Ecological Alternative for an Air-Water Heat Pump

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Introduction

In 1987 a comprehensive agreement was developed to phase- out production and use of CFC's. Montreal Protocol was considered one of the most successful international implemented agreements. Climate change was attributed directly or indirectly to human activity which alters the composition of global atmosphere.

In Figure 1, the hole in the ozone layer that forms over the Antarctic, in the year 1984-2009, is shown, the view being made by NASA TOMS (Total Ozone mapping Spectrometer) and GSFC (Goddard Space Flight Center) .

Global warming and ozone depletion are two separate environmental problems, but in the end, they are in connection. Romania signed the Kyoto (1997) and Montreal Protocol (1987) and in the same time, as a new member of EU, has the obligations to respect its environmenta

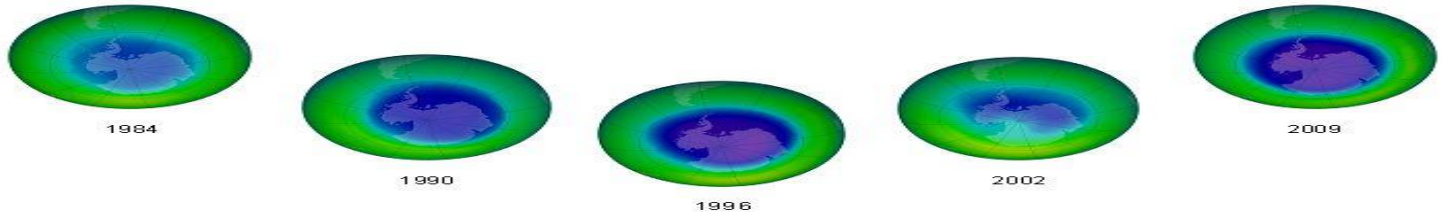


Fig.1 The ozone hole over the Antarctic

- The comparative study of these facilities followed the coefficient of performance of a plant and also the TEWI factor (Total Equivalent Warming Impact – in respect with EN 378-1).

- Energy efficiency is directly related to global warming and greenhouse gases emissions.

Theoretical study

The study case has a refrigeration capacity of 0.62kW. The evaporation temperature for the refrigeration system is -2°C and condensation temperature is +57°C. In the following lines, a few characteristics of heat-pump are also presented (Fig.2). The advanced technology of the water heater / heat pump guarantees superb, quiet operation (1). The high performance two-stage radial fan (2) permits the air to be routed through a pipe of up to 10 m in length and 200 mm in diameter. The thermostatic expansion valve and safety devices ensure the best possible circulation . The heart of the heat pump: the tough, durable compressors with oil coolers and waste heat utilisation by cooling the exhaust gases (3). The evaporator unit has a large surface area giving a self cleaning effect (4). Heat insulation of the storage tank: high insulating value, easily recyclable, made of CFC free polystyrene (5). The air connectors permit simple connection of air inlet/exhaust on site. Pollution free and flame resistant R134a safety working fluid. Quality 270 litre double enamelled hot water tank (6). Quality assurance ensures long life time, while the sacrificial anode gives increased safety (7). Helical tube condenser in the double casing ensures efficient heat transfer and the best possible safety (8). Internal plain tube heat exchanger (enamelled) for connecting solar collectors or boilers (9). Electrical immersion heater built in at the factory (10).

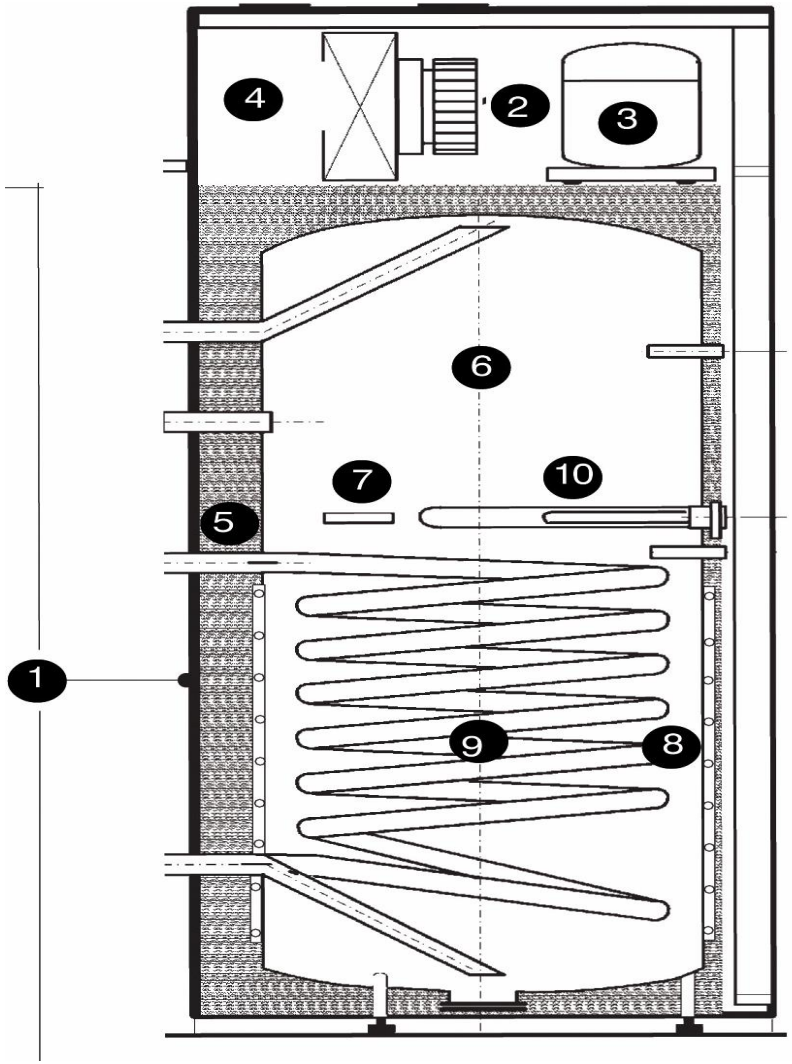
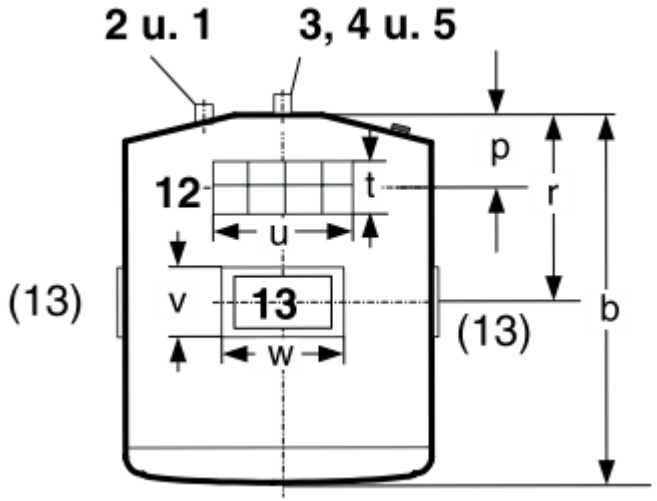
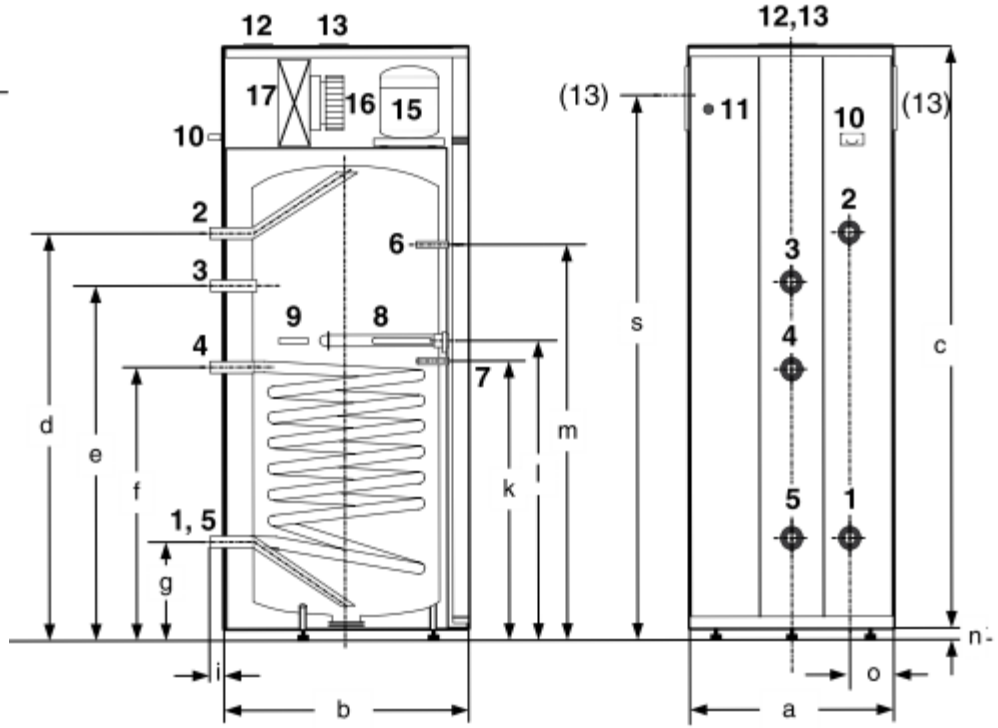
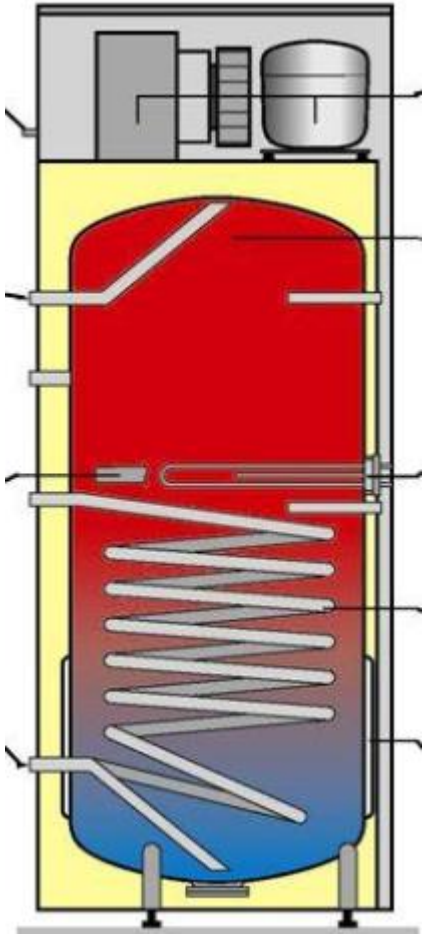


Fig.2. Air-Water Heat pump







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Refrigerant properties	R134a	R410a	R407C	R404A	R600a	R152a
p_0 (bar)	2,720	7,490	4,20	5,50	1,470	2,40
pc (bar)	15,650	35,500	23,20	26,000	8,000	14,000
t_0 (˚C)	-2,000	-2,000	-2,000	-2,000	-2	-2
tc (˚C)	57,000	57,000	57,000	57,000	57	57
COP (-)	4,20	3,80	4,09	3,45	4,41	4,48
ODP	0	0	0	0	0	0
GWP	1430	2088	1774	3260	3	124

Table 1. Comparison table made with the Cool Pack software

With the help of the Genetron software, we analyzed 3 refrigerants from the olefins range. The results are presented in the table below.

Refrigerant	GWP	Cooling COP	Heating COP
R1234YF	4	3.754	4,980
R1234ZE	7	3.749	4.967
R1233ZD	5	3.732	4.906

Table 2. Comparison table made with the Genetron software

In Figure 3. the technical drawing of the refrigerating system R 1234yf is presented

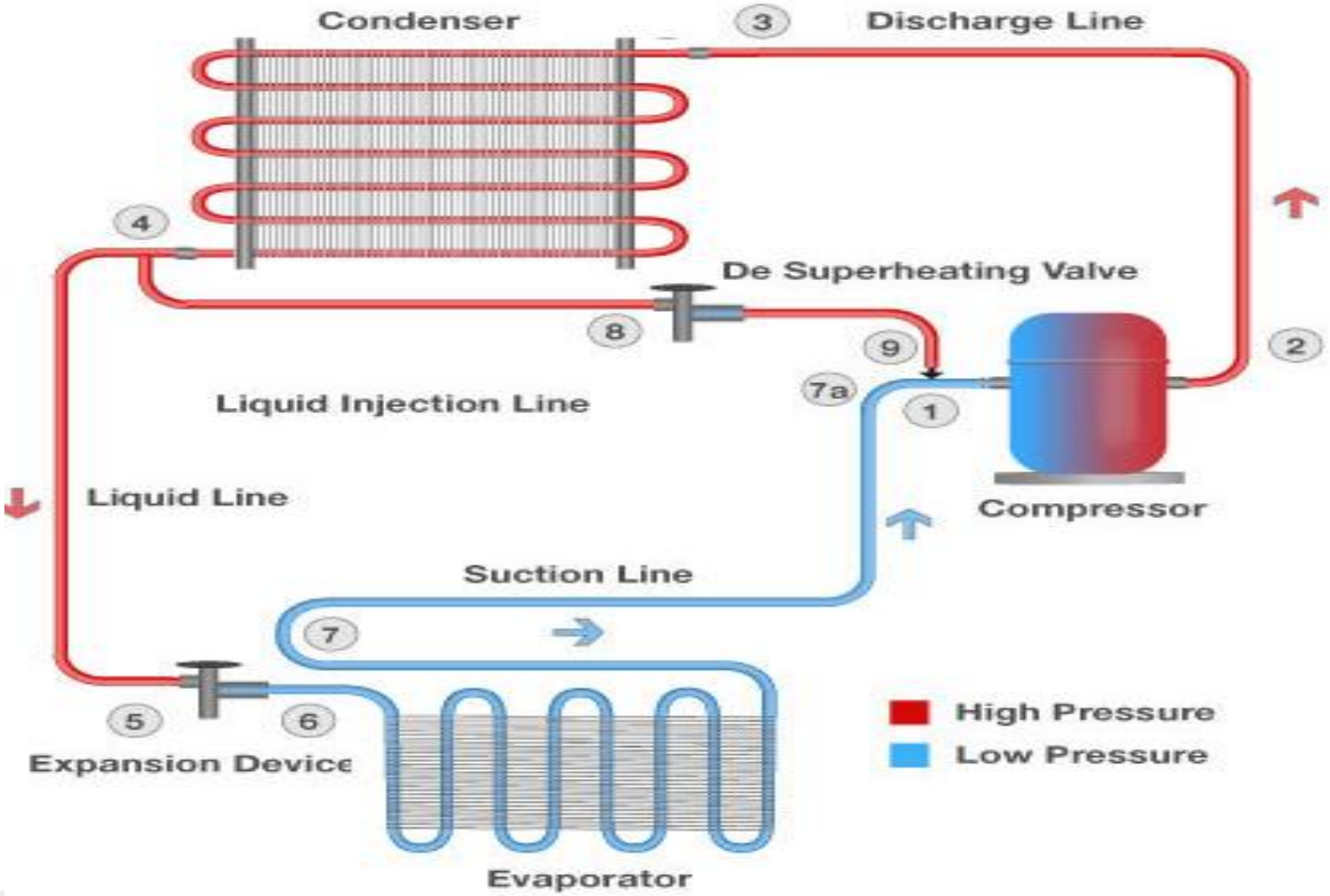

Fig.3 The technical drawing of the refrigerating system made with the Genetron software

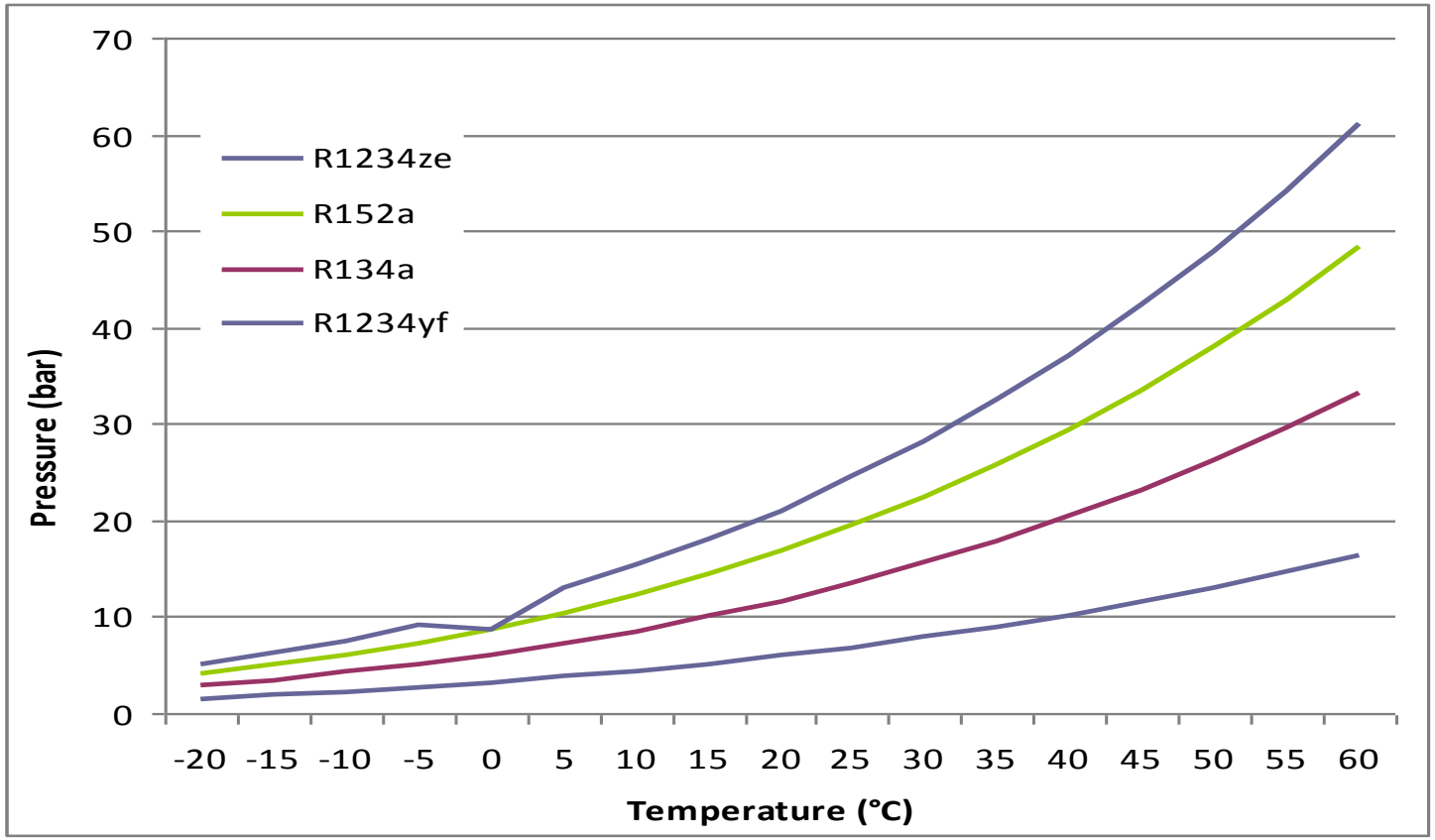

Fig.1. Temperature vs pressure

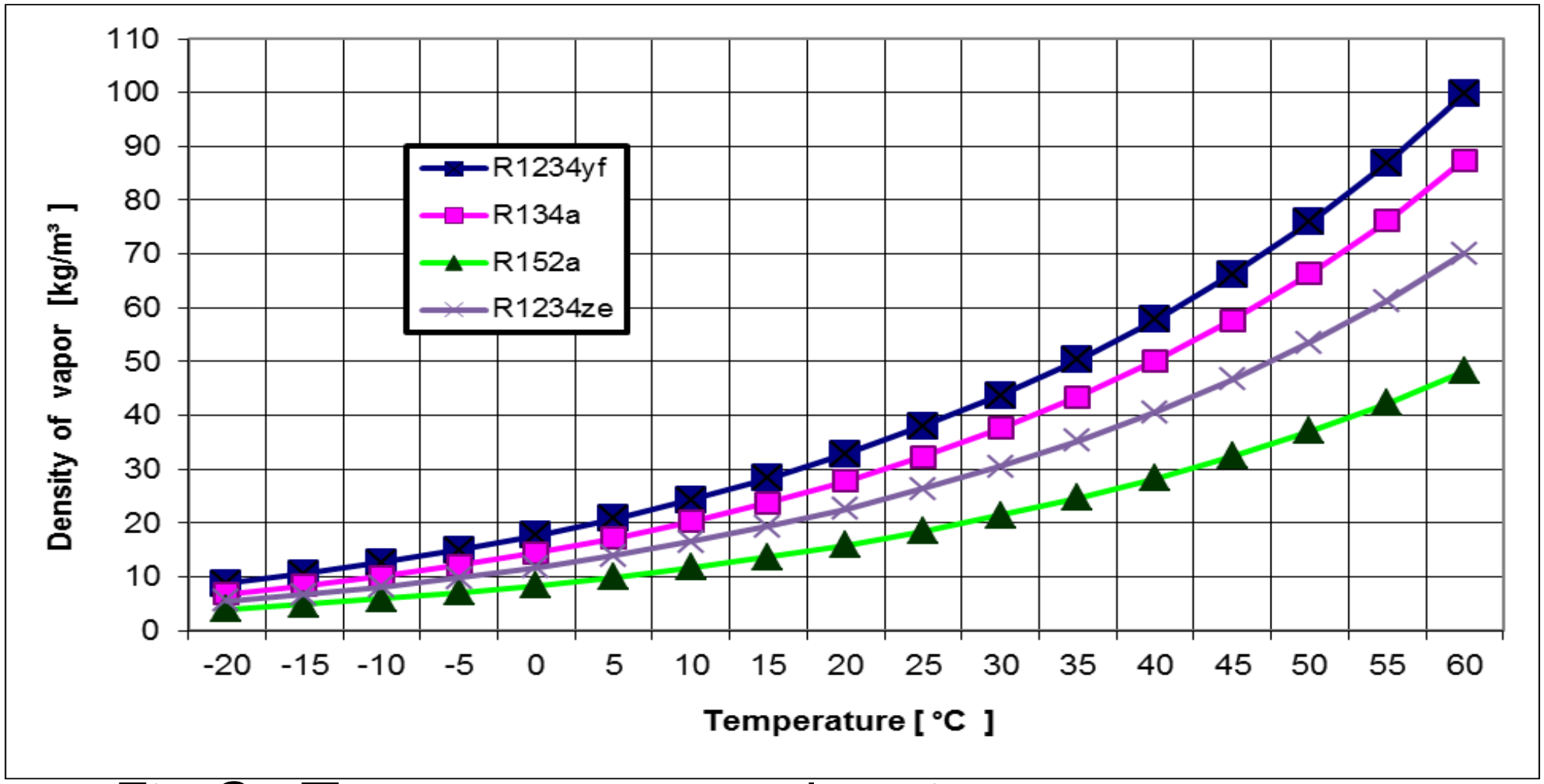

Fig.2. Temperature vs density

- The COP for the air conditioning refrigeration systems was calculated with GENETRON AND COOLPACK software and the TEWI factor was calculated in according with UE legislations.
- The total global warming potential method calculation (GWP) of the Ecological Alternative was done in according with REGULATION (EC) No 842/2006 (from 1 January 2015 REGULATION (EC) No 517/2014). The TEWI factor was determinate taking account of the Standard SR EN 378-1.
- To calculate the TEWI factor, the following assumptions were made: mass of refrigerants (Table 3) .
- The leakage of refrigerant was 8% from refrigerant charge with a recovery factor of 0.75. Operating time of the system was 15 years, and CO_2 emission was 0.37 kg / kWh for Romania.

Higher performance is highlighted when R1234yf is used - the reduced amount of refrigerant, a feature with environmental benefits reflected by the TEWI equivalent (Total Equivalent Warming Impact).In freon installations, the contribution to warming the atmosphere is both direct (due to the refrigerant) and indirect (through the energy used), the last being the most important.

	R 134 A	R407C	R410A	R152A	R600A	1234yf	1234ze	1233zd
GWP	1430	1774	2088	124	3	4	7	4,50
L	0,0624	0,05896	0,06064	0,0448	0,02744	0,05792	0,0596	0,05848
n	15	15	15	15	15	15	15	15
m	0,78	0,737	0,758	0,56	0,343	0,724	0,745	0,731
GWP X L X n	1338,48	1568,93	1899,245	83,328	1,2348	3,4752	6,258	3,9474
GWP X m(1-αrecuperare)	278,85	326,86	395,676	17,36	0,25725	0,724	1,30375	0,822375
n x E anual x β	8991	8991	8991	8991	8991	8991	8991	8991
TEWI in Kg CO2	10608,3	10886,8	11285,92	9091,688	8992,492	8995,199	8998,562	8995,77
TEWI in tone CO2	10,6083	10,8868	11,28592	9,091688	8,992492	8,995199	8,998562	8,99577

Table 3. The theoretical results of the Tewi factors of the refrigerant alternative.

Conclusions

- In this paper, calculations of the energy efficiency and ecological efficiency of the following refrigerants were followed: R134A, R407C, R410A, R152A, R600a, R1234yf, R1234ze and R1233zd, using 2 types of performance software and updated to the latest version of 2017, respectively CoolPack and Genetron.
- From an energy efficiency point of view, the most advantageous refrigerant is R1234yf with a COP of 4.98. From an environmental point of view, the R600a refrigerant has the best TEWI = 8,992 tons of CO_2.
- The next refrigerant in the ranking is R1234yf with a TEWI = 8,995 tons of CO2.
- As can be seen from the calculations, it appears that R1234yf remains the most advantageous as far as TEWI is concerned.

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