Researcher Links UK-Russia Workshop

Scientific and Technical Grounds of Future Low-Carbon Propulsion

19th - 22nd November 2018, Northumbria University at Newcastle, UK

Maintenance of the required temperature of a high-voltage battery for electric vehicles

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Northumbria University NEWCASTLE

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Newcastle University

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Main trends in the modern automotive industry

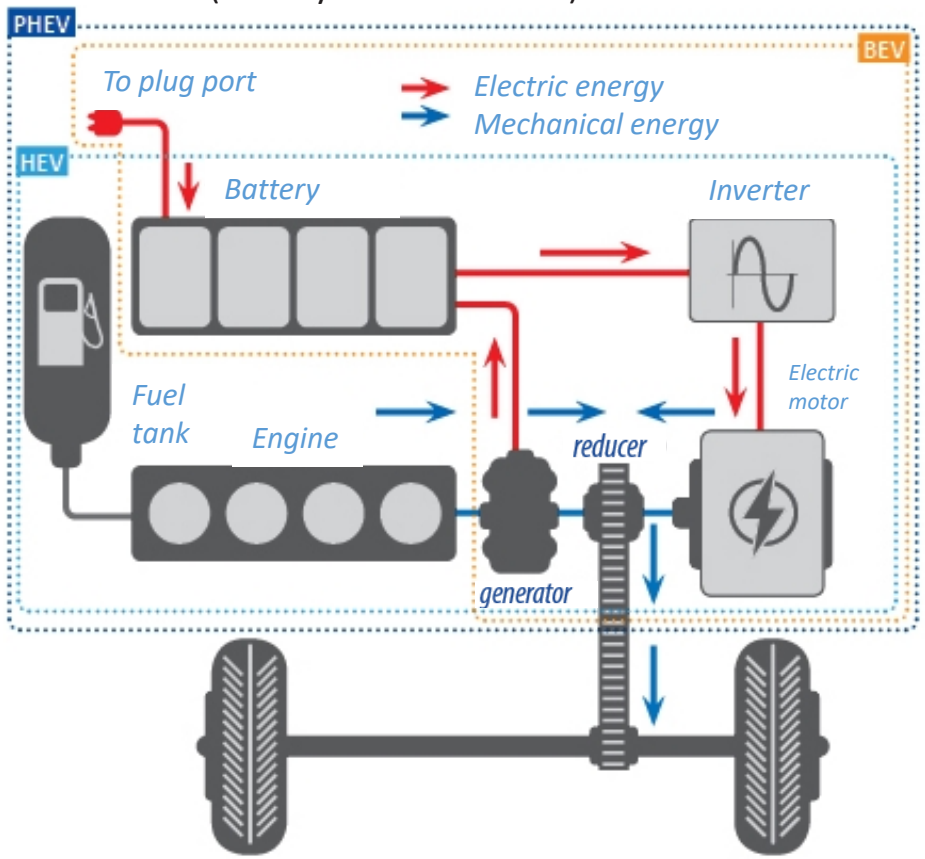
INTRODUCTION

- Reducing toxicity and fuel consumption
- Increasing energy efficiency

According to the forecasts of the Subcommittee on Strategic Innovations in the Automotive Industry of the Chamber of Commerce and Industry of the Russian Federation, by **2025** at least **50%** of the world's produced vehicles will be on electric traction.

Types of electric vehicle

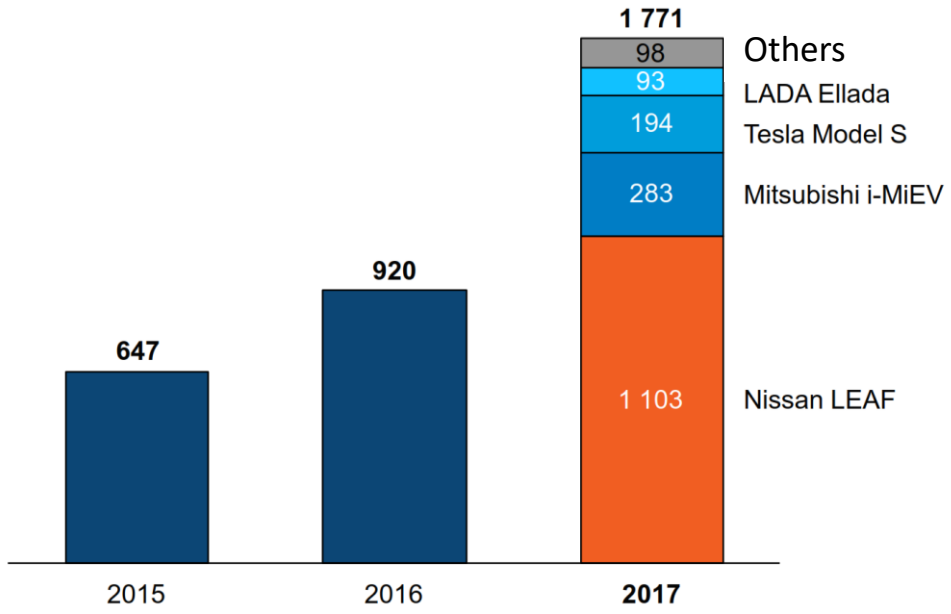
- HEV (Hybrid Electric Vehicle)
- PHEV (Plug-in Hybrid Electric Vehicle)
- BEV (Battery Electric Vehicle)



Electric Vehicles in Russia

INTRODUCTION

Park of electric cars in Russia



The main factors why transport is not popular in Russia are:

- underdeveloped infrastructure;
- climatic conditions

In the northern territories the winter period reaches 300 days and air temperature drops below -50 °C.

If we consider central Russia, the typical winter conditions last for at least six months.

In the south, winter lasts for not more than 40 days and the temperature rarely falls below -5 °C.

The number of days per year with an average temperature of 0 °C or less is 171 days on average for the Russian Federation as a whole, i.e. 47% of the year.

Climatic zone	The ambient temperature in winter, °C
I-II	- 9,7
III	- 18
IV	- 25
extra	- 41

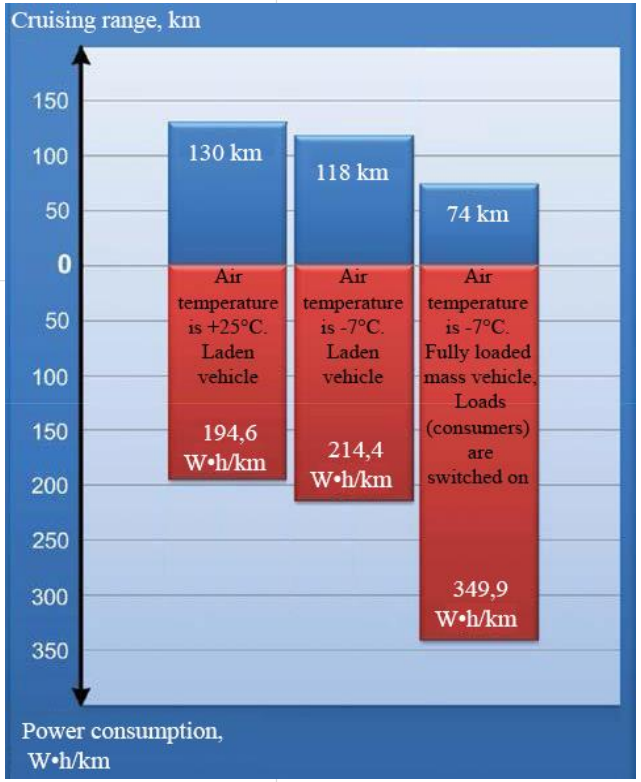
Electric Vehicles in Russia

PROBLEMS WITH BATTERY CAPACITY AT OPERATION IN COLD CONDITIONS

Studies show that the mileage of electric vehicles depends strongly on the temperature conditions of the high-voltage battery, which is one of the main elements of the functioning of such vehicles. At low temperatures, the mileage of electric vehicles falls sharply (to 30…40%), and at high temperatures, the high voltage battery can overheat, which can lead to degradation of battery cells.

Nissan Leaf electric vehicle test in the NAMI automotive test site in winter conditions

Test results are showed that the lowering of the outdoor temperature to + 25 °C to - 7 °C causes a reduction in power reserve of 9% and 44% when included consumers of energy.
Also when driving on loose snow, the range is 14% less than on dry asphalt.



Effect of ambient temperature and supplementary equipment on the driving range and energy consumption

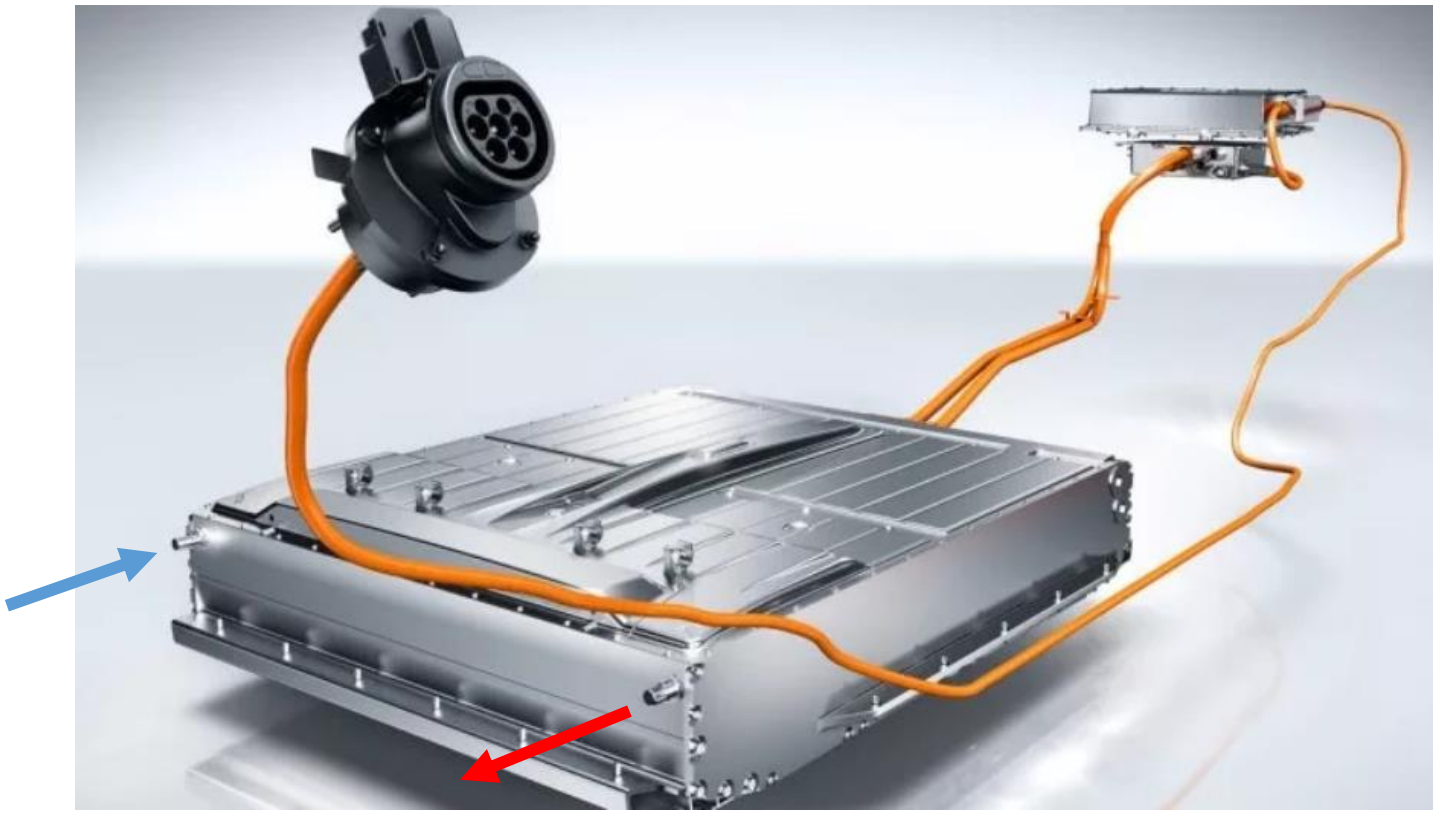
Tesla Model S electric vehicle test in Minnesota automotive test site in winter conditions

Test results are showed that at -10 ° C and the average level of snow cover, the range of the electric vehicle Tesla Motors C is reduced by 20%.

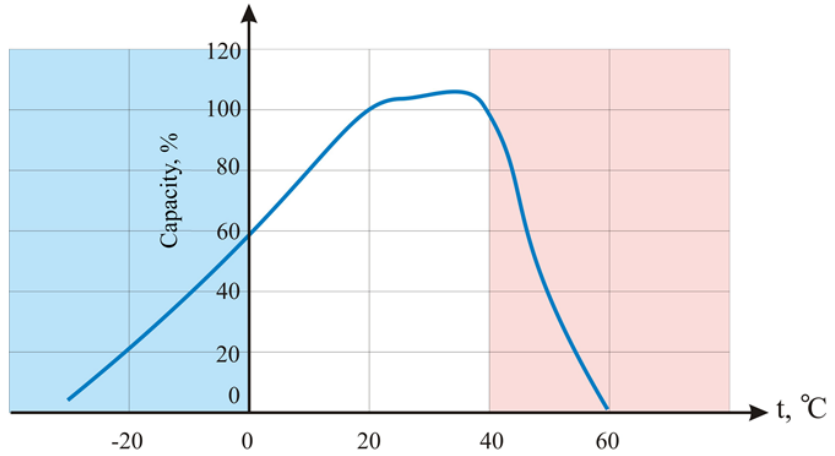
High-voltage battery

PROBLEMS WITH BATTERY CAPACITY AT OPERATION IN COLD CONDITIONS

Thus, the task of thermostating high-voltage battery is very important for our country.

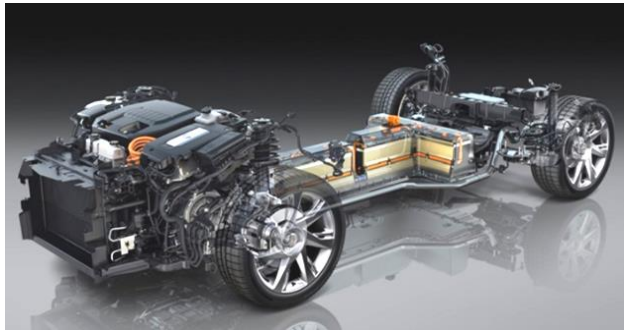


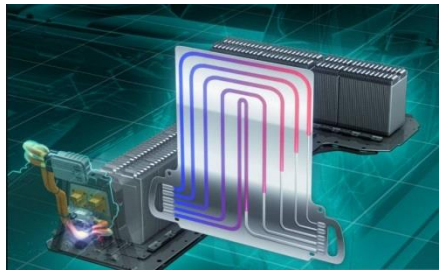
The operating range of the battery cell without a significant decrease in its life 0 ... 50 ºC.



The design of high-voltage batteries with thermostating systems of commercially produced vehicles on electric traction

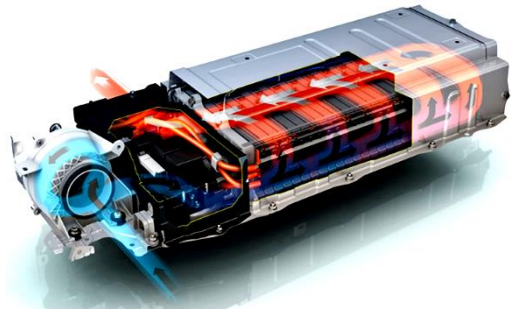
Chevrolet Volt





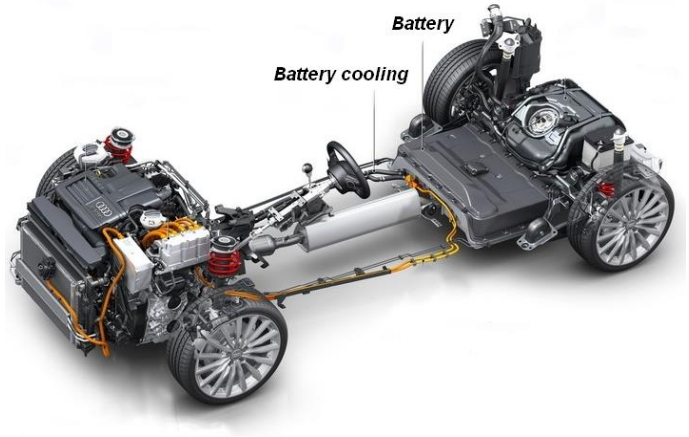
T-shaped lithium-ion high-voltage car battery Chevrolet Volt with aluminum cooling plate

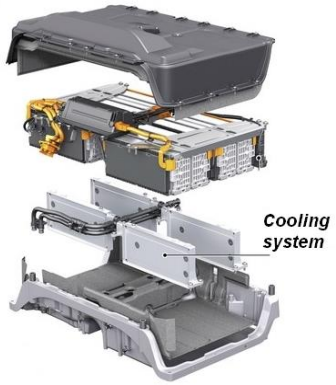
Toyota Prius Hybrid



High-voltage car battery Toyota Prius with air cooling

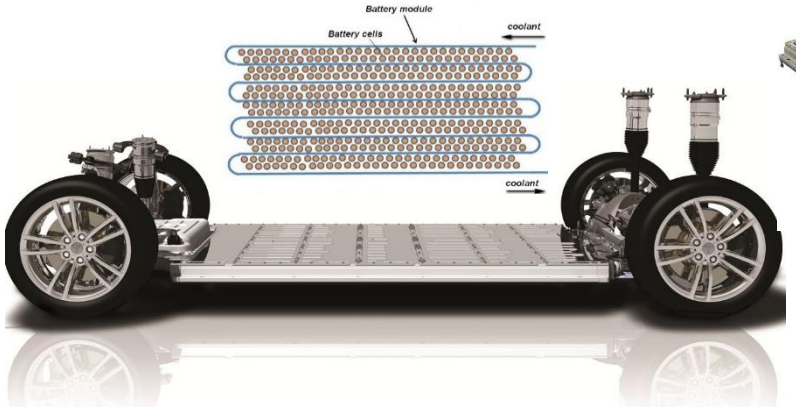
Audi A3 e-tron PHEV-20





High-voltage car battery Audi A3 e-tron PHEV-20 with four cooling plates which regulate the temperature of the eight modules

Tesla Model S



High-voltage car battery Tesla Model S consists of 16 battery modules with liquid cooling system

Modern developments of FSUE "NAMI" in the field of electric vehicles

Electric vehicle LADA Ellada with Range Extender

Technical characteristics	
Curb weight, kg	1307
Maximum speed, km/h	130
Acceleration (to 100 km/h), s.	13
Dimensions, мм	4040 / 1700/ 1600

Electric vehicle LADA with Sollar Battary

Technical characteristics	
Curb weight, kg	1315
Maximum speed, km/h	140
Acceleration (to 100 km/h), s.	12
Dimensions, мм	4040 / 1700/ 1610

Hybrid vehicle AURUS SENAT

Technical characteristics	
Curb weight, kg	2740
Maximum speed, km/h	250
Acceleration (to 100 km/h), s.	6
Dimensions, мм	5630 / 2020/ 1685

Thermal calculation of the battery

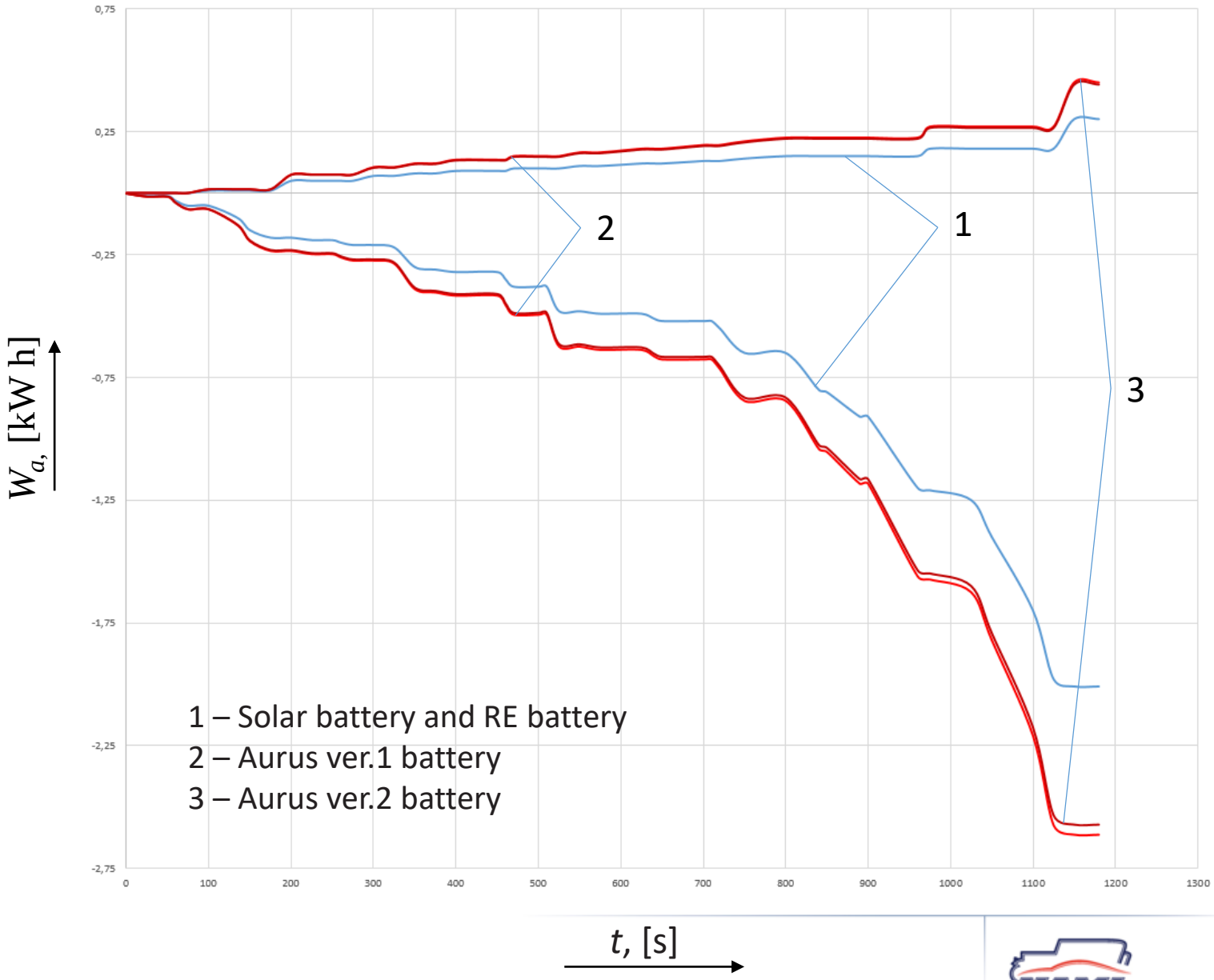
THERMAL ENERGY OF THE CELLS OF THE BATTERY IN THE CYCLE

$$W_a = W_{amax} - W_{amin} \quad [\text{kW·h}]$$

$$W_{te} = (W_a - W_a \cdot \eta) \cdot 1000 \ [\text{W·h}]$$

$$E_{te} = \frac{W_{te} \cdot 3600}{3 \cdot t} \quad [\text{W}]$$

W_a – The difference in energy flows accumulated and consumed during the cycle;
W_{te} – thermal energy of the cells ;
E_{te}- thermal energy of the cells per cycle;
t – time;
$\eta = 0{,}95$ - efficiency.

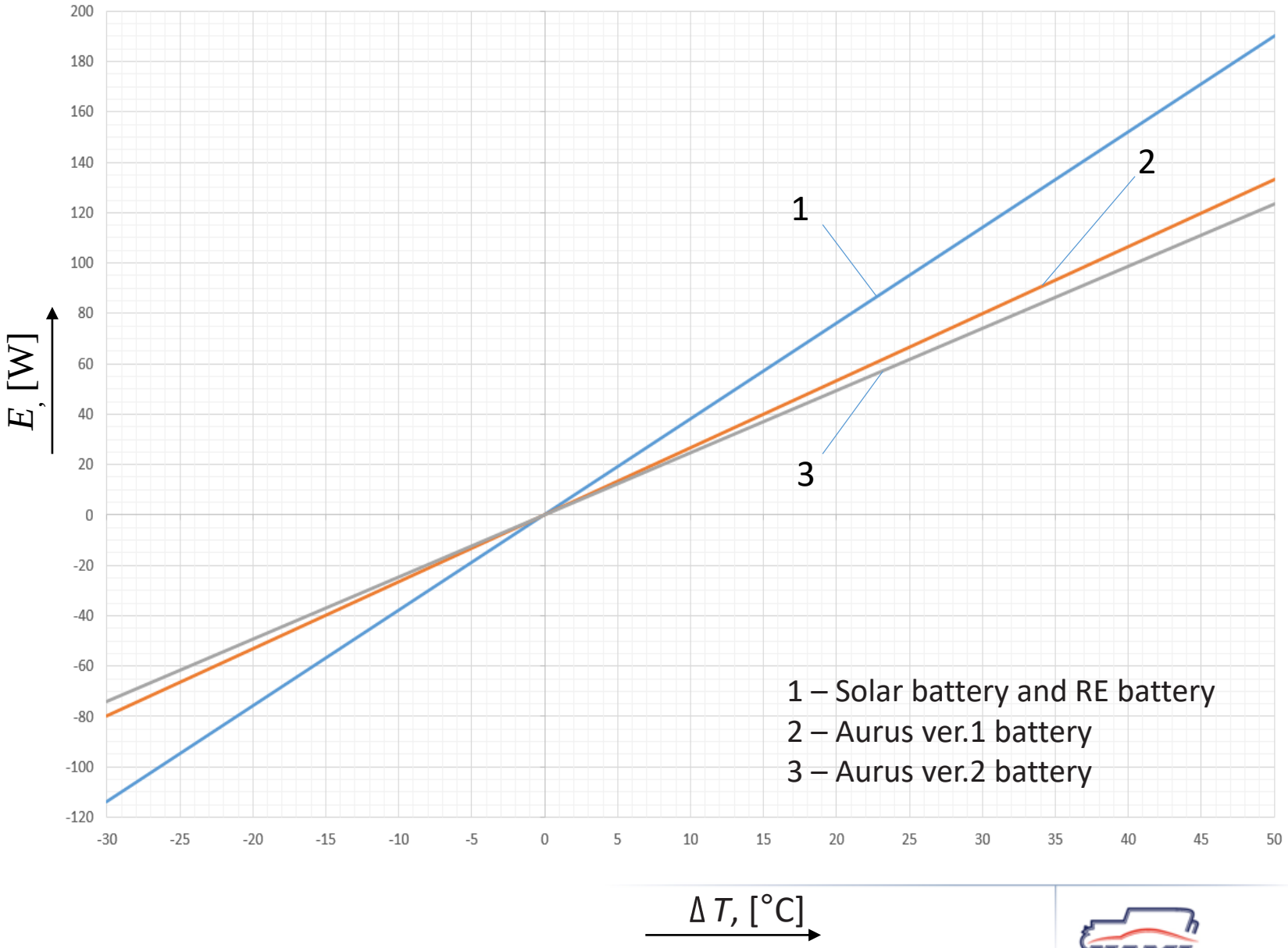


Thermal calculation of the battery

HEAT LOSS ENERGY OF THE BODY OF THE BATTERY

$$E = -\varkappa \frac{S \cdot \Delta T}{l} \quad [\mathrm{W}]$$

E – heat loss energy of the case of the battery
$\varkappa$ – coefficient of thermal conductivity
S – heat sink area
l – thickness of heat insulating material
ΔT – difference between external and internal temperatures

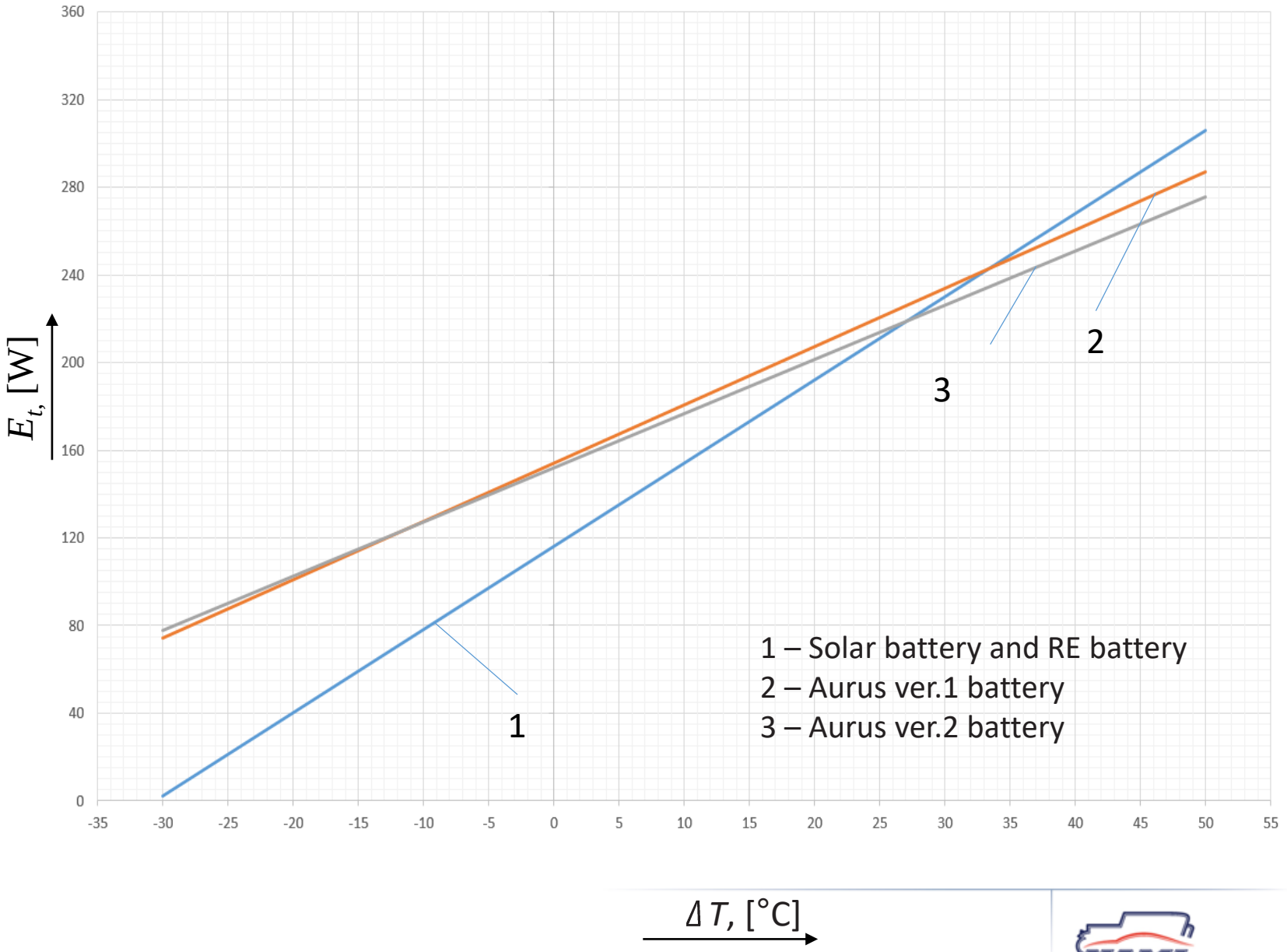


Thermal calculation of the battery

HEAT ENERGY OF THE BATTERY

$$E_t = E + E_{te} \quad [\mathrm{W}]$$

E_t – total heat energy of the battery



Russian electric vehicle

LADA ELLADA WITH RANGE EXTENDER

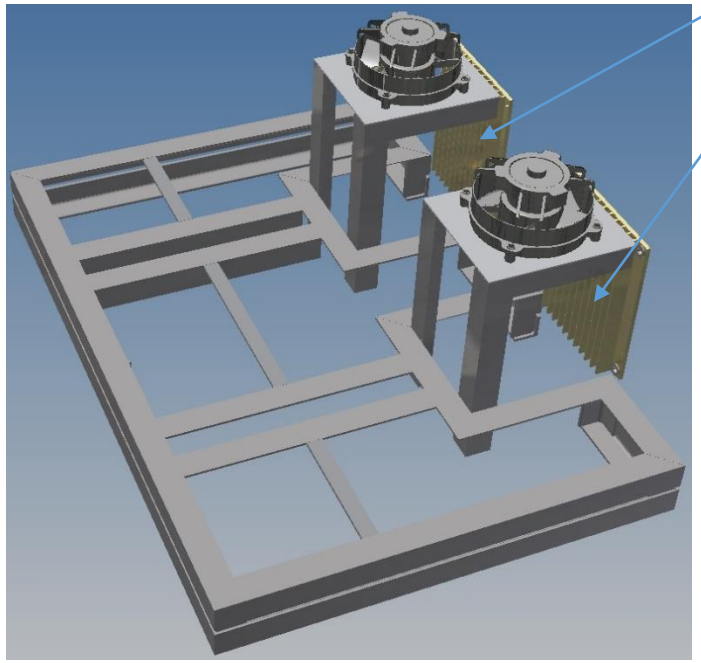
Russian electric vehicle LADA Ellada with Range Extender

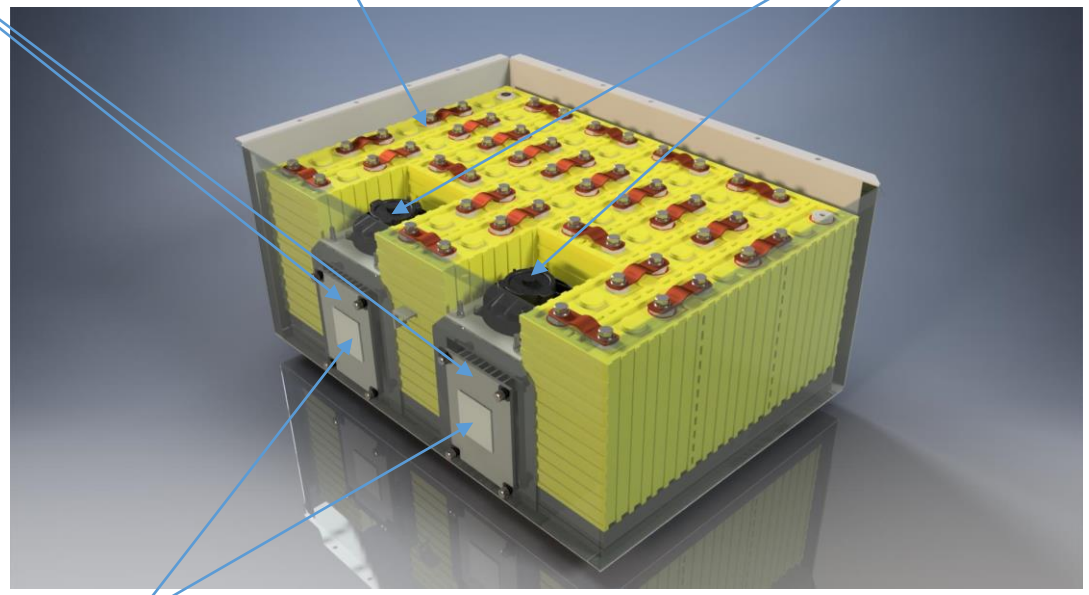
3D-MODEL OF HIGH-VOLTAGE BATTERY

Radiators of high-voltage battery

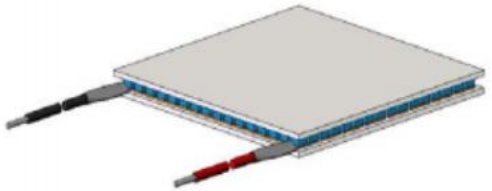
Cells Winston WB-LYP90AHA

Fans SPAL VA32-A101-62S





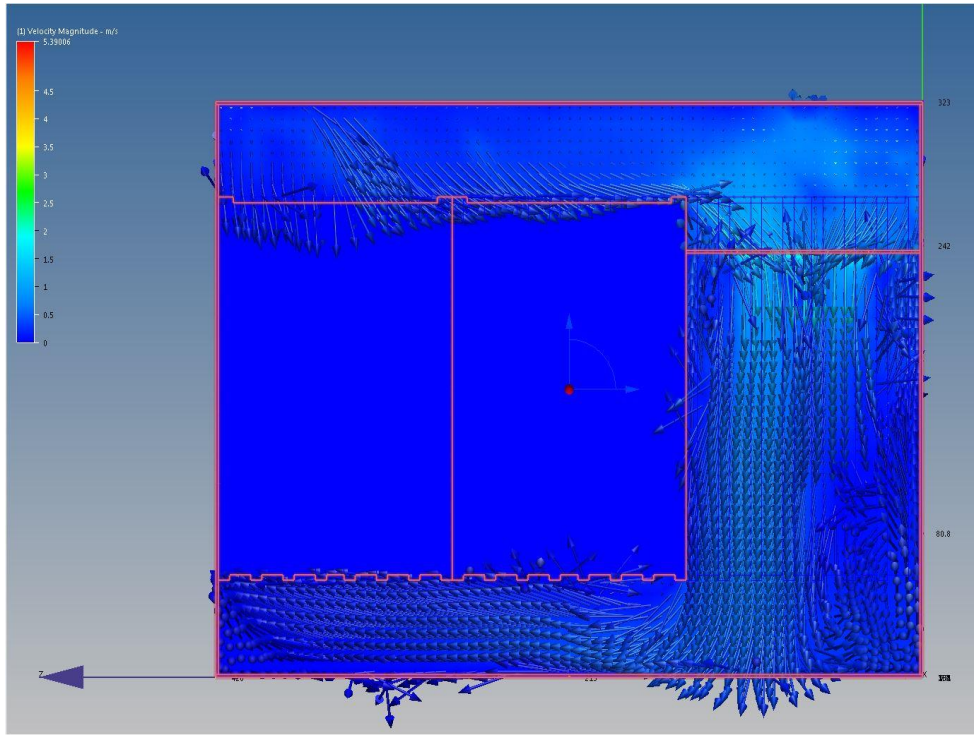
Peltier elements



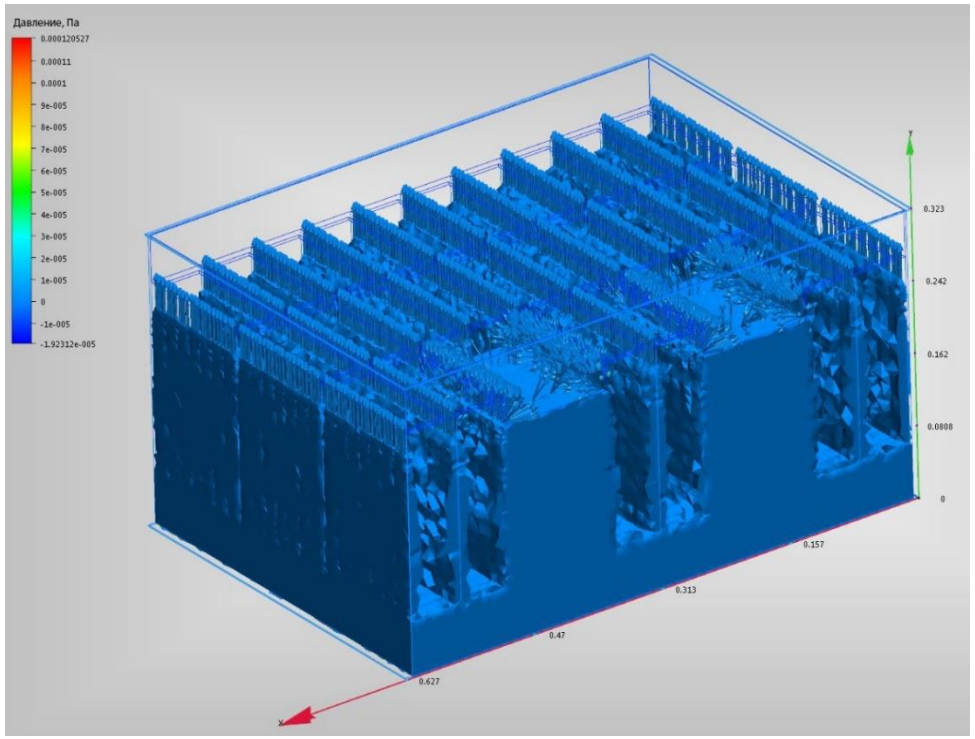
Operational parameters	*Unit*	*Value*
Working temperature range	°C	-50 ÷ +80
Max. processing temperature	°C	130

Russian electric vehicle LADA Ellada with Range Extender

SIMULATION OF THE EFFICIENCY OF THE SYSTEM OF THERMOSTATING OF A HIGH-VOLTAGE BATTERY



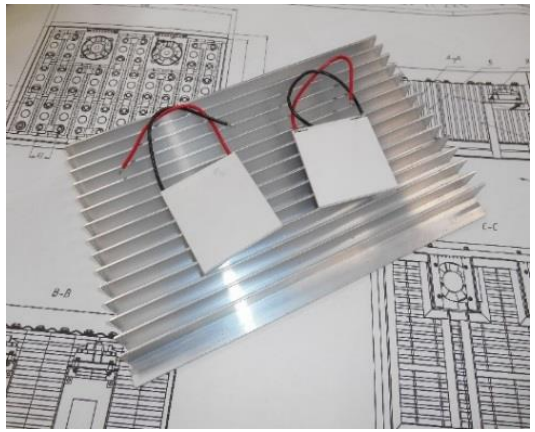
Distribution of the air-flux velocity within the storage module.

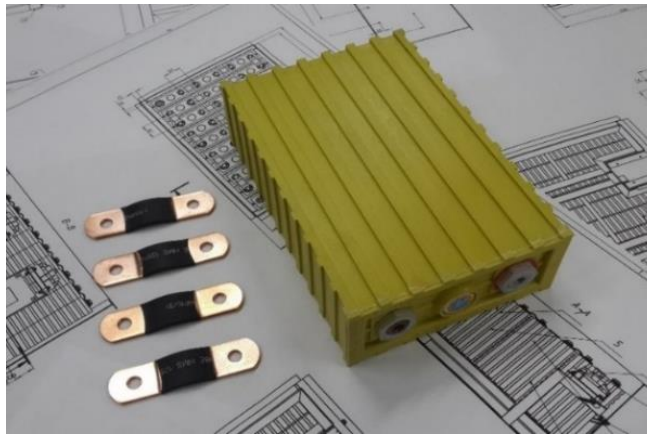


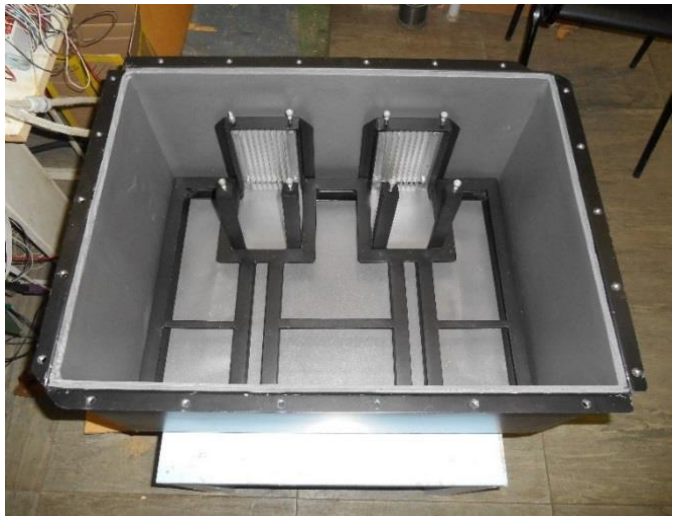
Distribution of pressure within the storage module.

Russian electric vehicle LADA Ellada with Range Extender

MANUFACTURING OF A HIGH-VOLTAGE BATTERY







Russian electric vehicle LADA Ellada with Range Extender

MANUFACTURING OF A HIGH-VOLTAGE BATTERY

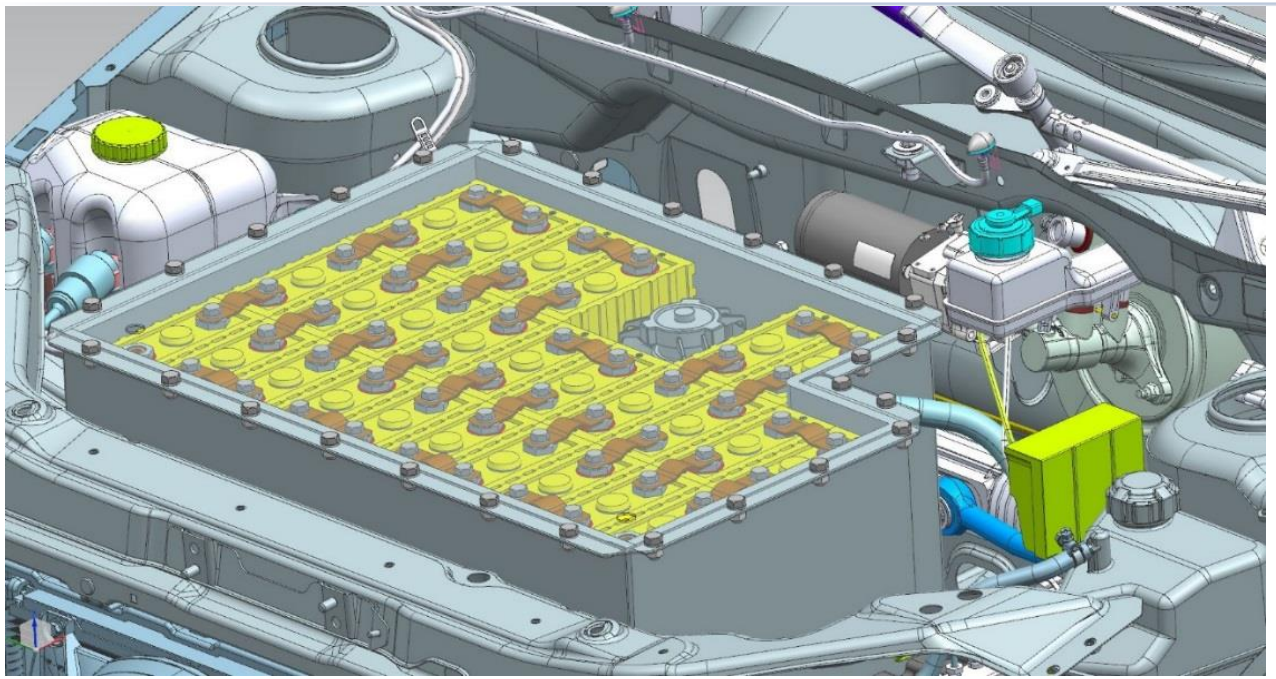
Technical characteristics	
Maximum power	11 kW
Rated power	7 kW
Stored energy	20 kWh
Rated voltage	300 V
Working temperature	-40…+50 °C
Dimensions	668X491X300 мм
Cooling type	Air
Weight	77 kg

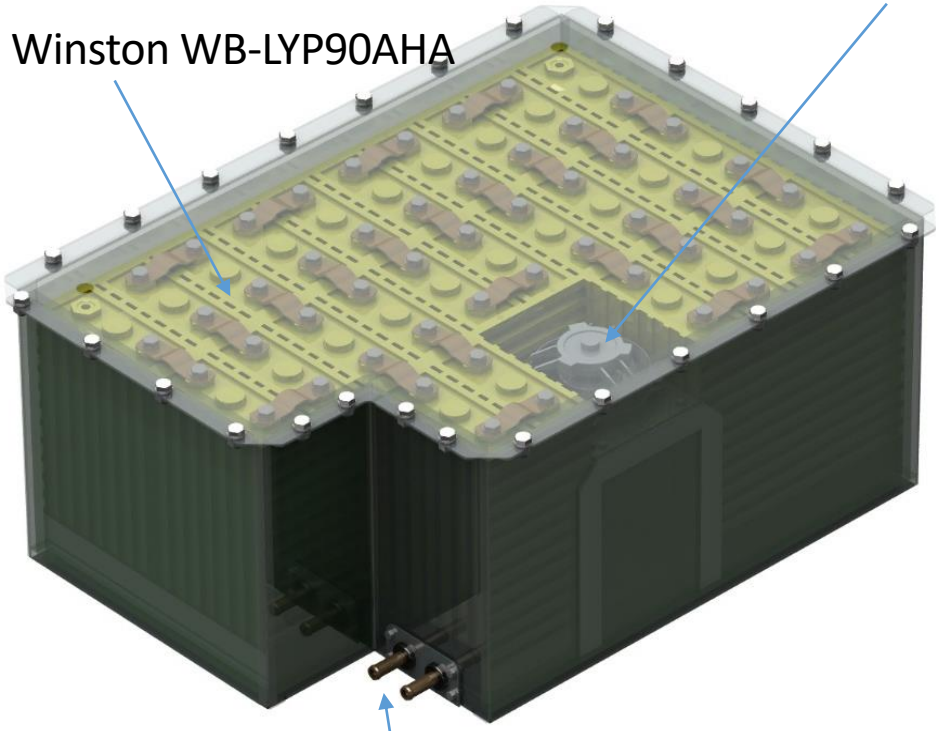
Russian electric vehicle

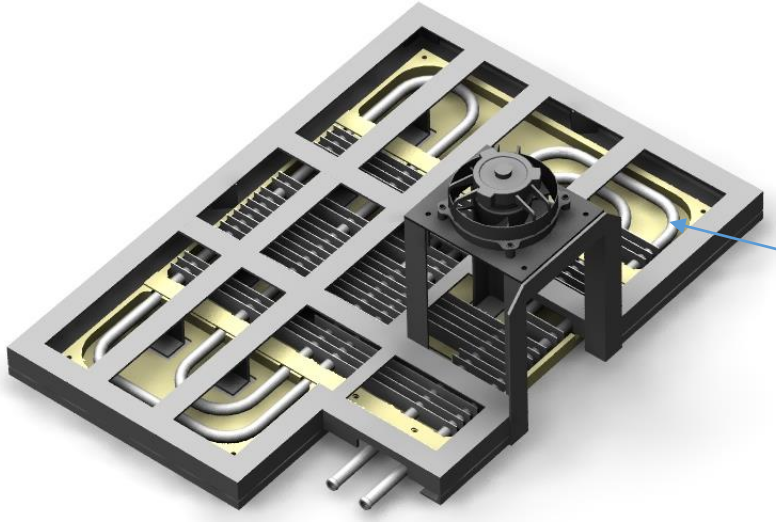
RUSSIAN ELECTRIC VEHICLE LADA WITH SOLAR BATTERY

Russian electric vehicle LADA with Sollar Battery

3D-MODEL OF HIGH-VOLTAGE BATTERY







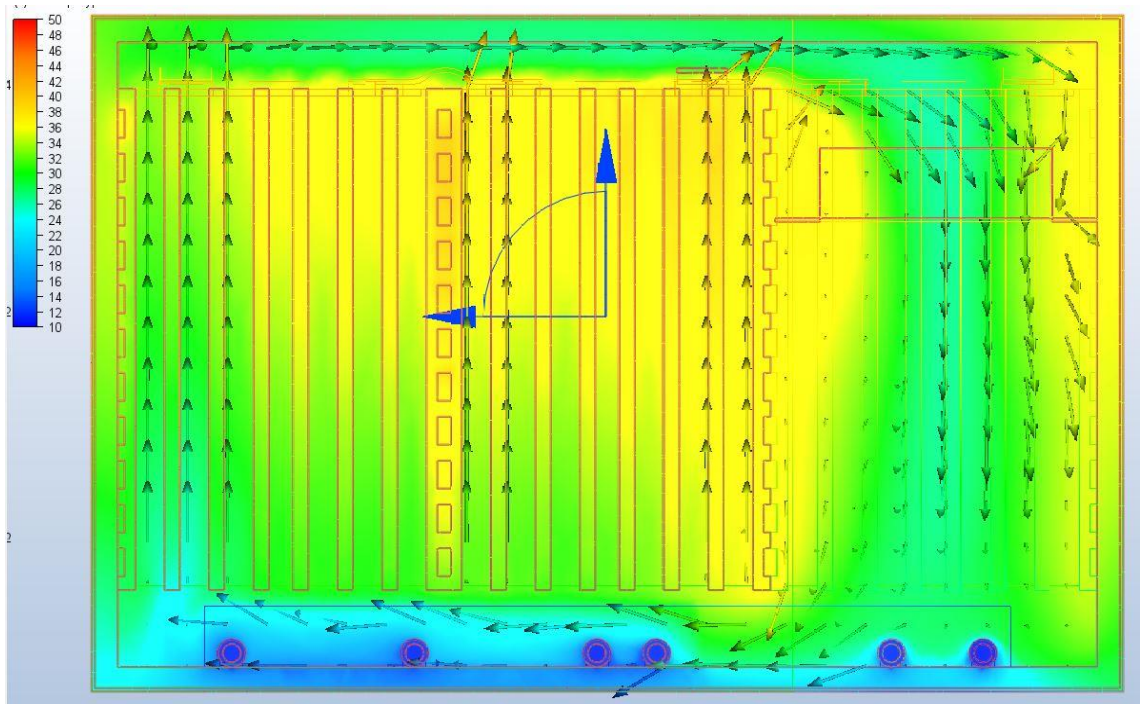
Copper radiator of
high-voltage battery

Russian electric vehicle LADA with Sollar Battery

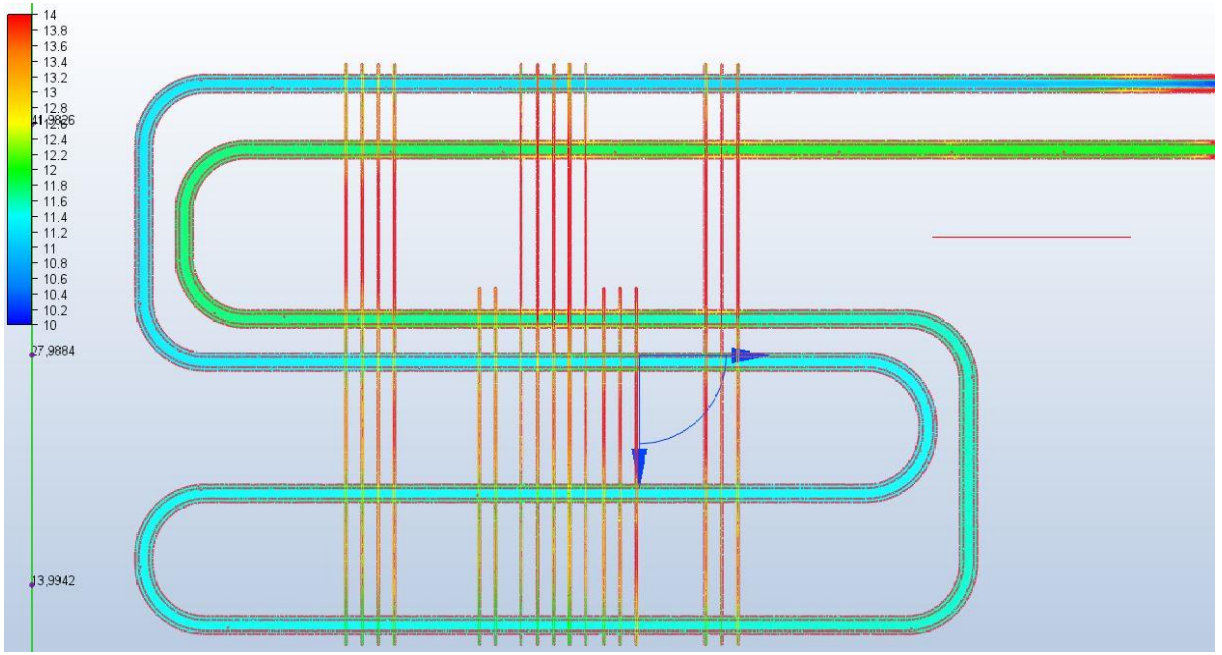
SIMULATION OF THE EFFICIENCY OF THE SYSTEM OF THERMOSTATING OF A HIGH-VOLTAGE BATTERY

The main task of the simulation was to determine the flow rate and temperature of the coolant through the heat exchanger, to provide the target temperature values of the battery cells (0…50°C).

Loaded battery operation mode. The ambient temperature is + 40 ° C.



Distribution of airflow and temperature in the battery

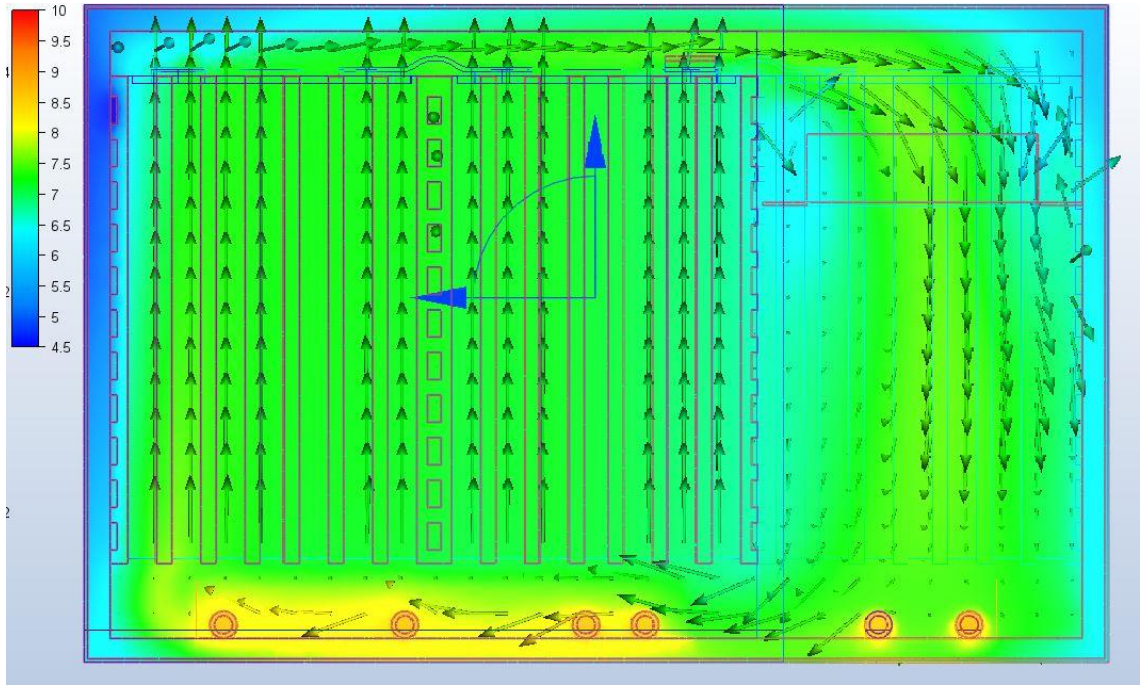


Section through a radiator

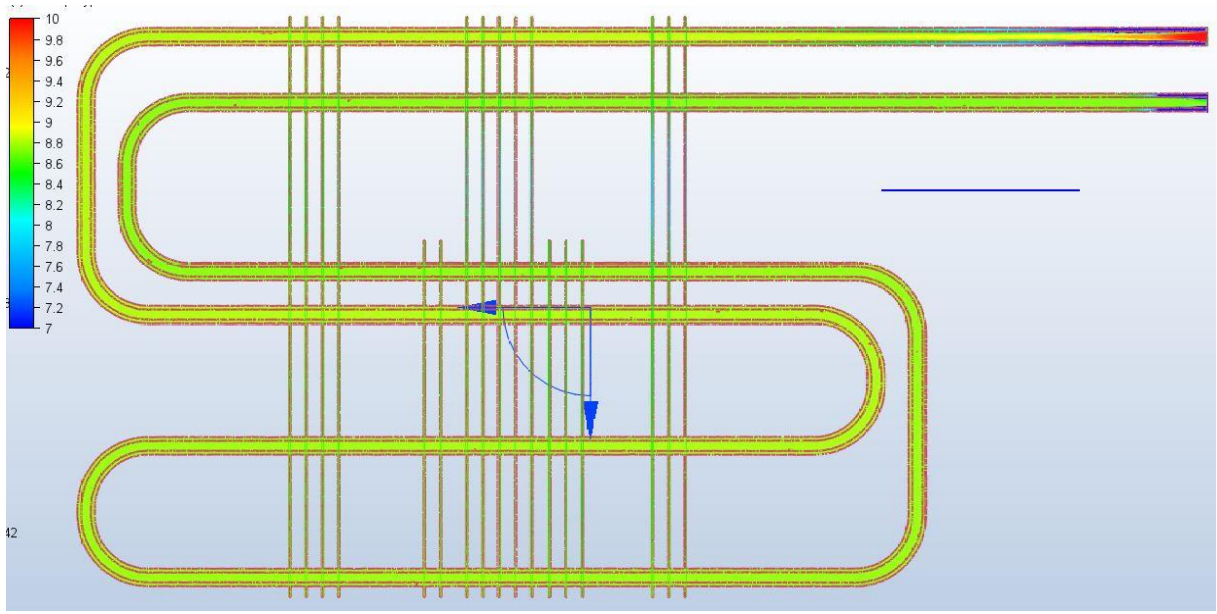
Russian electric vehicle LADA with Sollar Battery

SIMULATION OF THE EFFICIENCY OF THE SYSTEM OF THERMOSTATING OF A HIGH-VOLTAGE BATTERY

The battery is inactive. The ambient temperature is -25 ° C.



Distribution of airflow and temperature in the battery



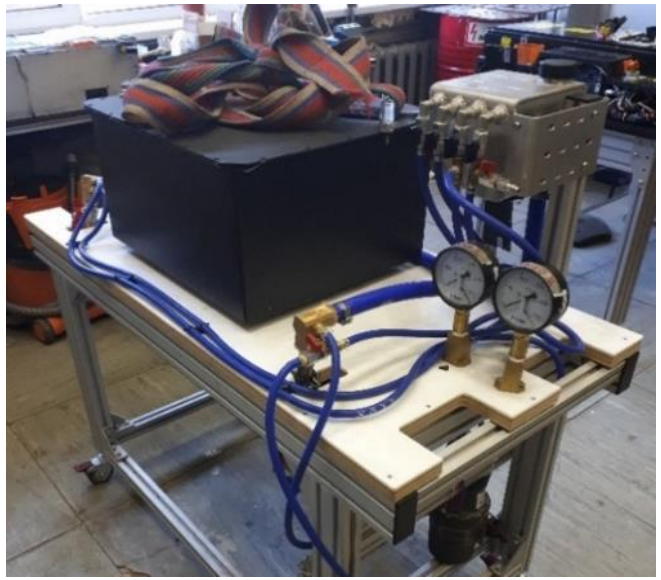
Section through a radiator

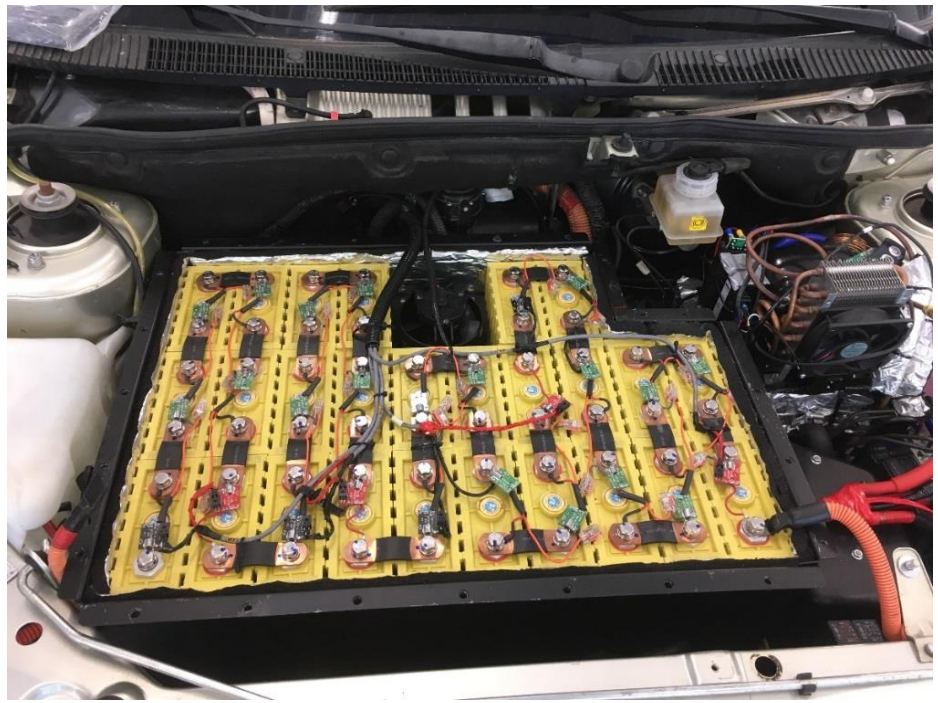
Russian electric vehicle LADA with Sollar Battery

MANUFACTURING OF A HIGH-VOLTAGE BATTERY

Russian electric vehicle LADA with Sollar Battery

CALCULATION OF THE EFFICIENCY OF THE SYSTEM OF THERMOSTATING OF A HIGH-VOLTAGE BATTERY



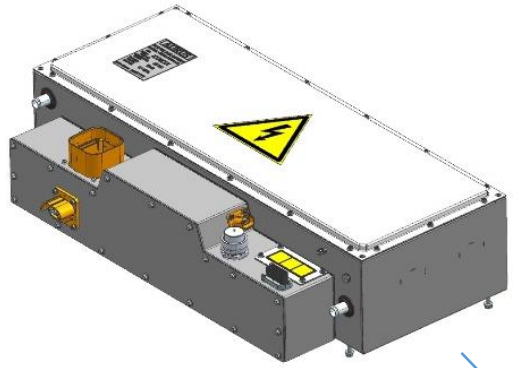


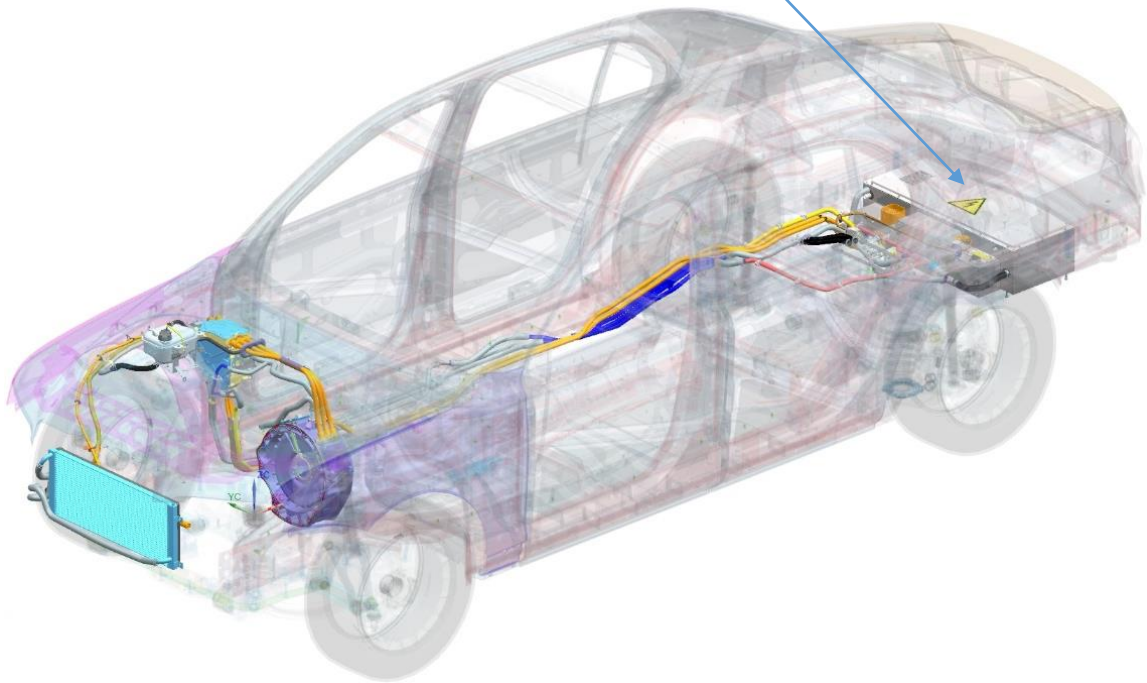
Technical characteristics	
Maximum power	11 kW
Rated power	7 kW
Stored energy	20 kWh
Rated voltage	300 V
Working temperature	-40…+50 °C
Dimensions	668x491x292 мм
Cooling type	Liquid-Air
Weight	80 kg

Russian Hybrid vehicle

AURUS SENAT

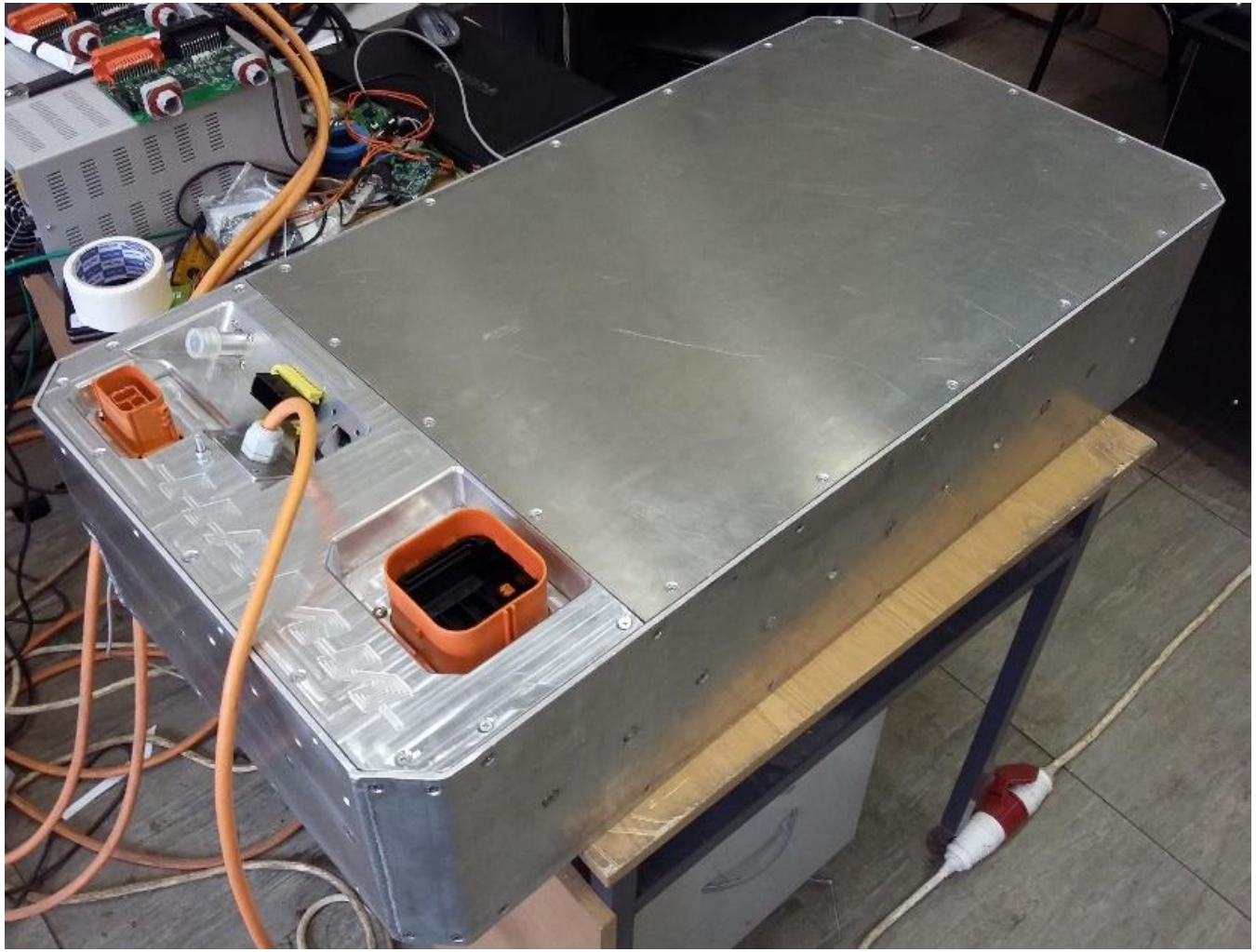
High-voltage battery





Russian Hybrid vehicle AURUS SENAT

HIGH VOLTAGE BATTERY



Main specification	
Maximum power	70 kW
Nominal power	40 kW
Stored energy	6 kWh
Voltage	316 V
Working temperature	-40…+50 °C
Dimensions	945X490X220 мм
Cooling type	liquid
Weight	98 kg

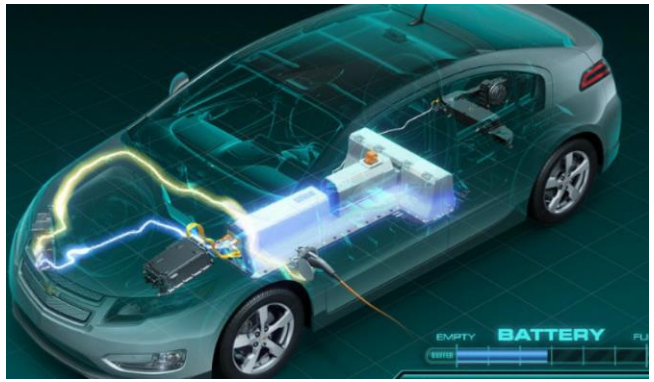
Russian Hybrid vehicle AURUS SENAT

HIGH VOLTAGE BATTERY

Main specification	
Maximum power	70 kW
Nominal power	40 kW
Stored energy	6 kWh
Voltage	316 V
Working temperature	-40…+50 °C
Dimensions	939X482X209 мм
Cooling type	liquid
Weight	130 kg

Stages of the research:

- definition of goals;
- analysis of technical solutions;
- design and engineering;
- calculations and simulation;
- manufacturing;
- tests in the laboratory;
- tests in the vehicle.



Researcher Links UK-Russia Workshop

Scientific and Technical Grounds of Future Low-Carbon Propulsion

19th - 22nd November 2018, Northumbria University at Newcastle, UK

Thank you for your attention
Ready to answer your questions

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