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COMPARATIVE STUDY ON THE USE OF UNCONVENTIONAL RESOURCES FOR PRODUCTION OF HEAT AND HOT WATER

BY

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Abstract. This paper presents a comparative study between two systems, the proposed using non-conventional energy sources and the reference using current sources of energy.

The study focuses on comparing the results obtained by the proposed system in comparison with the classical system to produce heat and hot water for a family home having four members.

To accurately assess the performance of a hybrid system providing heat and hot water requires some assumptions about the consumption of heat and domestic hot water, climate zones of the target location, intensity of solar radiation for these areas and energy price.

All these data are essential for effective design of a hybrid system that uses renewable energy sources.

Key words: system; solar energy; solar collector; biomass heating.

1. Introduction

One of the effects of technological development of all human societies over the past century is a more pronounced increase in energy consumption, but

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more pronounced dependence on fossil fuel consumption, especially as oil, natural gas and coal.

Development and human progress are related to the possibility of ensure natural resources in general and especially energetic ones. As technical progress and industrial civilization gain, total energy consumption increased significantly, a trend that manifests itself today.

The need for comfort in households today has triggered a variety of energy consuming devices. Although progress in science and technology has enabled machines with good performance in terms of relatively low energy consumption, however, overall, absolute consumption increases.

2. General Hypotheses Concerning the Simulation Performance of Assurance Systems Energy Independence

Simulation of performance, economic and financial systems to ensure energy independence for single-family household with four members was performed using the computer program RETScreen. For this calculation the following hypotheses were necessary:

a) To obtain meteorological data, the system was placed in the four tempe-rature zones (Miercurea-Ciuc – zone IV, Iaşi – zone III, Craiova – zone II, Timişoara – zone I).

b) Hot water requirements according to STAS 1478-90 is of 60 L/person/day with a running time of seven days per week for residential buildings.

c) Average heat requirement is

- 106 W/m^2 for residential buildings located in zone IV;
- 99 W/m^2 for residential buildings located in zone III;
- 92 W/m^2 for residential buildings located in zone II;
- 85 W/m^2 for residential buildings located in zone I.

d) Cost of natural gas in the year 2011 is of 0.036 €/kW.h.

e) The price of one ton of wood fuel (pellets) is 130 €/tone.

f) The inflation rate is considered of 5%.

g) For reference is using a natural gas plant with an efficiency of 80%.

3. Case Study – Simulation of Technical Performance, Economic and Financial of a Hybrid System to Insure Thermal Energy and Hot Water

In the main, block diagram of a hybrid plant for preparation heating and hot water has the following structure (Fig. 1):

a) Production subsystem, composed on solar collector, pellet central heating, the primary agent network, associated valves and equipment that ensure the smooth circulation of the primary agent.

b) Transport subsystem, composed on distribution networks and equipment to ensure smooth flow of the primary agent.

c) Subsystem for use, composed of radiant floor, radiator, and fan equipment for hot water (mixing batteries).

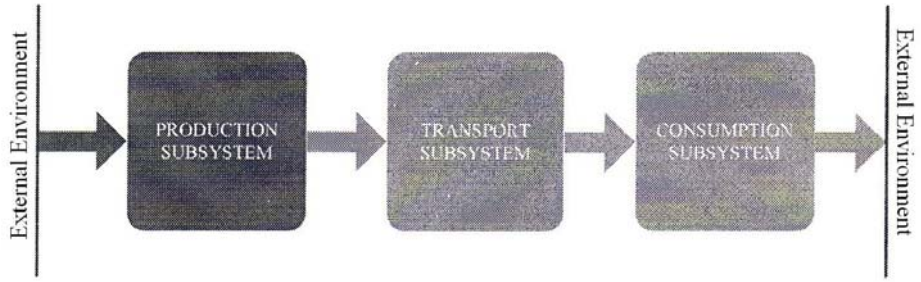

Fig. 1 –The system of hybrid installations for heat and hot water.

3.1. Solar System with Thermal Collectors and Heating Central on Biomass (Pellets)

The block diagram of a solar system with thermal collectors and heating central using biomass (pellets) for producing heat and hot water is represented in Fig. 2.

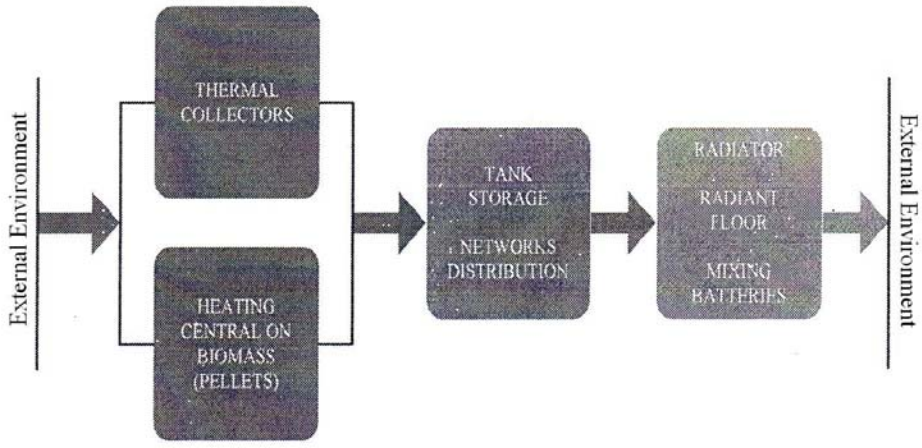

Fig. 2 – Solar system with thermal collectors and heating central using biomass for producing heat and hot water.

For the simulation, the system will be located in the four temperature zones. Biomass heating central will have different powers depending on the

temperature zone. The solar collector is a fixed type with a tilt of 45° and a conversion efficiency of 72%.

The following tables present the simulation results, the technical, economical and financial performance depending on the temperature zone of solar system with solar collectors and biomass heating system (proposed) compared with a classical thermal energy and hot water–gas fired central heating (reference).

A. For temperature zone IV (Miercurea-Ciuc) (Table 1).

Table 1

Technical and Economic Indicators of the Solar System for Temperature Zone IV

	Reference case	Proposed case
Indicator	House – 4 people	
Needs for ACS / person, [L/day]	60	
Needs for ACS, [MW.h]	5.6	5.6
Annual solar radiation – tilted, [MW.h/m^2]	–	1.41
Collector type	–	Plan collector
Number of collectors	–	3
Surface of solar collectors, [m^2]	–	6
Capacity storage / solar collector surface, [L/m^2]	–	200
Capacity, [kW]	–	4.2
Thermal agent delivered, [MW.h]	–	3.4
Solar fraction, [%]	–	61
Total area of heating, [m^2]	200	
Thermal load of the building, [W/m^2]	106	99
Total heat required, [MW.h]	49	46
Type of central heating	Central heating on natural gas	Central heating on solid fuel
Power of heating central, [kW]	25	
Fuel used	Natural gas	Biomass (pellets)
Seasonal efficiency, [%]	80	90
Fuel consumption – annual	61,815.8 kW.h	9.3 to
Fuel price	0.036 €/kW.h	130 €/to
Annual fuel cost, [€]	2,225	1,219

Financial analysis of the solar system was done according to the index value of fuel, inflation, life of the project and overall system costs.

Financial parameters of the solar system based on fuel value index are presented in the Table 2.

Table 2
Financial Indicators of the Solar System for Temperature Zone IV

System price thermal collectors + heating central on biomass, [€]	11,500		
Fuel index value, [%]	0	10	20
Inflation rate, [%]	5		
Project life, [years]	25		
Total annual costs, [€]	1,319		
Economy and total annual earnings, [€]	2,225		
Net GHG reduction, [tCO_2/year]	11		
Net GHG reduction [tCO_2]-25 years	267		
RIR, [%]	5.2	17.1	28.2
Simple payback period, [years]	12.7		
Profitability, [years]	13.3	7.9	6.1
Net present value (VAN), [€]	8,647	92,354	553,443
Annual savings in life, [€/year]	346	3,694	22,138
Cost-benefit (C–B)	1.75	9.03	49.13

B. For temperature zone III (Iaşi) (Table 3).

Table 3
Technical and Economic Indicators of the Solar System for Temperature Zone III

	Reference case	Proposed case
Indicator	House – 4 people	
Needs for ACS/person, [L/day]	60	
Needs for ACS, [MW.h]	5.2	5.2
Annual solar radiation – tilted, [MW.h/m^2]	–	1.50
Collector type	–	Plan collector
Number of collectors	–	3
Surface of solar collectors, [m^2]	–	6
Capacity storage / solar collector surface, [L/m^2]	–	200
Capacity [kW]	–	4.2
Thermal agent delivered, [MW.h]	–	3.4
Solar fraction, [%]	–	65
Total area of heating, [m^2]	200	
Thermal load of the building, [W/m^2]	99	90
Total heat required, [MW.h]	38	34
Type of central heating	Central heating on natural gas	Central heating on solid fuel
Power of heating central, [kW]	23	
Fuel used	Natural gas	Biomass (pellets)
Seasonal efficiency, [%]	80	90
Fuel consumption – annual	47,316.8 kW.h	7 to
Fuel price	0.036 €/kW.h	130 €/to
Annual fuel cost, [€]	1,703	908

Financial parameters of the solar system based on fuel value index for temperature zone III are presented in the Table 4.

Table 4

Financial Indicators of the Solar System for Temperature Zone III

System price thermal collectors + heating central on biomass, [€]	10,700		
Fuel index value, [%]	0	10	20
Inflation rate, [%]	5		
Project life, [years]	25		
Total annual costs, [€]	1,012		
Economy and total annual earnings, [€]	1,703		
Net GHG reduction, [tCO_2/year]	8		
Net GHG reduction, [tCO_2]-25 years	205		
RIR, [%]	2.9	15	26
Simple payback period, [years]	15.5		
Profitability, [years]	16.9	9.0	6.7
Net present value (VAN), [€]	4,076	69,916	432,582
Annual savings in life, [€/year]	163	2,797	17,303
Cost-benefit (C–B)	1.38	7.53	41.43

C. For temperature zone II (Craiova) (Table 5).

Table 5

Technical and Economic Indicators of the Solar System for Temperature Zone II

	Reference case	Proposed case
Indicator	House – 4 people	
Needs for ACS / person, [L/ day]	60	
Needs for ACS, [MW.h]	5.0	5.0
Annual solar radiation – tilted, [MW.h/m^2]	–	1.54
Collector type	–	Plan collector
Number of collectors	–	3
Surface of solar collectors, [m^2]	–	6
Capacity storage / solar collector surface, [L/m^2]	–	200
Capacity, [kW]	–	4.2
Thermal agent delivered, [MW.h]	–	3.4
Solar fraction, [%]	–	68
Total area of heating, [m^2]	200	
Thermal load of the building, [W/m^2]	92	83
Total heat required, [MW.h]	34	30
Type of central heating	Central heating on natural gas	Central heating on solid fuel
Power of heating central, [kW]	22	
Fuel used	Natural gas	Biomass (pellets)
Seasonal efficiency, [%]	80	90
Fuel consumption – annual	41,902.5 kW.h	6.1 to
Fuel price	0.036 €/kW.h	130 €/to
Annual fuel cost, [€]	1,508	792

Financial parameters of the solar system based on fuel value index for temperature zone II are presented in the Table 6.

Table 6
Financial Indicators of the Solar System for Temperature Zone II

System price thermal collectors + heating central on biomass, [€]	10,300		
Fuel index value, [%]	0	10	20
Inflation rate, [%]	5		
Project life, [years]	25		
Total annual costs, [€]	896		
Economy and total annual earnings, [€]	1,508		
Net GHG reduction, [tCO_2/year]	7		
Net GHG reduction, [tCO_2]-25 years	181		
RIR, [%]	1.9	14.2	25.1
Simple payback period, [years]	16.8		
Profitability, [years]	19	9.5	7.0
Net present value (VAN), [€]	2,490	61,720	387,982
Annual savings in life, [€/year]	100	2,469	15,519
Cost-benefit (C–B)	1.24	6.99	38.67

D. For temperature zone I (Constanța) (Table 7).

Table 7
Technical and Economic Indicators of the Solar System for Temperature Zone I

	Reference case	Proposed case
Indicator	House – 4 people	
Needs for ACS / person, [L/day]	60	
Needs for ACS [MW.h]	4.9	4.9
Annual solar radiation – tilted, [MW.h/m^2]	–	1.57
Collector type	–	Plan collector
Number of collectors	–	3
Surface of solar collectors, [m^2]	–	6
Capacity storage / solar collector surface, [L/m^2]	–	200
Capacity, [kW]	–	4.2
Thermal agent delivered, [MW.h]	–	3.4
Solar fraction, [%]	–	69
Total area of heating, [m^2]	200	
Thermal load of the building, [W/m^2]	85	76
Total heat required, [MW.h]	31	28
Type of central heating	Central heating on natural gas	Central heating on solid fuel
Power of heating central, [kW]	22	
Fuel used	Natural gas	Biomass (pellets)
Seasonal efficiency, [%]	80	90
Fuel consumption – annual	39,138.7 kW.h	5.6 to
Fuel price	0.036 €/kW.h	130 €/to
Annual fuel cost, [€]	1409	734

Financial parameters of the solar system based on fuel value index for temperature zone I are presented in the Table 8.

Table 8
Financial Indicators of the Solar System for Temperature Zone I

System price thermal collectors + heating central on biomass, [€]	9,500		
Fuel index value, [%]	0	10	20
Inflation rate, [%]	5		
Project life, [years]	25		
Total annual costs, [€]	840		
Economy and total annual earnings, [€]	1,409		
Net GHG reduction, [tCO_2/year]	7		
Net GHG reduction, [tCO_2]-25 years	169		
RIR, [%]	1.8	14.4	25.3
Simple payback period, [years]	16.7		
Profitability, [years]	19	9.4	7.0
Net present value (VAN), [€]	2,211	57,852	364,340
Annual savings in life, [€/year]	88	2,314	14,574
Cost-benefit (C–B)	1.23	7.09	39.35

4. Conclusions

The performance of technical, economic and financial indicators for two systems of reference were analysed and were proposed for heating and domestic hot water preparation for a home with four members.

For proper interpretation of results, the proposed system (central heating with biomass + solar collectors) was placed in the four areas of temperature resulting energy capacity installed and prices different for each area.

Analysing in the light of technical, economic and financial indicators the following conclusions may be drawn

1. Seasonal efficiency of the proposed case is with 10% better than the reference case.

2. In the proposed case fuel consumption is lower than in the reference case due primarily of use of solar collectors on the warm period and secondly due to high efficiency of biomass thermal central.

3. The price for fuel In the proposed case is with 50% lower than is the reference case.

4. Payback period for the proposed case is between 14 and 19 years depending on the temperatures zones.

Energy furnished by biomass is currently a practical endless energy source that can be operated continuously, regardless of weather conditions.

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STUDIU COMPARATIV PRIVIND UTILIZAREA RESURSELOR NECONVENȚIONALE PENTRU PRODUCEREA DE ENERGIE TERMICĂ ŞI APĂ CALDĂ DE CONSUM

(Rezumat)

Se efectuează un studiu comparativ între două sisteme, cel propus care utilizează surse de energie neconvenționale şi cel de referință, care utilizează sursele actuale de energie.

Studiul se concentrează pe compararea rezultatelor obținute de sistemul propus față de sistemul clasic pentru producerea de energie termică şi apă caldă de consum pentru o locuința unifamilială cu patru membri.

Pentru evaluarea corectă a performanțelor unui sistem hibrid de asigurare a energiei termice şi a apei calde de consum este nevoie de o serie de ipoteze legate de consumurile de energie termică şi apă caldă de consum, zonele climatice de amplasare a obiectivului, intensitatea radiației solare pentru aceste zone, prețul energiei. Toate aceste date sunt esențiale pentru o proiectare eficientă a unui sistem hibrid ce utilizează sursele regenerabile de energie**.**