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INFLUENCE OF CLIMATIC CONDITIONS OF RUSSIA AND THE COUNTRIES OF THE NEAR EAST ON LIGHTING EQUIPMENT

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ABSTRACT

The digital economy assumes an increase in the role and importance of the lighting engineering science in the industrial countries. Nowadays, the development of a country is largely characterized by its “light supply” with minimum energy consumption. In modern Western Europe, for example, it is impossible to separate climate protection policies from energy policy. In the countries of the Middle East, there is a rapid development of the construction industry as many residential and public buildings are being built, and energy consumption issues are acute. The article studies the influence of the light climate of Russia and the countries of the Middle East on the development of construction lighting equipment, which enables to optimize energy consumption, create comfortable working and leisure conditions.

Keywords: light, local climate, cloud cover, sky brightness, SNiP, daylight, artificial lighting, energy audit, energy saving, energy efficiency

1. INTRODUCTION

The standard of living and civilization in the twenty-first century are determined by the use of energy resources. The growth of energy consumption all over the world put on the agenda the need for enterprises and organizations to implement the international standard ISO 50001: 2011. Achievement of energy efficiency in modern industry is achieved not through the introduction of new energy-saving technologies, but through the changes in methods and management techniques [1,2,3]. Energy saving plays a primary role in shaping the world environmental policy. Thermal power plants running on coal and fuel oil, lead to pollution of the atmosphere and water. Currently, artificial lighting amounts to more than fifteen percent in the global energy consumption of the world community. Increasing energy consumption (Fig.1) and CO_2 emissions (Figs.2, 3,4) to the atmosphere contributes to the greenhouse effect and ultimately leads the world civilization to global climate change.

The British standard BS8207: 1985 with the changes introduced in 1994 continues to operate up to the present. The standard is used in the design of new buildings, repair of existing buildings, maintenance activities for residential buildings. Australian standards AS3595: 1990 and AS3596: 1992 are dedicated to financial aspects. For example, the standard AS3595: 1990 provides guidance for the financial evaluation of business projects under the energy management program. The standard AS3596: 1992 includes guidelines that allow users to analyze energy saving proposals.

The second edition of the Australian/New Zealand energy AS/NZS3598: 2000 is dedicated to the energy audit. The Danish standard DS2403: 2001 is focused on organizations implementing a full-fledged energy management system. The Irish Standard IS343: 2005 is developed by the Task Force of the National Standards Authority of

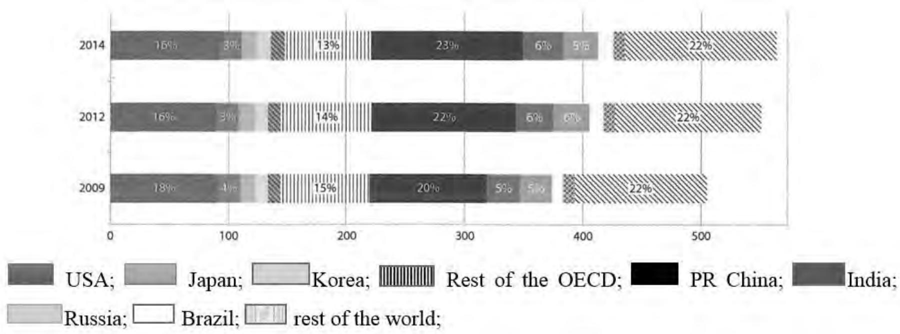

Fig. 1. Use of energy by countries or a group of countries in 2009, 2012 and 2014. [Calculations based on Extended World Energy Balances (IEA, 2016b)]

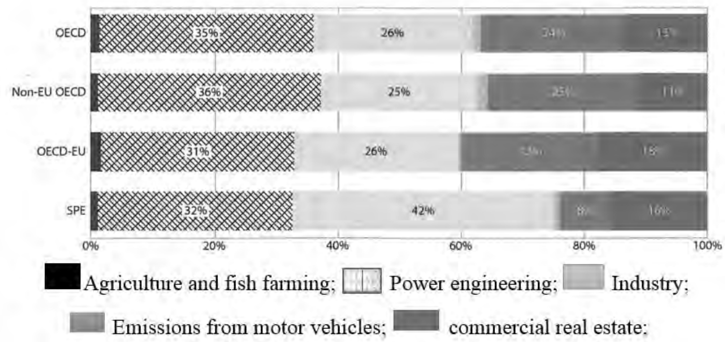

Fig. 2. Composition of CO_2 emissions from various economy sectors, 2014, in %. [Calculations based on Extended World Energy Balances (IEA, 2016b)]

Ireland (NSAI). The American national standard ANSI/MSE2000 for management system for energy (MSE) is adopted in the US in April 2005. The introduction of the standard allows organizations to lower energy costs and energy consumption provide control over the state of the environment. The American Standard ANSI/IEE739: 1995 contains a set of practical recommendations for energy management [2].

In the Russian Federation, in the field of energy conservation in 1999, next national standards were published:

– GOST R51387–99 “Energy Saving Normative and Methodical Support Basic Provisions”;

– GOST R51379–99 “Energy saving; Energy Passport of the Industrial Consumer of Fuel and Energy Resources; Basic Provisions; Typical Forms”;

– GOST R51541–99 “Energy saving; Energy Efficiency; Composition of Indicators; General Provisions”.

The Federal Law of November 23, 2009, N261-FZ “On Energy Conservation and on Improving Energy Efficiency and on introducing Amendments to Certain Legislative Acts of the Russian Federation” is important for national lighting technology [3].

In accordance with the Federal Law of the Russian Federation “On Energy Saving and on Improving Energy Efficiency and on Amending Certain Legislative Acts of the Russian Federation”, the Ministry of Energy of the Russian Federation issued Order No. 400 of June 30, 2014 “On Approval of Requirements for Conducting an Energy Survey and its Results and Rules for Directing Copies of the Energy Passport Compiled Based on the Results of the Mandatory Energy Audit”. The order specifies the requirements for conducting an energy survey and its results, which are assigned to self-regulated organizations in the field of energy inspection (hereinafter referred to as SRO), as well as to individuals entitled to conduct energy audits and to members of the SRO (further – energy auditor).

With clear-sky models, the countries of the Middle East need to abandon the British standard for natural light systems characteristic of the cloudy sky. The British colonization of the Middle East undoubtedly increased the level of lighting engineering culture. Today, when building residential and industrial buildings, it is necessary to take into account that the characteristics of the light climate in the UK, when designing natural lighting systems, are not applicable to the Middle East. The Middle East is a region with a total area of about 5,207,538 square kilometres, which is located in South-West Asia [5].

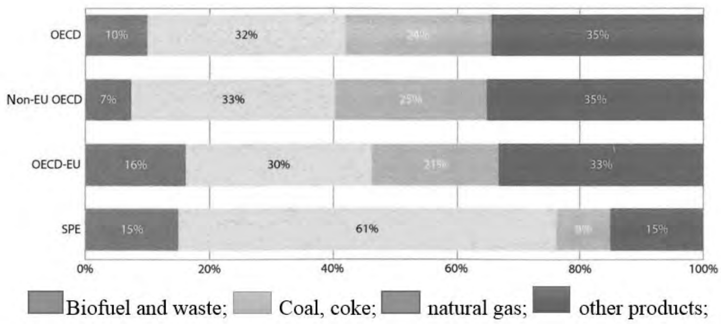

Fig. 3. Composition of CO_2 emissions as a result of using fuel energy for various groups of countries, 2014, in %. [Calculations…]

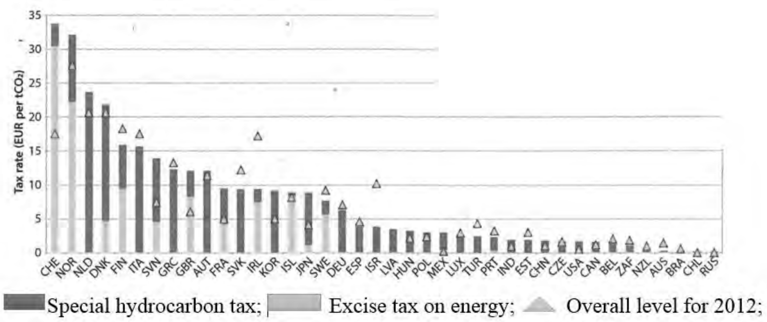

Fig. 4. Average effective tax rates from taxes and specific taxes on carbon by country in the road sector in EURO/tCO_2, 2015 and 2012. [Taxing Energy Use 2018. Companion to the taxing use Database]

2. THE PLACE OF LIGHT-CLIMATIC FACTORS IN THE CONSTRUCTION OF PUBLIC AND PRIVATE BUILDINGS

In the distant 1930s, the Soviet Union adopted the “Rules and Norms for the Development of Populated Areas, Design and Construction of Buildings and Structures”, regulating the ratio of the light area of windows to the floor area in residential buildings: from 1/10 to 1/7 for southern regions and from 1/8 to 1/6 for the middle and northern regions. Important was the climatic paradigm of the Soviet Union: in 1934, four regions were identified (based on the air temperature data for January and June): northern, middle, southern and subtropical [6]. In 1938, design temperatures were set to determine the amount of required resistance to the heat transfer of the outer walls (Chaplin’s formula). In 1948, in the “Rules for the Design of Residential Buildings,” the country’s territory is divided into five regions. Important for understanding the meaning of light engineering in construction is SNiP II-4–79 “Natural and Artificial Lighting”, 1980. In 1995, the Ministry of Construction approved SNiP 23–05–95. Beginning in 2011, in accordance with the Decree of the Ministry of Regional Development of the Russian Federation, the updated SNiP 23–05–95 began to be applied in the framework of the Code of Rules SP.52.13330.2011 [7]. In 2016, SP.52.13330.2011 partially lost its validity except for SP.52.13330.2011 “SNiP 23–05–95” “Natural and Artificial Lighting”, included in the List of national standards and codes of practice [7].

Methods for calculating climatic parameters for the Russian Federation are based on the scientific and applied guide to the climate of the USSR 1–34, parts 1–6 (GIDROMETEOIZDAT, 1987–1998). Simultaneously, on January 1, 2015, SNiP 23–02–99, which sets the climatic parameters that are used in the design of buildings and structures, heating, ventilation, air conditioning, water supply, planning and building of urban and rural settlements, operates on the territory of the Russian Federation [8].

The decree of the Chief State Sanitary Doctor of the Russian Federation of October 25, 2001 N29 “On the implementation of SanPiN 2.2.1/2.1.1.1076–01” contains mandatory requirements for the insolation of residential and public buildings, children’s educational and health institutions. The parameters of the light climate are calculated according to the formula:

$$E_{gl} = E_d + E_s + E_e,$$

where E_{gl} is the Global illumination, E_d is the direct sunlight; E_s is the diffuse light of the sky; E_e is the light reflected from the earth, on four sides of the world. The British standard of illumination is not applicable for the Middle East region: measurements of global illumination have shown that the level of outdoor illumination during working hours is above 2000 lx, while the British standard provides 5000 lx. The level of global coverage for most countries in the region ranges from 20,000 to 1,200,000 lx and allows the use of light potential for both industrial and residential premises. The category "light field" is defined through the concept of a light vector [9]. The definition of the light field is given in A.A. Gershun "Theory of the Light Field" (1936) [10].

Examples of natural illumination in the countries of the Middle East are much important. As an example, let us take a seven-story office building in Jordan, painted in beige with a reflection coefficient ρ and an area of 1000 m^2. As a source of daylight in the building, side windows with dimensions of (2×1.2 m) and upper zenith lanterns of 1.5 m in diameter are used. The illumination within the office premises during the calendar year was measured using sensors (Luxmeter-Pico), located at the level of the working surface. The measurements showed that the level of natural lighting of office premises (300 lx) for eight months is sufficient without the use of artificial lighting. Let us look at the calculation of the cost of consumed electricity in public lighting systems. As a basic example, consider a typical public building in Jordan. For artificial lighting, lighting systems with fluorescent lamps of 2×36W are used with electromagnetic ballasts [11]. These lamps have a loss of 10 % of the power consumption. For calculation, we use the fifth-floor systems: the number of lamps (including ballasts), their power, losses in the EM-ballast system, and the cost of consumed electricity. The total number of lighting chandeliers is 264 pieces, power and 10 % loss in ballasts, 72+10 = 82 W; 264×82 = 21.648 kW; working hours (7 hours); daily power consumption – 21.648×7 = 151.536 kW; daily power consumption of seven floors: 151.536×7 = 1061 kW; monthly power consumption (22 working days) 1061×22 = 23342 kW, all seven floors per year consume 22770×12 = 280104 kW; the cost of 1 kW of electricity is 0.11 Euro. Thus, the annual cost of electricity consumed in the seven-story office building is equal to 280104×0.11 = 30811.4 Euro [12].

3. CONCLUSION

The article substantiates the necessity of further development of construction lighting for the economy and reproduction of generator capacities of electric energy. For the Russian Federation, the correct light-climatic zoning is extremely important, enabling to calculate the economic effect from the introduction of new building technologies that provide for the use of energy-saving technologies. The paper explains the economic efficiency of using natural lighting systems in public buildings. The climatic conditions of the states of the Middle East and South of Russia, with differences in the temperature regime and the amount of precipitation, have many common features: numerous sunny days a year, beautiful ecology. The use of positive experience of the Middle East countries will find wide application in the construction lighting equipment of our country. In the "southern" regions of the Russian Federation, it is advisable to reduce the areas of light-holes.

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