USING SOLAR ENERGY AS NON-CONVENTIONAL ALTERNATIVE ENERGY IN SMALL AND MEDIUM-SIZED FARMS
/
UTILIZAREA ENERGIEI SOLARE CA SURSĂ ALATERNATIVĂ NECONVENŢIONALĂ DE ENERGIE ÎN FERMELE DE DIMENSIUNI MICI ŞI MEDII

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ABSTRACT
Solar energy represents a future solution for clean, sustainable energy, because the sun generates much more energy every day than it is necessary for daily consumption, unlike fossil fuels. The only limitation related to this renewable resource is the ability to transform this energy into electricity. The paper presents a functional model of equipment that allows the capture of solar energy using special panels, which can rotate according to the sun, so that the incidence of rays with the radiating surface of the panels is maximum, and the yields obtained at different angles of inclination (in the vertical plane: 30° and 45°, and in the horizontal plane: 0° to be maximum.

REZUMAT
Energia solară reprezintă o soluţie de viitor pentru o energie curată, sustenabilă, datorită faptului că soarele generează în fiecare zi mult mai multă energie decât avem nevoie pentru consumul zilnic, spre deosebire de combustibilii fosili. Singura limitare legată de această resursă regenerabilă este capacitatea de a transforma această energie în electricitate. În lucrare se prezintă un model funcţional de echipament care permite captarea energiei solare utilizând panouri speciale, care se pot roti după soare, astfel încât incidenţa razelor cu suprafaţa radiantă a panourilor să fie maximă, iar randamentele obținute la diferite unghiuri de înclinaţie (în plan vertical: 30° şi 45°, iar în plan orizontal: 0° să fie maxime.

INTRODUCTION
The sun provides the majority of the energy consumed by humanity on Earth. "Solar" energy is derived directly from the sun. Renewable energy is also known as environmentally friendly power, green power, sustainable power, or alternative energy. The surrounding stellar environment absorbs the majority of the sun's energy, so very little of it reaches Earth as radiation (*Majeed et al, 2023*).

A square meter on Earth's surface receives an average of 1366 W of solar energy (*Lindsey, 2009*), but this might vary depending on latitude (*Cocks, 2016*). The first stage in capturing solar energy is estimating the quantity of energy available from the sun in a specific area of the Earth. A country's economic and social success is determined by its ability to obtain a consistent and affordable supply of energy (*Fatai et al., 2004; Muneer et al., 2006*).

Renewable energy sources, such as wind and sun, can be used to power farm vehicles in a way that is beneficial to the economy and the environment (*Balasuadhakar et al., 2016*).

Clean energy, also known as renewable energy, is derived from non-anthropogenic sources such as the sun and wind. These sources can be replenished continuously, despite the fact that they are time and weather-dependent. On the other hand, fossil fuel is a collective name given to oil, natural gas, and coal, which are non-renewable energy sources generated from carbon-based dead and buried organisms that disintegrated millions of years ago (*Bhatia and Gupta, 2019; Zekai, 2008*).

Solar energy remains one of the oldest renewable sources of energy in the universe, which is taken in the form of solar radiation from the sun and primarily employed in three ways: a) electricity generation with solar cells in which photovoltaic or photoelectric cells are used; b) the sun heat can be used to warm water in a glass panel of a solar energy system through solar water heating; c) production of high temperatures from the sun through the use of furnaces and mirrors to collect the sun's energy is the primary focus, which may also be utilized in cooking and processing food, enhanced oil recovery, water desalination, chemical production, and mineral processing (*Zekai, 2008; Ihssen et al., 2014; Zhao et al., 2013).*

The global public and private sectors are actively pursuing new solutions to meet the demand for clean energy while lowering greenhouse gas emissions and energy costs in their operations. Consequently, the installation of renewable and sustainable energy systems became a priority (*Mekhilef et al., 2012; Kahraman and Dincer, 2022; Tong et al., 2022; Gâgeanu et al., 2011*). Thus, solar energy remains the most viable alternative energy source because it offers a number of advantages over other options (*Ahmed et al., 2022)*. Solar energy is naturally available as an environmentally beneficial energy source supplied by the sun, which may be exploited to directly generate power (*Jahid et al., 2018*). Furthermore, solar energy produces no pollution, requires little maintenance, and the product technology has a long life expectancy of around 20-30 years (*Jahid et al., 2018; Saidur and Mekhilef, 2010*). Solar applications were initially developed for rural electrification, telecommunications, and agriculture sectors, but they are now used in a wide range of applications, such as solar water heating, solar drying, and solar photovoltaics (PVs) (*Saidur, 2010; Mohammed Wazed et al., 2018; Zaharaoui et al., 2021; Xiong et al., 2021; Huang et al., 2022)*. Besides, solar power can supply 100 percent of the world's primary energy demand (*Perez and Perez, 2022*).

Heat transmission (HT) is a branch of heat research that studies the creation, use, modification, and preservation of thermal energy systems. In recent years, there has been a growth in interest in the topic of HT as people become more concerned about climate change and its implications for energy systems. Understanding the concepts of HT has never been more important as the world strives to decrease its carbon footprint and switch to renewable energy sources.

This study seeks to provide an overview of the fundamentals of HT, its uses, and its significance in the context of renewable energy and climate change. The study of HT includes several components, such as heat transfer by conduction, convection, and radiation (*Salawu et al., 2022*). Many academics offer different approaches to explaining heat transfer ideas in engineering challenges (*Hussain et al., 2021; Kartal, 2022*). Some of the applications studied include spaceship design, comets and asteroids, mass transfer preservation, heat exchanger design, and heat piping system development.

The accelerating depletion of fossil fuels, along with increased concerns about climate change, has driven the world to a critical juncture in its energy transition. During this paradigm change, hybrid renewable energy systems (HRES), especially those incorporating solar and wind power technologies, have emerged as key options to meet the difficulties of energy sustainability (*Marks-Bielska et al., 2020; Dincer, 2000*). However, such systems reduce the intermittency difficulties inherent in individual renewable sources, increasing the overall reliability and stability of energy production. Solar power's highest output occurs during daylight hours; however, wind power can be harvested even when solar availability is limited (*Garratt et al., 2023*). Integrating these sources makes the energy supply more consistent, lowering the chance of power outages during inclement weather. Furthermore, energy storage technologies integrated into hybrid systems provide surplus energy storage during peak production periods, allowing its usage during low production phases, enhancing total system efficiency, and lowering waste (*Hassan et al., 2023; Maican et al., 2019*).

MATERIALS AND METHODS

The operating principle of the solar collector is based on the use of the black body effect (achieved by means of the absorbent surface) combined with the greenhouse effect (achieved by the glass plate and the polyester film). The installation is made as an experimental model and uses flat solar collectors with gaseous thermal agent (air). Structurally, it was designed specifically for research. In addition to the basic function of capturing and converting solar energy into thermal energy by heating the air, the installation allows the horizontal and vertical rotation of the solar panels to further expand the scope of investigations depending on the angle of incidence of the sun's rays with the surface of the panel.

The experimental model of the module for capturing and converting solar energy into thermal energy (Figure 1) is located in an area with exposure to the sun throughout the day, at a distance that ensures minimal losses on the thermal agent transport network (air), from solar collectors to potential users such as a fruit drying facility. The main component subassemblies of the module for capturing and converting solar energy into thermal energy are: the support frame, the solar collectors and the air tubes with a low-pressure centrifugal fan. The rotation of the solar collectors around a central pivot by 45° left-right from the initial orientation position to the south and also the orientation of the solar collectors in the vertical plane at fixed angles of 30° and 45° is done manually and checked each time with appropriate measuring instruments. With these facilities, the variation of solar energy can be highlighted throughout the day by orienting the panels according to the position of the sun, and adjustments can be made to optimize the system's operating regime.

Fig. 1 – Module for capturing and converting solar energy

The module for capturing and converting solar energy into thermal energy consists of:

- *The support frame*, is an assembly made up of removable modulated elements, and forms the structure on which the solar collectors are mounted with their connecting elements and air ducts. On the upper part of the frame, two plates are mounted that can rotate with respect to each other and that allow the horizontal rotation of the panel support frame. The support of the solar collectors is mounted on the mobile plate, it supports the solar collectors and through a joint allows their angle to be adjusted in the vertical plane.
- *Solar collectors* transform the captured solar energy into thermal energy that is taken by means of a continuous air current produced by a low-pressure fan and led to a technological line that uses hot air.
- The *air ducts* are each connected by special connections to one solar collector and make the hot air transport circuit to the user (drying room). A centrifugal, low-pressure fan has been interspersed in the air circuit, which ensures counter-current air circulation.

The module for capturing and converting solar energy has as its operating principle the use of the black body effect (realized by means of the absorbing surface) combined with the greenhouse effect (realized by the glass plate and the transparent polyester film).

The sun radiates maximum energy in the visible spectrum, a field in which the glass plate and the polyester film are transparent. Thermal solar radiation has a wavelength between 0.72 and 400 μm, easily passes through the glass plate and foil and reaches the absorbent plate.

- *The absorbent plate* (black body of the collector) absorbs solar radiation, heats up to a temperature of $80 \div 120^{\circ}$C and radiates in the far infrared. The glass plate, transparent in the visible spectrum, is opaque in the infrared to radiation with a wavelength of over 4.5 μm and thus the collector becomes a trap for electromagnetic waves that once entered cannot leave it. Thus, the glass surface becomes a one-way gate for capturing solar energy. The module also has the possibility to change its position following the movement of the sun throughout the day. The module has a pull-type device (Figure 2) for changing the angle of inclination of the collector in the vertical plane within the limits of 30 and 60° compared to the horizontal plane of the ground.

Fig. 2 – Tie rod for changing the angle of inclination of the collector in the vertical plane

The measurement of the angle of rotation in the horizontal plane is done with an indicator (Figure 3), with a position index from 15 to 15°. Initially, the module is fixed with the zero position of the pointer to the south. From this position, the module can be rotated by 45° towards sunrise or sunset depending on the position of the sun in order to obtain a maximum efficiency of its radiation.

Fig. 3 – Angle indicator in horizontal plane

- The ducts for heated air have transducers along the route to measure the temperature and air flow. In order to benefit from warmer air, one can try to reduce the air flow by interposing a shutter with an adjustable section along the tube route. In order to reduce thermal energy losses, the ducts for hot air conduction will be insulated with a layer of glass wool and the shortest routes will be sought between the installation for capturing and converting solar energy into thermal energy and the technological line benefiting from the intake of hot air.

Main technical characteristics:

- the thermal agent used: air;
- number of collectors: 4;
- type of collectors: plane;
- mode of placement: on the ground, on a metal support frame;
- the capture surface: - on a collector: 1.5 m^2;
  - on the module: 6 m^2;
- the air passage section through the absorbent plate of the collector:
  - variant A………. 288 cm^2;
  - variant B………. 576 cm^2;
  - variant C………. 144 cm^2;
  - variant D………. 288 cm^2;
- the glass window: transparent glass, 4 mm;
- isolation: polyurethane foam;
- max. temperature of the absorbent plate: +130°C;
- max. temperature of air at the outlet of the manifold (in free circulation): +90°C;
- heated air flow rate (per module): approx. 100 m^3/h;
- the angle of inclination to the horizontal: min. 30°, max. 60°;
- the angle of rotation in the horizontal plane: 45° left-right;
- energy capacity: 350-700 Wh/m^2;
- dimensions of the entire module:
  - length (without tubes): 3 m;
  - width: 2.1 m
  - height: 4.15 m
- The panels can rotate both vertically and horizontally, thus:
  - inclination in the vertical plane (fixed angles): 30°, 45°, and 60°;
  - inclination in the horizontal plane (fixed angles): -30°, -15°, 0°, +15°,+30°, 0° representing the orientation to the south).

The experiments aimed at verifying the installation under normal operating conditions and identifying the optimal solution for building and operating the installation for capturing and converting solar energy into thermal energy **at angles of 30° and 45° in the vertical plane** (maintaining at 0° in the horizontal plane).

During the tests, depending on the time of day, was measured for each panel:

- inlet temperature (T_0) and outlet temperature from the panel (T_i);
- the speed of the air current (v_i) at the exit from each solar collector.

To differentiate them, the solar collectors (panels) were numbered as follows:

- panel no. 1, constructively defined as variant A;
- panel no. 2, constructively defined as variant B;
- panel no. 3, constructively defined as variant C;
- panel no. 4, constructively defined as variant D.

RESULTS

Experiments with tilting the collectors in the vertical plane at 30°

The results of measurements for the tilt position of the panels at 30° in the vertical plane and fixed orientation to the south are presented in Table 1 and in the related diagrams. The measurements were carried out with the testovent, an electronic device that measures the instantaneous values of current speed and air temperature.

Figure 4 shows the temperature variation for each panel with measurements taken in increments of 15 minutes, between 10 a.m. and 4 p.m. The graph shows that the temperatures recorded at panel 1 (T1) are the highest.

Figure 5 shows the variation of the air flows resulting from the calculation, depending on the speed of the air current measured in the outlet section of the collector. The flows were denoted by L1, L2, L3, and L4 and resulted by calculation according to the relation:

$$L = v \cdot S \ [m^3/h] \quad (1)$$

where:

$S = 0.12\ m^2$ – represents the area of the exit section of the solar collector where the measurement was made;

v – represents the speed of the air current.

Figures 6 and 7 show the variation of the heat accumulated by solar collectors during the day between 10 a.m. and 4 p.m., respectively the variation of the yields of the solar panels resulting from the calculation. The efficiency of the solar heat storage installation (yield) can be calculated with the relation:

$$\eta = \frac{Q_i}{Q} \quad (2)$$

where:

Q_i - is the heat accumulated by the solar collector ($i=1\div4$) [Kcal/h];

Q - is the total heat received by the collector [Kcal/h].

The heat accumulated by each collector was calculated using the relation:

$$Q_i = L_l \cdot c \cdot (T_i - T_0) \quad (3)$$

where:

L_i – the flows resulting from the calculation at each solar collector [m^3/h];

c – the specific heat of the working fluid [$Kcal/m^3\ °C$];

T_i – the temperature recorded at the exit from the panel ($i=1\div4$) [°C];

T_0 – environmental temperature [°C];

The total heat received from the sun was calculated using the relation:

$$Q = I \cdot A \cdot S_c \quad (5)$$

where:

I – average hourly radiation intensity [$Kcal/m^2h$];

A – absorption coefficient of solar radiation ($A \approx 0.90$);

S_C – the capture surface ($S_C = 1.5\ m^2$).

From Figures 6 and 7 it can be seen that the presented values are relatively close, the solar collector version A being, however, in the highest areas of the diagrams.

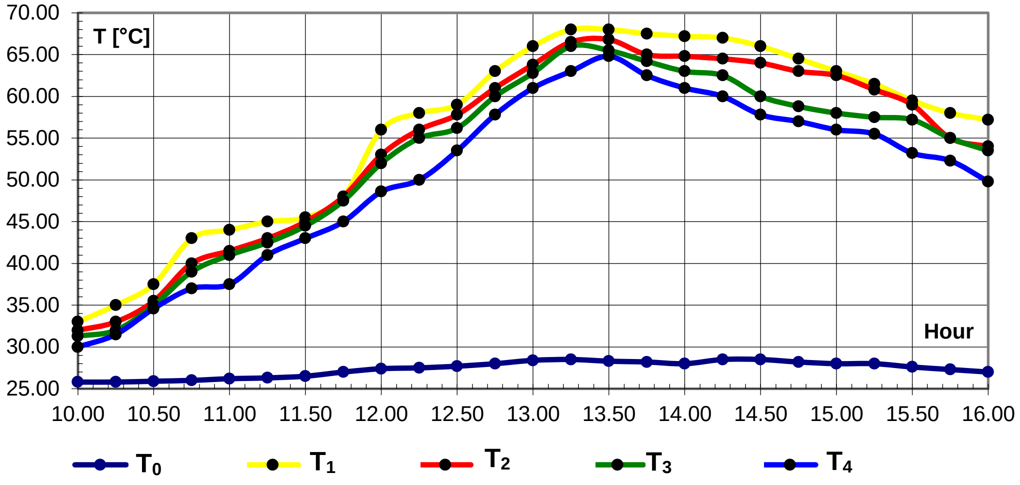

Fig. 4 - Variation of the temperature of the panels for tilting in the vertical plane at 30° from the horizontal plane
T_0 – environmental temperature; T_1 - panel 1 temperature; T_2 - panel 2 temperature; T_3 - panel 3 temperature; T_4 - panel 4 temperature

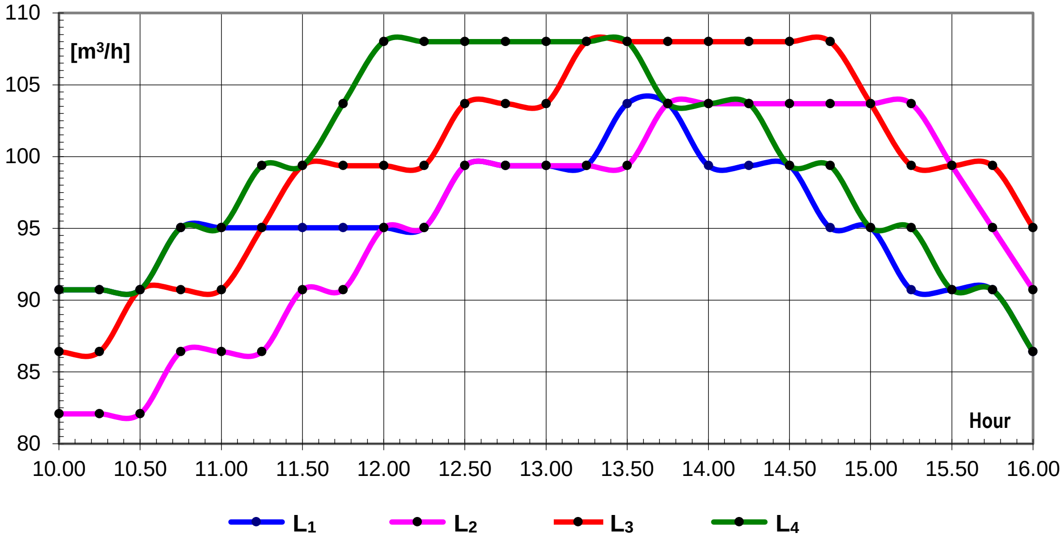

Fig. 5 - Variation of the air flows for tilting in the vertical plane at 30° from the horizontal plane
L_1 – air flow to the panel 1; L_2 – air flow to the panel 2; L_3 – air flow to the panel 3; L_4 – air flow to the panel 4

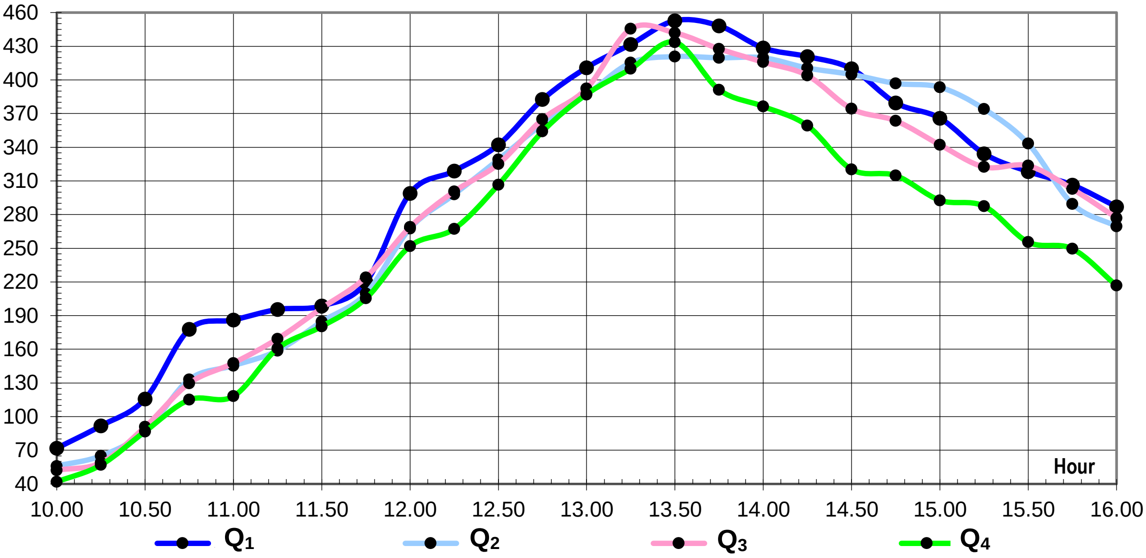

Fig. 6 - Variation of the accumulated heat on the panels for tilting in the vertical plane at 30° from the horizontal plane
Q_1 – heat accumulated on panel no. 1; Q_2 – heat accumulated on panel no. 2;
Q_3 – heat accumulated on panel no. 3; Q_4 – heat accumulated on panel no. 4

Table 1

Hour	Temperature differences ($T_{panel} - T_{environment}$) [°C]				Air flows [m³/h]				Accumulated heat [Kcal/h]				Average radiation intensity [Kcal/m² h]	Heat received [Kcal/h]	Yields [%]			
	Panel 1	Panel 2	Panel 3	Panel 4	Panel 1	Panel 2	Panel 3	Panel 4	Panel 1	Panel 2	Panel 3	Panel 4	-	-	Panel 1	Panel 2	Panel 3	Panel 4
10.00	7.20	6.20	5.50	4.20	90.72	82.08	86.4	90.72	71.850	55.979	52.272	41.913	270	364.5	19.71	15.36	14.34	11.50
10.25	9.20	7.20	6.20	5.70	90.72	82.08	86.4	90.72	91.809	65.007	58.925	56.881	280	378	24.29	17.20	15.59	15.05
10.50	11.60	9.60	9.10	8.70	90.72	82.08	90.72	90.72	115.76	86.676	90.811	86.819	290	391.5	29.57	22.14	23.20	22.18
10.75	17.00	14.00	13.00	11.00	95.04	86.4	90.72	95.04	177.72	133.05	129.73	114.99	320	432	41.14	30.8	30.03	26.62
11.00	17.80	15.30	14.80	11.30	95.04	86.4	90.72	95.04	186.09	145.41	147.69	118.13	325	438.75	42.41	33.14	33.66	26.93
11.25	18.70	16.70	16.20	14.70	95.04	86.4	95.04	99.36	195.50	158.72	169.36	160.67	355	479.25	40.79	33.12	35.39	33.52
11.50	19.00	18.50	18.00	16.50	95.04	90.72	99.36	99.36	198.63	184.62	196.73	180.34	410	553.5	35.89	33.35	35.54	32.58
11.75	21.00	21.00	20.50	18.00	95.04	90.72	99.36	103.68	219.54	209.56	224.06	205.23	450	607.5	36.14	34.50	36.88	33.79
12.00	28.60	25.60	24.60	21.20	95.04	95.04	99.36	108	299	267.64	268.87	251.86	560	756	39.55	35.40	35.56	33.31
12.25	30.50	28.50	27.50	22.50	95.04	95.04	99.36	108	318.86	297.95	300.56	267.3	575	776.25	41.08	38.38	38.72	34.43
12.50	31.30	30.10	28.50	25.80	99.36	99.36	103.68	108	342.10	328.98	325.04	306.50	600	810	42,23	40.61	40.13	37.84
12.75	35.00	33.00	32.00	29.80	99.36	99.36	103.68	108	382.54	360.68	364.95	354.02	610	823.5	46.45	43.80	44.32	42.99
13.00	37.60	35.40	34.40	32.60	99.36	99.36	103.68	108	410.95	386.91	392.33	387.29	625	843.75	48.71	45.86	46.50	45.90
13.25	39.50	38.00	37.50	34.50	99.36	99.36	108	108	431.72	415.32	445.5	409.86	630	850.5	50.76	48.83	52.38	48.19
13.50	39.70	38.50	37.20	36.50	103.68	99.36	108	108	452.77	420.79	441.94	433.62	640	864	52.40	48,70	51.15	50.12
13.75	39.30	36.80	36.00	34.30	103.68	103.68	108	103.68	448.21	419.70	427.68	391.18	650	877.5	51.08	47.83	48.74	44.58
14.00	39.20	36.80	35.00	33.00	99.36	103.68	108	103.68	428.44	419.70	415.8	376.36	600	810	52.89	51.81	51.33	46.46
14.25	38.50	36.00	34.00	31.50	99.36	103.68	108	103.68	420.79	410.57	403.92	359.25	560	756	55.66	54.39	53.43	47.52
14.50	37.50	35.50	31.50	29.30	99.36	103.68	108	99.36	409.86	404.87	374.22	320.24	550	742.5	55.2	54.53	50.4	43.13
14.75	36.30	34.80	30.60	28.80	95.04	103.68	108	99.36	379.49	396.89	363.53	314.77	540	729	52.06	54.44	49.87	43.18
15.00	35.00	34.50	30.00	28.00	95.04	103.68	103.68	95.04	365.90	393.47	342.14	292.72	530	715.5	51.14	54.99	47.82	40.91
15.25	33.50	32.80	29.50	27.50	90.72	103.68	99.36	95.04	334.30	374.08	322.42	287.50	515	695.25	48.08	53.80	46.38	41.35
15.50	31.90	31.40	29.60	25.60	90.72	99.36	99.36	90.72	318.34	343.19	323.52	255.47	510	688.5	46.24	49.85	46.99	37.10
15.75	30.70	27.70	27.70	25.00	90.72	95.04	99.36	90.72	306.36	289.58	302.74	249.48	505	681.75	44.94	42.48	44.41	36.59
16.00	30.20	27.00	26.50	22.80	86.4	90.72	95.04	86.4	287.02	269.44	277.04	216.69	500	675	42.52	39.92	41.04	32.10
														Average yield [%]	**45.59**	**43.21**	**42.69**	**38.83**

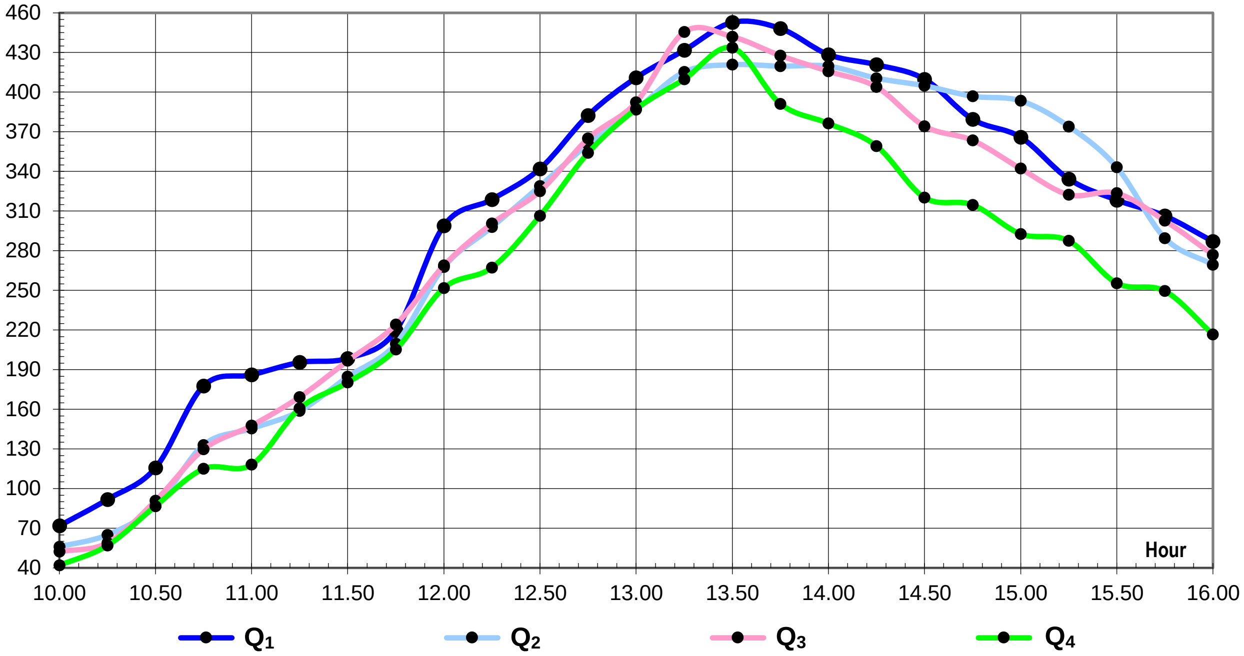

Fig. 6 - Variation of the accumulated heat on the panels for tilting in the vertical plane at 30° from the horizontal plane
Q_1 – heat accumulated on panel no. 1; Q_2 – heat accumulated on panel no. 2;
Q_3 – heat accumulated on panel no. 3; Q_4 – heat accumulated on panel no. 4

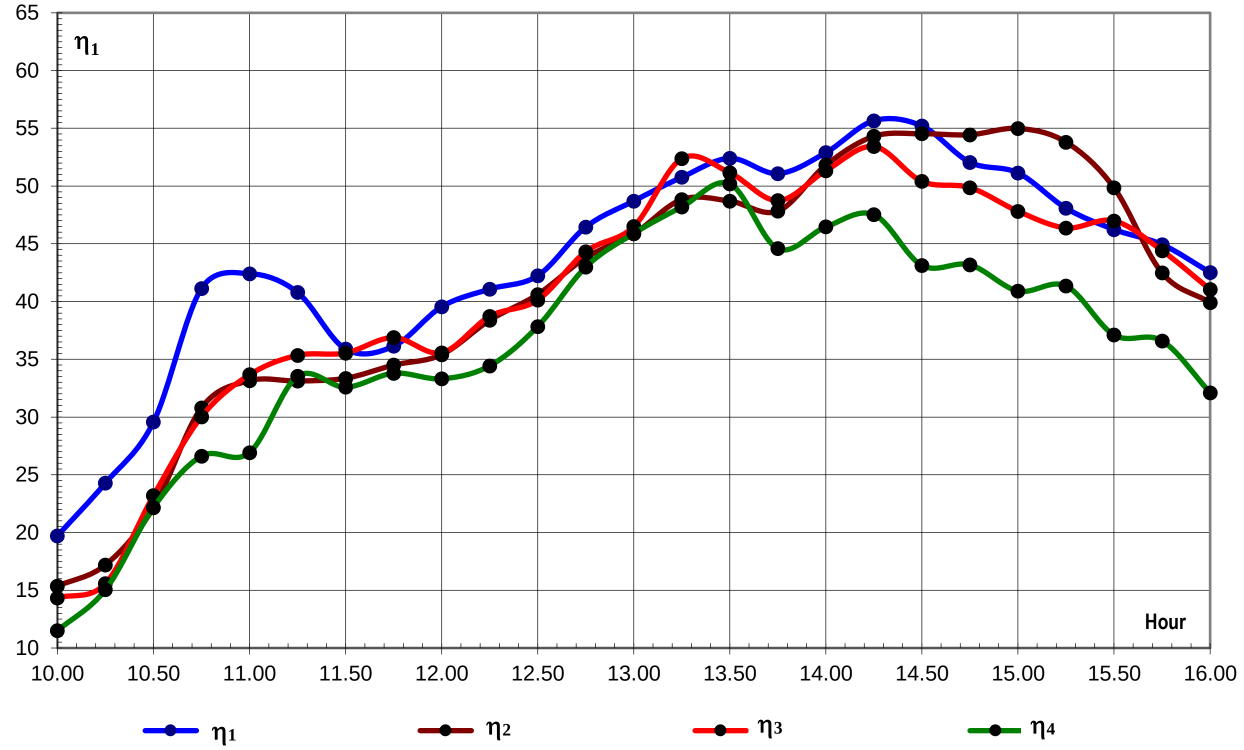

Fig. 7 - Variation of the yield at panels for tilting in the vertical plane at 30° from the horizontal plane
η_1 – yield on panel no. 1; η_2 - yield on panel no. 2; η_3 - yield on panel no. 3; η_4- yield on panel no. 4

Experiments with tilting the collectors in the vertical plane at 45°

The measurement results for the tilt position of the panels at 45° in the vertical plane and fixed orientation to the south are presented in the related diagrams. Figure 8 shows the temperature variation for each panel with measurements taken every 15 minutes between 10 a.m. and 4 p.m. The graph shows that the temperatures recorded at panel 1 (T1) are the highest. Figure 9 shows the variation of the air flows resulting from the calculation depending on the speed of the air current measured in the outlet section of the collector. Figures 10 and 11 show the variation of the heat accumulated by solar collectors during the day between 10 a.m. and 4 p.m., respectively the variation of the yields of the solar collectors resulting from the calculation.

It can be seen that the values of heat accumulated on the collectors inclined at 45° have the highest values for the collector variant "A", as well as the best efficiency.

Table 2 shows the results of the calculations performed for the temperature differences, the air flows, the accumulated heat, the total heat received from the sun and the average daily yields of the solar collectors. The values presented in the Table were processed in EXCEL with the help of relations (1-4). From the diagrams presented in Figures 10 and 11, it can also be seen that the collector variant "A" presents the highest values both for the accumulated heat and for the yield.

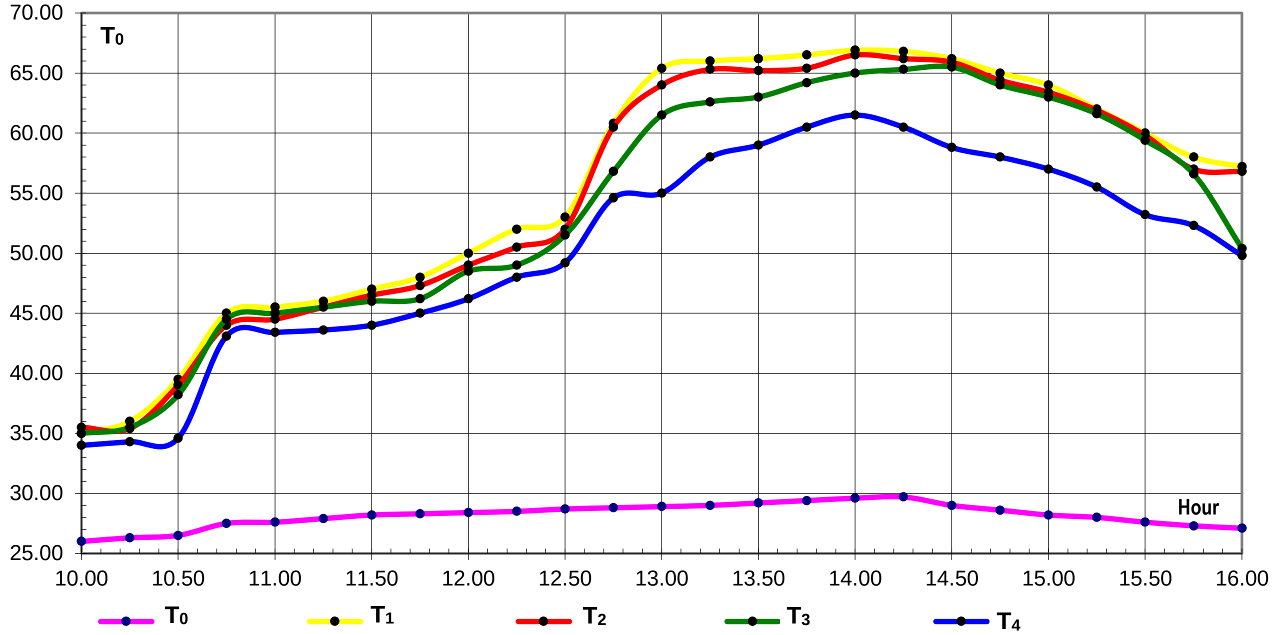

Fig. 8 - Variation of the temperature of the panels for tilting in the vertical plane at 45° from the horizontal plane
T_0 – environmental temperature; T_1 - panel no. 1 temperature; T_2 - panel no. 2 temperature;
T_3 - panel no. 3 temperature; T_4 - panel no. 4 temperature

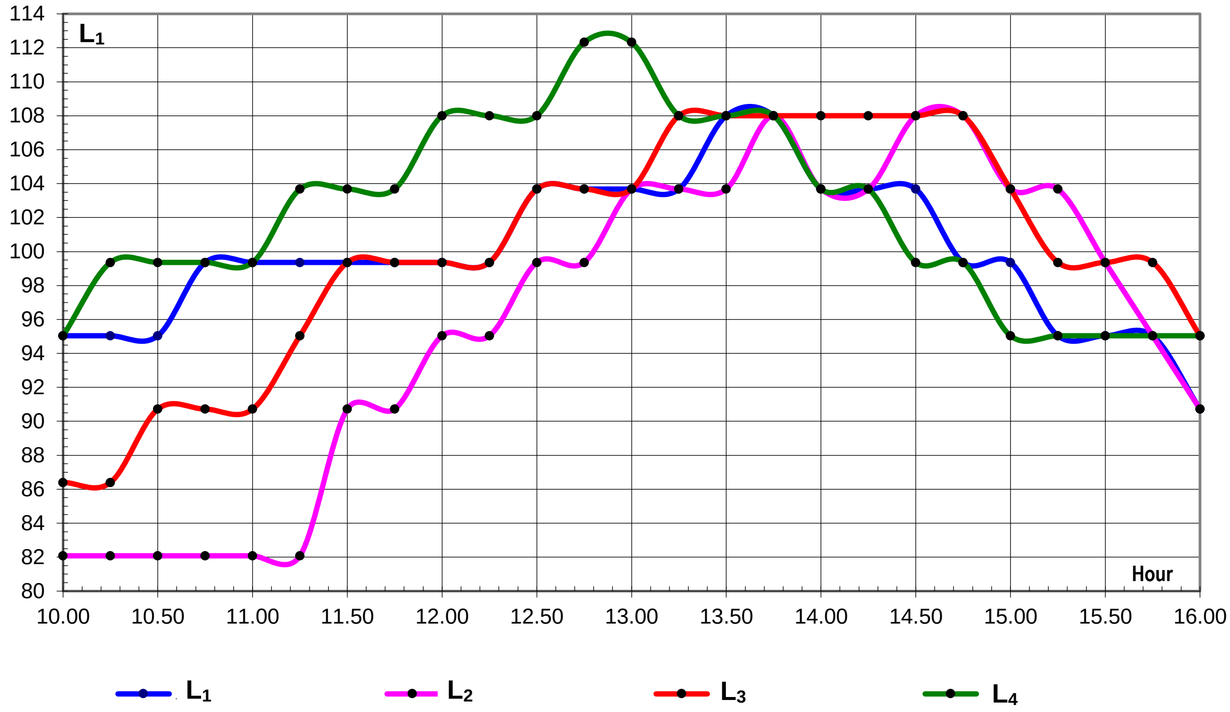

Fig. 9 - Variation of the air flows for tilting in the vertical plane at 45° from the horizontal plane
L_1 – air flow to the panel no. 1; L_2 – air flow to the panel no. 2; L_3 – air flow to the panel no. 3;
L_4 – air flow to the panel no. 4

Table 2

Hour	Temperature differences ($T_{panel} - T_{environment}$) [°C]				Air flows [m³/h]				Accumulated heat [Kcal/h]				Average radiation intensity [Kcal/m² h]	Heat received [Kcal/h]	Yields [%]			
	Panel 1	Panel 2	Panel 3	Panel 4	Panel 1	Panel 2	Panel 3	Panel 4	Panel 1	Panel 2	Panel 3	Panel 4	-	-	Panel 1	Panel 2	Panel 3	Panel 4
10.00	9.00	9.50	9.00	8.00	95.04	82.08	86.4	95.04	94.09	85.774	85.536	83.635	270	364.5	25.81	23.53	23.47	22.95
10.25	9.70	9.10	9.20	8.00	95.04	82.08	86.4	99.36	101.41	82.162	87.437	87.437	280	378	26.83	21.74	23.13	23.13
10.50	13.00	12.50	11.70	8.10	95.04	82.08	90.72	99.36	135.91	112.86	116.76	88.53	290	391.5	34.71	28.83	29.82	22.61
10.75	17.50	16.50	17.00	15.60	99.36	82.08	90.72	99.36	191.27	148.98	169.65	170.50	300	405	47.23	36.78	41.89	42.10
11.00	17.90	16.90	17.40	15.80	99.36	82.08	90.72	99.36	195.64	152.59	173.64	172.69	325	438.75	44.59	34.78	39.58	39.36
11.25	18.10	17.60	17.60	15.70	99.36	82.08	95.04	103.68	197.83	158.91	184	179.06	355	479.25	41.28	33.16	38.39	37.36
11.50	18.80	18.30	17.80	15.80	99.36	90.72	99.36	103,68	205.48	182.62	194.55	180.20	410	553.5	37.12	32.99	35.15	32.56
11.75	19.70	19.00	17.90	16.70	99.36	90.72	99.36	103.68	215.31	189.60	195.64	190.46	540	729	29.54	26.01	26.84	26.13
12.00	21.60	20.60	20.10	17.80	99.36	95.04	99.36	108	236.08	215.36	219.68	211.46	560	756	31.23	28.49	29.06	27.97
12.25	23.50	22.00	20.50	19.50	99.36	95.04	99.36	108	256.85	230	224.06	231.66	575	776.25	33.09	29.63	28.86	29.84
12.50	24.30	23.30	22.80	20.50	103.68	99.36	103.68	108	277.14	254.66	260.03	243.54	600	810	34.21	31.44	32.10	30.07
12.75	32.00	31.70	28.00	25.80	103.68	99.36	103.68	112.32	364.95	346.46	319.33	318.76	610	823.5	44.32	42.07	38.78	38.71
13.00	36.50	35.10	32.60	26.10	103.68	103.68	103.68	112.32	416.28	400.31	371.80	322.47	625	843.75	49.34	47.44	44.06	38.22
13.25	37.00	36.30	33.60	29.00	103.68	103.68	108	108	421.98	413.99	399.17	344.52	630	850.5	49.62	48.68	46.93	40.51
13.50	37.00	36.00	33.80	29.80	108	103.68	108	108	439.56	410.57	401.54	354.02	640	864	50.88	47.52	46.48	40.98
13.75	37.10	36.00	34.80	31.10	108	108	108	108	440.75	427.68	413.42	369.47	650	877.5	50.23	48.74	47.11	42.10
14.00	37.30	36.90	35.40	31.90	103.68	103.68	108	103.68	425.40	420.84	420.55	363.81	600	810	52.52	51.96	51.92	44.92
14.25	37.10	36.50	35.60	30.80	103.68	103.68	108	103.68	423.12	416.28	422.93	351.27	560	756	55.97	55.06	55.94	46.46
14.50	37.20	36.90	36.50	29.80	103.68	108	108	99.36	424.26	438.37	433.62	325.70	520	702	60.44	62.45	61.77	46.40
14.75	36.40	35.80	35.40	29.40	99.36	108	108	99.36	397.84	425.30	420.55	321.33	500	675	58.94	63.01	62.30	47.60
15.00	35.80	35.20	34.80	28.80	99.36	103.68	103.68	95.04	391.28	401.45	396.89	301.09	475	641.25	61.02	62.60	61.89	46.95
15.25	34.00	33.90	33.60	27.50	95.04	103.68	99.36	95.04	355.45	386.62	367.23	287.50	450	607.5	58.51	63.64	60.45	47.32
15.50	32.40	32.20	31.80	25.60	95.04	99.36	99.36	95.04	338.72	351.93	347.56	267.63	440	594	57.02	59.25	58.51	45.06
15.75	30.70	29.70	29.30	25.00	95.04	95.04	99.36	95.04	320.95	310.50	320.24	261.36	435	587.25	54.65	52.87	54.53	44.51
16.00	30.10	29.70	23.30	22.70	90.72	90.72	95.04	95.04	300.37	296.38	243.59	237.31	430	580.5	51.74	51.06	41.96	40.88
														Average yield [%]	**46.07**	**43.78**	**43.61**	**38.14**

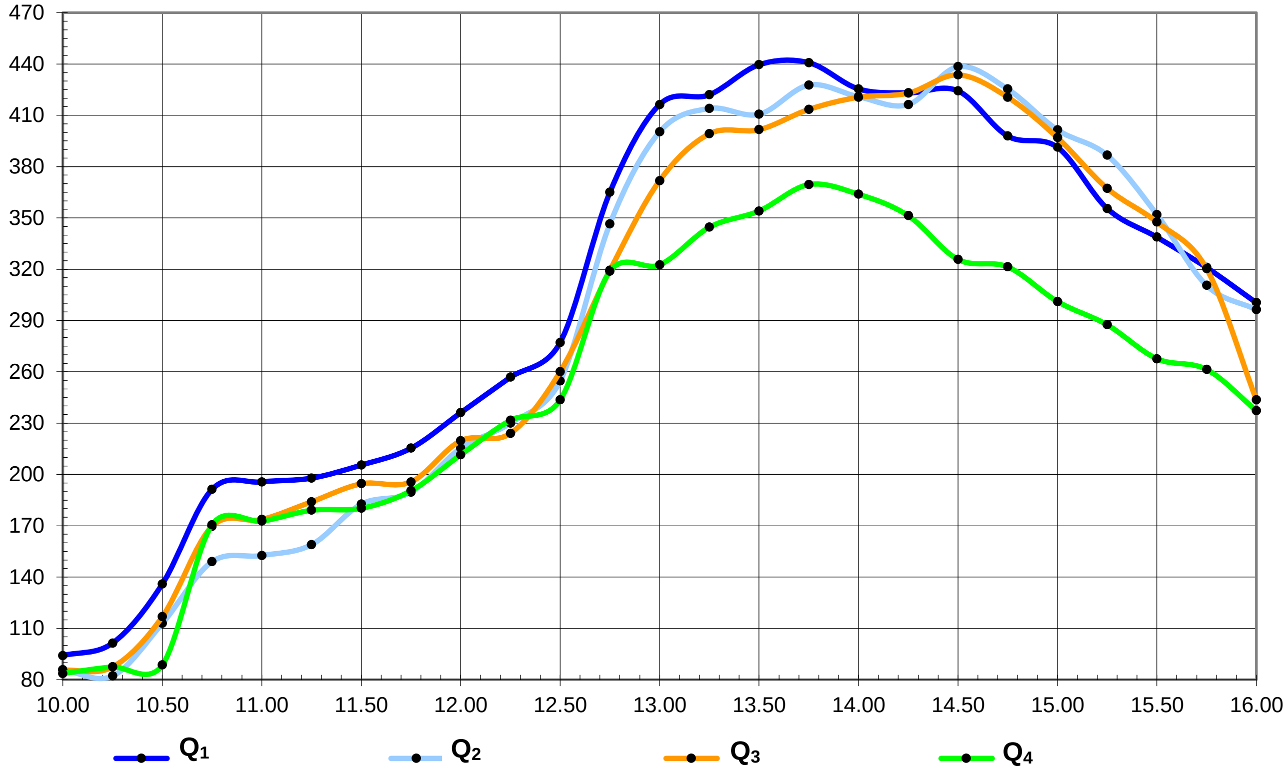

Fig. 10 - Variation of the accumulated heat for tilting in the vertical plane at 45° from the horizontal plane
Q_1 – heat accumulated on panel no. 1; Q_2 – heat accumulated on panel no. 2;
Q_3 – heat accumulated on panel no. 3; Q_4 – heat accumulated on panel no. 4

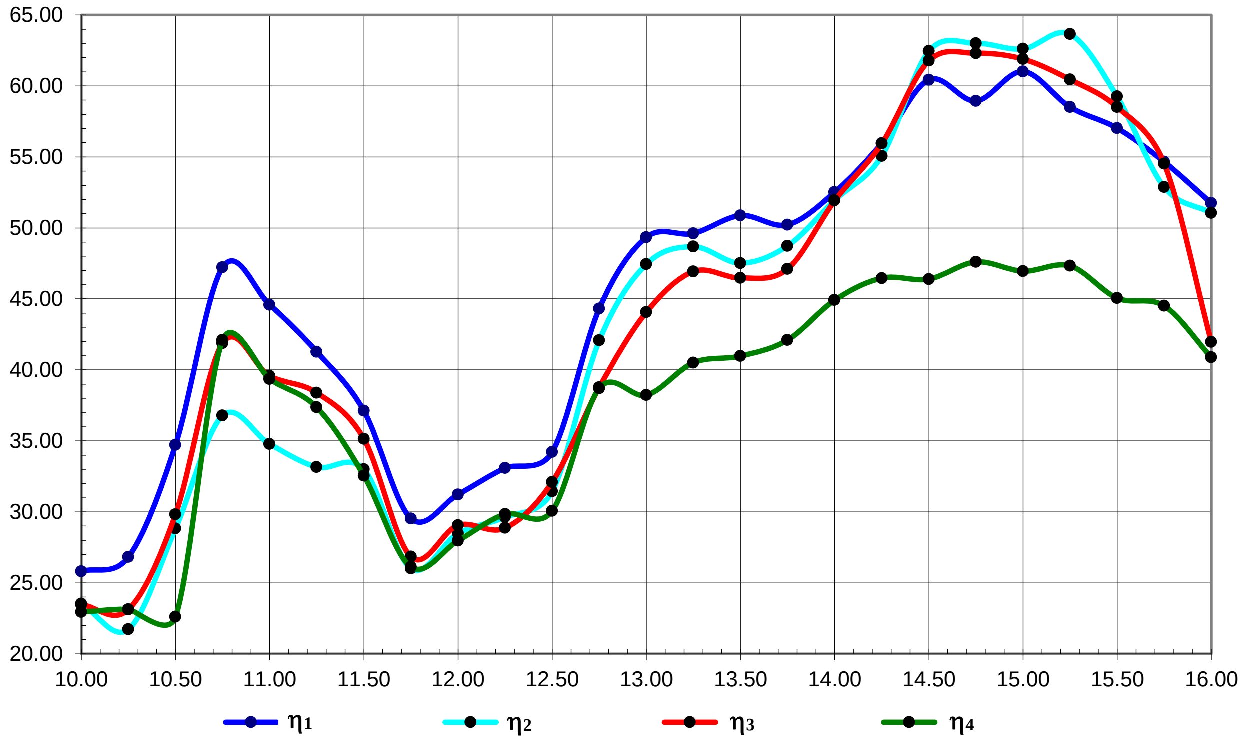

Fig. 11 - Variation of the yield at panels for tilting in the vertical plane at 45° from the horizontal plane
η_1 - yield at panel no. 1; η_2 - yield at panel no. 2; η_3 - yield at panel no. 3; η_4 - yield at panel no. 4

CONCLUSIONS

The experiments highlighted the fact that in the months of May - June in the Bucharest-Ilfov area, the angle of inclination of the solar collectors in the vertical plane is recommended to be 45°, at which the highest values for conversion yields of for solar energy into thermal energy were obtained.

As a result of the experiments carried out, it was found that of the four variants initially tested, variant A was the most efficient in terms of the heat transfer achieved, which recommends expanding the use of the installation in small and medium-sized farms for dehydrating vegetables and fruits, drying cereals and herbal medicine.

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