Combination of the solar energy systems for household use and apartment buildings

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SUMMARY

The future of humankind is built on reasonable use of nature resources, among other, energy saving. The "green ideas" are implemented not only through the increased level of human awareness but mainly due to economic justification. Use of the alternative energy sources is becoming more and more topical all over the world.

Considering the abovementioned, the research project plans to develop a new product – a combined hot air and hot water generation solar energy system usable in households. The project includes the industrial study and experimental development, and building of a prototype, among others.

INTRODUCTION

Today, solar energy is used both in generation of electricity and in production of hot water and air. The system costs for generation of any of the abovementioned energies are high. Households basically use systems operated by solar power to generate electricity and hot water. However, it is exactly the heating that accounts for the largest part of costs incurred by households. The market offers hot air generation systems operated by solar power. Use of the said systems in the conditions of the temperate climatic area provides only for seasonal energy generation options. Combination of the solar energy systems generating hot air and hot water permits. Operation of these systems throughout the year thus increased the systems efficiency. Solar energy systems that generate hot water are currently being rather widely used. If such a system is installed separately its costs are high and its yield is long-lasting. Installation of a hot air generating solar energy system, in its turn, provides only for limited use depending on the seasonality because in summer air heating is not necessary. A market research showed that solar energy systems providing for simultaneous generation of hot water and hot air that would suit our climatic conditions are not available currently. Creation of a combined system will permit its use throughout the year, providing in its turn 100% use of sunny days for energy generation which is very important in our weather conditions. Today, the market offers only combined electricity and hot air generation solar energy systems basically intended for use in industrial objects.

Considering the abovementioned, the research project plans to develop a new product – a combined hot air and hot water generation solar energy system usable in households. The project includes the industrial study and experimental development, and building of a prototype, among others.

The aim of the research is to conduct an industrial study and experimental development to work out a prototype of a new product - a combined hot air and hot water generation solar energy system usable in households. The project output will be the prototype of the new combined solar energy system. The developed combined hot air and hot water generation solar energy system for households will provide for generation of energy from the solar power, thus increasing the building's energy efficiency and decreasing the traditional energy costs and energy dependence.

The hot air and hot water generation solar energy system usable in households to be developed is a new product not only in Latvia but also in the world. The new system will differ from the systems available on the market with that it could provide for simultaneous generation of hot air and hot water from solar power, thus increasing the building's energy efficiency and decreasing the costs of use of the traditional energy, permitting use of the new system all around the year regardless of the season. Presently there are only the combined electricity and hot air generation solar energy systems available on the market intended basically for industrial use.

Solar wall

SolarWall is an air heating system that uses solar heat to warm up and ventilate spaces in new and renovated buildings.

Solar Wall:

- Reduces fuel use by employing solar energy;
- Improves air quality indoors;
- Has low operating costs compared to other solar units.

This type of technology amounts basically to air heating; this is used in a number of countries across the world, mostly for heating large industrial structures. In Latvia, this technology has already been installed on the territory of the Riga Airport, heating a 26,000m^2 warehouse. The principle is as follows: SolarWall panels are mounted onto studs fastened to a wall. The panels are perforated, making air tunnels once mounted. After the walls are assembled, they are connected to a ventilator or directly connected to air ventilation and handling units which funnel air along the SolarWall air tunnels to a given space. An assembled SolarWall can be seen on Figure 1. When a wall is connected to an engine that sucks air out through SolarWall panels with air tunnels, the air warms up thanks to energy radiated by the sun, and enters the space indoors at a higher temperature. Depending on air temperature requirements for that space, the air may require additional heating to reach the requirements.

Consider an example. After SolarWall was installed, measurements were taken on a cold February day. Air temperature was -10°C, but thanks to sunny weather, SolarWall heated the air inside to +14, +15°C, whereas the required temperature was +18°C. Obviously, the amount of additional heating needed was minimal. By combining this system with heat recuperation and heat regeneration units, very high heat economy may be achieved, as shown in the case of one specific warehouse.

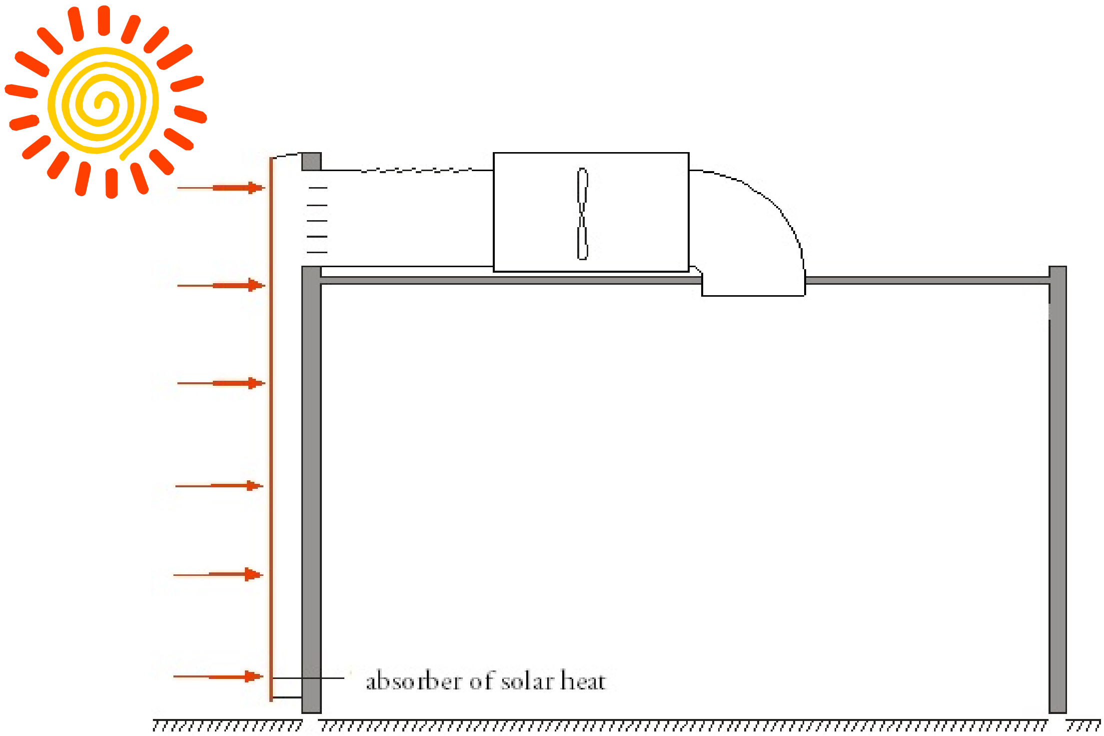

Figure 1. SolarWall

A solar unit for heating water, consisting of solar collector and heat exchanger/ accumulator. A heat carrier (antifreeze) is circulated through the solar collector. The heat carrier heats up by absorbing solar heat in the solar collector, transferring it to the water through a heat exchanger coupled to the accumulator tank. The accumulator tank stores hot water for use, so good heat insulation is crucial.
The use of solar heating of water is an expedient choice throughout the warm season, March through September. A unit with a ratio of solar trap area to accumulator tank volume equal to 2 m^2/ 100 l has a 50-90% probability of maintaining a daily heating temperature of no less than 370°C, 30-70% probability of maintaining at least 450°C, and 20-60% for 550°C. The maximum probability percentages apply to summer months.
For example, let's take appropriate apartment building at the neighborhood of Riga neighborhood, with 100 people where the warm water norm is 100 l per capita.

RESULTS

The average July solar radiation sizes on horizontal plate in Riga are E= 192 kWh/m^2.
The net power from the collector:

$$P = E*b*d*e = 110.6 \text{ kWh/m}^2 \quad (1.)$$

where b=0.8 - collector efficiency, d= 0.8 -useful solar radiation (ineffective solar radiation in morning and evening), e= 0.9 – heat loses.

Average output per hour produced by 1m^2 collector P = 0.15 kWh/m^2;
Warm water consumption for apartment building per day -10000 m^3;
Heat consumption for our apartment building for water heating per day:

$$Q = G * dT * c \quad (2.)$$

where G = 10000m^3 amount of heatable water, dT =45°C ;temperature of heated water T_2=50°C, temperature of cold water T_1= 5°C; c = 1 ccal*kg/C,

Q =450000ccal it means that Q = 387 kW per day.

The coefficient of the empirical data found a similar home consumption per hour, taking into account the circulation of heat loss: 0.3

Q = 116.1 kW

Heat consumption per hour: Q = 4.84 kW/h

Manifold, the number of square meters required for domestic hot water: Q = 33 m^2

In view of the aforementioned facts, plans are in progress within the framework of an RTU and FEI project to develop a combined warm air and hot water solar system for household use (hereinafter referred to as the FEI Panel). The plans include industrial research and experimental design, including the production of a prototype.

The new system will be different from other solar heating systems available on the market in that it will be able to provide solar heating of both air and water, thereby increasing energy efficiency and reducing spending on traditional energy resources with year-round operation, regardless of seasonality.

Several examples exist across the world where Solar Wall technology is used in tandem with PV type batteries which provide power, although at our latitudes, where cities, for instance, predominantly have central heating and heat economy issues are much more topical, a more interesting option would actually be Solar Wall in combination with vacuum hot water handling traps. It could be particularly interesting for apartment buildings, where hot water supply is centralised and tenants must also pay for circulation heat loss through hot water risers. In such cases, heat use for heating water can be reduced outside the heating season, while in winter stairways of apartment buildings would be filled with warmer air, significantly reducing heat loss in the building.

Global solar infrared radiation in our region fluctuates from season to season. From May to September, the sun gives 700-740kW/m^2 in Latvia; from October to April, 200-240 kW/m^2; November to February, 40 - 50 kW/m^2. [2]

Solar panels are an environmentally friendly way to obtain energy that causes no pollution, be it physical, radiation or aesthetic. Combined warm air and hot water heating panels are applicable for both the summer and the winter seasons. In summer, vacuum heat traps for heating water provide water for household use, whereas in winter, air channels inside the panel provide fresh, warm air indoors.

The market for selling the new product is both stand-alone homes and apartment buildings; apartment buildings are more numerous. A large problem for apartment buildings is heating of common use spaces in winter, and hot water circulation losses. Traditionally, common use spaces are not heated, in order to save on heating; if they are heated, heat loss is very high. However, if these spaces are unheated, they cool down thanks to the windows and balconies, as well as entrance doors, practically creating another external wall for each apartment; this cools all dwelling spaces, so monthly bills increase. An FEI panel could funnel partly warmed air through air ducts to the common use spaces, i.e. stairwells. Depending on its temperature, this solar-heated air may partially require additional heating from the heating system. Installation of a heat recuperation system may achieve even lower heat consumption. Reduced heat consumption for common use spaces means a building will use less heat, significantly reducing heating costs in the winter months. In summer, the air ducts connected to the FEI panels could be used for ventilating spaces or even cooling them, provided a cooling unit is connected. For instance, if a Heat pump is used as the main heat production device, the operational schedule for this device could be divided into seasons: working within 65 – 40C temperature boundaries in winter, 7 – 12°C in summer.

It is only possible to heat water sufficiently for household needs, i.e. to 50 – 55°C, on several days in winter. However, it can be achieved all throughout the summer.

Heating of water for apartment buildings during the summer months is the main purpose of an FEI panel.

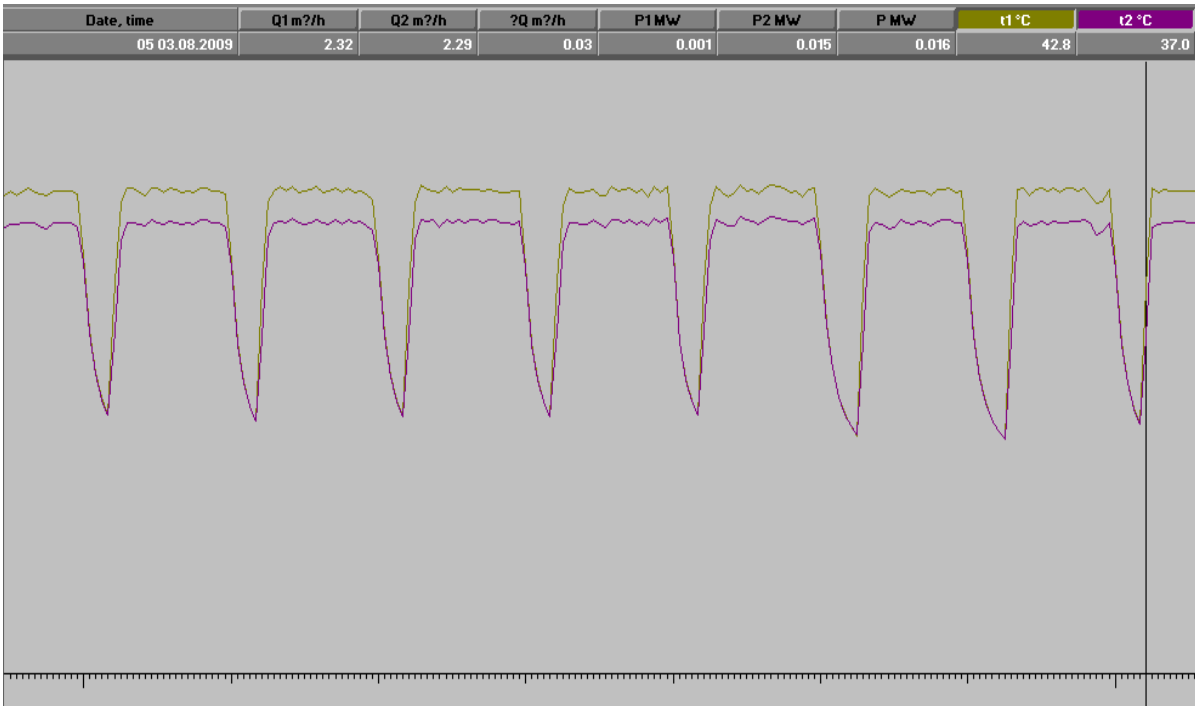

Figure 2. Daily heat consumption shows normal hot water use around the clock

With centralised heating, apartment buildings also have a heat delivery mode. The mode, volume and heat carrier temperature are adjusted depending on a predefined schedule installed according to heating area and hot water consumption. Circulation heat, which provides hot water in apartment buildings after 24.00, is disconnected, and resumed at a specific time according to the inhabitants' wishes – usually 6.00. This is done to achieve savings on heating. An FEI panel is well-suited to such an operational mode, since there is no solar radiation at night and no heat can be produced.

During the day, solar radiation resumes and the FEI panel may be used for providing hot water. In order to provide hot water according to household requirements in summer and centralised heat provider, a 63-65°C heat carrier temperature within a building's heating unit is sufficient for providing hot water. The lower the heat carrier temperature, the less heat it radiates from the surface of heating mains. An FEI panel can maintain this heat carrier temperature in summer. Connected to a building's heating unit heat exchanger, it can provide hot water for household use. At times when the FEI panel cannot provide sufficient heat carrier temperature to maintain circulation heat, heat can be taken from the centralised heating network. There is an issue with high hot water consumption in the morning and evening, which is linked to tenants' work schedules. In the morning, insufficient solar radiation will preclude the FEI panel from maintaining circulation heat, so during the day heat must be accumulated in a heat accumulation tank sufficient for the volume of heat consumption, thereby evening out heat consumption and minimising consumption of heat from the heat provider.

CONCLUSIONS

In the future, FEI Panels would be useful for heating and hot water production in private houses as well as apartment buildings, along with ventilation and improvement of air quality;

An FEI Panel works well in combination with any type of generic heating.

An FEI Panel project is designed so as to adjust the needs of inhabitants in a certain region, according to specific, essential heat consumption requirements;

The use of an FEI Panel improves heat retention and partially remedies flaws in houses built 30-50 years ago, as well as improves air quality and saves heat in new buildings.

The rising prices of energy resources, the issues related to mass reconstruction of old houses, and green energy are just a few of the considerations that promise a successful introduction of FEI Panels to the market.

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