

Aowei's Ultra-Capacitors (UC)

The Most Advanced Energy Storage System
in the World

Now You Can Upgrade Your Electric
Transportation System



Aowei UC technology

- Aowei's technology has accumulated more than 9 years and more than 10 million km of experience;
- light weight, small volume energy storage packages, enabling longer range of up to 20 km on a single 5 minutes charge;
- average energy recuperation rate of the ultracapacitor is 32.2%, reaching up to 40%;
- low cost-over-life of the ultracapacitor system, less maintenance and more reliability;
- ultracapacitor is mounted in a safety container preventing any risks in case of bus crash or accident;
- used in trolley buses and electric buses since 2006 without any failures;
- about 18x more efficient than UCs used in electric/ hybrid buses nowadays.



Contents

- UC based Electric Buses
- The Belicon (the Landshut University) report.
- UC for Hybrid Trolley buses
- UC for Trams

Ultra Capacitors Based Electric Bus

Chariot e-bus: the autonomous trolley bus



Why autonomous?

- does not need overhead wires;
- does not require a permanently connected pantograph to the overhead wires;
- has the autonomy required of a regular combustion city bus, so long as it stays within range from the charging station.

Trolleybus-like features:

- charged with electricity from the trolley power grid;
- identical body and drive-train structure;
- roof mounted pantograph;
- requires a street charging station.



The UC-powered Chariot E-bus

Chariot E-bus



Charging poles & pantograph



Charging station



Ultracapacitor pack



Key features

- capable of travelling about 20 km on a single charge performed for 5 - 6 minutes at the terminal;
- charging at the terminal(s) only and not on bus stops;
- economical means of transportation with proved consumption of less than 1 kWh/km on average;
- low maintenance cost due to absence of expensive-to-maintain systems typical for combustion engine vehicles;
- does not require overhead power line, thus avoiding heavy infrastructure building and maintenance costs;
- no energy storage replacement-related costs;
- not influenced by outside temperature and capable of operating with ease in various weather conditions;
- passengers capacity of a regular trolleybus.



Charging system

- one or two charging stations at terminal(s) could service all vehicles in the line;
- fully automated charging system eliminates the need of human operation;
- When not charging there is no electric power in the charging poles;
- charging stations with direct current DC (600V - 700V) power supply; alternating current AC (3X240V) charging system available;
- charging station currently used for Sofia pilot project: 150 kW; in 660V DC/ out 585V DC; 250 A;
- charge time fits within driver's break at the terminal, enabling „24/7“ operation.



Pantograph



Advantages of UCs over batteries



- Cost of UC electric bus lower than of a batteries electric bus;
- lower infrastructure investment (only one charging unit for each city line);
- Actually no range limit per 24 hours;
- Due to the low curb weigh of the UC e-bus, equal passengers capacity to a diesel bus;
- No fire risk in cases of impact, quick discharge, etc.;
- Temperatures down to as low as - 25 °C do not affect the performance of the UC;
- No need to spend energy on warming the UC pack;
- UC pack's guaranteed lifespan is 8 years with no km limit;
- UC does not contain any toxic substances: no safety or environment hazards, no costs related to final disposal;
- UC has significantly higher recuperation rate, as compared to batteries.

Sofia Chariot e-bus pilot project: since May 2014



- trolleybus line № 11;
- line length of 11.2 km, crossing downtown;
- passengers enjoy low floor, kneeling, wheel-chair ramp, Wi-Fi;
- remote monitoring, diagnostic and video surveillance system.



The Belicon Report

(Landshut University, Germany)



Main findings:

- Average energy consumption of a loaded 12 meters Chariot e-bus - 0.95 kWh/Km;
- Average recuperation rate – 32%; Max. recuperation rate – 40%;
- The average cycle speed is 16km/h (not including standing times between cycles) and is thus in the range of SORT-2-Level.

The full report is available. Please ask us.

Independent validation of Chariot e-bus performance



HOCHSCHULE LANDSHUT
HOCHSCHULE FÜR ANGEWANDTE WISSENSCHAFTEN

BELICON laboratory
University of Landshut, Germany

Validation by an independent laboratory

BELICON laboratory at the University of Landshut is amongst the most prestigious European institutions for testing of buses and heavy trucks. It performs and presents independent studies of the performance of diesel, CNG, hybrid, and electric buses.

Main investigation data

In October 2014 BELICON has conducted a technical study for Chariot e-bus. The investigation shows average consumption of Chariot e-bus of 0.95 kWh/km, under regular urban environment serving passengers. The total energy consumption including losses from charging station is 1.1 kWh/km.

General conclusions

- Reported average daily consumption of Chariot e-bus is 0.95 kWh/km. This is an excellent result for consumption in urban environment at average speed of 16.3 km/h.
- A regular battery electric bus consumes about 35% more electricity compared to Chariot e-bus .
- The excellent average consumption of Chariot e-bus is a result of the high energy density of the UC and the unsurpassed energy recuperation reaching 39% with average of 32.2%.

Electricity consumption: independent report

Datum	08.10.14						
Zustand	Fahrt 1	Fahrt 2	Fahrt 3	Fahrt 4	Fahrt 5	6-8	Tagesbilanz
Messpunkt	Messpunkt 2: Ultra-Caps						
P _{max} Entladen / kW	-140,6	-150,5	-149,7	-150,6	-147,7	...	-147,6
P _{max} Laden / kW	103,6	109,5	110,0	108,0	111,8	...	107,0
E _{Ultra-Cap} Abgabe / kWh	-15,51	-18,17	-15,58	-18,05	-13,54	...	-125,34
E _{Ultra-Cap} Aufnahme / kWh	5,75	6,40	5,98	6,17	5,09	...	40,8
Δ Energie _{Ultra-Cap} / kWh	-9,76	-11,77	-9,60	-11,88	-8,45	...	-84,6
E _{Pantograph} Laden / kWh	13,42	13,30	11,53	13,12	9,13	...	99,5
Zeit / min	41,0	45,0	38,0	47,7	36,3	...	5h 26min
Wegstrecke / km	10,8	11,8	10,8	11,8	10,9	...	88,7
Rekuperation / %	37,1	35,2	38,4	34,2	37,6	...	32,2
Verbrauch / kWh/km	0,91	1,00	0,89	1,01	0,78	...	0,95
Verbrauch / kWh/min	0,24	0,26	0,25	0,25	0,23	...	0,26

Aowei's Ultra Capacitors for Hybrid Trolley Buses



Aowei's ultra-capacitor is the most advanced and suitable energy storage application for a hybrid trolleybus.

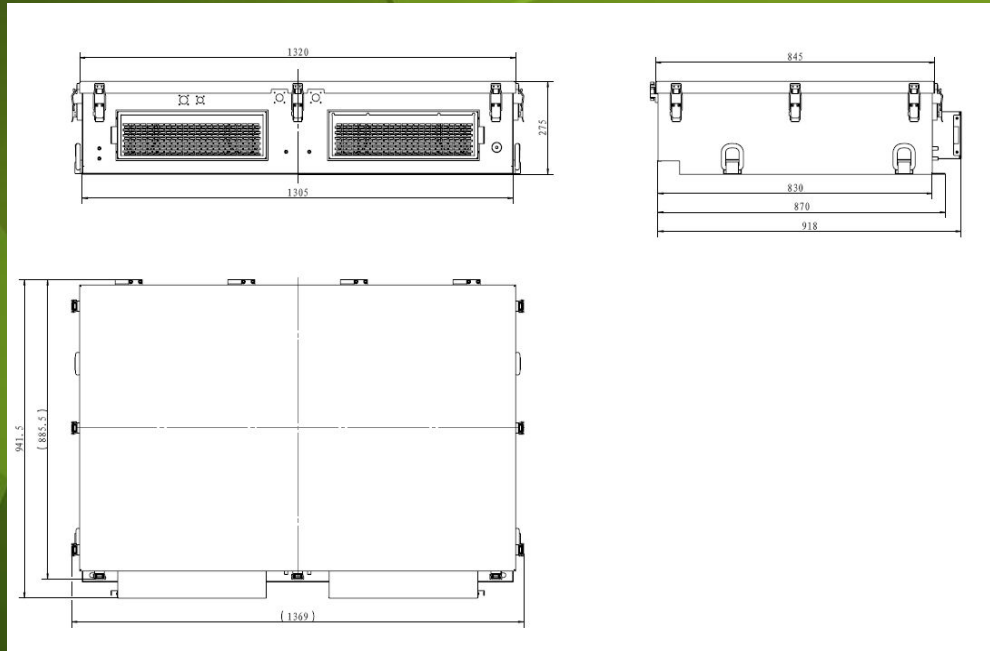
Aowei is the pioneer that has implemented UC system at trolleybuses already 11 years ago!!

Benefits of using Aowei's ultra-capacitor in hybrid trolleybus



- No maintenance needed;
- Highest recuperation rates – up to 40%!!;
- Lower cost of the UC pack;
- 5 kWh UC pack enable wireless run of:
 - 5 Km for a 12 meters trolley bus;
 - 3 Km for 18 meters articulated trolley-bus.
- The UC performance is not influenced by outside temperature. Operates at -25°C - $+65^{\circ}\text{C}$ with full efficiency;
- 8 years warranty.

Characteristics of Aowei's ultra-capacitor for hybrid trolleybus



5.2 kWh UC pack dimensions:

- 915×1320×275, mm (L×W×H)
- Volume: 0,33 m³
- Weight: 180 kg

- Very compact design;
- Working voltage: 448 - 650 V;
- Max charge /discharge current 150 A (20 s);
- Standard charge /discharge current < 90 A;
- Working t°: -25 °C ~ 65 °C;
- Charging time of 3 minutes via catenary & regenerative energy;
- Scalable system;

Awei's ultra-capacitor vs other technologies



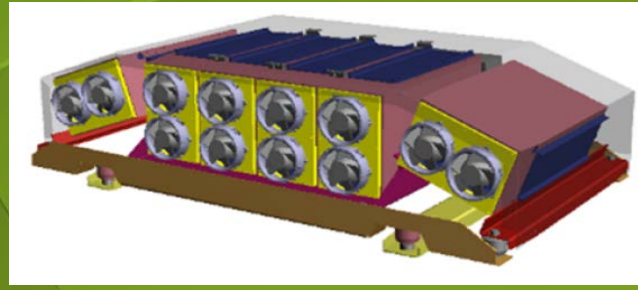
UC pack of 5.2 kWh within 180 kg and 0.33 m³

Supercapacitors at hybrid trolleybuses

Volume: 0.34 m³

Weight: weight 300 kg

Capacity: 0.55 kWh



Diesel engine backup in a trolleybus



800 kg Ni-Cd Battery in a trolleybus



Aowei's ultracapacitor vs. diesel motors



	Aowei UC 5 kWh	Diesel motor & auxiliaries 75 kW
Required space	0.3 m ³	higher
Weight	180 kg	> 400 kg
Local emissions	-	Yes
Maintenance	-	Yes
Noise	-	Yes
Vibrations	-	Yes
Weather influence	-	Yes, winter time
Energy braking recuperation	Up to 40%	-
Energy consumption, 12 m vehicle	~1 kWh/km	4.4 kWh/km
Benefits for the grid	Yes	-
Unit price	Cheaper than diesel engine	x
Running costs	-	- maintenance costs - higher energy costs
Social & environmental benefits	Yes	-

Aowei's ultracapacitor vs. batteries



	Aowei UC module 5 kWh	Li – Ion battery pack 70 kWh
Usable SOC	100 %	55% - 60%
Weight	180 kg	Up to 1000 kg
Mileage	5 km 15 km achievable by 540 kg UC pack	15 km
Recuperation	Up to 40%	Up to 28%
Energy consumption, 12 m	~ 1 kWh/km	1.3 kWh/km
Weather influence	No	Both summer & winter
Replacement	No	2-3 times over vehicle lifespan
Lifetime, cycles	> 30,000 - 8 years warranty	3000 to 12,000
Charging time, full SOC	> 5 min	> 70 min
Hazardous	No	Yes
Risk of fire	No	Yes
Unit price + Running costs	Cheaper than battery pack	<ul style="list-style-type: none"> - Replacement cost s - Lower energy savings - Final disposal cost

Aowei's ultra-capacitor vs. other super-capacitors used at trolleybuses



	Aowei UC	Supercapacitors used in trolleybuses
Module Weight (kg)	180 kg	250 kg – 300 kg
Capacity of the Module (kWh)	5.2 kWh	0.55 kWh
Module volume (m ³)	0,33 m ³	0.34 m ³
Capacitance, Farad	169	63
kWh/kg	34	2.3
kWh/m ³	15.6 kWh/m ³	1.6 kWh/m ³
Wireless mileage coverage	5 km	< 0.5 km
Warranty	8 years !	
Unit price	<u>Significantly</u> cheaper	x

Aowei's ultra-capacitors for trams



- Aowei's 45 kWh Ultra-capacitor package enable a 75 tons City-car wireless run for 10 Km between charging.
- The UC is being charged by the Tram's recuperation.
- First world's wireless trams equipped with Aowei's UC are already in their 2nd year of successful operation.

Aowei's ultracapacitor application for wireless city-car



The city electric train while using the old technology with the upper electric wires infrastructure.



The city electric train while running in the new line using the UC without the external upper wires.

Aowei's definite advantages vs. other leading ultra capacitors' producers



The function and its values	The world's leading UC producers	AOWEI	In order to provide Aowei's values others will need
Capacity of the Module	14.4 kWh	45 kWh	45 kWh
Module's weight	4,100 Kg	1,800 Kg	12,810 Kg
Wight/kWh ratio	7.11	1	
Module's volume	5.5 M ³	2 M ³	17.3 M ³
Volume/kWh ratio	8.6	1	
Cells in each module	6,880	2,160	21,500 cells
Cells number/kWh ratio	9.95	1	
Recuperation rate		42% !! World's highest	

In order to provide the same capacity of Aowei's module, other companies will need to provide modules of 7 times the weight and 8.6 times the volume!!!

Aowei's ultracapacitor application for wireless tram



Wireless tram run



Wireless tram charging



CHARIOT MOTORS WISHES YOU A NICE WIRELESS TRIP!



info@chariot-motors.com