Modeling an energy storage device for electric vehicles

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Abstract. The article discusses the most promising areas for improving energy efficiency in urban electric transport. The object of research is the rolling stock of urban passenger road transport. The subject of the study is to establish the dependence of the energy-efficiency of selecting the type of energy storage, energy consumption and power storage devices, a location of energy storage.

1. Introduction
Currently, the energy component of urban electric transport up to 30..50\% of the total costs of enterprises, so that the question related to the decrease energy use through the creation of high-tech models of vehicles, is very relevant to the GET as a whole. One such area is the development of new types of efficient energy converters which have qualitatively new properties, which enable their effective use in the transportation industry, improving efficiency, reducing power losses, increasing equipment life and reliability of the electric transport system as a whole [1].

At the turn of XX and XXI centuries, due to the rapid development of information technology, it is possible to effectively and quickly produce labor-intensive calculations, to create software systems that simulate the processes of the vehicle. As a result, it became possible to increase the accuracy of calculations significantly.

Scientists V.E. Rosenfeld, I.S. Efremov, I.P. Isaev, G.V. Kosarev, KG Marquardt, LS Bayryev, Vladimir Shevchenko VP Feklistov, A. Ruffer, D A Booth, N V Gulia, N V Schurov, V I Sopov, A A Bars, E A Spiridonov and others have made a significant contribution to solving the problems identified, such as energy efficiency for electric transport, application storage devices, the development of techniques which you estimating the actual movement processes [2-4].

2. Theory
The main reason for a loss of transport enterprises, specializing in passenger transport is a constant rise in the cost energy carrier with large energy consumption of urban electric transport. Therefore, the introduction of energy-saving technologies is particularly important [5, 6].
Under federal law on energy saving and energy efficiency, energy efficiency - a "characteristics, reflecting the ratio of the useful effect of the use of energy resources to the cost of energy resources produced in order to obtain such an effect" [7, 8]. With regard to urban electric transport, beneficial effects are to ensure comfortable conditions for passengers. Thus the specific energy consumption, measured usually in V/h×km, is a key indicator of the electric energy transport. The article deals with the urban ground trackless passenger transport. A trolleybus is the most massively used and the traditional views of urban transport.

The first vehicle energy sources define the concept of the mode of transport for urban passenger transport by road. They may be catenaries, heat engine or other drive sources of mechanical or electrical energy Rack on rolling stock [9, 10].

Figure 1. Distribution and converting electrical energy into a complex urban electric transport.
In connection with the rapid development of element base of power semiconductor technology, the introduction of which the rolling stock of urban electric transport it possible to develop new traction drives, which allow achieving significant savings of electricity consumed in the traction mode. At the ground electric truck, reducing the consumption of energy in the movement when replacing resistor-contactor control systems on semiconductor can save from 20 to 30% of consumable earlier [11].

Electrical transport is electro technical complex in which the conversion and distribution of electric energy. The main ways of distribution and transmission system in the urban electric transport powered by a contact network are shown in Figure 1.

The consumption of electric energy and converting involves two main parts public electric transport: the composition and the system of electric power. Urban energy system, feeding traction substations voltage of 6 or 10 kW are the primary source of electrical energy. The power supply system for traction substations converts values of primary voltage to the standard for electric vehicles - 600 VDC. Energy transfer to electro rolling composition provides traction network. Conversion of electrical energy into kinetic energy of motion of the electric vehicle comes to electric rolling stock, a portion of which is spent for traction electric rolling stock, less loss in traction drive [12, 13].

As well as the energy spent on the work of auxiliary electrical equipment of electric rolling stock. To determine ways to improve the energy efficiency of electrical transport complex needed cost estimate energy when converting to different stage other substantial energy saving trend is to reduce the energy loss in the power supply system. At rated voltage on tire traction station 600 may decrease the voltage at the current collector of electric rolling stock to a value of 400, i.e. the transfer of energy loss can exceed 30%. Figure 2 shows a block diagram of power consumption received from the source user. Source is a system of external power, which may be a power station, a substation connected to a traction cable or aerial power lines. Conversion electricity substation accompanied by its losses, which are reflected in the figure in the form of losses. Electricity is supplied to consumers by the traction network, the switch-off contact and a rail network, cable or air supply line. The remaining part of the consumed energy from the source is supplied to the rolling stock where distributed:
- between the traction motor;
- not traction consumers;

![Figure 2. Energy consumers.](image)

Reducing the amount of electricity consumed by the network will reduce the average size of the load of traction substations, to reduce losses on its transmission, as well as make more uniform load, reduces the conversion loss of electric power to the traction substations. Reduction of energy consumption for own needs is another way to increase the energy efficiency of electric vehicles [14,
Significant power for heating the cabin, and the amount of energy consumed to satisfy the needs of the EPS is required in the winter, in some cases even exceed the amount of energy consumed in thrust.

3. Systems simulation engine output calculation

The power of the DC motor is detected by the system, performing calculations for traction predetermined time being in traction mode. Traction trolley simplistically divided into two parts:
- constant acceleration during low speeds;
- constant traction drive power at a high constant speed;

Of these two modes is selected the mode in which the traction drive is realized tractive force is minimal. Motor shaft power is determined by the system is calculated in two ways: from the maximum speed limit \( P_{\text{max}} \) and limitation on acceleration \( P_a \):

\[
P_a = ((1 + \gamma)m + w(V)mg)\cdot V\cdot kW
\]

(1)

Also calculated acceleration of the vehicle necessary for calculating the relationship \( V(t) \):

\[
a = \frac{\min(P_a, P_{\text{max}})}{(1 + \gamma)mV} \cdot w(V)g \cdot \frac{l}{(1 + \gamma)} \cdot \text{m/s}^2,
\]

(2)

calculating engine acceleration and mechanical power traction drive in traction mode trolley shown in Figure 3, the simulation results are shown in Figure 4.

![Figure 3](image)

**Figure 3.** Depending mechanical power and acceleration traction motor speed and the path of the vehicle from time to time in the traction mode
Figure 4. Calculating the power system and accelerating the trolley in traction mode.

4. Conclusion
During the course of the research we considered the progressive system of electric supply, urban electric transport power produced by the analysis. We developed simulation model of traction drive trolley with the base of the storage of energy in the supercapacitor and software package MatLab Simulink. It is shown that the main object of study in the model is the rolling stock of urban passenger rail transport with its physical characteristics [16]. The dependencies of energy efficiency on the choice of type of energy storage, energy intensity and power of storage devices and the location of energy storage were determined.

References
[1] Bykadorov A L, Zarutskaya T A and Muratova-Milekhina A S 2015 Increase of efficiency of short-circuits fault location in traction networks of alternating current on the basis of information technologies. Bulletin of transport of the Volga region 6(54) 15-19
[2] Filyushov Yu P, Zonov P V, Malozemov B V and Wilberger M E 2011 Energy efficient control of an alternating current machine. The Polzunovsky Herald. 2011 2 45-51
[3] Kuznetsov S M 2011 Setting of electronic security with simulation model corrected. Transport Science, Technology, Management. VINITY 12 30-34
[4] Kuznetsov S M, Demidenko I S, Yaroslavtsev M V and Krivova A O 2009 Mathematical model study of traction network dynamics of direct-current railway with train starting. / Scientific transport problems of Siberia and Far East. NAWT 2 324-327
[5] Malozyomov B V, Vorfolomeyev G N and Schurov N I 2005 Reliability and diagnosing electrotechnical systems. In the collection: Proceedings - 9th Russian-Korean International Symposium on Science and Technology, KORUS-2005 347-350
[6] Ivanov G Ja and Malozyomov B V 2005 Reliable power saving electric drive of wide application. In the collection: Proceedings - 9th Russian-Korean International Symposium on Science and Technology, KORUS-2005 330-332
[7] Shchurov N I and Wilberger M E 2011 Spectral analysis of rectifier unit current for unbalance and non-sinusoidal supply voltage *Transport: science, technology, management* 12 41-43

[8] Mischenko T M 2011 The mathematic stimulation of transient process in a.c. - system “electric-traction network - LOCOMOTIVE”. *Transport: science, technology, management* 12 105-109

[9] Anurov V I 2008 Modeling of transient processes in case of short circuit in the traction network and the presence of electric locomotives on the feeder zone. *Electro. Electrical engineering, electric power industry, electrotechnical industry* 2 16-18

[10] Ardashkin I B, Yakovlev A N, Martyushev N V 2014 Evaluation of the resource efficiency of foundry technologies: Methodological aspect *Advanced Materials Research* 1040 912-916 DOI: 10.4028/www.scientific.net/AMR.1040.912

[11] Palyanova N V, Zadkov D A, Chubukova S G 2017 Legal framework for the sustainable economic and ecological development in the coal industry in Russia *Eurasian mining* 1 3-5 DOI: 10.17580/em.2017.01.01

[12] Pshchelko N S, Vodkaylo E G, Pastukhov A I 2017 Improvement of thin films adhesion by means of electric field. *Proceedings of the 2017 IEEE Russia Section Young Researchers, Electrical and Electronic Engineering Conference, ElConRus*, 7910771, pp. 1186-1188

[13] Sharok V V, Vakhnina E G, Yakovleva Yu A 2019 Health resource of national physical education and sport system: northern dimension. *Teoriya i praktika fizicheskoy kultury* 3(969) 45-46

[14] Gura D A, Shevchenko G G, Gura A Y 2016 *Journal of Engineering and Applied Sciences* 11(13) 2885-2888 DOI: 10.3923/jeasci.2016.2885.2888

[15] Dubenko Y V, Gura D A, Dyshkant E E 2019 International Multi-Conference on Industrial Engineering and Modern Technologies, *FarEastCon 2019*, 8934179 DOI: 10.1109/FarEastCon.2019.8934179

[16] Broslavsky I. I 2019 ENVIRONMENTAL SAFETY: GLOBAL WARMING AND CLIMATE CHANGE (LEGAL PROBLEMS). *Business, management and law* 4 15-20