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PHOTOVOLTAIC SYSTEM AND ENERGY DEMANDS OF THE OFFICE BUILDING

During the research, there was developed methodology to calculate the amount of produced electricity, which is directly based on measured weather conditions for the city of Košice during the last years. According to this calculation we can assume coverage of electricity consumption of the circulation pumps in the heating and cooling system.

Key words: Photovoltaic system, heat pump, renewable energy sources.

Розроблено методику розрахунку кількості виробленої електроенергії, яка заснована безпосередньо на виміряних погодних умовах для міста Кошице протягом останніх років. Відповідно до цього розрахунку можна підсумувати покриття споживання електроенергії циркуляційними насосами в системах опалення та охолодження.

Ключові слова: фотоелектричні системи, теплові насоси, відновлювані джерела енергії.

Introduction

One of the most important elements essential to life on earth is sunlight. Even if one day the sun goes out and extinguished, currently is considered as the inexhaustible source of energy. Sunlight can be converted into other types of energy that we used for the operation of various buildings. The most common transformations are the conversions of solar energy into heat or electricity. In this article we will pay more attention on conversion of sunlight into electricity using photovoltic system.

Connection of photovoltic system

Most used for connection of photovoltaic panels is a direct connection to the electricity network (on-grid). This connection has wide application of PV system in areas where there is sufficient cover of electricity grid. The system does not need any batteries because the produced electricity is either directly consumed by appliances in the building or surplus electric energy is supplied to the electricity grid. With this connection, there is expected return of the photovoltic system, but it depends on the aspects that I will discuss in the next chapter [1][2].

Used methods

Photovoltic system, on which the measurements take place from December 2009, is located on a flat roof building in Košice. The system itself consists of 40 photovoltaic panels that are attached to two electric power converters. These converters recorded at 5-minute intervals the amount of produced electricity.

To simulate photovoltaic system is used simulation program PVGYS.

In calculating the amount of electricity was developed methodology to calculate the amount of incident solar energy on Earth's surface for any location and inclination of solar panels. There is prepared methodology for calculating the amount of electricity produced by photovoltic system, which partly uses the measured values for the city of Košice (cloud cover, ambient temperature, direct sun glare).

Installed photovoltic system

Photovoltaic panels (2x2x10pc.) are placed in rows on the flat roof of the building in the metal framework structure. The resulting DC power from photovoltaic panels is transformed into DC voltage with 2 inverters for single-phase AC voltage and automatically phased inverter for single phase AC voltage to two phases of low voltage distribution grid. Each inverter is equipped with security protection, which in case of deviations of monitored parameters from the limits of standard values automatically disconnects the photovoltaic solar generator from the distribution network.

Photovoltaic solar system is composed of 40 pieces of photovoltaic panels. The peak power of one photovoltic panel is 230 Wp (Fig. 1).

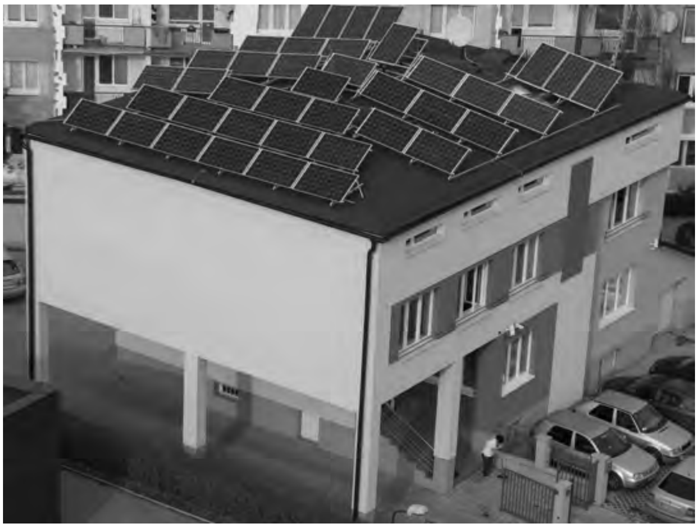

Fig. 1. Installed photovoltic system

Results of measured values

The following chart is processed measured results of photovoltaic system encased in Košice (Fig. 2).

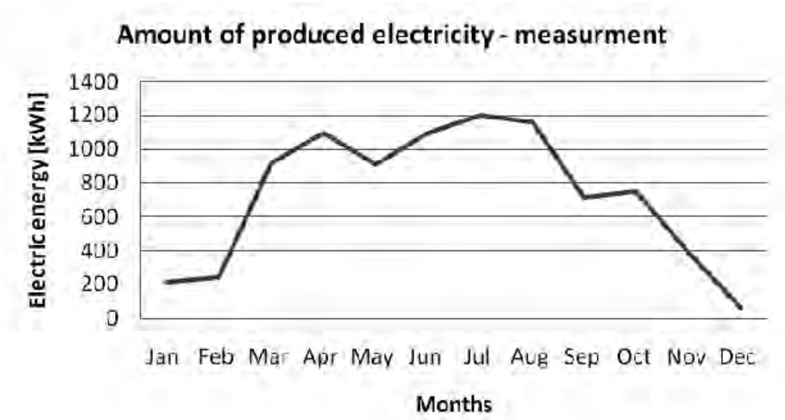

Fig. 2. Amount of produced electric energy – measurement

In the next graph is described amount of produced electricity, which are the results of simulation of installed photovoltaic system in the program PVGIS (Fig. 3).

Calculation methodology of generated electric energy is based on the methodology of calculating the amount of incident solar energy on Earth's surface. The following chart shows the curves of solar radiation incident on inclined surface at an angle of 36 ° from the horizontal plane.

The graph shows the curve of calculated quantity of produced electricity by treatment methodology of calculating the amount of produced electric energy (Fig.4) [3][4].

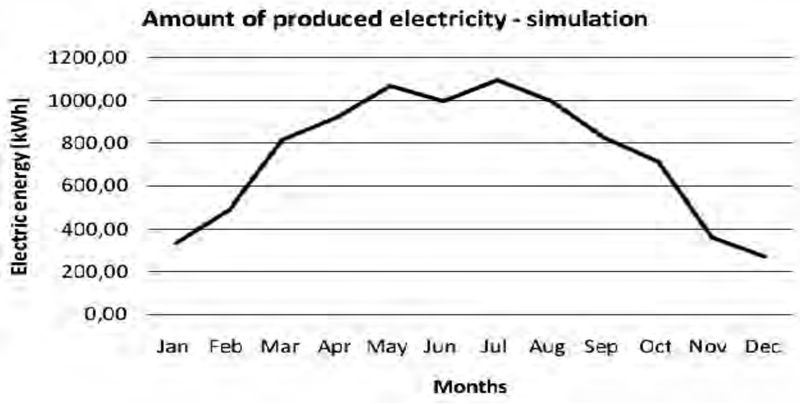

Fig. 3. Amount of produced electric energy – simulation

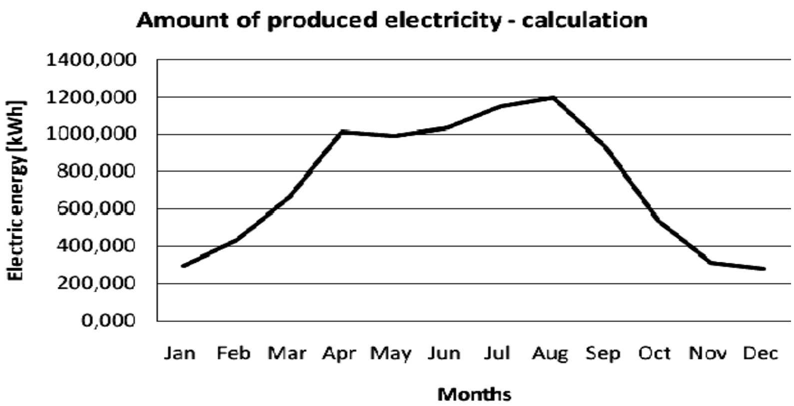

Fig.4. Amount of produced electric energy – calculation

When comparing these three graphs, there are some variations, but generally those are minor deviations (Fig. 5).

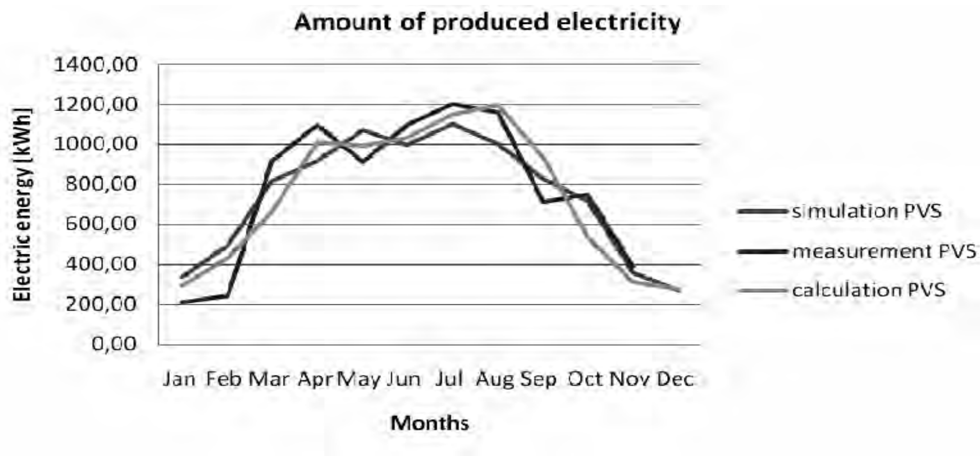

Fig.5. Graphical comparison of resulting values

Energy flows in the administrative building

Solar energy which is converted into electricity using photovoltaic panels, is due to connect to the network passed on to the electricity grid. Consequently, electricity is withdrawn from the grid to operate the office building. Taken electrical energy is consumed for running ordinary electrical equipment in the building, such as computers, lights, printers, etc. According to a season when it is necessary to either heat or cold, so that electrical energy is directly consumed to drive the heat pump and circulation pumps throughout the system.

Integrated RES diagrams and energy flows of consumer systems of public buildings

Schematic diagram of the photovoltaic panels and heating system with the heat pump in public buildings. Our demonstration project analyses a variety of operational and technical variations of energy systems (PV system and heat pump heating system) involved in an individual or integrated production side of the heating, cooling, lighting, hot water and electricity. The individual operational involvement and energy balances, and the parameters of public buildings are scheduled below the picture.

Scheme and the involvement: is the PV involvement where is possible, that these energy scenarios are running the administrative building.

- Electricity produced by PV system placed at the building after the transformation of the Sun's energy is delivered to the public electrical grid.
- The building needs for its operation of the heating circuit electricity taken from the public electricity grid. This electricity is consumed by the heat pump during heating season primarily to power heating circuit in which they are used well pump, circulation pumps and heat pump.
- The building needs for its operation of the cooling circuit electricity taken from the public electricity grid. This electricity is consumed by the circulation pumps and well pump during cooling season.
- In the case of turning off the heating or cooling circuit, the energy will be consumed solely for the operation of electrical appliances in the building (Fig. 6).

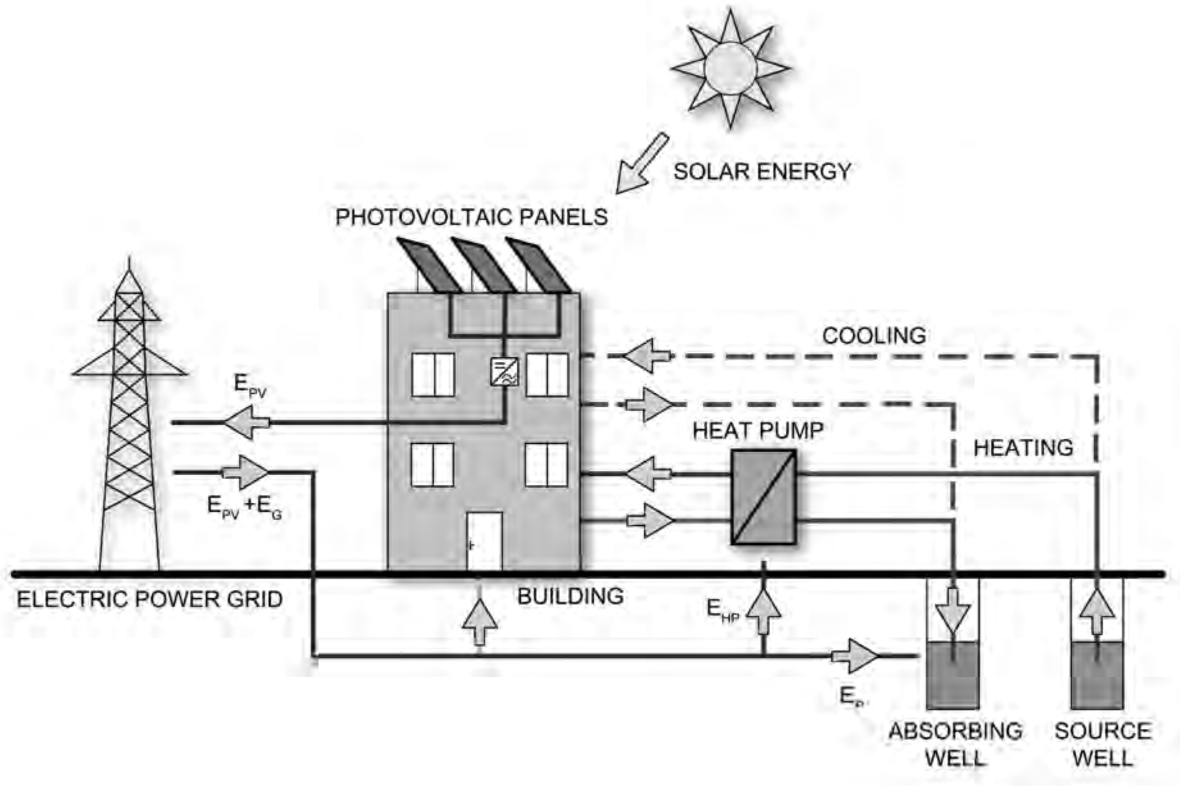

Fig.6. Schematic diagram of PV system, heat pump system and capillary mats

Coverage of electricity in winter

In winter, during the heating period starts the heat pump system. Heat pump with circulating pumps in the system are the largest consumers of electricity in the administration building during this season period. The following table describes the amount of energy consumed for the entire building as well as the energy consumed by the heat pump and the percentage coverage of electricity produced by photovoltaic system (Table I).

Table I

Percentage cover of electricity needs by produced electricity from the PVS – winter

	produced electricity PVS1	produced electricity PVS2	produced electricity total	electricity consumption total	electricity consumption total	temperature	sunshine	cloudiness	percentage cover total	percentage cover heat pump
	[kWh]	[kWh]	[kWh]	[kWh]	[kWh]	[°C]	[hours]	[-]	[%]	[%]
22.1.2011	4,131	4,125	8,256	603,5	450,46	-0,9	1,2	9	1,4	1,8
23.1.2011	6,338	8,012	14,35	603,5	450,46	-1,4	4	7	2,4	3,2
24.1.2011	4,703	4,585	9,288	603,5	450,46	-2,3	1,7	8,3	1,5	2,1
25.1.2011	4,663	4,799	9,462	603,5	450,46	-3,2	0,1	9	1,6	2,1
26.1.2011	0,094	0,026	0,12	603,5	450,46	-4,3	0	10	0,0	0,0
27.1.2011	1,414	3,582	4,996	586,75	436,69	-3,3	3,6	5,7	0,9	1,1
28.1.2011	11,045	13,903	24,948	570	422,92	-1,9	5,8	1,7	4,4	5,9
average	4,627	5,576	10,203	596,3	444,6	-2,5	2,3	7,2	1,7	2,3

Coverage of electricity in spring

In spring time the outside temperature increases, but the heating in the building continues. This increases the quantity of electricity on the other hand, reduces power consumption to drive the heat pump, the energy surplus is achieved in the administration building, which can then be used to operate electrical equipment in the building (Table II).

Table II

Percentage cover of electricity needs by produced electricity from the PVS – spring

	produced electricity PVS1	produced electricity PVS2	produced electricity total	electricity consumption total	electricity consumption total	temperature	sunshine	cloudiness	percentage cover total	percentage cover heat pump
	[kWh]	[kWh]	[kWh]	[kWh]	[kWh]	[°C]	[hours]	[-]	[%]	[%]
20.4.2011	25,036	26,469	51,505	34,38	11,81	11	12,3	2	149,8	436,1
21.4.2011	14,959	15,82	30,779	34,38	11,81	12	7,4	7,3	89,5	260,6
22.4.2011	21,212	22,648	43,86	34,38	11,81	8	12	2,3	127,6	371,4
23.4.2011	27,001	28,346	55,347	34,38	11,81	8	11,6	4	161,0	468,6
24.4.2011	26,462	24,894	51,356	34,38	11,81	13	11,5	2,7	149,4	434,9
25.4.2011	27,299	28,648	55,947	34,38	11,81	16	13,2	0,7	162,7	473,7
26.4.2011	25,193	26,458	51,651	34,38	11,81	14	12,1	1,7	150,2	437,3
average	23,880	24,755	48,635	34,4	11,8	11,7	11,4	3,0	141,5	411,8

Coverage of electricity in summer

In summer, the building is cooled using capillary matting and circulation pumps in the system of building environment and omitted heat pump from the cooling circuit. Production of electricity is highest. Consumption of electricity to drive heat pumps would be set at zero but is used for cooling, power consumption is higher in that period but we still cover about 30% of the electricity needed to operate the entire building (Table III).

Table III

Percentage cover of electricity needs by produced electricity from the PVS – summer

	produced electricity PVS1	produced electricity PVS2	produced electricity total	electricity consumption total	electricity consumption total	temperature	sunshine	cloudiness	percentage cover total	percentage cover heat pump
	[kWh]	[kWh]	[kWh]	[kWh]	[kWh]	[°C]	[hours]	[-]	[%]	[%]
18.7.2011	20,352	21,22	41,572	122,58	0,00	23,9	9,3	4,3	33,9	-
19.7.2011	22,468	22,819	45,287	122,58	0,00	23,5	8,0	6,3	36,9	-
20.7.2011	16,254	16,445	32,699	100,93	0,00	19,7	6,0	9,0	32,4	-
21.7.2011	8,925	9,284	18,209	79,29	0,00	17,4	2,6	9,0	23,0	-
22.7.2011	14,474	14,452	28,926	79,29	0,00	16,6	4,1	7,0	36,5	-
23.7.2011	18,738	19,477	38,215	79,29	0,00	17,6	6,8	9,3	48,2	-
24.7.2011	5,983	6,071	12,054	79,29	0,00	17,0	0,2	9,3	15,2	-
average	15,313	15,681	30,995	94,7	0,0	19,4	5,3	7,8	32,7	-

Coverage of electricity in summer

In autumn, the building gradually begins to heat. Heat pump is engaged into the circuit. The necessary electrical energy does not reach such a size as needed during the winter operation of the building, but the amount of generated electric energy can provide coverage to 10% (Table IV).

Table IV

Percentage cover of electricity needs by produced electricity from the PVS – autumn

	produced electricity PVS1	produced electricity PVS2	produced electricity total	electricity consumption total	electricity consumption total	temperature	sunshine	cloudiness	percentage cover total	percentage cover heat pump
	[kWh]	[kWh]	[kWh]	[kWh]	[kWh]	[°C]	[hours]	[-]	[%]	[%]
17.10.2011	20,715	22,122	42,837	388,65	279,17	2,7	9,1	0,0	11,0	15,3
18.10.2011	19,875	21,197	41,072	388,65	279,17	3,5	8,8	0,3	10,6	14,7
19.10.2011	12,046	13,55	25,596	388,65	279,17	7,2	5,2	5,7	6,6	9,2
20.10.2011	0,951	0,941	1,892	388,65	279,17	6,7	0	10,0	0,5	0,7
21.10.2011	10,071	9,902	19,973	388,65	279,17	7,0	4,9	7,7	5,1	7,2
22.10.2011	2,569	2,612	5,181	388,65	279,17	7,0	0	9,3	1,3	1,9
23.10.2011	4,926	4,968	9,894	388,65	279,17	8,6	0,6	7,0	2,5	3,5
average	10,165	10,756	20,921	388,6	279,2	6,1	4,1	5,7	5,4	7,5

Conclusion

The conversion of solar energy into electricity using photovoltaic cells are currently beginning to emerge into the consciousness of people as one of the potential uses of renewable energy sources. But nowadays is more prevalent economic evaluation of the system and also the ability to cover the burden of energy in buildings. In the present investigation the two administrative buildings where are installed modern system of buildings environment as well as photovoltaic panels, the amount of electricity needs and the amount of produced electricity is shown in the last chart, where it is obvious that complete energy cover we can ensure only in the days when there is no need that administrative building needs to be heated or cooled. This occurs about three to four weeks throughout the year. In the future we will strive for the best use of both studied systems in order to maximize the energy independence of administrative buildings (Fig. 7).

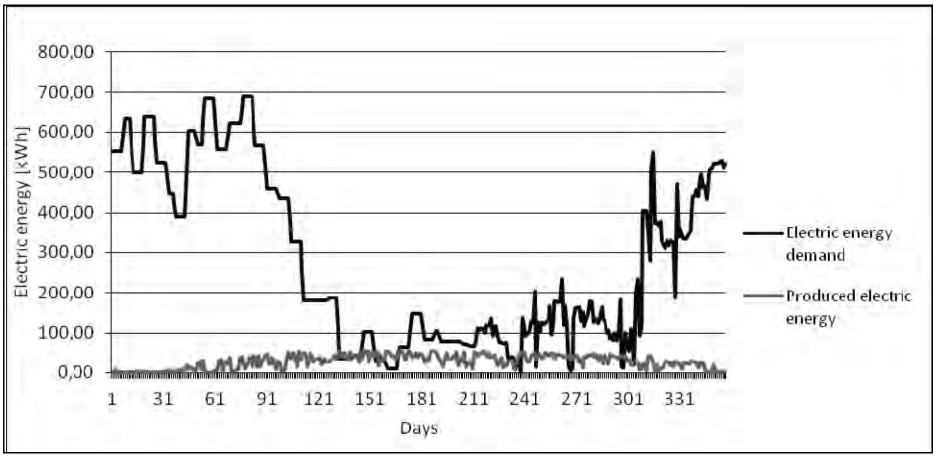

Fig.7. Comparison of the produced electricity to the electricity consumption

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VEGA 1/0748/11 Theoretical and experimental analysis of Building services and HVAC systems from the point of view of microbiological risk and regarding to effective use of renewable sources.

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