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USAGE OF UNCONVENTIONAL ENERGY SOURCES AGAINST REDUCING IMPACT ON ENVIRONMENT
CASE STUDY

BY

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Abstract. In order to analyse the building reducing environmental impact by using unconventional energy sources (in this case solar energy) will calculate the annual energy necesary for the studied building (annual energy needs for heating and will add one for hot water and household electric consumers). Then it is calculated the energy consumption and CO_2 emissions when using conventional energy sources (solid fuel boiler and the national energy system). Due to excessive amount of produced surplus energy, even using most performant existing batteries, their lifetime is much diminished. It is recommended the use of surplus energy for other purposes, namely for hot water or heating water in a pool. It is noted that mounted surface of photovoltaic panels provide all the building's energy needs for about four months, between late April and early September.

Key words: unconventional energy; photovoltaic panels; solid fuel boiler; wood pellet boiler.

1. Introduction

In order to analyse the building reducing environmental impact by using unconventional energy sources (in this case solar energy) it is calculated the annual energy necessary for the studied building (annual energy needs for

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heating and will add one for hot water and household electric consumers). Then it is calculated the energy consumption and CO_2 emissions when using conventional energy sources (solid fuel boiler and the national energy system).

Because the roof has been designed so that surface of solar collectors is facing South, roof pitch being optimized for Iaşi zone, the final analysis will consist on reducing CO_2 emissions and solid fuel consumption, when are used in parallel systems using solar energy installations.

2. Energy requirement

2.1. Energy Requirement for Hot Water Achievement

Expression of energy requirement for hot water achievement is

$$Q_{acm}=\frac{V_{ac}\rho c\left(t_{ac}-t_r\right)}{3.6\times10^3}+Q_p=\frac{73\times985.6\times4.182(55-12.5}{3.6\times10^3}+1.1=3{,}907.4\ \text{kW.h/year}. \quad (1)$$

2.2. Energy Requirement for Electronic and Electric Household Consumers

Electric household necessary energy will be spreadsheeted (*e.g.* Table 1), daily consumers being properly for an unifamilial building.

Table 1
Daily Necessary Energy for Electronic and Electric Household Consumers

Consumers	Consumers Power, [W]	Number of consumers	Daily using time, [h]	Hourly consumed power, [W.h]
Submersible pump	1,500	1	2	3,000
Central pump	250	1	24	6,000
ACM pump	250	1	2	500
Security systems	30	1	24	720
TV sets	150	1	7	1,050
Washing machine	3,000	1	0.5	1,500
Refrigerator	1,500	1	1	1,500
Induction oven	1,000	1	1	1,000
Iron	1,800	1	0.2	360
Hood	350	1	1	350
Personal computer	100	1	1	100
Vacuum cleaner	1,500	1	0.3	450
Garden bulbs	11	6	14.00	924
Boiler bulb, toilet	21	4	3	252
Floor bulbs	15	11	2	330
Ground floor bulbs	21	11	6	1,386
Ground floor living bulbs	21	30	1	105
Total				19,527

3. Fuel Consumption

3.1. Fuel Consumption and CO_2 Emissions for a Classic Boiler

Fuel consumption and CO_2 emissions will be calculated only for heating energy requirement assurance and hot water acquirement, whose value is

$$Q_{\text{ac}m\,+\,\text{înc}} = 16{,}583.5 + 3{,}904.7 = 20{,}488.2 \text{ kW.h/year.} \qquad (2)$$

In case of using a gas boiler specific fuel consumption (C-107, 2005) is

$$V_{\text{used gas}} = Q_{\text{ac}m\,+\,\text{heat}}\, c_s = 20{,}488.2 \times 0.10 = 2{,}048.82 \text{ m}^3, \qquad (3)$$

where: c_s is the specific gas consumption (c_s = 0.10 m^3/kW.h) and CO_2 emission is calculated with relation

$$E_{CO2} = e_{CO2} Q_{\text{ac}m\,+\,\text{heat}} = 0.19 \times 20{,}488.2 = 3{,}892.75 \text{ kg}, \qquad (4)$$

with: e_{CO2} – specific emission of CO_2 (e_{CO2} = 0.19 kg/kW.h).

3.2. Fuel Consumption and CO_2 Emission for a Wood Plant

When using a wood boiler specific fuel consumption will be

$$V_{\text{consumed wood}} = Q_{\text{ac}m\,+\,\text{heat}} c_s = 20{,}488.2 \times 0.001 = 20.49 \text{ m}^3, \qquad (5)$$

where: c_s is the specific gas consumption (c_s = 0.001 m^3/kWh) and CO_2 emission is

$$E_{CO2} = e_{CO2} Q_{\text{acm}\,+\,\text{heat}} = 0.36 \times 20{,}488.2 = 7{,}375.75 \text{ kg}, \qquad (6)$$

with e_{CO2} – specific emission of CO_2 (e_{CO2} = 0.36 kg/kW.h).

Taking into account that price of cubic meter of pilled timber is almost 140 Ron, and a pilled meter is equal with 0.7 m^3 it results that are necessary 4,016.04 Ron to assure necessary fuel with a double CO_2 emission.

3.3. Fuel Consumption and CO_2 Emission for a Pellet Plant

When using a pellet plant will be analysed fuel consumption for a plant produced by ecoHORNET (Fig. 1).

For the presented plant specific consumption is 0.188 kg/kW.h so that, quantity of consumed pellets will be

$$C_{\text{consumed pellets}} = Q_{\text{ac}m\,+\,\text{heat}}c_s = 20{,}488.2 \times 0.188 = 3{,}865.69 \text{ kg.} \qquad (7)$$

Fig. 1 – Pellets plant.

In the case of these plants CO_2 emission is under 250 mg/m^3, emission of organic volatile compounds under 10 mg/m^3 and particles emission under 8 mg/m^3 throughout the operation. The values are reduced because is considered that consumed carbon dioxide during growth of a tree will balance CO_2 emission.

Taking into account that the price of one kilo of pellets is between 0.5 and 1.5 Ron it results an amount between 1,932.8 and 5,798.5 Ron depending on pellets supplying mode.

4. System Facilities that Use Solar Eergy

It is proposed the version where whole area of South-facing roof will be covered with photovoltaic panels, thus providing all the necessary electricity for domestic use, the surplus being used for hot water.

South-facing roof area has a length of 13 m and width of 2.70 m with an inclination of 53° from horizontal. Thus on this area of 35.1 m^2 will be located an integer number of photovoltaic panels.

Photovoltaic cells fall into four categories, namely

a) Monocrystalline.
b) Polycrystalline.
c) Thin layer.
d) Others.

Depending on the application, available land area and available volume of investment, will choose the optimal cell type. Life of the photovoltaic cells is of 20…25 years. During this time they lose about 20% of their capacity to convert light into electricity.

Chosen photovoltaic cells (Fig.2) has the following characteristics:

a) Polycrystalline photovoltaic module with 60 cells, with an output of 190 W.p.

b) Maximum efficiency: 14.9%.

c) Size: 80.8 × 158.0 cm.

d) Thickness (framed): 35 mm.

e) Weight: 15.5 kg.

f) System maximum tension: 600 V_{DC}.

g) Operating temperature: –40ºC…80ºC.

h) Connection box: IP – 65, with protection diode by-pass.

i) Output cable: symmetrical cable length of 4.8 m, S = 4 mm^2, double insulation layer, with halide - free, resistant to UV radiation.

Fig. 2 – Polycrystalline photovoltaic panel with 60 cells.

Panel dimensions allow us to sit on the chosen surface a total of 22 panels (Fig. 3). Thus, surface of mounted photovoltaic panels on the roof will be of 28.086 m^2. In order to calculate the energy produced by these panels, are used the corresponding data of Iaşi city.

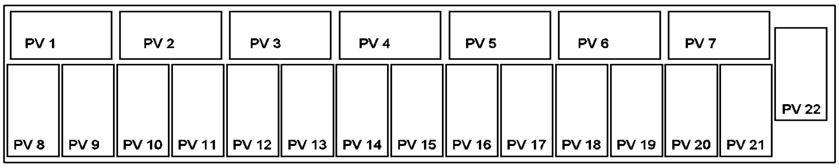

Fig. 3 – Arrangement of photovoltaic panels on south-facing roof surface.

Iaşi is located in zone II in terms of intensity of solar radiation, average being about 1,500 kW.h/m^2.year for the optimal slope and 1,250 kW.h/m^2.year for horizontal one.

Considering the maximum efficiency of the presented panels and monthly average solar radiation intensity variation, were calculated energy values produced by surface of panels. With the obtained values was ploted the curve from Fig. 4. In order to determine the necessary energy for households was taken into account the fact that in the summer months, circulation pump providing heating plant is stopped also by the number of days of each month. It can be observed, as expected, that in the summer months when power consumption is lower due to higher solar radiation intensity, excess energy is almost double. Due to excessive amount of produced surplus energy, even using most performant existing batteries, their lifetime is much diminished. It is recommended the use of surplus energy for other purposes, namely for hot water or heating water in a pool. It is noted that mounted surface of photovoltaic panels provide all the building's energy needs for about four months, between late April and early September.

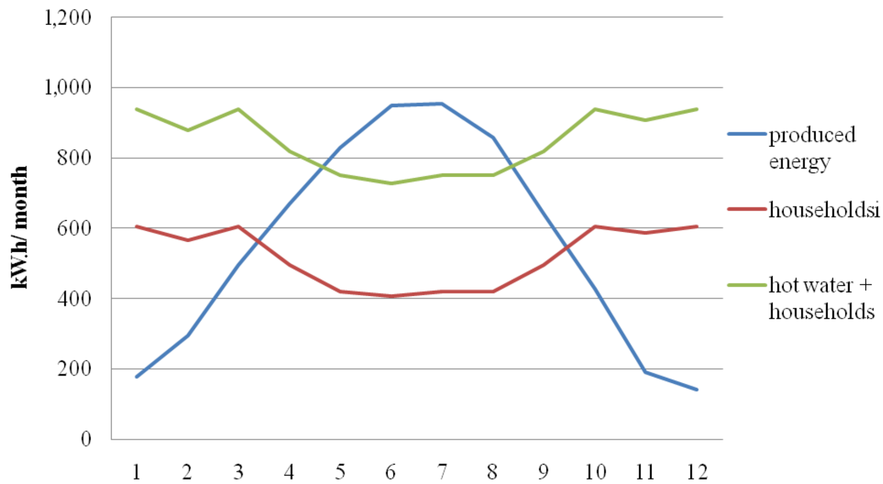

Fig. 4 – Variation of energy produced by panels and household consumption.

5. Conclusions

The power requirements for electronic and household consumers will be provided by the proposed system during the period between early April and late September, which means a reduction in fuel consumption and CO_2 emissions of about 12.96%. Between early May and late August, mounted photovoltaic panels can also provide energy needs for domestic hot water production, which will make an input of 6.4% in reducing fuel consumption. To these values is added the energy from the panels produced in the rest of the year, panels that will provide only a part of the energy for households, namely a reduction in fuel consumption by another 7%. Thus, a classical plant will only work eight months a year, leading to a decrease in annual fuel consumption and CO_2 emissions of around 6.4%. This causes a decrease of 130.66 m^3 and 248.25 kg of CO_2 emissions, for a gas plant, with 1.31 m^3 of wood and 470.38 kg CO_2, for a wood plant or 245.64 kg pellets for a pellet plants.

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UTILIZAREA SURSELOR NECONVENŢIONALE DE ENERGIE PENTRU DIMINUAREA IMPACTULUI ASUPRA MEDIULUI
Studiu de caz

(Rezumat)

Cu scopul de a analiza diminuarea impactului clădirii asupra mediului prin utilizarea surselor neconvenţionale de energie (în cazul dat energia solară) se calculează necesarul anual de energie pentru clădirea analizată (necesarului anual de energie pentru încălzire i se adăugă cel pentru prepararea apei calde menajere şi cel pentru consumatorii electrici de uz casnic). Apoi, se calculează consumul de energie şi emisia de CO_2 în cazul utilizării surselor clasice de energie (centrală termică pe bază de combustibil solid şi sistemul energetic naţional). Datorită faptului că acoperişul clădirii a fost astfel proiectat pentru a putea fi amplasaţi captatori solari pe suprafaţa orientată spre sud, înclinaţia acoperişului fiind optimă pentru zona Iaşi, în final se analizează diminuarea emisiei de CO_2 şi a consumului de combustibil solid, în cazul utilizării în paralel a unor sisteme de instalaţii ce utilizează energia solară. Necesarul de energie pentru consumatorii electronici şi electrocasnici este asigurat de către sistemul propus pe durata cuprinsă între începutul lunii aprilie şi sfârşitul lunii septembrie, ceea ce înseamnă o diminuare a consumului de combustibil şi a emisiei de CO_2 cu aproximativ 12,96 %.