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How we can use energy produce by heat pump to get vegetables?

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Abstract **– We live an energy crisis and we need to find solutions to assure the heat in residential buildings and why not to produce vegetables. An option is to use the heat pump air-water. We intend to design a plant based on heat pump air- water to warm the soil in greenhouses. The power necessary to work the heat pumps will be produce by the sun using photovoltaic systems.**

Keywords – air- water, energy, greenhouse, heat-pump.

1. INTRODUCTION

Natural gas and coal are mainly used to produce the thermal energy required for heating buildings as well as for use in industrial processes in Romania. The new Energy Efficiency Directive (EU)2023/1791 has been published in the EU Official Journal. It will enter into force 20 day after publication, members countries have two years to implement it. By banning gas plants, the EU want to save 11.7 % of final primary energy compared to the reference scenario(year 2020) [1].

A very large share of the primary energy consumption within the European Union represents the technological consumption. That, is why a solution for harnessing energy from the environment is the use of air-water heat pumps, the thermal energy produced has a reduced potential corresponding to temperatures below 50℃ [2].

Thus, when choosing a heat pump, regardless of the nature of residential or technological consumers, the degree of energy coverage of the heat requirement and the share of electricity related to the pump must be analyzed. In the case of thermal agent parameters lower than 50℃, we expect the ratio between the degree of energy coverage and the relative nominal electric power of the heat pump to be a favorable one [3].

The installation of a photovoltaic system and an air-water heat pump can lead to a decrease in electricity costs by more than 40% compared to the existing situation where consumers are supplied with thermal energy from the city's thermal network and electricity from national system. Also, for an even greater increase in the efficiency of the air-water heat pump, it is obtained by lowering the temperature regime in the consumers' facilities, thus resulting in a decrease in the consumption of electricity from the national network by more than 7%.[4], [5].

The use of thermal energy produced by thermal power plant for heating soil in greenhouses was studied in 1971 and 1978 according to [6]. Great attention was paid to the utilization of residual heat obtained from technological processes. The cooling water of condensers with low parameters of 25-40℃ was used to heat the soil in the greenhouse with the aim of increasing vegetable production.

In this paper we propose to present the integration of the air water heat pump for production of thermal agent with low parameters 25-35℃ to heat the soil in greenhouses in order to produce vegetables. The study demonstrates the sustainability of solution.

2. EXPERIMENT DESCRIPTION

In our study we use aaheat pump air water with maximum heating power 10 kW. In the graf below we present the relation between extermal temperature and heat capacity for our pump, information offert by the producer (according with the technical data).

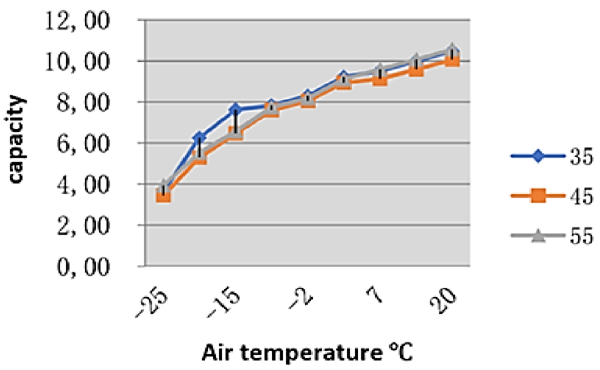

Fig 1 Relation between air temperature and heat capacity for a heat pump with max 10 kW-according with the technical data

In our study we make the analize for a month, January 2022, for this month we have the external temperature, Tab.1, below.

The energy requirement provided by the pump for the month of January 2022 is shown below by applying the method of temperature intervals (bin method). The method establishes the hourly frequency of temperatures during the month of January 2022 by summing the hours characterized by a certain temperature interval. Table no. 2 show the application of the bin method and the calculation of the resulting energy requirement Tab.3. [8].

Table 1

Interval temperature ^{0}C	Temperature ^{0}C	Hours
-9/-7	-8	8
-7/-5	-6	24
-8/-6	-7	21
-5/-3	-4	16
-4/-2	-3	24
-3/-1	-2	24
-2/0	-1	16
-1/1	0	16
1/3	1	40
1/3	2	24
2/4	3	24

3/5	4	16
5/7	6	40
7/9	8	16
8/10	9	24
9/11	10	8
11/13	12	8
15/17	16	8

Table 2 Bin method to calculate de energy consumption and Standard COP for Heat Pump air –water 10kW

Air temperature	COP
-25	2.17
-20	2.56
-15	3.01
-7	3.67
2	3.98
7	4.58
12	4.99
20	5.59
Water temperature	35C

3. RESULTS AND SIGNIFICANCES

Table 3 The performances of Heat pump air –water 10kW. Bin method

Temp.	Nr.hours	q_{bin}[w]	q_{bin}[kw]	Heat capacitystand, kW	qbin/Heat capacity stand	Reduce factor FACC	Real heat capacity kW	Electric power kW	COP stand	COP real	Time fraction E5/15	Heat provide by heat pump [kWh]	Electric energy consumption kWh
0	16	5400	5,4	9	0,6	0,9	8,1	3	3,95	2,7	0,66667	86,4	32
1	40	4950	4,95	9,1	0,543956	0,88599	8,0625	3	3,96	2,6875	0,61395	198	73,6744186
2	24	4500	4,5	9,21	0,4885993	0,87215	8,0325	3	3,98	2,6775	0,56022	108	40,33613445
3	24	4050	4,05	9,3	0,4354839	0,85887	7,9875	3	4	2,6625	0,50704	97,2	36,50704225
4	16	3600	3,6	9,35	0,3850267	0,84626	7,9125	3	4,2	2,6375	0,45498	57,6	21,83886256
6	40	2700	2,7	9,4	0,287234	0,82181	7,725	3	4,5	2,575	0,34951	108	41,94174757
8	16	1800	1,8	9,6	0,1875	0,79688	7,65	3	4,6	2,55	0,23529	28,8	11,29411765
10	8	900	0,9	9,7	0,0927835	0,7732	7,5	3	4,7	2,5	0,12	7,2	2,88
12	8	0	0	9,98	0	0,75	7,485	3	4,99	2,495	0	0	0
16	8	-1800	-1,8	10	-0,18	0,705	7,05	3	5	2,35	-0,25532	-14,4	-6,127659574
-1	16	5850	5,85	8,3	0,7048193	0,9262	7,6875	3	3,8	2,5625	0,76098	93,6	36,52682927
-2	24	6300	6,3	8,29	0,7599517	0,93999	7,7925	3	3,78	2,5975	0,80847	151,2	58,20981713
-3	24	6750	6,75	8	0,84375	0,96094	7,6875	3	3,76	2,5625	0,87805	162	63,2195122
-4	16	7200	7,2	7,9	0,9113924	0,97785	7,725	3	3,72	2,575	0,93204	115,2	44,73786408
-7	21	8550	8,55	7,82	1,0933504	1,02334	8,0025	3	3,67	2,6675	1,06842	179,55	67,31021556
-6	24	8100	8,1	7,85	1,0318471	1,00796	7,9125	3	3,73	2,6375	1,0237	194,4	73,70616114
-8	8	9000	9	7,7	1.1688312	1,04221	8.025	3	3,5	2,675	1,1215	72	26.91588785

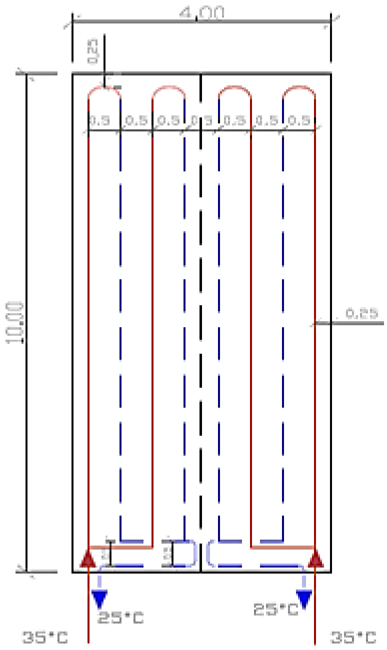

Fig 2 Placement of the soil heating coil in the greenhouse (polyethylene DN 40 mm positioned at 30 cm in the ground)

To determine the heat taken by the soil from thermal agent we will consider the pipes placed in the soil according with Fig. 2 at depth 30 cm, these pipes will lose heat according with relation (1):

Δq = (t_ag-t_s)/R_s [W/m] (1)

The temperature of thermal agent is [35]^°C, the temperature of soil is [10]^°C, the thermal conductivity of soil is 1.2 [W/mK]. Thermal resistance of soil we calculate it and we get 0.44 [mK/W]. The heat taken by the soil is 56.81 [W/m].

So, the heat taken by the soil is approximate 5000W.

4. CONCLUSION

This study wants to demonstrate the application of heat pump in agriculture as well in heating building. For a greenhouse with 40 sq m the heat pump air water can provide water with 35 ℃ to heat the soil and to supply energy to heat the air inside the greenhouse (we calculate the heat load for 12℃ inside temperature). Analyzing the Table 3 we concluded that energy of air could assure the heating load for a greenhouse.

So, to heat the soil in greenhouse with 40 sq m we can use an heat pump air water with 10 kW heat power.

The general conclusion of the study is: the air water heat pump can be an option for providing the energy necessary for the operation of a greenhouse.

5. REFERENCES

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Note:

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