100 MW. It says waves of the necessary one meter height are almost continuous in much of the world. Orbital (1.5MW) and others with open sea tidal power say the tide in many places turns in only 5-10 minutes.
Fast charge then structural – ZapGo

Gen 3: Can be used in combination with Li-Ion

Carbon-Ion cells fit under seats

POD London Heathrow Terminal 5: Autonomous vehicle Carbon-Ion cells work alongside lithium-ion. Carbon-Ion cells charge in 35 seconds.
Bombardier light rail and others use supercapacitor energy harvesting recovering up to 35% of electricity on braking of trains and trams. This used to be done with lithium-ion batteries.

Tolerates faster charging. Fit and forget. Space/cost not a problem.
Rail: two ways of applying supercapacitors

On board

Bombardier's “EnerGstor”

Wayside
Energy Storage Reports
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