



ANALYSIS OF ELECTRICITY USE IN THE TOURISM SECTOR OF IVANO-FRANKIVSK REGION

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Keywords: ecological safety, tourism industry, electricity consumption, renewable energy sources.

Abstract: *The article presents an analysis of electricity use in the tourism sector of Ivano-Frankivsk region. The territorial structure of electricity consumption distribution in the tourism sector across the regions of Ivano-Frankivsk region has been studied, and quantitative indicators of electricity use by the tourism sector over the last five years have been modeled. It has been demonstrated that as the number of tourists increases, the proportion of electricity consumed from the overall energy network also increases, as the share of electricity generated from renewable sources for self-sufficiency of the tourism sector is currently negligible. Analysis of global experience allows us to assert that the use of renewable energy sources is environmentally friendly, modern, safe, and resource-efficient, and is the path chosen by all developed countries. A review of information sources suggests that modern tourism development includes several aspects: reducing carbon footprint, reducing the impact on local ecosystems, and increasing economic benefits for local communities. It is important to understand that expenditures on ecology and nature conservation measures are not just unavoidable costs, but also investments in business. Such an attitude allows for benefits and profits. Investments in green technologies always pay off, as today's modern tourists are willing to pay for comfort and ecology. The necessity of referring to global experience in using renewable energy sources in tourism is emphasized, and trends in implementing global experience in the practice of tourism industry in Ivano-Frankivsk region are analyzed.*

1. INTRODUCTION

In the modern world, the development of research on environmental safety is becoming increasingly relevant, especially when it comes to sustainable development and ways of

preventing negative impacts on the environment through the use of alternative sources [1]. Additionally, the tourism industry is gradually recovering after experiencing catastrophic consequences during the pandemic. The latest UNWTO data indicate that tourism is slowly returning to pre-pandemic levels starting from 2021. However, this positive trend also brings about a number of negative impacts on the environment, as the share of electricity use, water supply, and pollution in recreational areas increases. Today, it is extremely important for Ukraine to address the issue of rational use of electricity, as the energy infrastructure has suffered catastrophic consequences from military actions on its territory [2]. Analysts estimate that the full restoration of the energy infrastructure could take from two to five years, and restrictions on electricity use may last until the end of the war. Since the tourism industry is directly dependent on the energy system and requires round-the-clock electricity supply, it is necessary to study electricity usage trends in the largest tourist areas of Ukraine [3].

Since February 2022, the number of internally displaced persons in the Ivano-Frankivsk region has reached almost 140,409 people, according to the head of the regional military administration. In the first months of the war, the hotel industry in the Ivano-Frankivsk region reached 100% occupancy rate, which negatively affected the level of environmental impact of accommodation facilities, as the use of electricity increased several times, leading to an increase in PM10, SO₂, and NO_x emissions. Therefore, we consider research on the use of electricity in the tourism industry to be relevant and will lead to further addressing the issue of increasing the level of ecological safety of the territory. It also stimulates the search for new energy supply systems for the tourism industry in order to reduce environmental damage.

2. RESEARCH COURSE

Based on the above analysis of the problem and the accumulated scientific and practical experience, the following tasks have arisen before us:

- to study the ecological problems and negative consequences caused by irrational use of energy resources;
- to investigate the current state of tourism development in the Ivano-Frankivsk region;
- to analyze the use of electricity in the Ivano-Frankivsk region and to investigate the share that falls on the tourism industry;
- to study the prospect of widespread use of renewable energy sources (RES) in the tourism sector.

The article employs general scientific methods, including dialectical method and systemic approach. Additionally, analysis and synthesis methods, as well as statistical analysis, were used to investigate the use of electricity by the tourism sector.

3. RESULTS

Ecological safety during the exacerbation of threats associated with the negative impact of war on the environment is the most important component of overall safety. Situations related to natural and man-made safety are considered at meetings of the National Security and Defense Council of Ukraine. The materials of such discussions form the basis of decrees of the President of Ukraine. Decrees coordinate the efforts of executive authorities aimed at preventing emergencies, disasters, and other extraordinary situations, as well as aimed at improving the system of regulation and improving the state of natural and man-made safety [3].

According to energy expert V. Vidzyhovskiy, in the conditions of war, it is necessary to have prepared solutions to maintain reliable operation of Ukraine's energy security. In addition, the director of energy programs at the Razumkov Center, Volodymyr Omelchenko, believes that the risks of Russian missile strikes on Ukraine's energy infrastructure are directly proportional to the de-occupation of Ukrainian territories [3]. Therefore, the destruction of thermal power plants (TPPs) and combined heat and power plants (CHPPs) is a significant problem for ecological security, as it leads to uncontrolled air pollution, which is assessed by three indicators of emissions: PM10 - solid micro-particles of ash dust with a size of up to 10 microns, which can cause respiratory diseases; SO₂ - sulfur dioxide, which in high concentrations can cause life-threatening fluid accumulation in the lungs; NO_x - nitrogen oxides - gases that cause inflammation of the respiratory tract and disrupt cellular mechanisms [4].

Furthermore, thermal power plants (TPPs) are one of the main sources of environmental pollution, causing acid rain that drastically reduces soil fertility and crop yields, and leads to forest destruction. Just one coal-fired TPP with a capacity of 1000 MW emits about 90 tons of arsenic, 300 tons of barium, 20 tons of mercury, and other toxic elements into the environment annually. Even the emissions of radioactive substances from coal-fired TPPs are 2-5 times higher than those from nuclear power plants. Therefore, the issue of reducing the ecological footprint of the energy system remains relevant.

In particular, the Cabinet of Ministers of Ukraine's Order No. 907-r dated August 4, 2021, approving the Energy Security Strategy, states that the country's energy infrastructure is worn out and characterized by high energy losses during production, transportation, and consumption, a lack of energy-efficient changes, and the structure and characteristics of generating capacities do not meet the needs. Furthermore, the generating capacities that operate using coal are among the largest polluters of the environment, are on the brink of a critical resource limit and physical deterioration, and require replacement with more sustainable and environmentally friendly energy production. [5]

To analyze the use of electricity in the tourism sector, it is advisable to analyze the latest official statistical indicators of the development of the tourism industry in the Ivano-Frankivsk region.

Starting from 2015 to 2018, the tourism industry in Ivano-Frankivsk region had a positive trend of increasing the number of tourists. In 2017, the region was visited by 2.1 million tourists, while in 2018 the number increased to 2.2 million. Since 2019, there has been a slight decline in the number of tourists, with 2 million visitors recorded that year. In 2020, the figure was 1.8 million, a 10% decrease from the previous year. In 2021, the number of visitors returned to the 2019 level and amounted to 2.0 million tourists. *Figure 1* shows the number of tourists who visited the region from 2017 to 2021.

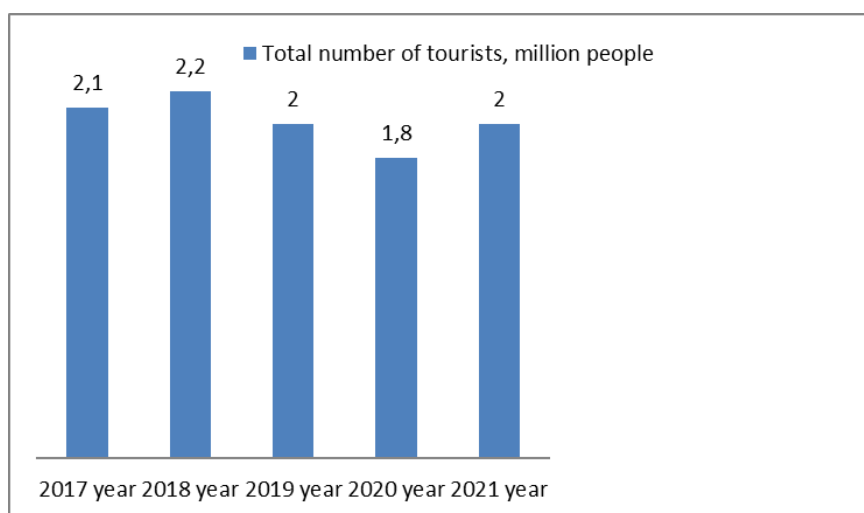


Figure 1. The total number of tourists who visited the Ivano-Frankivsk region in 2017-2021 [6]

The website of the Ivano-Frankivsk Regional State Administration does not provide data on the consumption of natural gas and electricity in the Ivano-Frankivsk region, so we can model the calculation of one-time electricity usage by tourists.

According to energy experts, on average, one person consumes approximately 11.47 kWh of electricity per day [7]. Accordingly, the daily electricity consumption by tourists over the past five years is as follows:

- In 2017 - 24 million kWh;
- In 2018 - 25.23 million kWh;
- In 2019 - 22.9 million kWh;
- In 2020 - 20.64 million kWh;
- In 2021 - 22.9 million kWh.

According to the results of a monitoring sociological study of the tourism industry in the Ivano-Frankivsk region [8], the average stay of tourists in the region is 3 days, so we can obtain an approximate indicator of electricity consumption by the tourism sector per year. The graphical representation is shown in *Figure 2*.

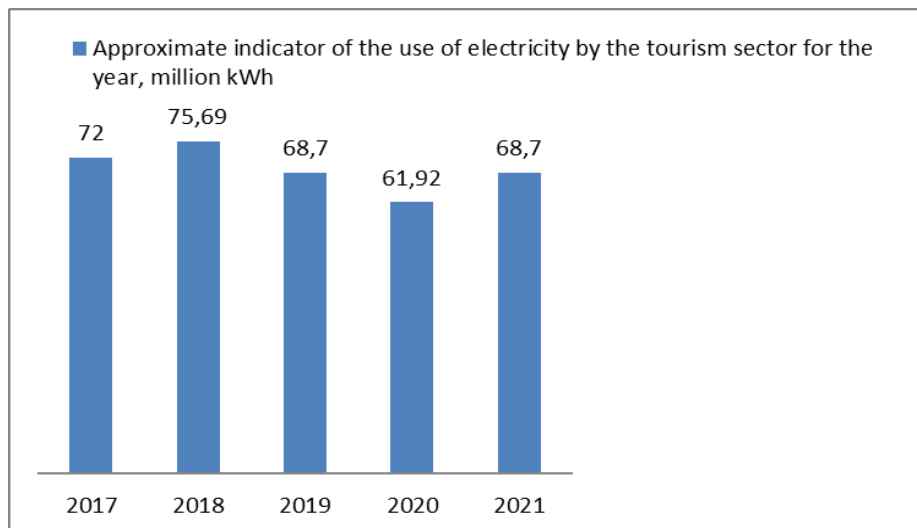


Figure 2. Estimated indicators of electricity use (million kWh) by the tourism sector of the Ivano-Frankivsk region over the past five years

Thus, as the number of tourists increases, the share of electricity consumption also increases. The geography of the visited regions in Ivano-Frankivsk region is as follows: the largest number of tourists were concentrated in the territories of Polianytska local community, Yaremchanska local community, Ivano-Frankivsk city, and Vorokhtianska local community.

In the report by the Chief of the Tourism Department of the Department of International Cooperation, European Integration, Tourism, and Investments of the Ivano-Frankivsk Regional State Administration, Vitaliy Perederko, it was noted that the tourist tax of Ivano-Frankivsk region for 12 months of 2022 amounted to 17.96 million UAH. The largest territorial revenues were recorded in the following communities: Polianytska - 9,813.02 thousand UAH (54.65% share of the total volume of revenues in the region), Yaremchanska - 3,274.08 thousand UAH, Ivano-Frankivska - 2,428.72 thousand UAH, Vorokhtyanska - 975.15 thousand UAH, Kosivska - 306.23 thousand UAH, Vygodska - 187.75 thousand UAH, Kolomyiska - 166.95 thousand UAH, Verkhovynska - 156.98 thousand UAH, Delyatynska - 81.34 thousand UAH, Bohorodchanska - 80.32 thousand UAH [8].

Therefore, based on this data, we can model the territorial structure of the distribution of electricity consumption by the tourism sector in Ivano-Frankivsk region, *fig. 3*.

So, the most energy-intensive area in the tourism sector is Polyanitska tourist group, which accounts for approximately 56% of the total electricity consumption in the tourism sector of Ivano-Frankivsk region. Therefore, the most relevant area for the development and implementation of alternative sources of electricity production is Polyanitska tourist group.

Currently, the tourism sector in Ivano-Frankivsk region almost does not use renewable energy sources in its activities. We believe that in this case, there is a need to turn to the world experience of using renewable energy sources in tourism and implement it in the practice of the tourism industry in Ivano-Frankivsk region.

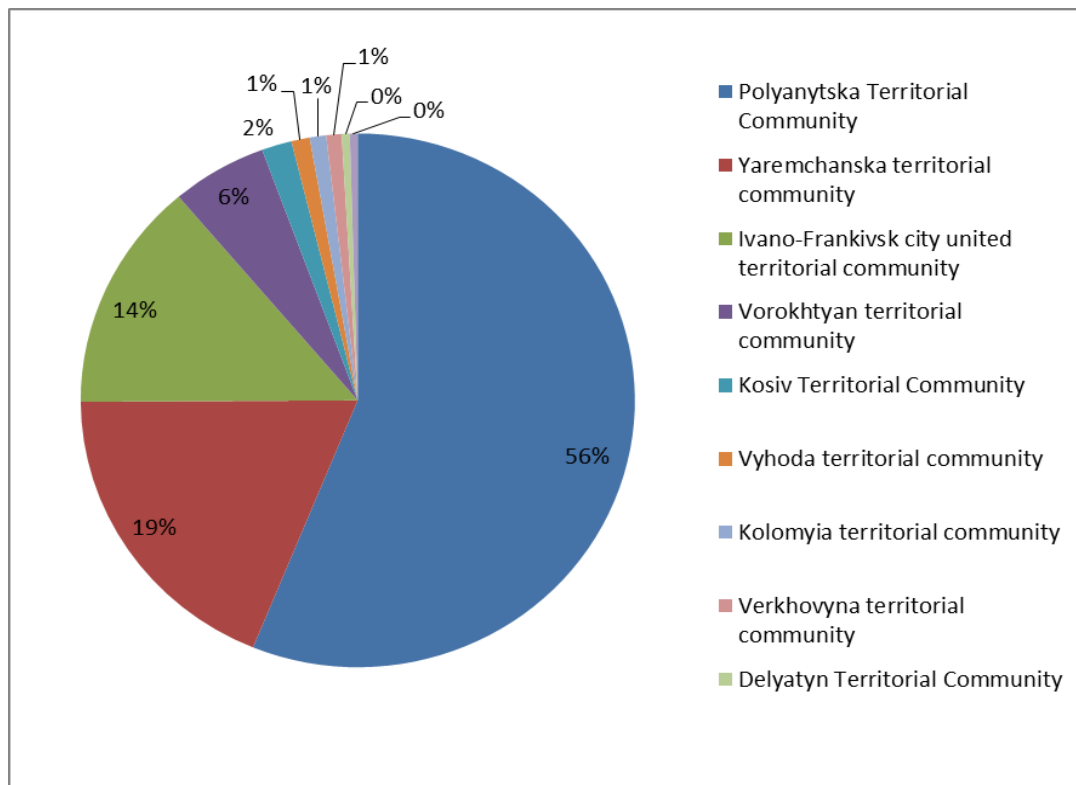


Figure 3. Territorial structure of distribution of electricity consumption by the tourist sector of Ivano-Frankivsk region

In recent years, due to a significant decrease in the cost of photovoltaic panels and, consequently, the production of electricity on them (up to 0.05-0.10 USD per kWh), their use in providing energy for tourist and hotel facilities is becoming increasingly economically effective. Generating electricity on solar installations located on the roofs of hotels, parking lots, and tourist facilities allows owners to reduce the amount of network electricity consumption, not only reducing costs but also attracting tourists with "green energy supply." For tourist facilities connected to power grids, the trend of creating duplicating capacities on renewable energy sources together with diesel generators to provide uninterrupted tourist services during wartime is particularly promising [9].

Alternative energy sources are not considered a niche product. First of all, providers of transport services - one of the pillars of the travel industry - see a perspective in eco-innovations.

Translate this text into English. Today, customers of the German railway company Deutsche Bahn on domestic IC and ICE routes use exclusively environmentally friendly electricity; by 2030, 80% of the group's energy needs will be met from renewable sources. And together with the Siemens Mobility division, trains with hydrogen fuel cells are being developed, which will be tested from 2024 with the prospect of replacing diesel locomotives still used on some non-electrified routes.

With a greenhouse gas emission level of 31 grams per passenger-kilometer, the bus sector in Germany can already claim to be the cleanest type of transport in the tourism industry.

The total environmental costs of a bus, which in addition to CO₂ emissions also include construction, maintenance, disposal, and fuel supply, are exceptionally low, not least thanks to ongoing innovations [10, p.139].

As hotels are the second-largest energy consumer in the tourism industry, it is crucial that accommodation providers reduce their emissions and use renewable energy. There are compelling economic arguments in favor of reducing emissions in the hotel industry: transitioning to low-carbon models will ensure cost-effectiveness while simultaneously boosting competitiveness.

There are energy-efficient technologies that facilitate such transformations, as well as advanced methods of hotel design and operation. However, to achieve full success, the market must provide favorable conditions for low-carbon growth, including financial, structural, institutional, and regulatory mechanisms.

At the same time, small and medium-sized hotels, which make up 90% of the hospitality sector in Europe, need access to adequate and easily accessible information about low-carbon business models, as well as independent technical consultations and financial support. Measures to increase awareness involving consumers and utilizing digital technologies will allow for necessary changes in behavior and attitudes towards this issue [11].

The founder and chairman of Jetwing (Sri Lanka) has always believed that people and nature cannot exist in isolation from each other. Accordingly, Jetwing Hotels has always demonstrated its commitment to environmental conservation, which has been embodied in the company's Sustainability Strategy. To reduce emissions associated with hotel activities, Jetwing Hotels first reduced its dependence on the grid by reducing energy consumption through innovative energy-efficient solutions, and secondly invested in solutions related to renewable energy.

More than 50% of the energy needs of Jetwing Hotels are met through renewable energy sources such as fuelwood from sustainable primary sources, solar electricity (photovoltaic panels), solar thermal energy, and biogas. To achieve this, absorption refrigerators, centralized hot water supply systems, solar photovoltaic panels on roofs, and biogas reactors are installed in all hotels. Reducing dependence on the national grid is strategically important and allows this network of hotels to actively use its own methods to ensure energy and ecological sustainability [12].

Another good example: a number of tourist attractions in Egypt have started transitioning to the use of clean or renewable sources of energy in an effort to conserve the environment and attract "green tourism." The transition to renewable sources of energy is taking place within the framework of the "Green Energy Protocol," signed in December 2013 by the Ministries of Ecology, Tourism, and Electricity. The protocol encourages the use of wind, solar, or water power in electricity production, as electricity production in Egyptian tourist facilities generally produces emissions of about 35 million tons of carbon dioxide per year into the atmosphere.

Egypt has initiated a series of projects related to the application of various target indicators related to "green" and renewable energy, which aim to generate over 50% of the necessary energy using non-fossil fuel sources by 2030.

By implementing the existing action plan and adhering to ecological principles, the Egyptian government is taking a number of actions in three main directions.

The first direction involves encouraging and supporting cities with developed tourism and corresponding infrastructure in reducing carbon emissions and transitioning to clean and renewable energy. The local administration of such cities as Sharm El-Sheikh or Hurghada has developed policy measures at the city level to ensure sustainability, which includes setting targets for achieving the status of carbon-free cities. These measures rely on initiatives to increase awareness, including a comprehensive media campaign aimed at conserving Egypt's natural resources, promoting individual use of clean energy, and supporting and popularizing "green" tourism [13]. In addition, numerous seminars, training courses, and conferences have been organized for key stakeholders aimed at increasing awareness. European countries that have succeeded in using clean energy in the tourism industry, including Belgium, Germany, and Italy [14], provide assistance in implementing Egypt's protocol.

Today, during the war, we can observe a widespread use of generators in the work of tourism companies in the Ivano-Frankivsk region. On the one hand, this allows tourism establishments to continue their activities uninterrupted during power outages, but such activity entails a number of negative impacts on the environment.

In particular, according to the curator of the social project LUN, Anna Denysenko, who studies air quality in cities using her own tracking system, the use of generators causes pollution with a mixture of carbon monoxide, fine particulate matter, nitrogen oxides, and so on. The use of poor quality filters results in the appearance of fine particulate matter (PM1, PM2.5, PM10) in the air. They can enter the bloodstream, lungs, and affect the nervous system, heart, brain, and cause a range of chronic diseases. Additionally, generators emit carbon monoxide, nitrogen oxides, and other hazardous compounds into the air [15].

Therefore, the most promising direction for the development of the tourism sector is the widespread use of renewable energy sources.

In Ivano-Frankivsk region, there are currently 45 industrial solar power plants with a total capacity of 128 MW, built with private investor funds, of which 17 began operating in 2019. In addition, 1,100 private households have connected to the electric grid of "Prykarpatteoblenergo" (4th place among regions in terms of the number of installed solar energy systems and 3rd place in terms of installed solar energy capacity). Their total capacity is approximately 27 MW, and the electricity generated covers the own needs of more than 7,000 households. Renewable energy sources account for about 2.0% of the total electricity generated in the region. In early 2018, the first stage of a wind power plant with a capacity of 0.6 MW was launched in Shevchenkove village, Dolyna district. There are five small hydropower plants with a capacity of 3.6 MW on the rivers of the region. The biogas plant of LLC "Goodwell

Ukraine" with a capacity of 1.2 MW has produced 3 million kWh of electricity and 3,207 Gcal of thermal energy. There are two biogas plants of LLC "Clear Energy" with a total capacity of 0.7 MW operating on the landfill of TPV in the territory of Rybnenska village council.

It should be noted that the main destructive factor affecting the modernization of the tourism industry in Ivano-Frankivsk region is the military aggression from Russia, which has a negative impact on the restoration of international tourism due to flight bans, rising oil prices, and disruptions in food supply chains. In the future, this will result in a decrease in population income and job opportunities, ultimately leading to a decline in tourist flow. Rising oil prices require a shift towards renewable energy sources and the implementation of energy-saving technologies. This emphasizes the need for ecologization of the tourism industry and requires increased investments, as well as a comprehensive policy aimed at increasing the number of international tourists and expanding the use of environmentally friendly energy sources.

4. CONCLUSIONS

Thus, the use of renewable energy sources is environmentally friendly, modern, safe, resource-efficient, and is the path chosen by all developed countries.

Today, modern tourism development includes several aspects: reducing carbon footprint, minimizing impact on local ecosystems, and increasing economic benefits for local communities. It is important to understand that expenses on ecology and nature conservation measures are not just inevitable costs but investments in business. Such an approach allows for benefits and profits. Investments in green technologies always pay off, and today's modern tourist is willing to pay for comfort and ecology.

The article analyzes the use of electricity in the tourism sector in the Ivano-Frankivsk region. The territorial structure of electricity consumption by the tourism sector in the regions of the Ivano-Frankivsk region was studied, and quantitative indicators of electricity consumption by the tourism sector for the last five years were modeled. It has been proven that as the number of tourists increases, the share of electricity consumed from the general energy grid also increases since the share of electricity generated from renewable sources for self-sufficiency of the tourism sector is negligible at the moment.

The article states that tourism plays a leading role in some of the most innovative initiatives in sustainable energy in the world. Technological solutions for hotel energy supply are analyzed, as well as a myriad of other initiatives that indicate that tourism is at the forefront of transformations aimed at ensuring environmentally friendly energy.

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