Application of solar energy receivers and heat pumps in the heating system on the example of the hospital in Pirot

•In this paper it will be discussed about development, design and implementation of solar energy as well as the assessment of cost-effectiveness and application of heat pumps in heating systems.

•Our planet is facing with great and difficult challenges.

•non-renewable energy sources greatly affect the environment due to the emission of substances that have very harmful effects on it.

Solar energy

- Solar radiation is the most important natural resource.

- Solar energy offers potentials for the production of heat and electricity that can be used efficiently in modern economic and various production activities

•Direct solar energy can be used in practice by its transformation into thermal, electrical and chemical energy. The transformation into thermal energy is considered here, since it is the simplest way to practically use solar energy.

•Heat of low temperatures up to 100ºC is used to obtain hot hygienic water and heat the rooms. This is achieved by flat solar collectors.

Heat pump

- Heat pumps deliver clean heat using solar, air or ground energy. These energy sources are renewable, and their use is becoming increasingly important.

- There are several types of hest pumps.

Calculation of the solar system on a real object (Pirot Health Center)

- Connected heat consumers:
- Heating, ventilation and air conditioning of the room - heat capacity about 7500 kW

- The total heat capacity of the consumer is about 9790 kW

•The idea of this project is that during the summer mode, the preparation of hot water is done exclusively with the help of solar energy, while in the winter mode, this system would be used to support the already existing heating system.

•A solar collector plant is planned to heat the building, which is connected to the existing, built plant. The solar collector plant is connected in parallel with the existing heat source.

Projected working conditions:

- number of patient beds n = 400
- norm of hot water consumption gn = 200 l / day per bed
- maximum hot water temperature t2 = + 600ºC
- average cold water temperature thv = + 100ºC
- average consumption of hot water per bed gpr = 130 l / day per bed
- average daily consumption of hot water

$$G_{dn} = n \cdot g_{pr} = 400 \cdot 130 = 52.000\, l/day = 52\, m^3/day \Delta t = t_2 - t_{hv} = 60 - 10 = 50^0 C$$

The plant in each period of operation should provide:

- Required amount of water:

$$G_i = 85 \cdot 125\, l/dan$$

- Adopted hot water temperature for consumers + 50ºC.

The required amount of heat for heating the daily amount of water to + 50ºC is:

$$Q_i = G_i \cdot c_w \cdot \rho \cdot (t_3 - t_{hv}) Q_i = 1627,89\, kWh/day$$

Adopted: $Q_i \approx 1630\, kWh/day$

Calculation with collector "SI-SOL 1.4-ST", manufacturer "Gorenje":
Degree of efficiency and heat gains during the heating period with Qkm collector “SI-SOL 1.4-ST” - “Gorenje”:

$$Q_{km} = \eta_k Q_{dm}$$

TABLE - Degree of utility and heat gains by the collector “SI-SOL 1.4-ST”

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Avg	Sep	Oct	Nov	Dec
t_{sr} [^{0}C]	-1,3n	0,9	4,9	10,0	14,6	17,5	19,3	19,0	15,4	10,4	5,2	0,7
t_{srk} [^{0}C]	55	55	55	55	55	55	55	55	55	55	55	55
[^{0}C]	56,3	54,1	50,1	45,0	40,4	37,5	35,7	36,0	39,6	44,6	49,8	54,3
[^{0}Cm^2/W]	0,07	0,068	0,063	0,056	0,05	0,047	0,044	0,045	0,05	0,056	0,062	0,068
η_k	0,26	0,38	0,43	0,47	0,52	0,55	0,57	0,56	0,52	0,47	0,43	0,38
Utilization Q_{km}/m^2 collector surface [kWh/m^2 mon]	25,17	42,18	57,32	75,62	93,5	96,64	110,81	110,32	88,76	74,78	40,42	33,17

The total amount of heat that can be obtained by one meter of collector surface during the year is: 848.69 kWh / m2.

To determine the number of collectors, the month of April was taken, which represents the average between winter and summer operation.

The required collector area is: Ak = 424m2

Required number of collector units: nk = 314.07

N = 320 collector units are adopted for safety.

The area of the flat roof on which the collectors are placed is 22 x 45 m, which means that 320 collectors measuring 1.83 x 0.85 m can be accommodated in 8 rows of 40 units connected in parallel.
The net area of the absorber field is:
Heat gains by the solar system by months are given in TABLE.

$$Q_{Dm} = Q_{dm} A_{anet} \eta_k$$

TABLE - total heat gains by the solar system "SI-SOL 1.4-ST" by month

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Avg	Sep	Oct	Nov	Dec
Q_{dm} [kWh/ m^2mon]	96,8	111	133,3	160,9	179,8	175,7	194,4	197	170,7	159,1	94	87,3
η_k	0,26	0,38	0,43	0,47	0,52	0,55	0,57	0,56	0,52	0,47	0,43	0,38
Q_{Dm} [kWh/ mon]	10.872,6	18.221,8	24.761,8	32.669,1	40.390,3	41.746,3	47.869,1	47.658,2	38.346,0	32.303,7	17.461,4	14.331,2

Total heat gains from the active solar system during the year are:

$$Q_{Duk} = \sum Q_{Dm} = 366.631{,}5\ kWh/year$$

The goal of installing a new plant is:

- more economical and rational operation of the plant,
- substitution of conventional fuel consumption, which is now used by the boiler room, fuel oil and electricity, with renewable solar energy,
- Improving the ecological working conditions of the plant by using energy that does not pollute the environment.

Solar energy is the only inexhaustible source of energy. Due to the variability of the action of solar radiation during the day, month and year, it is not possible to report the construction of a solar system that would enable complete heating of the building during the entire winter period. For the same reasons, solar systems for solar heating of the house are combined with some of the other energy sources in which some of the other forms of conventional energy are consumed: liquid fuel, gaseous fuel, electricity, pellets, solid fuel.

In the period when there is not enough solar energy, solar collectors are used in combination with a heat pump. Such systems are used for heating and cooling of households, business premises, swimming pools, greenhouses. Solar collectors in combination with a heat pump provide the highest possible degree of energy savings and energy efficiency of up to 75%. These systems, in addition to great energy savings, do not produce pollution of the human environment, such as boilers for wood, coal, gas, fuel oil, etc.

•All that is stated in this paper speaks about the fact that solar collector systems and the installation of heat pumps pay off sooner or later, and on the other hand, conventional fuel is not used, which was one of the goals at the beginning of this paper.

•Solar energy is "clean" energy, so that solar collectors have an advantage over other systems in terms of environmental pollution

Thank you for your attention!