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RESEARCHES CONCERNING THE IMPLEMENTATION OF A NEW SYSTEM FOR GENERATING ECOLOGICAL THERMAL ENERGY IN BUILDINGS LOCATED IN THE HILL AND MOUNTAIN AREAS

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Abstract:

The paper presents the studies and researches carried out and the obtained results regarding the installing of a new system for generating ecological thermal energy and its introduction into an integrated circuit of production and energy supply of a building located in the sub mountain area.

The research results can be applied in any hilly and mountaneous area, and favourable conditions are found in those places with dense hydrographic networks where water can be captured directly from springs or streams in a gravimetric system (without pumping it).

It is highlighted: the block diagram of generating ecological thermal energy; installations; the integrated system of using it; represented by heat sources and cogeneration and heat supply installations.

Key words: *thermal ecological energy; thermal installations; integrated system.*

INTRODUCTION

The researches presented in this paper is part of a wider program of studies aimed at developing new solutions for generating electrical and thermal energy in the context of recommendations offered by the sustainable development programs, promoted at national and international level (Grecu 2015).

The first studies were materialized and highlighted in the article entitled “Research on the creation of a system for the conversion of the water kinetic energy of hill and mountain rivers into green energy using recycling materials" (Grecu 2017). Complementary studies are currently developing an integrated system for cogenerating photovoltaic, wind and geothermal energy.

The achievements presented in the paper are part of this program for the development of an integrated system, which being used, will lead to a total energy independence of the buildings located on the hills and mountains (and not only), and to the valorisation of some recycled resources and fuels of lower quality. In this context, the promotion of solid fuels resulting from the pre-industrialisation of wood material from forestry exploitations as well as from forestry or gardening cuttings of orchards and gorges cuttings, fences, etc. is being promoted to produce the current heating.

OBJECTIVE

1. Elaboration of the water supply scheme of the thermal system - Gravimetric version (V1) and with well or fountain (V2).
2. Design and implementation of the system which generates thermal ecological energy.
3. Design and implementation of the integrated heat supply system of a building located in the sub-mountain area.

MATERIAL, METHOD, EQUIPMENT

The materials used for the installations are both traditional and commercial. The fuels used are those that are not currently marketed for use in their primary form.

1. Elaboration of the water supply scheme in the gravimetric system from the spring or the mountain streams (V1)

This water supply system aims at the use of water from dense hydrographic areas or springs (ex. the northern slope of the Făgăraş Mountains) with possibilities of gravimetric captures. The implementation of such a system whose principle scheme is presented in (Fig. 1) implies the existence of a difference of level between the capture area and the building it serves so that the free play of the water pressure in the system could ensure its function. In the case of this study it is about 10 m. The capture area of the spring or stream water involves making and using a coarse protective device (sieve) (meshes 5 - 10 mm) to prevent the various bodies from entering the supply pipe. This pipe is made of PVC and it is necessary to be buried under the freezing depth of the area (about 1.0 – 1,1 meters).

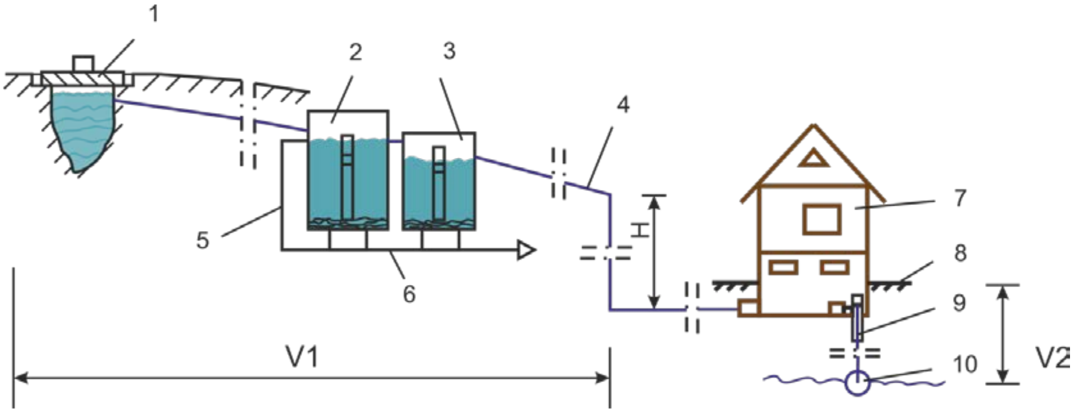

Fig. 1.
Water supply in gravimetric system, from spring or mountain river
V1-water supply from its own fountain or deep well, with hydrophore or submersible pump –V2
1 - spring capture; 2 – decantation tank; 3 decantation-treatment-filtration tank 4- supply pipe in gravimetric system; 5-overflow pipe; 6-exhaust pipe; 7-building ; 8 -land , 9- fountain; 10-deep well.

The system involves the construction or installation of two alluvial decantation tanks with overflow pipes and exahust pipes for cleaning them.

The first tank performs a primary (coarse) decantation and the second one a fine decantation, and it can be used to treat water when it is appropriate.

Water supply from fountain or deep well (V2)

It is a variant in which water is pumped into the system with a hydrophore or pump from its own fountain or deep well (Fig.1). This option involves to dig a fountain or a deep well, in the vicinity or even under the building it serves (example the variant).

In V2 variant the water pumping and recirculation systems are powered by electrical current produced from ecological energy (Grecu 2017). Both versions can be used in parallel, (Fig.1). This gives safety to exploitation, in the case of natural calamities or regional conflicts, etc.).

2. Design and implementation of the ecological thermal energy generation system (SGETE)

This system was designed to operate by capturing solar energy (direct solar radiation) on a panel made of metal elements especially of aluminium (Al) or copper (Cu), both of them being very good heat conductors (Fig. 2). A pipe of the same material is fastened on the back of each element (metal plates).

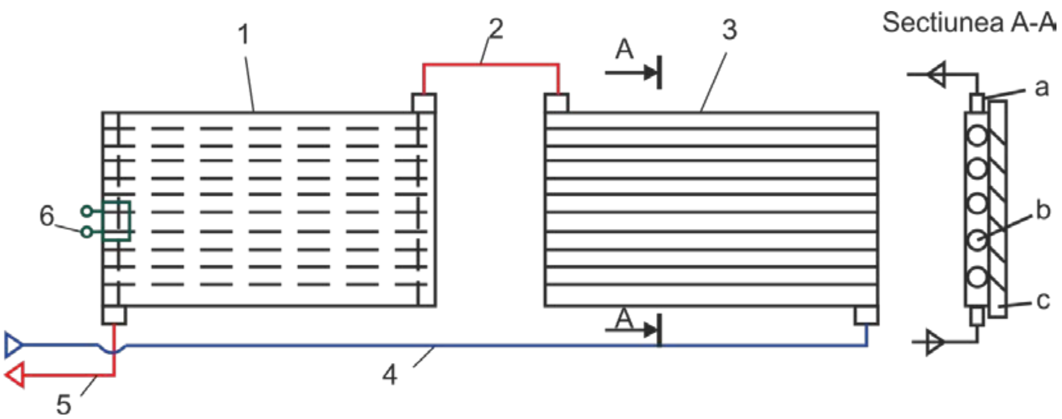

Fig. 2.
Solar collectors system
1- solar collector; 2- connection pipe ; 3-solar collector-section A-A, a-connector, b-aluminium pipes, c- aluminium radiant elements; 4- cold water supply pipe; 5- hot water exhaust pipe.

The plates with metal pipes are connected to a panel for capturing and generating ecological thermal energy integrated in the system of generating total thermal energy of the building. In this case the collector panel (pipes and metal elements) are made of aluminium and the PVC supply pipes. The dimensions of a panel are (800X2000) mm, and the diameter of the metal and PVC pipes is 20mm. The connections between the panels and the water supply and exhaust pipes are removable. The capacity of a collector is about 28 litres (Fig. 3)

Fig. 3.
Solar collectors made of aluminium panels installed on a closed terrace with transparent elements.

Functioning

The collector panels are supplied with cold water in a gravimetric system or with a pump (Fig. 4). They heat the water up to the temperature (25-80)°C depending on the area and the way they are installed, the intensity of the solar radiation and the exposure time.

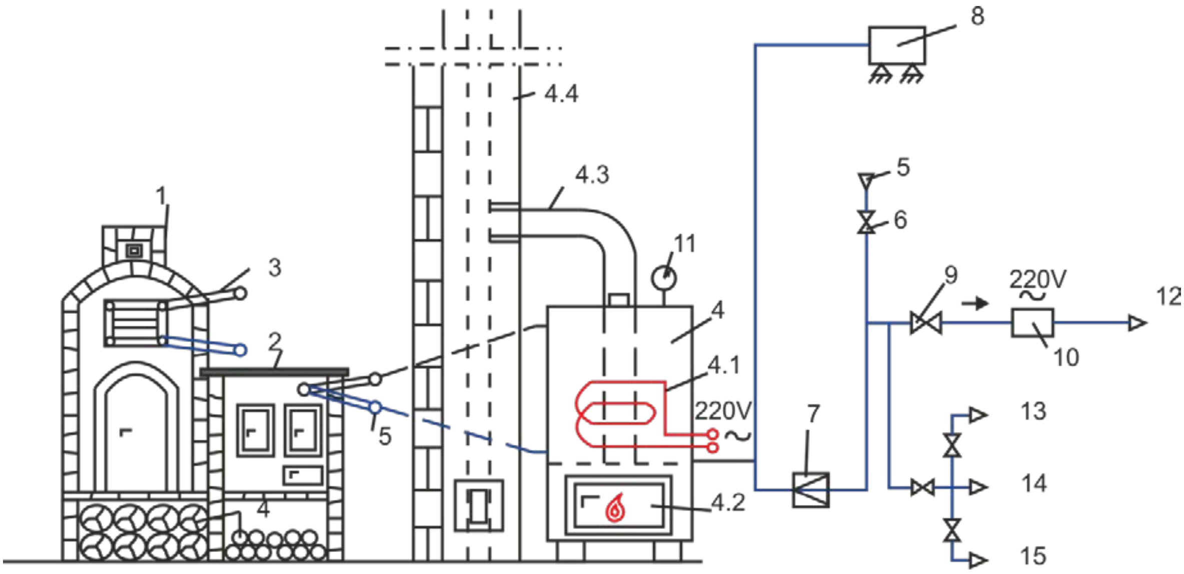

Fig. 4
Thermal system and cold water supply
1-fireplace; 2- multifunctional stove with solid fuel; 3-serpentine; 4 - thermic system for bathroom; 4.1 - boiler heating resistance with electric current; 4.2- solid fuel heater; 4.3- chimney connection; 4.4-chimney; 5-stove serpentine –general supply with cold water; 6-tap; 7-one way valve; 8-expansion vessel; 9 taps; 10-pump for recirculating water; 11 - pressure gauge; 12- collectors for water recirculation; 13 cold water circuit for bathroom; 14 cold water circuit for kitchen; 15-other cold water circuit.

Hot water is discharged directly to the installations of the bathroom, kitchen, or related installations (outside) or can be recirculated through the boiler tank (Fig. 4) by means of a pump in order to heat the water inside it. If the water is recirculated through the tank, the command to start the pump is given by a temperature sensor installed on the final end collector if several collectors are installed in series. The cycle is repeated as many times as the sensor records a predetermined temperature on the surface of the exhaust pipe of the hot water. A complete cycle of water heating in the collectors at about 50°C lasts 30 minutes, on a sunny day (in July, two pm - in the sub-mountain area).

The two collectors used in the experiment were installed on a terrace closed with transparent, mono-block polycarbonate, with thickness of 4mm, related to the building which is the object of this study. (Fig. 3).

3. Design and implementation of the integrated thermal system

This system consists in 3 subsystems (a; b; c).

a - generation of ecological thermal energy with solar collectors (Fig.3).

b - generation of thermal energy in a multifunctional stove and fireplace with solid fuels, installed in a kitchen and dining room (Fig.4).

c - generation of thermal energy in a boiler fuelled with solid fuels or electric energy installed in the bathroom (Fig.5).

The design of the systems took into consideration the following conditions:

- the served building may also be one that is seasonally exploited (with discontinuous activities),
- the ecological heating system operates predominantly during the hot season,
- multifunctional stove provides heating and domestic hot water for kitchen and bathroom during cold days,
- the fireplace is mainly used in the cold season,
- the boiler installed in the bathroom is used for generating hot water in those situations when the system is maximally exploited (repeated cycles in short time) and for the permanent storage of hot water in its tank.

RESULTS AND DISSCUSIONS

The cold water supply mode of the integrated system is presented in Fig. 4. Cold water is introduced through the general supply installation (5) into the system gravimetrically, or with a hydrophore. The cold water reaches directly the tank of the boiler (4), to the serpentine of the stove (5), to the serpentine of the fireplace, to the solar collectors (depending on the heating variant), to the solar collectors (13) and to the other consumers (bathroom -14, kitchen-15 etc.).

In the figure there are also represented: the fireplace (1), the stove (2) installed in a separate multifunctional space; the boiler (4) with the water tank, the combustion furnace and the electrical equipment (electrical resistance, temperature control block etc.) are installed in the bathroom.

The implementation of the integrated thermal system, the last objective of the studies and researches carried out is highlighted by the principle scheme in (Fig. 5).

There are the connections between the three thermal energy cogeneration subsystems and the hot water (h.w.) recirculation mode.

V1 – h.w. produced in the fireplace and stove circulates to the tank and then directly to the users.

V2 – h.w. produced in the multifunctional stove, circulates to the tank of the boiler and then directly to the consumers.

V3 - V4 – h.w produced in a boiler with electric current or solid fuel circulates directly to the consumers.

V5 – h.w. produced in solar collectors (9), circulates directly to consumers.

V6 – h.w. it is recirculated with the pump (12) through the solar collectors (9) and introduced into the tank of the boiler (4) from where it is redistributed to the consumers.

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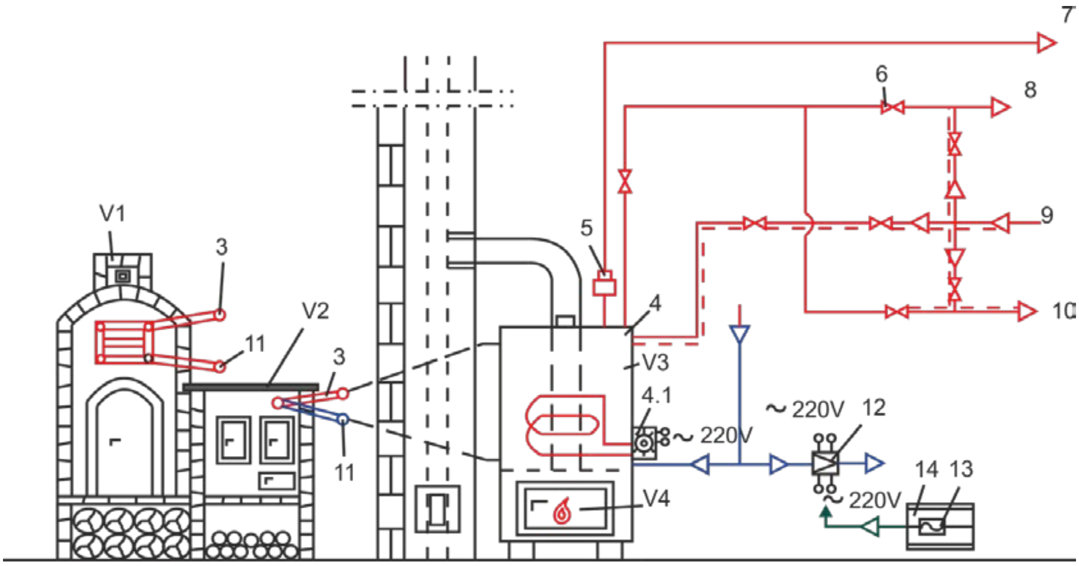

Fig. 5.
Thermal system and hot water supply
Variant V1 - thermal heating with fireplace - solid fuel; Variant V2 - heating with multifunctional stove - solid fuel; Variant V3 - heating with electrical current; Variant V4 - heating through a boiler furnace - solid fuel. Variant V5 – heating with solar collectors.
1-fireplace; 2-multifunctional stove; 3 hot water pipes; 4-boiler with electric resistance and solid fuel furnace; 5-overpressure valve; 6-taps; 7 – exhaust pipe for overheating water; 8- bathroom-kitchen hot water distribution; 9-hot water from solar collectors; 10- hot water distribution to other consumers; 11 - general cold water supply; 12-pomp for recirculating cold-hot water; 13 - temperature sensor on solar collectors; 14- solar collectors.

When the building is not permanently exploited (occasionally in the cold season), the heating circuit will be modified by introducing an additional serpentine into the fireplace, and the water will be replaced with an antifreeze substance with a freezing temperature below minus 30°C Domestic water will be introduced into the thermal system when the system starts working.

The fireplace (1) and stove (2) are made of hand-made brick, being resistant to high temperatures and reused from an old building. Their design is rustic, with elements of Romanian traditional architecture, specific to the area (Fig. 6)

Fig. 6.
Fireplace and multifunctional stove.

The multifunctional stove and the fireplace were placed in a room of the building designed for food preparation, dining and even relaxation; again a specific approach to the traditional custom in which a space is designed to multiple functions in order to reduce the fuel and electricity consumption. Serpentines (3) and (5) were made of stainless steel and the connecting pipes of copper. The integrated system is equipped with single-way valves and overpressure control devices and exhaust system for directing steams outdoors in case of overheating (Fig. 5; Fig. 7)

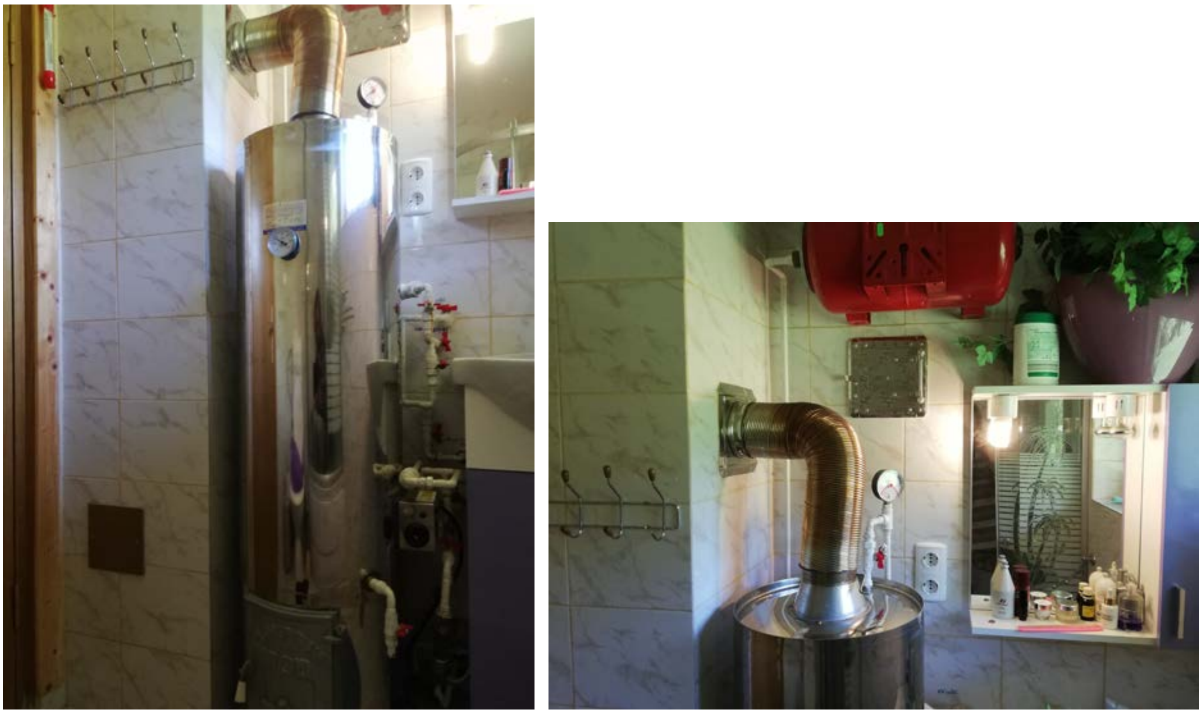

Fig. 7.
The boiler and thermal system equipment.

The amount of wood used is the result of cuttings of tree branches and stems of different species, with different thicknesses, from the area where building is located.

According to the size of the heated surfaces of the building and the required amount of domestic hot water, additional quantities of wood can be obtained from pre-industrial wood operations in the local area, where large amounts of branches, pieces of stems are found everywhere and the price is very low. This also implies a sanitation of the exploitation areas.

Obtained Parameters

The first experiments highlighted the functionality of the integrated system and its efficiency.

The capturers provided water with a temperature between (25-80°C) for about 7 months per year.

The capturers heat up the water in the boiler tank (110 litres), in (2-3 hours), depending on the daily solar radiation.

The multifunctional stove raises the temperature in the room with dimensions (5x4, 5x2,3) m, where it is installed, from 10 degrees to 20 degrees, in about an hour (when the house was uninhabited).

The stove simultaneously heats the domestic water in the boiler tank at about 50 degrees.

The stove is operating together with the fireplace and heats the room from 2 degrees to 20 degrees in about 2 hours.

The heat stored in the stove and the fireplace is stored for at least 24 hours; the temperature drops from 24 degrees to 18 degrees, while the outside (outside) temperature drops from 18 degrees to 6 degrees. The experiments are at the beginning, all this to be continue.

CONCLUSIONS

The installation of solar collectors in a closed terrace with transparent materials, amplifies, through the greenhouse phenomenon, radiation and temperature at their surface, while maintaining the stored heat. The solar collectors provide domestic hot water during sunny days in the warm seasons.

Maintenance costs (periodical cleaning with water under pressure, painting at about 10 years) are very low. The estimated reliability of the installed collectors in the protected area lasts at least 50 years.

Reusable materials, bricks, were used to build the stove and the fireplace. Putting them into practice in a way that highlights their craftsmanship creates a special look and enriches the place where they are located.

The use of fuels resulting from the silvicultural cuttings of the orchard trees and the clearing of the surroundings where the building is located has eliminated the costs of shredding, evacuating, transporting or destroying them. The burning of fuel in the stained-glass stove or the fireplace in a multi-functional room (kitchen-dining room) is a real show appreciated both by owners and guests. In this way, we can discover, or even create, a connection between the traditional and the modern techniques, a way of living in communion with nature.

The integrated thermal system offers safe exploitation, ensures rapid heating of the rooms and domestic water. It is reliable and easy to use.

A final conclusion; the achieved results correspond to the proposed objectives; the use of the thermal , electrical, ecological energy sources, the reusable materials and the revaluation of the fuels resulting from forestry processes provide 100% of the heat and domestic water for the experimental building.

The studies will emphasize the other ecological systems of energy (photovoltaic, wind and geothermal) in order to complete the energy resources needed for a building under the most unfavourable conditions (when some of the installations may become inoperable).

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