POSSIBILITIES TO USE PHOTOELECTRIC ENERGY SOURCES IN MICROCLIMATE SYSTEM OF TELECOMMUNICATION STATION

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Abstract. Communication services in Lithuanian villages are rendered with the help of container type automated telecommunication stations (ATS). Backup automated electric power supply systems are installed in these stations, but ATS equipment is powered from the electrical network. The investigations disclosed that ATS equipment uses approximately 6582 kWh of electric power the 33 % of which (2176 kWh) is consumed by microclimate equipment. Thus, trying to minimize the electric energy amount taken by ATS equipment from the electrical networks the possibilities to meet the electric power demand of the microclimate system of ATS equipment are analyzed using the solar photoelectric power sources. The tests showed that the electric energy consumption in ATS microclimate system depends on the ambient air temperature the change of which in the course of the year depends on the quantitative variations of solar energy striking the land surface. The investigation of the dynamics of solar energy variations and the electric power consumption of the ATS microclimate system showed that the demands of the electric power consumption of the ATS microclimate system can be met using the converted solar energy.

Keywords: telecommunication system, electric power, energy demand, solar energy, microclimate system.

Introduction

Telecommunication systems are an inseparable part of the speedy development of modern society. Rapidly introducing the information communication technologies increases the power consumption in telecommunication systems. Thus, the great importance is devoted to the development of technologies saving the power and using the energy effectively [1; 2].

The equipment of telecommunication services in EU countries use about 8 % of electric power and generate approximately 2 % of CO_2 emission [3]. Thus the European Commission emphasizes the necessity for the industry of information communication technologies to prepare the plan of the means enabling to minimize the consumption of electric power by 20 % until 2015. It has been estimated that in telecommunication systems the potential of power consumption is reduced from 40 to 60 % [4].

Modern automated telecommunication systems (ATS) are equipped with sophisticated telecommunication equipment, thus the specific requirements should be met by the premise microclimate of these systems [5; 6]. Microclimate systems of various designs are used to keep the optimum premise microclimate [6; 7]. The investigations showed that the facilities of microclimate systems consume about 30 – 50 % of all the electric power used by ATS annually [4; 8; 9].

The automated telecommunication systems providing telecommunication services are installed in the premise of a container or building type of 15 – 25 m^2 [8; 9]. The electric power enabling to keep the microclimate of the premise and the telecommunication equipment of the stations is supplied from the electrical network. Thus the power consumption depends on the technology of ATS telecommunication system, premise design and the climate of the locality [8 – 11]. In order to minimize the power consumption in microclimate systems the possibilities of implementation of the means saving the passive energy are analyzed [4]. The coatings of external enclosures, the coating colors, the thermal characteristics of protection enclosures and other protective means have been investigated [6 – 9]. Automated operation means of various microclimate installations have been analyzed trying to minimize the consumption of electric power [5; 6].

ATS transmit the electric power using the sustainable renewable energy sources [10 – 15]. ATS possibilities to supply the electric power with the help of hybrid solar, wind, fuel element systems have been analyzed in literature [13; 14]. To increase the reliability of the electric power supply and reduce the environment pollution the hybrid solar and diesel-type power station systems have been proposed. The authors have noticed that hybrid systems can be used in various countries. But the optimum part of the power generated by the photoelectric modules in the complex system depends on the solar energy resources of the locality [12]. Effective and reliable supply of the electric power has been achieved by combining the power generated by the alternative energy sources with the power supplied by the grid [10; 11].

To minimize the consumption of the power supplied by the grid, alternative solutions should be sought for and the possibilities to use the renewable energy sources in the microclimate systems of ATS should be analyzed. Therefore, this investigation should help find the dynamics of the electric power consumption of ATS microclimate system facilities and define the possibilities to satisfy these power needs with the help of the photoelectric power sources.

Materials and methods

The trials were made in the automated container-type telecommunication station which provided the wire communication (telephone) and the Internet access services to the clients in rural areas of Lithuania. The telecommunication installations of this ATS can provide the telephone communication services to 250 clients and the Internet access services to 159 clients. During the research the ATS provided wire communication services to 222 clients and the Internet access services to 125 clients.

The electric power consumption of the ATS installed in the container-type premise of 15.6 m^2 (3 x 5.2 x 9 m) has been investigated. The thermal resistance of the external protective enclosures of these premises is 2 $m^2 \cdot K \cdot W^{-1}$, and that of the ceiling and the floors is 3 $m^2 \cdot K \cdot W^{-1}$. Electric power is supplied from the grid to the ATS telecommunication and microclimate equipment.

An automated microclimate control system is used in the tested ATS. This system with the help of the predetermined algorithm controls the installed thermal heater of 1 kW, the conditioner of 2.8 kW used for premise cooling and the ventilator of 0.3 kW used for the air replace.

The electric power consumption in container-type ATS has been calculated from the data of the installed meter. The meters EMS – 134.41.3, up to standards LST EN 62052-11, LST EN 62053-21 and LST EN 62053-23 have been used to record the consumption of electric power. This device measures the active and reactive electric power and the momentum currents, voltage, power and other values in three-phase power grid. The specialized “LZPEMS” software has been used to transfer the data from the meter memory.

The potential of the solar radiant energy and the average ambient air temperature have been estimated using the meteorological measurement data of Kaunas hydro-meteorological station (HMS) in 2008 – 2010 [16].

Results and discussion

Approximately 6582 kWh of electric power per year has been used in the tested ATS (during the period of 2008-2010). In spring and summer (from May till September) the power consumption of ATS increases to 632 – 787 kWh per month. In comparison, during the autumn and winter (from October till April) the power consumption decreases to 374 – 507 kWh per month (Table 1).

Table 1

Electric power needs of ATS, average ambient air temperature and solar power potential

Month	Consumption of electric power of ATS, kWh			Average ambient temperature, °C	Solar energy striking onto the land surface perpendicular to the solar beams, $kWh \cdot m^{-2}$
	Telecommunication equipment	Microclimate equipment	Total		
1	366.6	83.3	449.9	-4.9	32.6
2	361.8	11.9	373.7	-1.7	59.8
3	369.9	22.5	392.4	1.4	114.4
4	359.0	143.6	502.6	8.3	195.6
5	364.4	267.7	632.1	12.8	222.4
6	384.2	359.6	743.8	15.7	232.5
7	369.7	417.7	787.3	19.2	234.3
8	348.5	372.1	720.5	17.9	183.3
9	367.0	261.1	628.2	12.5	150.2
10	370.0	137.2	507.2	6.1	76.1
11	363.9	46.8	410.7	3.7	31.1
12	380.7	52.5	433.2	-3.3	16.7
Total	4405.6	2176.1	6581.7	-	1549.0

The telecommunication facilities in the tested ATS have consumed about 4406 kWh of electric power per year. The power consumption in the system does not change significantly in the course of the year, thus the average electric power consumption per month is about 370 kWh. Constant power consumption has been reached by using the telecommunication system the equipment of which has operated at nominal regime independently on the intensity of the supplied services and by keeping the optimum microclimate in the premise. The telecommunication equipment consumes approximately 82 % of electric power used by ATS annually.

The heat is emitted from the operating telecommunication equipment, the flows of which should be monitored to keep the optimum microclimate in the premise [5; 8; 10]. The automated microclimate system equipment installed in the tested ATS maintains 10 – 25 ºC temperature in the premise. This equipment consumes 2176 kWh of electric power per year, i.e., 33 % of the annual power consumption.

The power consumption in ATS microclimate systems has been investigated in various countries. The trials disclosed that during the summer period 28 % of all the power consumed per year is used to cool the ATS premise. During the winter period 30 % of all the power consumed per year is used to heat the ATS premise [4]. Other researchers state that about 30 – 50 % of all the power is consumed by the microclimate systems of ATS [8; 9]. These test data disclose that power consumption in ATS microclimate systems depends on the meteorological situation of the locality.

Analyzing the dynamics of the electric power consumption by ATS microclimate equipment and the change of the ambient air temperature in the course of the year the following relationship has been made (Fig. 1).

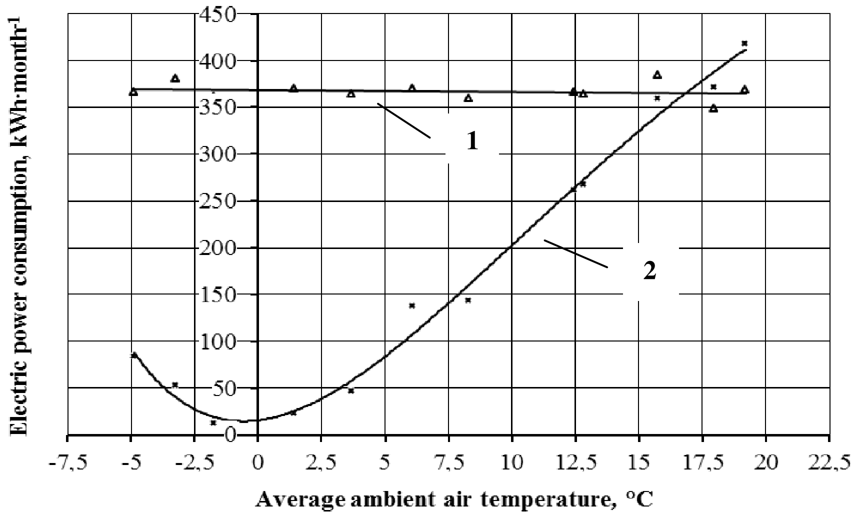

Fig.1. **The relationship of electric power consumption by ATS equipment with average ambient air temperature:** 1 – telecommunication equipment; 2 – microclimate equipment

The test data show that the power consumption by the ATS microclimate system equipment depends on (r = 0.99) the average monthly ambient air temperature and the relationship can be described by the equation:

$$Q = 15.25 - 0.00006 t_{a.v}^5 + 0.0047 t_{a.v}^4 + 0.16 t_{a.v}^3 + 2.79 t_{a.v}^2 + 3.32 t_{a.v} \quad (1)$$

where Q – the consumption of electric power per month by the microclimate system, kWh·month^{-1};

$t_{a.v}$ – the average ambient air temperature per month, ºC.

The container-type ATS are autonomous buildings the power consumption of which to maintain the microclimate in the premise depends on the heat flows emitted in the premise, ambient air temperature, solar radiation and other factors. The impact of these factors on the power consumption in the microclimate systems of ATS premise has been analyzed in the literature [5 – 10]. The trials show that solar power has no significant impact on the power consumption when the external walls of ATS are covered by the light color coating absorbing solar power [8; 9]. Meanwhile, the ambient air temperature impacts the power consumption in the microclimate system. Thus, in order to minimize the power consumption the thermal characteristics of the external structures of protection enclosures and means controlling heat flows have been analyzed [7 – 9].

The data of ambient air parameter changes measured in Kaunas HMS disclosed that the ambient air temperature depends linearly (r = 0.88) on solar energy, striking onto the horizontal surface [16]. Therefore, it is appropriate to consider the possibility to meet the electric power needs of the ATS microclimate system equipment using solar energy.

The potential of solar energy onto the horizontal surface in Kaunas is about 1037±32 kWh·m^{-2} per year [16]. Meanwhile, about 1549±97 kWh·m^{-2} of solar energy per year reaches the surface perpendicular to solar beams (Table 1) [16]. The greatest amount of solar power on the surface perpendicular to the solar beams that reaches it during summer (from May till July) is 222 – 234 kWh·m^{-2}. During this time the ATS microclimate system consumes about 268-418 kWh electric power per month. In winter (from November till January) the surface perpendicular to the solar beams reaches about 17 – 33 kWh·m^{-2} of solar energy in Kaunas. During this time the ATS microclimate system consumes about 47 – 83 kWh electric power per month.

For practical use of solar energy the recalculation of solar power flows onto the surface inclined at some special angle in respect of the sun is made. But the greatest amount of solar energy is received using the solar tracking systems of various structures and designs which divert the surface of photoelectric modules perpendicular to the solar beams during the day time. Thus, it is appropriate to consider the possibilities to satisfy the needs of electric power of the ATS microclimate system equipment using the solar power that reaches the surface perpendicular to the solar beams.

Analyzing the test data, the strong linear correlation (r = 0.87) between the electric power consumption by ATS microclimate system and the solar energy reaching the surface perpendicular to the solar beams was discovered (Fig. 2).

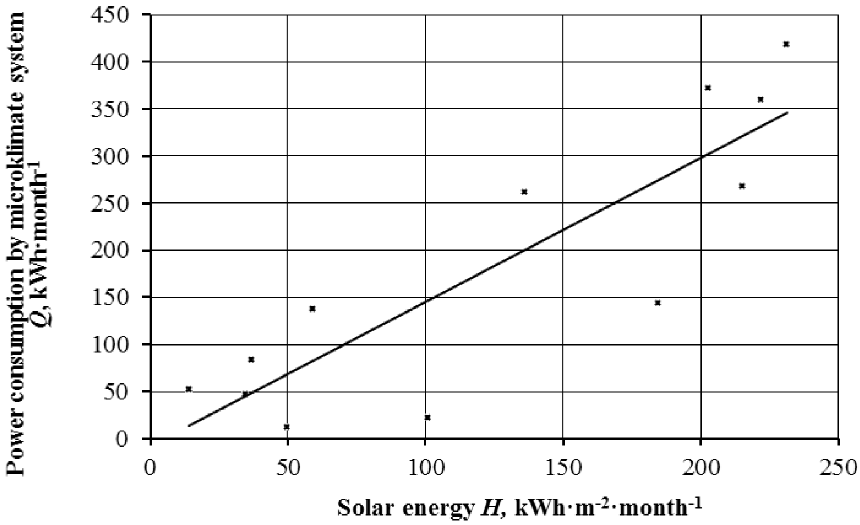

Fig. 2. **The correlation relationship of the electric power used by ATS microclimate system and the solar energy that reaches the surface perpendicular to the solar beams**

The correlation relationship of the electric power used by ATS microclimate system and the energy potential that reaches the surface perpendicular to the solar beams (Fig. 2) can be described by linear equation:

$$Q = 1.53H - 8.13 \tag{2}$$

where H – the potential of solar energy onto the surface perpendicular to the solar beams per month, kWh·m^{-2}.

The trails disclosed that the amount of electric power that is needed for the ATS microclimate system equipment (2176 kWh) can be achieved with the help of solar tracking system, that reflects the solar photoelectric modules perpendicularly to the solar beams during the day time. When the system uses the solar photoelectric modules the efficiency of which is about 15 %, the active area should be about 9.4 m². In this area of photoelectric modules the power amount can be generated meeting the power needs of the ATS microclimate system.

The trails show that about 1790 kWh of solar energy converted into the electric power could be used directly. That would make approximately 82 % of power consumed annually by ATS microclimate system (Fig. 3). But annual differences of about 386 kWh would occur between the electric power converted in the solar photoelectric modules and the consumption in the microclimate system, i.e., approximately 18 % of all the consumed electric power per year. The extra electric power generated in the solar photoelectric modules can be used in ATS telecommunication facilities, and for the increased needs of the microclimate system the power can be taken form the grid. In this case the long-term power storage could be eliminated.

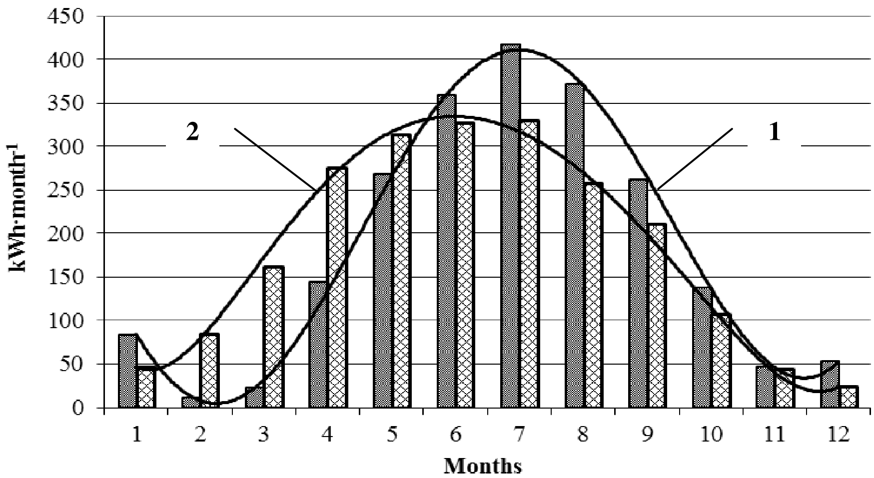

Fig. 3. **The electric power demand satisfaction of the ATS microclimate system using the solar photoelectric modules:** 1 – power needs of microclimate system, 2 – electric power generated in solar photoelectric modules

The power demands of ATS microclimate equipment could be fully satisfied from February till May. The surplus of 45 – 138 kWh of converted power per month would occur during this period. Meanwhile, from June till February, the power demand of the microclimate system would not be fully satisfied. The lack of 29 – 225 kWh of the converted power per month would occur during this period. But in November all the power converted by the solar photoelectric modules of the system would be fully used by the ATS microclimate system.

The test results state that the total ATS power consumption from the grid could be minimized by 33 % when the electric power is supplied from the solar photoelectric station to the ATS microclimate system equipment. The above mentioned percentage of electric power could be taken by substituting it with environmentally-friendly renewable energy.

When the required amount of solar power equal to 2176 kWh that was defined during the tests and equated to the converted electric power that could be estimated as the optimum power amount of the solar photoelectric station necessary to generate. Thus, designing and choosing the system of solar photoelectric modules according to the defined relationship (2), it is necessary that the system could generate the required amount of the electric power. Meanwhile, the active area of the photoelectric modules used in the system of solar photoelectric modules can be chosen in relation to the effectiveness and other energy parameters. The relationship (2) defined during the tests shows the optimum power needs satisfaction by ATS microclimate system with the help of solar energy.

Conclusions

1. It has been defined that the container-type ATS uses in average about 6582 kWh of electric power annually 33 % of which (2176 kWh) is consumed by the microclimate system equipment.

2. The tests show that the consumption of electric power by the ATS microclimate system ($r = 0.99$) depends on the average ambient air temperature the variation of which in the course of the year is formed by the solar energy striking onto the land surface.
3. It has been defined that the demand of the electric power of the ATS microclimate system could be met using the solar photoelectric modules the average active area of which is 9.4 m^2, and the efficiency is 15 %. The active surface of these modules during the day time should be diverted perpendicularly to the solar beams.
4. When the ATS microclimate system equipment is supplied with the electric power from the solar photoelectric station, the total energy consumption supplied from the power grid could be reduced by 33 % in the tested ATS.

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