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# **The specificity of the popularization of hybrid and electric vehicle in the Russian Federation**

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## **Summary**

The scientific paper examines the specifics of the promotion and introduction of vehicles with alternative energy sources in Russia. Shown measures to promote market development of hybrid and electric vehicles by the government of Russia. Examines the issues of creation and operation of hybrid and electric vehicles in difficult climatic conditions of the Russian Federation. Describes the development of an innovative electric vehicle with a Range Extender system. Presents excerpts of an integrated bench and road tests, which are accompanied by the main results. Predictions on the development of vehicles with alternative energy sources in the Russian Federation.

*Keywords: EREV (extended range electric vehicle), energy storage, battery, thermal management, efficiency*

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## **Introduction**

Individual mobility is a basic need of humans. Growing income goes hand in hand with more individual mobility. In early 2000, we had a total about 750 million vehicle, but in 2016, we have over 1 billion vehicles in the world. Currently most of the world's automotive countries link the solution of a complex ecological safety and problems of energy saving by regulating CO<sub>2</sub> emissions, as well as increasing adoption in the production of electric vehicles, which can significantly reduce the pollution on the planet. According to forecasts of the European Commission for transport by 2020 in Europe 7 % of all new passenger and light commercial vehicles will be electric, increasing to a massive 31% by 2030. This measure is a forced connection with the sharp deterioration of the situation on the planet associated with air pollution and global warming. The solution of these problems is the creation of electric vehicles, production of which is established in the leading countries of the world [1, 2, 3].

## **Main part**

The main user of energy in transport is the road transport with 90% of the energy consumption. Passenger vehicles contribute with 64%. The challenge is therefore to compensate the energy consumption and the CO<sub>2</sub> emission of a strong growth in vehicle numbers up to 2050 [2].

In the Russian Federation, transport is one of the major environmental pollutants. Transport pollutes the air, soil, surface water, creates noise and vibration impacts on public health, etc. Transport contribution to air pollution in Russia on average about 45%, and in big cities reaches 90%. In connection with what is in the area of unacceptably high health risk, there are at least 15 million citizens. According to experts, only from noise, air pollution and impact on climate, the annual environmental damage up to 2.5 billion euros. The transport complex of Russia, is one of the biggest air pollutants. The main damage (about 63%) out of all vehicles causing road transport, with most concentrated on the emissions of harmful substances 90%.

Electric transport is an integral part of our lives, but it has several significant shortcomings such as limited mileage on a single charge, the lack of well-developed infrastructure of charging stations, the complexity when operating in conditions of negative temperatures, etc., these disadvantages slow down its promotion in the global markets, especially in countries with difficult climate and long distances between cities. The Russian Federation is a country with a cold climate prevalent in most areas: average annual temperatures in the Northern and Central regions are in the range 0...- 22 °C that you can see on the temperature map presented as fig. 1. While electric vehicle shall be operated over the full temperature range of the region in which it is used, the critical factor is the lowest temperature. The average winter temperature in the Russian Federation is Krasnodar -2°C, Moscow -6°C, Irkutsk-23°C. While in Moscow, winter temperatures can be below -30°C, and in Irkutsk – below -50°C (Fig. 2). Lithium-ion battery system can operate in a rather wide range of temperatures, but there are extrema, which is worth remembering all the time, especially in countries with cold climate and many time zones, such as Russia.

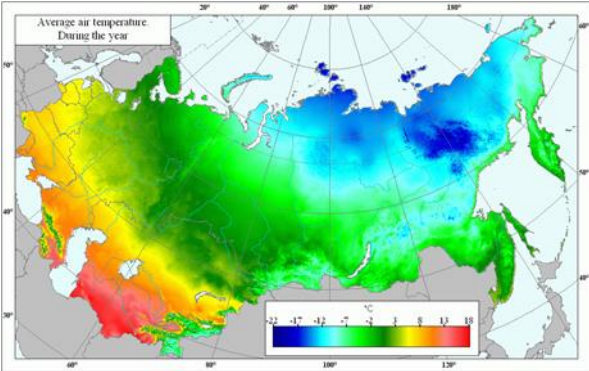


Figure 1: The Map of average annual air temperatures in Russia

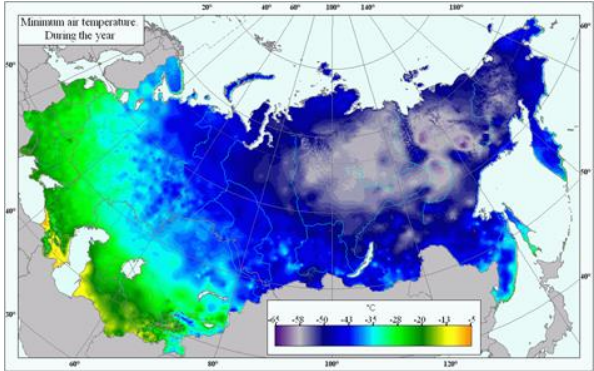


Figure 2: The map of minimum annual temperatures in Russia

In the Northern regions of Russia, the annual duration of the period of negative temperatures can reach 250-270 days. Electric and hybrid vehicles did not have the capacity control the temperature of the traction batteries for their normal functioning in such conditions of temperature that negatively affects the durability of the traction batteries.

The creation of vehicles with alternative energy sources is a priority for scientists, researchers and engineers around the world. NAMI Russian State Scientific Research Center for many years are developing environmentally friendly vehicles, taking into account peculiarities of operation in difficult climatic conditions of Russia [4, 5]. Examines the issues of stimulating the development of means of transport on

alternative sources of energy, such as providing tax benefits to owners of such vehicles, the free Parking spaces, free charging infrastructure, etc. In NAMI Russian State Scientific Research Center, in the period from 2014 to 2016 have been designed, developed and tested an experimental model of an extended range electric vehicle (EREV) as fig. 3 [6, 7].



Figure 3: EREV

The vehicle is a passenger car of a small class. As the traction engine used asynchronous electric machine with liquid cooling. The drive of front wheels is electromachines through two-stage spur gear constant-mesh, the main gear having a rigid kinematic connection through the differential from the hubs of the driving wheels through two drive shafts of different lengths, comes with hinges of equal angular speeds on both sides to enable sharing of the drive, steering and suspension. As traction batteries used blocks of battery cells arranged in the front and rear of the body. The battery has a modular design and is sealed. Each battery module is equipped with an innovative temperature control system based on thermoelectric elements to maintain the set temperature (fig. 4).



Figure 4: Front block traction batteries with a thermostating system

The system temperature control consists of 26 of the battery cells placed in an airtight container. The container has an inner insulating coating and built-in temperature control device, built on two thermoelectric Converter Peltier and two SPAL fans. The system thermostat is powered by the onboard battery voltage of 12 V. In case of temperature increase in the battery pack above  $+20^{\circ}\text{C}$ , at block enable control signal  $U_{on}$ . The signal  $U_{\pm}$  is absent. Turn on the fan and the Peltier element operates in a cooling mode. The inclusion continues until the temperature drops below  $+20^{\circ}\text{C}$ . If in conditions of low external temperatures the

temperature of the battery decreases below  $+10^{\circ}\text{C}$ , the control unit battery are formed signals  $U_{on}$ ;  $U_{\pm}$  and the Peltier element is switched on in heating mode. The advantage of Peltier element is small in size, the absence of any moving parts, as well as gases and liquids. Turning the direction of the current, perhaps as a cooling and heating — this allows for temperature control when ambient temperature is both above and below the temperature of the thermostat. Was carried out aerodynamic and thermal calculations temperature control system. It is possible to find the optimal layout of the battery module. The task of aerodynamic calculation was solved with the use of a complex of programs allowing to carry out solid modelling, and the integration of the movement of the air flow by the finite element method. Figure 5 shows how the airflow near the fans are distributed without significant turbulence, which minimizes the effect of surge.

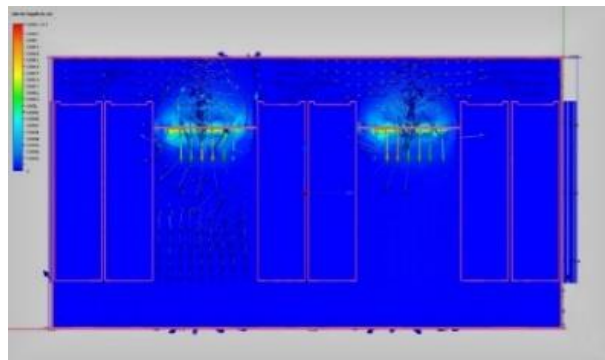


Figure 5: Visualization of airflow near the fans

At the rear of the vehicle the system is installed, in the world more commonly known as Range Extender. The Range extender consists of an internal combustion engine having a small displacement, and the electric machine operating in generator mode (fig. 6).



Figure 6: Range Extender

EREV has passed a comprehensive bench and road tests. Key indicators:

- the maximum speed of the vehicle - 134 km/h;
- full-time airbag deployment and recovery in high-speed range 5...120 km/h;
- provides automatic stopping and starting of the internal combustion engine when operating in the "Stop – Start";
- meeting the standards EURO 5;

- decrease in fuel consumption 12...14 % in comparison with existing analogues of hybrid vehicles;
- system of accumulation and storage of electrical energy provides a voltage supply of a traction drive 305 V, the energy intensity of 23 kW/h;
- the system of temperature control is allowed to ensure the working operation of the drives of electric energy in the temperature range of +12 – 18 °C, with external temperatures from -40°C to +50°C;
- the maximum mileage on a single charge on the combined cycle (EV) – 140 km;
- the maximum mileage on a single charge on the combined cycle (EREV) – 353 km.

## Conclusion



The creation of hybrid and electric vehicles in the Russian Federation requires significant nuances associated with the peculiarities of operating in difficult climatic conditions [8]. Developed in the framework of this project combined power plant on the basis of the Range Extender allows you to modify already manufactured electric vehicles, or create a vehicle with improved energy efficiency on the basis of serial models with traditional power plants. It seems appropriate to apply them in the areas of urban transportation, like taxi, mail transportation, LTL freight and other [9, 10]. The presence of the traction battery enough intensity will allow vehicles equipped with developed hybrid vehicles, to move in the Central areas of cities with low to medium speeds on electric and the movement at higher speeds will be provided by energy of the Range Extender. Total vehicle mileage at the expense of battery power and the Range Extender will allow for its continuous operation during the whole working day without recharging and to ensure that the average daily ranges corresponding to typical operating characteristics for the listed types of transportation.

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