Monitoring of Electrical Consumption, Including Self-Isolation During the COVID-19 Pandemic

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***Abstract*—To date, one of the most relevant tasks is a justified calculation of the electrical capacity of residential buildings and public facilities. Studies conducted by the "Roselectromontazh" Association have shown a significant difference between the actual and calculated electrical capacity, which is further confirmed by the reports of electric grid companies. In some cases, there is a 3-fold difference. This occurs due to the emergence of a sustainable culture of electricity consumption and the use of highly energy-efficient devices. In 2019, the results of the research work were taken into account in the regional urban planning standards of the Republic of Tatarstan. On average, the normative values have been reduced by 2 times. This enabled a significant reduction in the difference between the actual and calculated electrical capacity. From 2020 onwards, leading construction companies in the Republic of Tatarstan are applying up-to-date values to decrease utility services' construction costs. For power grid companies the savings consist of reduction of electrical energy losses and "locked electrical capacity" and the elimination of inefficient investments. It is important to note that specific values of electrical load were calculated taking into account summer and winter peaks in order to exclude the emergencies. However, it was impossible to predict a time when people would need to stay self-isolated at home to prevent the spread of severe acute respiratory syndrome–related coronavirus SARS-CoV-2 (COVID-2019). Corresponding diagrams relative to 2019 were constructed to determine the impact of the electricity consumption of residential buildings during lockdown.**

Keywords—locked electrical capacity, standby electric power, electrical power supply system, calculated electrical load, daily power profiles, COVID-19

I. INTRODUCTION

The Association "Roselectromontazh" is engaged in expert activities in the field of electrical production, as well as the development, approval and distribution of industry regulatory technical documentation. In 1997, the Association established the Technical Committee of Rosstandard TC337 "Electro-Building Installations", which is actively engaged in the development and approval of IEC (International Electrotechnical Commission) draft standards. In recent years, the Association has developed more than 10 standards for the status of GOST R (Russian National Standard), four sets of rules. On an ongoing basis the revision and release of regulatory and technical documentation for electrical installation works as standards of the organization in accordance with the Law on Technical Regulation (as of 10.10.2018) is being conducted. During this period, 11 instructions, 48 technology maps, 19 technical information letters and 11 standard albums were released [12].

The research work on actualization of specific calculated electrical loads is one of the priority areas for the Association. This work has been carried out since 2016 under the leadership of Dr.Tech.Sc. Professor Soluyanov Y.I [12]. Over the years, a significant difference between estimated (acting) and actual electrical loads of residential and public buildings was found. The valid values used for the design of electrical networks specified in 256.1325800.2016 "Electrical installations of residential and public buildings. Design and installation rules" [10], as a rule, are overestimated from 150 to 250% [1-3]. It should be noted that over the past decade, the electrical power consumption of household appliances has changed downwards due to the implementation of new technologies [6].

In the Republic of Tatarstan, for the first time in the Russian Federation, the Association, on the instructions of I. Sh. Fardiyev, General Director of JSC "Grid Company", accomplished the work of updating specific values of electrical loads for apartment buildings [11].

As a result of which the approval of the resolutions of the Cabinet of Ministers of the Republic of Tatarstan No. 805 dated 09.09.2019 "Republican standards of town-planning of the Republic of Tatarstan" [13]. This regulation has been implemented in practice, and developers of the Republic of Tatarstan are actively using these values to determine the declared electrical capacity in the construction of housing facilities.

Fragmentary studies of the specific electrical loads of apartments in several regions of the country, performed by the Association, have revealed their significant differences [1-3], which is further confirmed by [15]. Consequently, respective standards for regions to calculate the electric load should be implemented.

The need to carry out this work is implicitly spelled out in the instructions of the President of the Russian Federation dated May 25th, 2020 No. INS-843 "On recommendations for optimization of regulatory requirements", according to which on July 28th, 2020 The Ministry of Construction, Housing and Utilities of the Russian Federation held a meeting with the Ministry of Energy of the Russian Federation, the Federal Autonomous Organization "Federal Centre for Normalization, Standardization and Federal Centre for Normalization, Standardization and Technical Conformity Assessment in Construction Industry", major developers and

the Association on the issue of updating chapter 7 of 256.1325800.2016 "Electrical equipment of residential and public buildings. Rules of design and erection" Code.

II. Regional Differences

Measurements on transformer substations (TS) for Kazan are presented in Fig. 1 (where kl-transformer load factor). From Fig. 1 it may be concluded that TS, loaded by less than 30%, constitute approximately 80% of cases, among which 53% are loaded by less than 15%. Consequently, transformers operate with low efficiency [4,5] and high losses [14].

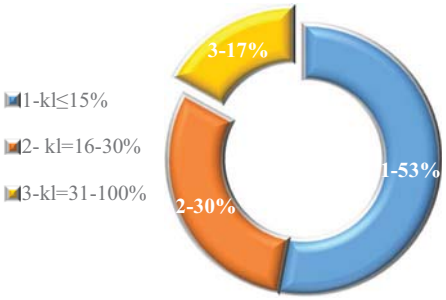

Fig. 1. Transformer substations loading capacity - 0.4/10kV in Kazan

Fig. 1. describes a large reserve of electric power. It is important to note that in most cases this power is "locked" as it is not possible to use it, but as per documents it is used.

The work carried out in the Republic of Tatarstan was based on 3 years of statistical studies of electrical loads of residential buildings and public facilities, including seasonal load peaks. The study group included several thousand houses with evidence of the representativeness of the sample. Significant differences were distinguished, which resulted in the identification of three groups of residential buildings [1-3]: the 1st group - residential buildings without elevators and with gas stoves, this category included 1-5 floors' apartment buildings; the 2nd group - residential buildings with elevators and gas stoves, this group included 6-10 floors' apartment buildings; the 3rd group - residential buildings with elevators and electric stoves, this group includes apartment buildings with the number of floors above 11 as it is impossible to install gas stoves in buildings above 10 floors without the implementation of additional measures requiring approval in accordance with the procedure established by law. Based on the analysis of the data of the housing stock in Kazan [9], the following diagram of distribution by the number of floors for apartment buildings commissioned since 2010 in the city of Kazan was obtained, as shown in Fig. 2.

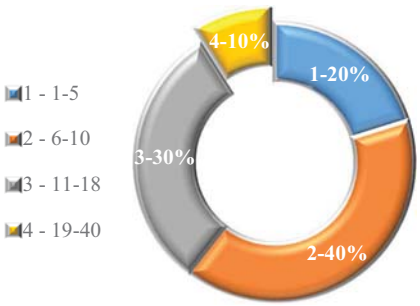

Fig. 2 Number of floors of the apartment buildings in Kazan commissioned since 2010.

Fig. 2 indicates that since 2010, the commissioning of apartment buildings of the 2nd and 3rd groups prevails in Kazan, which is equal to 80% of the total capacity. The distribution between the 2nd and 3rd groups of apartment buildings is equal. The number of apartment buildings exceeding the 18th floor is 10%.

The monitoring with the subsequent actualization of the calculated specific electrical loads will enable:

1. For the developers of the Republic of Tatarstan to reduce the cost of construction of electric networks, as the housing commissioning in the Republic of Tatarstan in 2019 equaled 2.675 million sq.m . [10]. The expected economic effect of the actualization of the estimated electrical loads for developers, based on [1], was about 495 million rubles per year;

2. For network organizations, the approximation of estimated electrical loads to actual ones will lead to a number of positive results, including reducing electricity losses, reducing "locked electrical capacity" and eliminating inefficient investments [2]. For example, for the JSC "Grid Company" (the Republic of Tatarstan) in 2019, the supply of electric energy to the network - 22.751 billion kWh, and the loss of electric energy - 1.495 billion kWh (3.86 billion rubles) [11]. On average, the cost of losses of 1 kWh of electricity is 2.58 rubles (3.86 billion rubles/1.495 billion kWh). The reduction of electric power losses may reach approximately 275 million kWh, which is 18.4% of the total electric power losses in 2019. The estimated economic effect will reach about 709.5 million rubles per year, excluding capital expenditures during construction and reconstruction of electric networks.

3. For entrepreneurs – reducing the cost of technological connectivity to electrical network.

4. For the population and businesses – the possibility of lowering or maintaining existing electricity prices, as well as reducing the cost of commercial and residential real estate by reducing the cost of construction of electricity networks.

The results showed that the generalized effect of the practical use of the "Republican standards of town-planning of the Republic of Tatarstan" [13] will significantly reduce costs for all parties. The expected annual economic effect – while maintaining the current pace of construction in Republic of Tatrstan – will be more than 1 billion rubles per year.

The same pattern is observed in the Sverdlovsk Region Research carried out for the city of Yekaterinburg.

In the city of Yekaterinburg, the JSC Electric Grid Company of Yekaterinburg provides electricity transmission and technological connection of consumers. [8].

Analysis of the loading of transformer substations of free power at power centers below 35 kV at the end of the 4th quarter of 2018 [8] is presented in the Fig. 3.

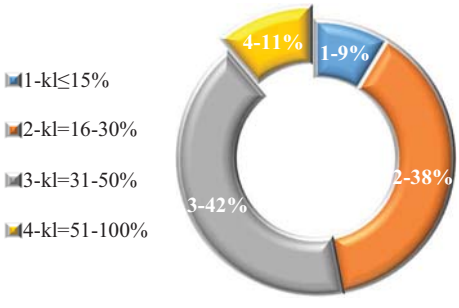

Fig. 3 Transformer substations loading capacity - 35kV in Yekaterinburg.

Fig. 3 shows that transformer substations working with a maximum load of less than 50% constitute approximately 89%, of which 47% are loaded by less than 30%. Consequently, the data indicate that there is a problem with a significant discrepancy between actual and calculated electrical loads. It is important to note that TSs in Yekaterinburg are more loaded than in Kazan. This once again demonstrates the need to actualize the calculated electrical loads for each region separately.

It is necessary to take into account the regional nature of the loads, as fragmentary studies of the specific electrical loads of apartments in several regions of the country, performed by the Association, have revealed their significant differences [1-3]. Based on the analysis of information from the housing stock of Yekaterinburg [9,16], the distribution of apartment buildings by number of floors was obtained. Therefore, Fig. 4 shows the number of floors of apartment buildings for Yekaterinburg, which have been built and commissioned since 2010.

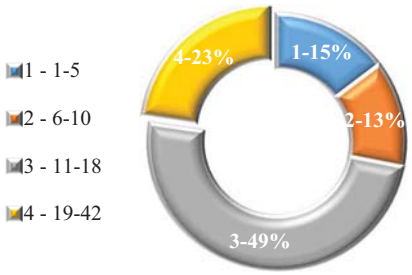

Fig.4 Number of floors of the apartment buildings in Yekaterinburg commissioned since 2010.

Fig. 4 demonstrates that commissioning of the 3rd group of apartment buildings in Yekaterinburg, which constitutes 72%, has been prevailing since 2010. The number of apartment buildings exceeding the 18th floor is 23%, which is more than twice as much as in Kazan. Comparing Fig. 2 and Fig. 4, it can be concluded that the number of floors considerably differs from the city of Kazan, which also indicates regional differences. The analysis of the electricity consumption of the apartment buildings in Yekaterinburg is presented in Fig. 5.

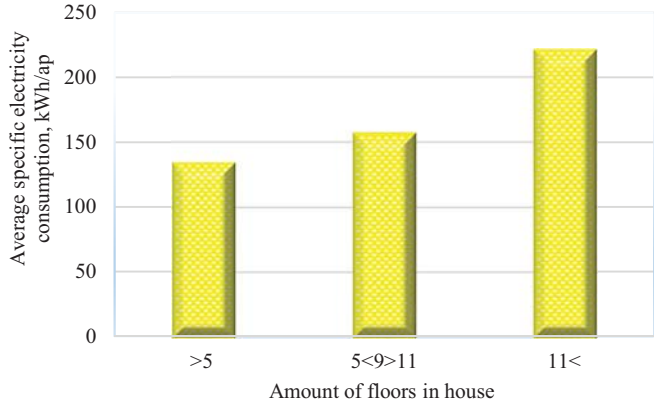

Fig. 5. Electricity consumption of apartment buildings for the city of Yekaterinburg (apartments and general household loads).

Fig. 5 as well as [1-3] present the division into three groups. Power consumption of apartment buildings, Fig. 5, has demonstrated the similarity with Kazan [1-3]. Fig. 6 demonstrates the power consumption depending on the number of rooms in an apartment.

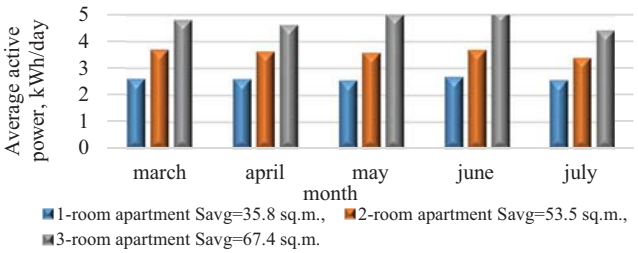

Fig.6. Electricity consumption depending on the number of rooms in an apartment.

III. Metering of Electricity Consumption During Self-Isolation During the COVID-19 Pandemic

The actualization of estimated electrical loads should be based on at least a 3-year survey [1-3] in order to consider seasonal peaks of electrical loads and climatic anomalies. However, the situation in which almost the entire population is self-isolated in their apartments (houses) during the COVID 2019 pandemic is impossible to predict. A period of non-working days was introduced in the Russian Federation from March 30th to May 11th, 2020. A significant shift in electricity consumption was assumed. In this regard, the studies to measure electricity consumption during the period of self-isolation relative to 2019 for all groups were conducted. The example for the 2nd group of apartment buildings is illustrated on Fig. 7, and for the 3rd group on Fig. 8 (1-number of apartments with reduced electricity consumption relative to 2019; 2-number apartments with increased electricity consumption relative to 2019; 3 - electricity consumption of the house relative to 2019). Apartment consumption data were provided by LLC "DOMKOR" for Naberezhnye Chelny.

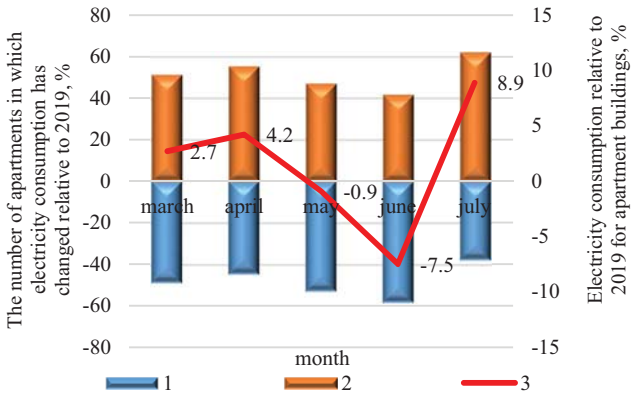

Fig. 7. Electricity consumption shift in 2020 relative to 2019 for the second group of apartment buildings.

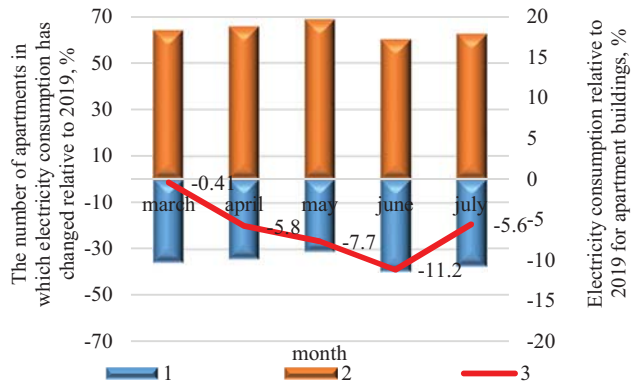

Fig. 8. Electricity consumption shift in 2020 relative to 2019 for the third group of apartment buildings.

Based on Fig. 7 and 8 an insignificant change in power consumption compared to 2019 can be observed. Fig. 8 illustrates a decrease in electricity consumption, which could be related to the fact that some residents moved to private houses for a more convenient lockdown. Fig. 9 shows the electrical load of General Secondary Schools during working and non-working days.

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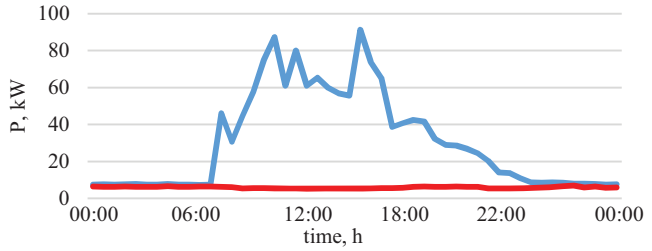

Fig.9 Load curve of the General Secondary School with a total number of 1214 students.

Fig. 9 indicates that on non-working days there is practically no electrical load. Fig. 10 illustrates the electrical load of preschool educational institutions during working and non-working days.

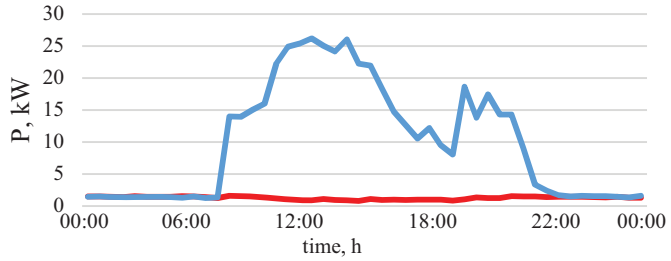

Fig. 10 Load curve of the preschool educational institution with a total number of 331 pupils.

Fig. 10 indicates that on non-working days, the electrical load is much lower than on working days. That can also be explained by the lockdown. As the load of public and residential buildings is centered on TS, during lockdown they were loaded less than on working days. Hence, such circumstances do not contribute to an increase in the electrical load on transformer substations.

IV. Conclusions

The following can be regarded as conclusions on the work done:

1. The electrical consumption of apartments in the period of self-isolation in relation to the same period in 2019 has changed insignificantly. The TS loading capacity in the period of lockdown has decreased due to the non-working General Secondary Schools and preschool educational institutions.

2. The monitoring of electrical consumption during the period of self-isolation to prevent the spread of COVID-2019 did not exceed the standard rates for the Republic of Tatarstan, thus confirming their efficiency despite these unprecedented circumstances.

3. In Sverdlovsk Region, as well as in many regions of the country, an underloading of the majority of TS is observed. There are regional differences, including the number of floors of apartment buildings, indicating benefits of developing of regional standards. Electrical energy consumption of apartments depends on the number of rooms in them. Therefore, it is necessary to take into account these data when calculating the electrical capacity. The annual economic effect for the Sverdlovsk Region will be at least 1 billion rubles, if the current rate of construction is maintained.

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