 https://doi.org/10.1051/e3sconf/202337604022

Digital management of electricity consumption as a factor of transport company value

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Abstract. Transport industry enterprises consume a significant amount of electricity, and management impacts on this process with the help of digital technologies will reduce costs and allow to obtain other beneficial effects. The paper points out that the development of transport infrastructure, electric transport and all categories of smart transport increases the dependence of the efficiency of the functioning of transport companies on the consumed volumes and quality of electric energy. The authors considered the effects from using new methods of digital management of resource consumption, which include increasing the stability of the power system, increasing the accuracy of measuring consumed resources, as well as solving the problems of effective planning and resource allocation. The influence of the effects of digital management of electricity consumption is considered from the standpoint of value-based management. The key conditions for the information support of the functioning of control systems is a change in the format and method of information exchange, i.e. the transition from the transmission of analog data to digitized information blocks. The results of the study are to confirm the positive impact of the use of digital technologies in the management of electricity consumption, primarily on reducing operating costs and, as a result, increasing the value of transport companies, as well as highlighting the prospects for their widespread use in transport systems, which may be the subject of future research. Keywords: power consumption management; value-based management; technological innovation; AC voltage normalizer; smart transport; smart city; smart energy network; distributed control system.

1 Introduction

Digital energy as a part of digital economy consists in the formation of new mechanisms of economic interaction, giving business entities a new potential to increase the efficiency of functioning. Transport industry enterprises around the world consume a significant amount of electricity and actively introduce new technologies related to electricity consumption in one way or another. Thus, at present, the development of transport infrastructure is continuing, much attention is paid internationally to environmentally friendly electric transport and innovations in the field of smart transport. Consequently, the efficiency of the functioning of both the transport system as a whole and individual transport companies largely depends on the quality and volume of electricity consumed.

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The issues of improving the digital management of electricity consumption were dealt with by researchers Burr M.T., A. G. Fishov, V. Z. Manusov, P. V. Matrenin, Ghanim A. Putrus, Dan D. Micu, Oguzhan Ceylan, Deakin M., Reid A., Kim H., Choi H., Kang H., An J., Yeom S., Hong T., Thornbush M., Golubchikov O., D. A. Klavsuts, A. G. Rusina, and others. The theory and practice of value-based management is described in the works of many scientists: T. Copeland, A. Damodaran, T. Koller, N. Antill, K. Lee, D.L. Volkov, M.V. Melnik, V.G. Kogdenko, I.V. Ivashkovskaya, and others. The research of the above scientists has shown the following: energy is a life support industry. The economy of the state, its policy, economic activity and the position of the state in the world community is directly related to the state of energy, the high rates of development of which require the development of innovative methods for managing objects in a smart energy system - Smart Grid.

The purpose of this research is to develop digital methods for managing electricity consumption as an essential element of operating costs of transport enterprises aimed at ensuring the growth of the transport company value.

Digital management of electricity consumption in a transport system is understood in this paper as management based on automation of all business processes related to electricity consumption by transport enterprises

The achievement of this goal involves solving the following tasks:

- to determine the beneficial effects from using digital power consumption management technologies at transport enterprises;
- to choose a methodology for assessing the impact of the use of digital power consumption management technologies on the cost of business;
- to outline the prospects for widespread use of new methods of managing electricity consumption in a transport system.

The key conditions for the information support of the functioning of control systems are a change in the format and method of information exchange, i.e. the transition from the transmission of analog data to digitized information blocks.

2 Materials and Methods

One of the goals of a transport system, which includes transport infrastructure, transport companies, vehicles and ensures the functioning of all modes of transport, is to meet transport needs at minimal cost. This research is aimed at solving this issue in terms of electricity costs. Electric transport (trams, trolleybuses, trains, metro, etc.), as well as the entire infrastructure (train stations, stations, parking and repair of transport) consume a huge amount of electricity [1-3]. The basis for managing any complex system is information flows. In the energy sector, which is the fundamental branch of life support, information flows are transmitted using automated control systems [4, 5].

Generally accepted automated control systems practically do not support data exchange with information systems outside the perimeter of the enterprise and have limited computing resources. This, in turn, imposes a number of restrictions on the effective management of geographically distributed technological processes of Distributed Control System (DCS).

The real way out of this situation, according to the authors, is the possibility of conjunctive (external) influence on the system as a whole by end consumers, i.e. specific objects – consumers of electric energy and other resources, which requires the development and implementation of innovative methods and devices for managing objects in Smart Grid, Smart Cities systems [6, 7].

The proposed and investigated solution to this problem is based on the development of digital models for managing electricity consumption in the transport system based on a new technology that includes a patented method and devices – AC voltage normalizers (patents). Normalization technology has been implemented in all spheres of the economy of the Russian

Federation, the CIS, and the EU for 11 years and has already become the basis of energy cooperation of these countries.

2.1 The main effects of the use of digital technologies for managing electricity consumption in transport systems

For resource management tasks that are solved with the help of automatic process control systems, it becomes relevant to use digital technologies based on microprocessor technology, namely technologies for processing large data arrays, artificial intelligence, distributed registry systems. First of all, the use of technology will allow to obtain a significant economic effect, because transport companies around the world are consumers of significant amounts of electricity. According to Rosstat, the level of electricity consumption by transport in 2018-2019 amounted to about 90 billion kilowatt-hours per year, which corresponds to 8.1% of the total electricity consumption in the country (see Fig. 1) In many countries, this share is higher, which is an essential factor for finding solutions in terms of resource conservation, reserves for improving the efficiency of transport enterprises. In developed countries, electric transport within cities provides more than 50% of transportation [https://ru.wikipedia.org/wiki/Electric transport].

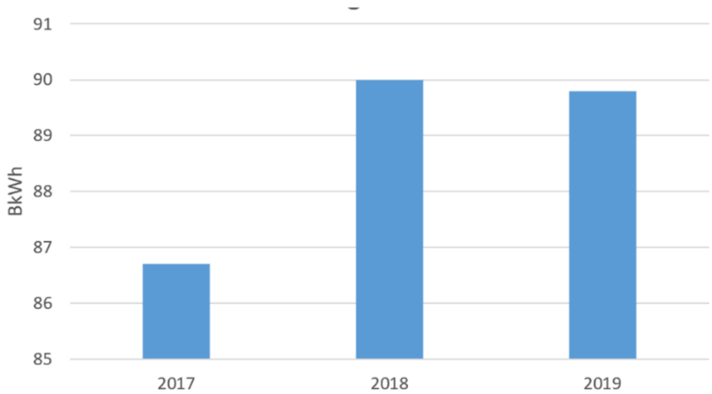

Fig. 1. The level of electricity consumption by transport in Russia. Source: compiled by the author on the [Transport in Russia. 2020: Stat.sat. / Rosstat. – M., 2020. – 108 p.].

The use of digital technologies has a systemic effect both for individual transport companies and for the entire transport system, as well as for the state.

The main effects for the transport system as a whole:

- predictive analytics of operating modes;
- planning of preventive maintenance (preventive service);
- improving the quality of operation of the main and auxiliary equipment;
- formation of a database for the implementation of the benchmarking function.

To introduce end-to-end digitalization technologies into resource supply systems, it is necessary to organize the transmission of readings from primary metering devices on electricity consumption, which are transmitted via digital communication channels to a single information and analytical center. Resource consumption, in particular, refers to the amount of electricity consumed per unit of time. These technologies can also be applied to the management of other resources (thermal energy, water supply, etc.). At that, the amount of medium measured in volumetric units is called volume flow, and in mass – mass flow. The measured parameters of the electricity used are: voltage, current, power factor (cos φ) - a scalar physical quantity showing how efficiently consumers consume electrical energy.

Based on the accumulated data, real technical and economic indicators are calculated using the digital model of the enterprise, forecast calculations are performed for the effective operation of equipment and the introduction of new technologies. Based on the collected data, it becomes possible to perform analytical calculations not only for one enterprise, but also for geographically distributed objects as a whole.

2.2. Resource consumption management based on intelligent digital devices of electricity normalizers

To use cloud computing, it is necessary to organize a channel for transmitting the values of the measured parameters of the technological processes of the enterprise to computing resources [8]. In this regard, a new Low-power Wide-area Network (LPWAN) standard has been developed, which has a data transmission range of more than 10 km with low power consumption, while data is transmitted at a low speed (~10 Kbit/s), but for telemetry tasks this speed is acceptable [9, 10].

Thus, the values of the measured parameters are digitally transmitted to cloud computing resources that are located outside the perimeter of the enterprise.

Let's consider the main types of cloud computing resources that are provided by leading providers in this field, and which can be used to solve problems of resource consumption management using intelligent digital devices – electricity normalizers:

- data storage;
- calculation of mathematical models;
- providing the results of calculations in the form of a user interface, for example, on devices such as a PC, tablet, smartphone, or for other information systems.

The results of calculations can be presented both as an interactive user interface (graphs, tables, etc.) and as open formats for machine-to-machine interaction eXtensible Markup Language (XML), JavaScript Object Notation (JSON), etc. via the Application Programming Interface (API), which is located on cloud resources

The services provided on cloud resources are constantly expanding. For example, services for working with devices in the IoT concept are already available, namely, operating systems, data collection and interpretation tools, analytical tools, remote control.

The joint use of the method and devices of normalizers and cloud computing resources makes it possible to significantly expand the range of tasks to be solved. This allows not only to reduce the costs of solving standard computing tasks, but also to develop new approaches to interaction for stakeholders, government officials, science and business.

The works [11-14] describe the results of scientific research and long–term practice of using innovative technology, including a patented method and device for controlling electricity consumption - an alternating voltage normalizer, developed and manufactured under the trademark NORMEL®© by the scientific and production enterprise AVEC LLC (Novosibirsk, Russia) - www.normel.ru. Intelligent digital devices - normalizers are connected to the electrical inputs of buildings, structures, industrial equipment, street lighting, i.e. to all consumers of electricity.

The normalizer devices can be integrated into an automated control system of the electric power system, as they have all the necessary information channels for this.

The systematic mass application of the method and devices in the electric power systems of many countries makes it possible in practice to maintain International Standards for electricity quality standards that are identical in different countries of the world, such as:

- GOST 32144-2013 - interstate standard of Armenia, Belarus, Kyrgyzstan, Russian Federation, Tajikistan, Uzbekistan - "Electric energy. Electromagnetic compatibility of technical means. Standards for the quality of electrical energy in general-purpose power supply systems";

- Standard EN 50160: 2010 (NEQ) - standards of the European Union - «Voltage Characteristics in Public Distribution Systems»;
- relevant standards in all regions of the world.

The cumulative economic effect of the normalization technology is more than 50% savings in financial and other resources related to the production, transmission and consumption of electric energy, as well as all relevant environmental and social effects.

The essence of the solution proposed by the development team is as follows - to ensure the functioning of the normalizer while preserving all its positive properties, and at the same time endowing it with new functions

A distinctive feature of the new generation of normalizers is the ability to collect data from primary metering devices of technological processes of the enterprise (current, voltage, temperature, resource consumption, etc.) and transfer the collected data via digital communication channels to a data center based on enterprise computing resources or cloud technologies.

2.3 Ensuring the growth of the cost of a transport enterprise based on methods of managing electricity consumption.

The most important indicator of the efficiency of the enterprise is the growth of its value. The effects of the use of digital technologies in the management of electricity consumption are manifested in such important aspects as reducing operating costs, improving the wear resistance of equipment by improving the quality of electricity. These effects will also lead to a reduction in the risks of entrepreneurial activity. These parameters can be taken into account in the projected cash flows from the business and, in turn, changes in cash flows can be converted into changes in the transport company value.

To perform the corresponding calculations, the income approach to business valuation is applicable, within which the discounted cash flow method should be selected. Value-based management and the features of calculations are described in [15-19]. The calculations are based on the classical discounted cash flow method and the terminal value accounting method using the Gordon model (formula 1) [20]:

$$V = \sum_{i=1}^{n} \frac{CF_i}{(1+DR)^i} + \frac{TV}{(1+DR)^n} = \sum_{i=1}^{n} \frac{CF_i}{(1+DR)^i} + \frac{CF_n \times (1+t)}{(1+DR)^n \times (DR-t)} \quad (1)$$

where

V – enterprise value; TV – terminal value$

i – year number after the valuation date;

n – number of years within the forecast period;

CF_i –cash flow of the i-th forecast year;

DR – discount rate;

t – long-term capital gain rate in the post-forecast period.

The cash flow model and the method of calculating the discount rate are selected in accordance with the specifics of a particular enterprise.

Calculations according to the formula (1) for a particular enterprise are carried out simultaneously in two situations: 1) in a situation without changes (V1); 2) in a situation taking into account the use of digital technologies for managing electricity consumption (V2). Let us consider the practice of determining the impact of using the digital power consumption management technology on transport enterprise value (Table 1).

Table 1. Calculation of transport enterprise value with and without the use of digital technology for managing electricity consumption.

Indicator	V_1	V_2
Discount rate (DR), %	19.00	18.00
Cash flow of the 1-th forecast year (CF_1), thousand rubles	10,948.52	10,733.89
Cash flow of the 2-th forecast year (CF_2), thousand rubles	11,167.49	12,159.30
Cash flow of the 3-th forecast year (CF_3), thousand rubles	11,446.68	12,463.28
Long-term capital gain rate in the post-forecast period (t), %	2.10	2.20
Terminal value (TV), thousand rubles	69,154.19	75,818.29
Enterprise value (V), thousand rubles	64,916.35	71,560.02

The calculations based on the data of a specific transport enterprise take into account the impact of the considered technology for managing electricity consumption in the following way:

- the use of technology helps to reduce the risks of economic activity, which will lead to a reduction in the discount rate by 1%;
- in the first forecast year, a decrease in cash flow is projected due to investments in energy consumption management technology, which is not covered by beneficial effects in the first year, and for subsequent forecast years and post-forecast period, energy savings of at least 10% due to the use of the technology described in the paper are taken into account;
- the change of long-term capital gain rate in the post-forecast period by 0,1 % of the base option (from 2.1 to 2.2%) is achieved due to the reduction of expenses on idle time and repair of electrical equipment and other related effects.

The difference in enterprise value ($\Delta V = V2 - V1$) shows the change in the value of a particular company due to the use of digital technologies for managing electricity consumption:

$$\Delta V = 71{,}560.02 - 64{,}916.35 = 6{,}643.67 \text{ thousand rubles}$$

Or $\Delta V (\%) = (6{,}643.67 \div 64{,}916.35) \times 100\% = 10.23\%$

Thus, calculations have shown that the use of the technology described in the paper is effective and, according to forecast calculations, allows for a cost increase of about 10%.

3 Results

The efficiency of the functioning of transport enterprises depends on the volume and quality of electrical energy consumed.

The research suggests options for using digital technologies to solve problems of managing electricity consumption, taking into account the requirements of quality, sustainability and environmental friendliness. The possibility of using innovative intelligent digital devices - normalizers is analyzed. In this case, it becomes possible to transfer part of the information functions of the automated enterprise management system to the data center, due to remote processing of transmitted data from primary metering devices of transport enterprises. Delegated information functions of automated process control systems include: event registration, information-computing and analytical functions, archiving information, logging information.

When delegating information functions, the company receives the following advantages:

- the costs of supporting the relevant infrastructure (specialists, software and hardware complexes) are reduced;
- the risks of data loss are reduced;
- the cost and timing of the introduction of new technologies are reduced;
- diagnostics of technological processes is carried out in automatic mode;
- the development of recommendations for improving efficiency is carried out by external, highly qualified specialists based on the collected data.

The main effects of the use of devices in transport enterprises:

- failures in the operation of any electrical equipment associated with voltage surges in the network are excluded;
- the service life of the equipment is increased due to the gentle mode of power supply and protection from pulse and high-frequency interference;
- the consumed electricity is saved up to 25% due to the patented "voltage limiting method" and discharge of supply lines by current if the voltage in the building is increased, which is typical for most cities of the world;
- the payment for the consumed electricity is reduced.

It is proposed to take into account the above effects from the position of influencing the value of the business based on the discounted cash flow method. Reducing the cost of electricity consumed, reducing the risks of activities and others, as well as the payback period for investments in new technologies, can be taken into account when calculating cash flows and discount rates. The beneficial effects of the introduction of digital technologies contribute to the growth of business value.

A promising task is to ensure interaction between normalizers and the data center. Machine-to-machine interaction can improve the quality of the normalizer and the technological process, by working ahead of the curve, a more objective assessment of the efficiency (economy) of work based on a larger amount of data. A large volume of data means not only data obtained directly from devices for collecting information about the consumption of resources inside the facility, but also data from external sources that are both technical in nature, describing the main parameters of the supplied resources, and information-statistical and economic in nature, for example, data on energy prices, etc.

4 Conclusion

The intelligent digital methods of electricity consumption management considered in the paper are relevant for transport enterprises, since they are consumers of a significant amount of electricity. The expected effects from the use of digital technologies make it possible to organize machine-to-machine interaction. This approach allows you to combine a network of normalizers over the Internet and consider them as part of the Internet of Things (IoT). A new class of tasks that can be solved when collecting data from normalizers in a single data processing center is described.

A new generation of normalizers is able to perform functions for collecting, processing and transmitting information on all types of resources supplied to consumers, with the possibility of using wireless technologies (GPRS, LPWAN). The use of feedback in normalizers with resource-supplying organizations makes it possible to remotely control all resources. Thus, a new generation of normalizers can perform new functions.

Creating a data collection system at the level of resource consumers (object level) with the possibility of transferring them to a higher level makes perfect sense in the case of implementing active feedback functions designed to be able to regulate resource consumption parameters. Thus, we are talking not only about the implementation of Smart Grids System functions inside the object, but also about active interaction with resource consumption management systems in general.

The use of new methods of digital management of resource consumption leads to energy savings, business value growth and other beneficial effects. It is promising to use the considered digital methods for management not only at individual transport enterprises, but also in the entire transport system as a whole.

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