The Creation of Modern Electric Vehicles with Additional Source of Energy

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Abstract. The development of electric vehicles as energy-efficient transport sets the direction of research in the field of renewable energy, such as solar radiation, expressed in the application of photovoltaic converters. NAMI Russian State Scientific Research Center carried out work on the application of the photoelectric Converter in the electric vehicle. Obtained from photoelectric converters of the data give the possibility of compensating for self-discharge and applicable to maintain the climate control, in addition to the low-voltage precharge and high-voltage batteries. The study examined the main climatic zones of the Russian Federation and the level of solar radiation, the possibility of accumulation of electricity using photovoltaic converters in **the** largest regional cities, developed technical solutions for the integration of a module of photoelectric converters in the basic design of the vehicle with a large storage of electrical energy (hybrids, electric vehicles). Results and solutions obtained during the research works, to extend the capabilities of energy electric and hybrid vehicles.

1. Introduction

Personal mobility is a basic need of humans. In 1998, we had a total about 700 million vehicle, but in 2018, we have over 1 billion vehicle in the world. Hybrids and electric vehicles developed differently in the last 30 years, but they had hard way into the market. 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.

2. Main Part

Development and creation of modern electric vehicles for both personal and commercial use, in the last 10 years have become relevant. The transition to vehicles with low emission of harmful substances during operation becomes the primary task in the automotive industry. This is an emerging area of research in the field of electric drive in vehicles for various purposes [1].

Pure Electric vehicle is characterized by storage accumulation and electricity in a high voltage battery and traction motor.

As components of the system of accumulation and storage of electricity (SHI) used a variety of batteries: lead, Nickel-metal hydride, lithium-polymer (Li-Pol), lithium-iron-phosphate (LiFePo4), lithium titanate (LTO), lithium-cobalt (LiNiCo) and others [2,3].

At present time, in total the technical characteristics in the manufacture and development of electric vehicle preference is given to a battery with lithium-ion based. However, they remain expensive and cumbersome to provide adequate reserve of electric vehicles along with the capabilities of a traditional combustion engine.

Often the mileage of the electric vehicle with the storage and accumulation of energy in the battery of lithium-ion batteries the energy capacity of 20 kWh is not more than 160 km [4]. However, it began a trend in which automakers began to equip their electric cars more energy-intensive batteries. Thus, there has been a trend in the increase of the traction battery and not in the discovery and application of new chemical foundations.

Any battery needs charging, that is, the replenishment of energy reserves. It is known that in modern cars the electric cars a full charge time is 4 to 8 hours, and some models have optional on-Board charger that allows, with the appropriate charging station to produce replacement electricity supply to 80% in 30 minutes from an external power source.

Long time stop for charging SHI are one of the main problems of electric vehicles. To reduce the charging time from a stationary source of energy and to increase the mileage we developed a large number of variants of the combined power plant with additional energy sources such as electrochemical fuel cells in the hybrid vehicles on electric (Toyota Mirai), Range Extander composed of a parallel hybrid (BMW i3) and photovoltaic converters (FEP) (prototypes and production models based on Toyota Prius, Ford C-Max, Tesla Model 3, The Fisker Karma) [5,6].

At the moment in the global automotive industry to find a balance between cost and power consumption of traction batteries, as the chemical composition of cells. So the next step is the study and application of ways of reducing charging time and increasing mileage. It should be understood that the additional power Converter and having multiple storage of energy in an electric car puts it in the category of hybrid vehicles. Thus, electric vehicles with a Range Extender classified as "hybrid vehicle" (a vehicle with at least two different energy converters (engines) and two different (side) energy storage systems for the purpose of propelling a vehicle), and is already able to throw out harmful substances into the atmosphere during the process of energy conversion.

Electric vehicles with integrated batteries solar cells is considered not a hybrid, since the energy storage system he structural one. The obvious advantage is that the fuel for solar cells, use of renewable energy – energy solar radiation and in the process of conversion of solar radiation into electrical energy battery solar cells does not produce harmful substances. Thus, the increase of energy efficiency of electric vehicles through the introduction in the design of batteries, solar cells, powered by renewable energy source, is ideologically more correct than vehicle electric vehicle internal combustion engine.

The ideology of solar cells based on the principle of converting optical radiation into an electrical signal. Optical range is a region of the spectrum of electromagnetic radiation from the deep ultraviolet (0.01 μm) to the far infrared (up to 1000 μm). The function of solar cells is the conversion of optical radiation into an electrical signal. This function is performed with various radiation detectors, which mainly belong to two groups — the actual photovoltaic and thermal. Radiation is: a) self radiation of the investigated object; b) reflected or scattered its surface; C) a partially absorbed (with semi-transparent body).

Table 1. Specifications of SUNPOWER solar cells

№	Specifications	
1	Manufacturer	SunPower
2	Country of origin	Taiwan
3	Panel type	Monocrystalline
4	The material of manufacture of the module	Pure silicon
5	Power, W	3.3 - 3.4
6	The voltage in the mode XX,	0.682
7	Power short-circuit current, And	6,25
8	Operating voltage, V	0.574
9	Operating amperage, And	5,8

10	The size of the solar cells, mm	125x125
11	The bending angle of the element is not more degrees	30

NAMI Russian State Scientific Research Center developed a system of additional power source on the solar cells that are integrated into the design of vehicle LADA (Fig. 1,2). The area of coverage of the surface of the car battery photoelectric converters is 1.8 m2 (115 items dimension 125x125 mm). Were applied flexible monocrystalline cells with an efficiency of at least 20% (detailed characteristics in Table 1).

The study examines the main climate zone of the Russian Federation, including those where a high density of road transport with the aim of studying the impact on the environment. Also, the mathematical pilot study in the introduction of photoelectric transducers in the design of electric vehicles was investigated the energy distribution of the sunlight on cities of the Russian Federation. The most effective in this regard were: Astrakhan, Sochi, Vladivostok. These cities represent different climatic zones, but the annual flow of energy is quite high and is approximately at the same level (table 2). These studies indicate that even at 20% efficiency solar cells per square meter the maximum amount of energy will not exceed a total of 274 kWh per year. When connecting to the Smart Grid technology V2G, it is possible that a vehicle could be a mini power station with battery and solar cells to generate electricity for domestic purposes [7]. Table 2 shows town in the Russian Federation with the highest and lowest annual rates of solar radiation energy.

Table 2. Average values of solar radiation for town of Russian Federation

Town	**Month low (December)**	**Month high (June or July)**	**The total for the year**
Astrakhan	95.8 MJ/m^2 (26.6 kWh/m^2)	755.6 MJ/m^2 (209.9 kWh/m^2)	4.94 GJ/m^2 (1371 kWh/m^2)
Sochi	124.9 MJ/m^2 (34.7 kWh/m^2)	744.5 MJ/m^2 (206.8 kWh/m^2)	4.91 GJ/m^2 (1365.1 kWh/m^2)
Vladivostok	208.1 MJ/m^2 (57.8 kWh/m^2)	518.0 MJ/m^2 (143.9 kWh/m^2)	4.64 GJ/m^2 (1289.5 kWh/m^2)
Petrozavodsk	8.6 MJ/m^2 (2.4 кВт·ч / м^2)	601.6 MJ/m^2 (167.1 kWh/m^2)	3.10 GJ/m^2 (860.0 kWh/m^2)
Arkhangelsk	4 MJ/m^2 (1.1 kWh/m^2)	575 MJ/m^2 (159.7 kWh/m^2)	3.06 GJ/m^2 (850 kWh/m^2)
Saint Petersburg	8 MJ/m^2 (2.2 kWh/m^2)	578 MJ/m^2 (160.6 kWh/m^2)	3.02 GJ/m^2 (840 kWh/m^2)

Developed and tested in laboratory conditions, optimization algorithms control the charging process and the generation of solar energy in the modes changes the light and temperature conditions (0…30 ^{o}C). Results and solutions obtained during the research work allow to expand the possibilities of electric transport with renewable energy and improve energy efficiency, reduce losses during transportation of electricity from power plant to consumer.

To perform computational experiments was chosen two basic driving cycle and one additional. The first basic cycle is a mixed cycle New European Driving Cycle (NEDC), which is currently used in the certification procedures, Rules of the United Nations No. 101, in accordance with which will be carried out experimental evaluation of the characteristics of the developed electric vehicle. The second basic cycle is WLTC (Worldwide Harmonized Light Vehicle Test Cycle) – mixed driving cycle, which is designed as a replacement for the outdated NEDC and already introduced in the European certification procedure. An additional cycle is ARTEMIS (Assessment and Reliability of Transport Emission Models and Inventory Systems) will be combined, developed in the 2000s in Europe to assess the environmental properties of vehicles. He is selected as the current model European speed limit of the road.

In the process of developing mathematical models and computational experiment for electric vehicle battery, solar cells were used annual changes in environmental factors in the city of Moscow, as well as the possibility of infrastructure for electric transport with the aim of equipping charging stations with batteries, solar cells [8]. Considered a large number of conditions that impact simulation tests WLTC cycles, NEDC, ARTEMIS change the following conditions:
- move North, South, West and East at different times of day with an interval of 3 hours;
- at different times of the year.
The result was achieved, indicating that extra power source on the basis of solar cells can generate an electric power, which is enough to increase mileage up to 20% in summer daytime in the absence of clouds (NEDC). However, in the winter in January power generation is so small that the values obtained in the calculations does not exceed 1%.

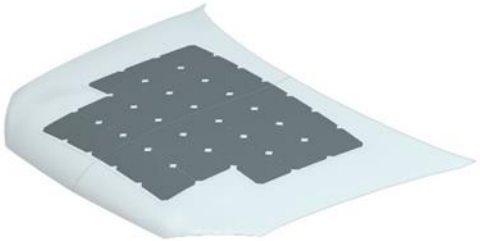

Figure 1. The location of the solar cells on the hood.

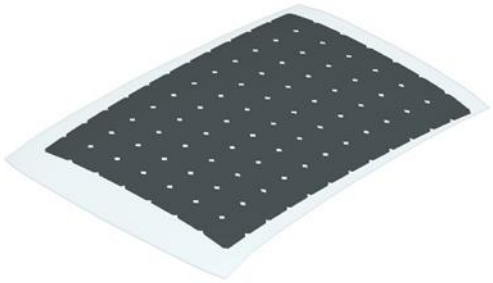

Figure 2. The location of the solar cells on the roof.

3. Results and discussion

The results of the study allow to formulate the main aspects of ensuring the effective functioning of the auxiliary power source to solar cells. Obviously, the best effect is achieved in regions with a warm climate and with minimal shading, for example, Astrakhan. However, it is known that for each degree over 25 ℃, the efficiency of solar cells be reduced. However, the estimated experiment showed the possibility of increasing mileage up to 20% through the use of a renewable source of energy. Thus, during prolonged idle electric vehicle battery self-discharge and energy costs, in the form of the cabin air, it is possible to compensate for the expense of batteries, solar cells, thus able to avoid CO_2 emissions.
Even with the introduction of Autonomous systems of heating of the battery, for example, by using thermoelectric converters Peltier, daily power consumption at -30 ℃ for at least 1.6 kW [9, 10, 11]. Therefore, long-term Parking lot in the winter periodically possible heating of the battery due to the energy received from the power source based on solar cells.

4. Conclusion

1. Claimed by manufacturers of electric vehicles operating characteristics in the form of a driving range can be increased due to additional power plant for renewable fuels – a battery of solar cells. When the current efficiency of 22%, the use of solar cells as a magnifier mileage already is relevant.
2. The use of additional power sources based on solar cells with a power of 400 watts, will in the course of the year to up to 270 kWh, which corresponds to 132 300 g/CO_2 produced by the energy sector for an equivalent amount of electricity (490 g/kWh).
3. With the introduction of additional power sources based on solar cells in the design of electric vehicles it is possible to achieve increased mileage up to 20% at certain times of the year.
4. The developed system additional power sources based on solar cells for electric vehicles, which is able to increase the mileage of electric vehicle recharging renewable energy.

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