CO2-HEAT PUMPS

Mechanisms for Overcoming Ukrainian Dependence on Russian Gas

The second half of 2021 exposed the problem of gas dependence on Russia. It was at this time that natural gas transitioned from being a source of energy to a source of blackmail - the latest hybrid weapon.

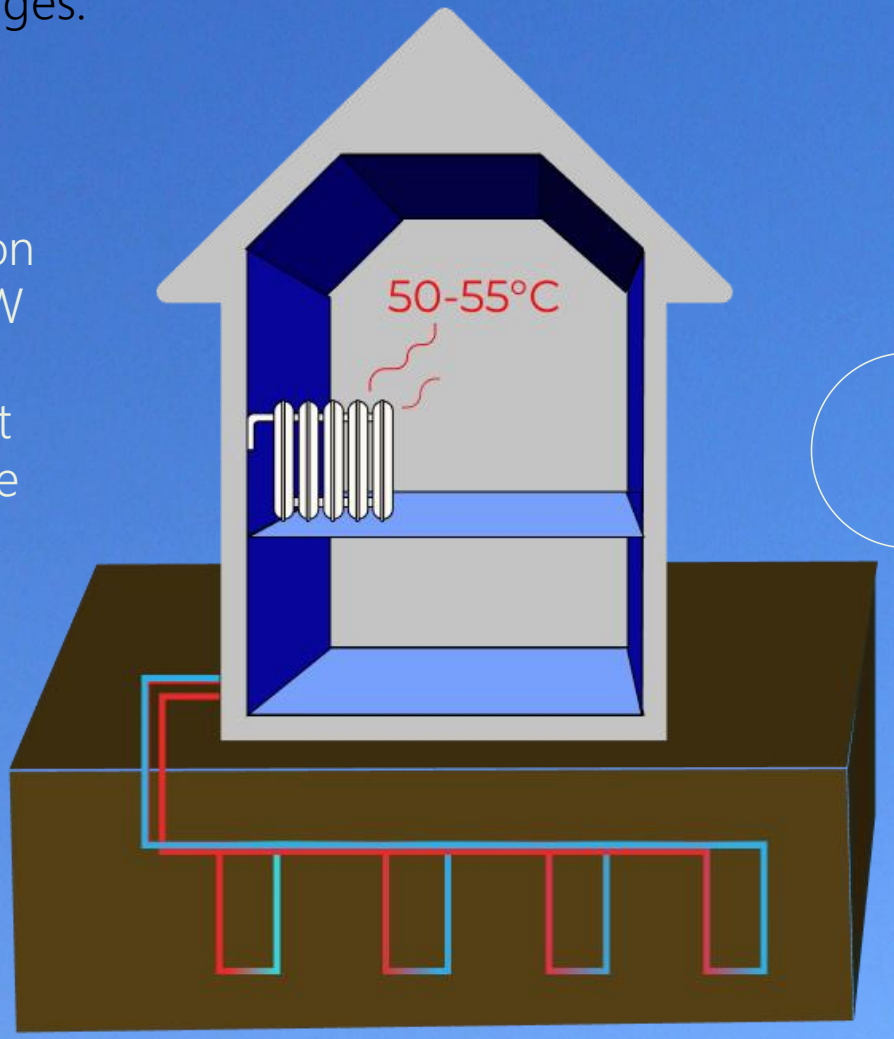
How can a country that is permeated by gas tracks find a way out of total gas dependence? An integrated approach will be needed to solve this problem.

Challenge accepted!

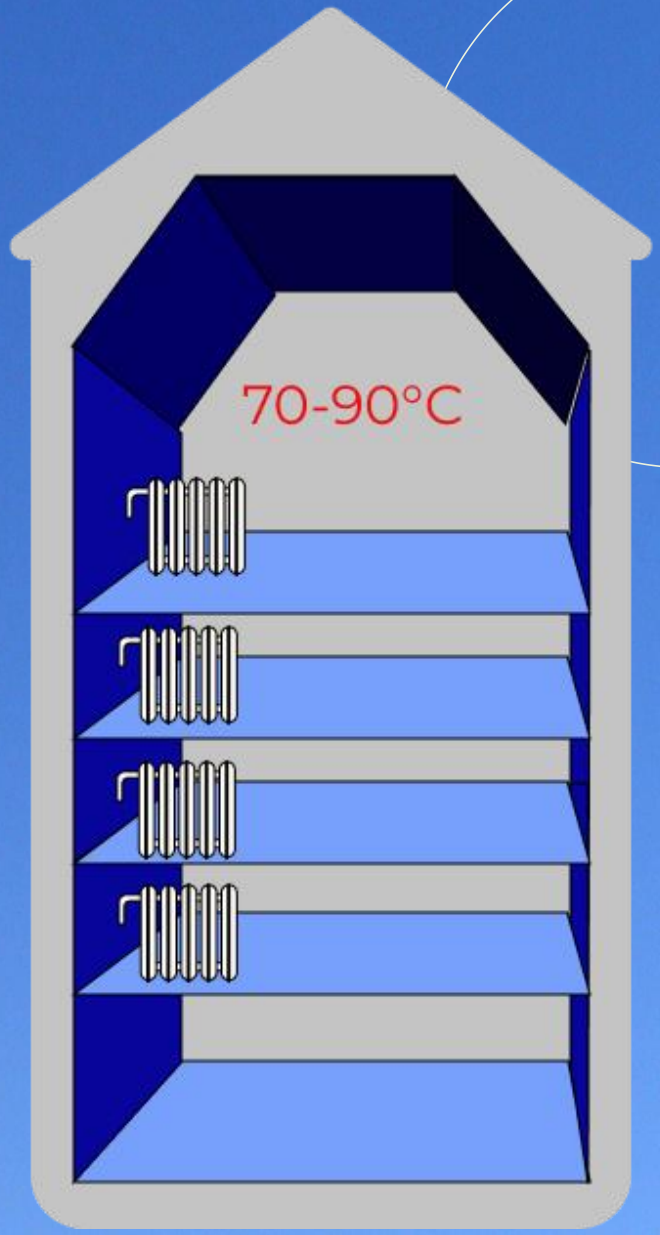
One of the available options is the use of a **heat pump.**

However, classic heat pumps, despite their significant advantages, have a number of disadvantages:

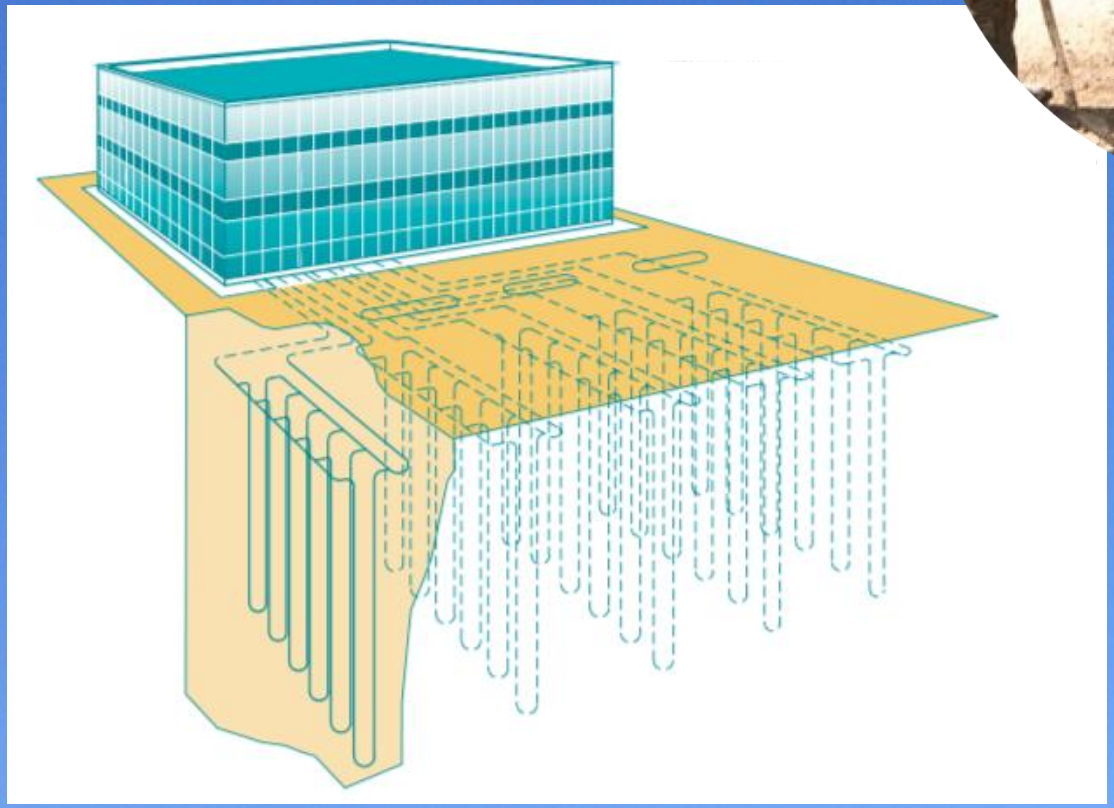
1. The classic brine-water geothermal heat pump has a COP = 4 (COP is a conversion factor that shows that by consuming 1 kW of electricity, we get 4 kW of heat). Such heat pumps work quite efficiently even at ambient temperatures of minus 22°C. The maximum supply temperature of the coolant varies between 50-55°C.



But, in general, the heating systems of most buildings in Ukraine are designed for even higher temperatures: 70-90°C, which the heat pump can not provide under any circumstances. In addition, a geothermal heat source known as a geothermal field, must be installed to operate the geothermal heat pump.



For example, for a heat pump to produce 1 MW of heat, 400 wells with a depth of 50 m must be drilled in 6 m increments. This is more than 2 football fields. It is almost impossible to find such volumes of land in dense urban areas dotted with communications.



2. The air-to-water heat pump has a significant advantage in the absence of drilling, as the source of heat for it is air. However, this advantage is significantly offset by a too low COP. When the temperature outside is 0 ° C - 7 ° C, such heat pumps work quite well. However, the outdoor units are periodically defrosted to remove an "ice shell", which develops during operation of the heat pump in the form of freezing condensed moisture from the air.

   During the thawing process, thermal energy is not provided to the consumer, and the system also removes it from the room in order to send it to an external heat exchanger to melt the ice. COP = 2 for an outdoor temperature of -7°C. When the outside temperature reaches below -7°C, the COP of such a heat pump will be 1.5. This means that the system is approximately equivalent to the electric boiler in terms of energy efficiency.

   At the same time, the maximum temperature of the coolant also decreases. For -15°C outside, it will be only 35-40°C.

Електрокотел

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Additionally, in both the first and the second cases, refrigerants are used - refrigerants with a GWP index (Global Warming Potential) of 1600 and above. In order to minimize the impact of CFCs on ozone depletion and the problem of global warming, on December 12, 2019, the Law of Ukraine 376-IX "On regulation of economic activity with ozone-depleting substances and fluorinated greenhouse gases" was adopted.

глобальне потепління

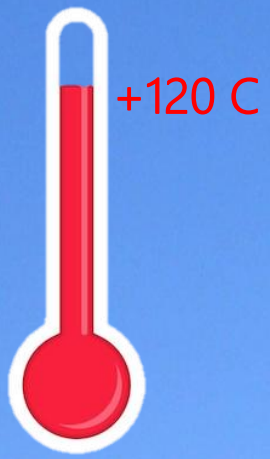
CO2 - HEAT PUMPS

All the above disadvantages for freon heat pumps are absent for a heat pump that runs on CO2. As a refrigerant for such a heat pump, CO2 is used instead of Freon.

1 CO2 has zero GWP potential, because CO2 is used as a reference measure for calculating GWP.

2 The lowest temperature for the use of CO2 as a refrigerant is -56.6°C. This means that the CO2 heat pump can easily operate not only at an outdoor temperature of -22°C, but it will run smoothly even at -50°C outdoors.

3 Thanks to the CO2 heat pump it is possible for the coolant to reach a temperature of +120°C. Thus, with such a heat pump it is possible to generate steam. At the same time, the temperature rise occurs almost without reducing the COP (as in freon heat pumps). And this, in turn, allows you to heat the room without replacing outdated heating system components such as cast iron radiators or registers.



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CO_2 is quite common, so it has little cost. It is extracted from the air and does not depend on imports. Therefore, it will not rise in price further, in contrast to CFCs, the cost of which will increase several times in the near future. Moreover, in the case of a leak, Freon contributes to the destruction of the ozone layer while the leakage of CO_2 from the heat pump is a completely natural process of returning CO_2 to the atmosphere from which it got there before.

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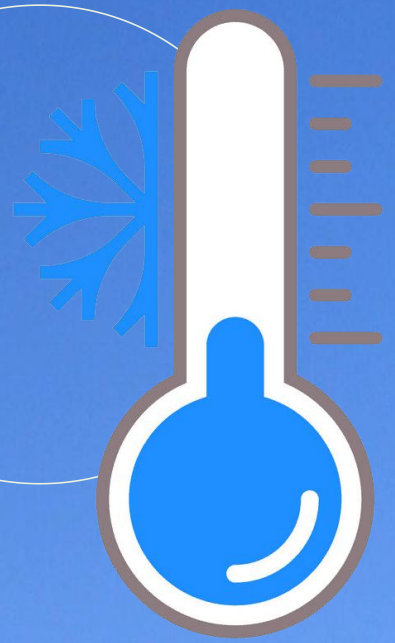
COP of such a heat pump is 15-30% higher than its freon counterparts. Although, it is difficult to call them analogous, because the temperature ranges of equipment on CO_2 are unattainable for freon heat pumps.

Summarizing the above, we understand that air-to-water heat pumps on CO2 can operate at temperatures of -22°C and below and the supply temperature of the coolant can easily reach +90°C (and even higher).

Defrosting occurs during operation of the heat pump - even without stopping it.



Consider the following scenario: CO2 heat pump on a mobile platform is delivered to any room (kindergarten, school, hospital, office building), in a few hours connect it to the existing heating system and mains, and it immediately begins to heat even an uninsulated room with an outdated high-temperature heating system. At the same time, on the street it can be -22°C.

This scenario is called "goodbye to gas dependence".

Specifics CO2 - HEAT PUMPS

1. Of course, CO2 equipment has its own characteristics.
This is the high operating pressure inside the heat pump, which reaches 100 Bar and even more. But, in general, this is not something abnormal. For example, the hydraulic brake system of any car operates at a pressure of 180 Bar, and it does not bother anyone. Therefore, a set of safety measures addresses this issue.

2. The cost of a heat pump with CO2 is 30-50% higher than the cost of freon analogues. But we have already understood that there are no analogues, because the equipment on freon can not provide the parameters that are typical for technology on CO2.

3. It is appropriate to use such equipment at capacities of 100 kW and above, because automation systems cost the same for 10 kW and 100 kW. Therefore, small heat pumps will be unreasonably expensive.

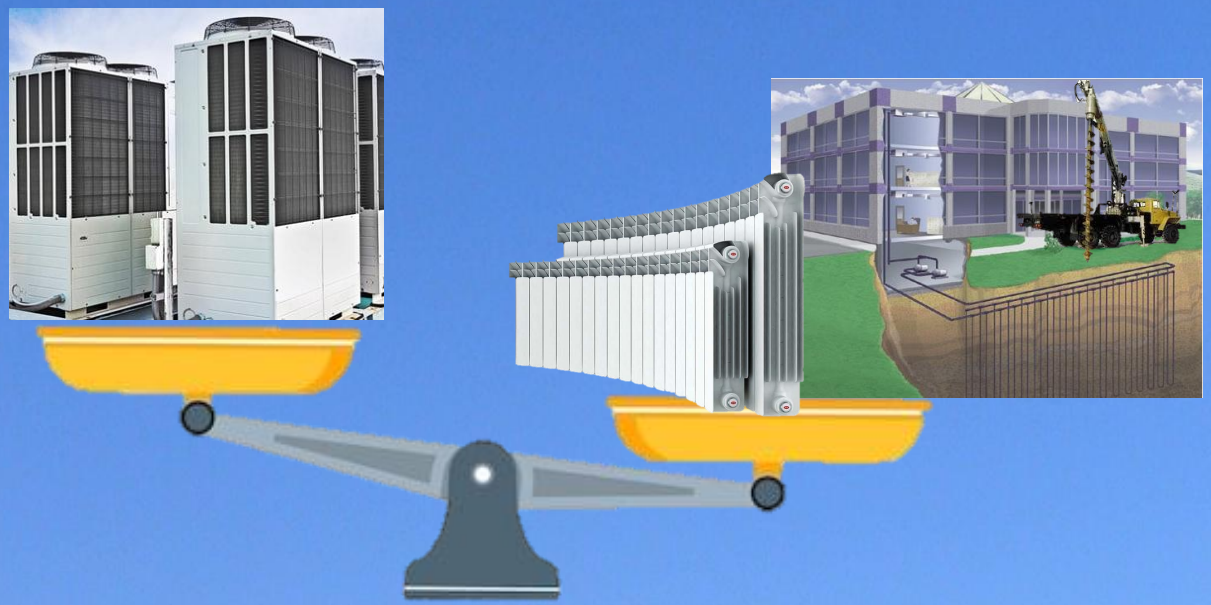
4. Due to the high pressure in the system and the complexity of such a heat pump, its maintenance should be regular, without interruption.

• Economic component •

We have already understood that a CO2 heat pump 100% covers the need for heating and hot water supply (as well as cold) regardless of the outside air temperature (-22°C and even lower).
At the same time, it doesn't matter whether there is an outdated heating system or a new one. Even with an increasing of a coolant supply temperature the COP remains unchanged.

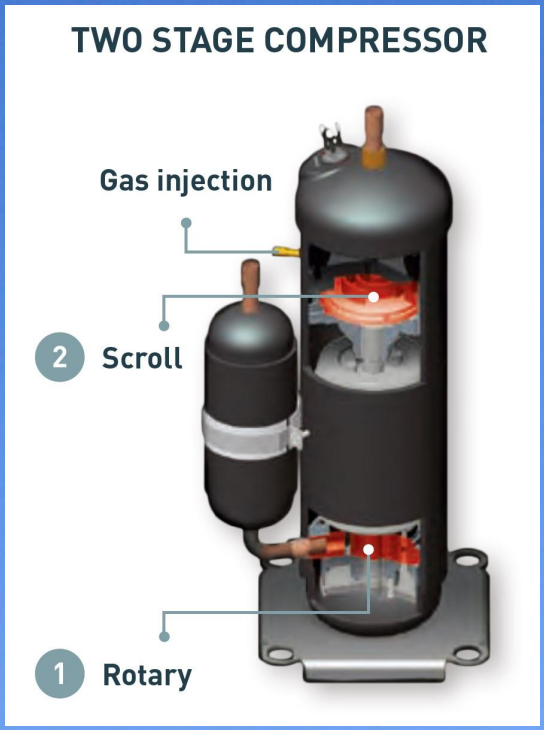
Thus, when calculating the investment in a CO2 heat pump, we have on one hand only the cost of the heat pump, and on the other hand: quick installation and start-up, no drilling the geothermal field and no major reconstruction of the heating system with its conversion to low temperature.

If you take into account all these factors, it becomes obvious that the heat pump for CO2 is more cost effective than a classic freon heat pump.



Why haven't such heat pumps been introduced before?

Technology on CO2 has been known for a long time, but due to the need to work at high pressures (100 Bar), technology has developed quite slowly. The impetus for faster development of technology (and, consequently, cost reduction) was facilitated by the need to eliminate ozone-depleting CFCs from the refrigeration market. A number of innovations have been found that have advanced the use of CO2 as a refrigerant for refrigeration equipment. This includes the operation of "parallel compressors", the use of ejection technologies, etc.



Experience with heat pumps

Our group of companies RES - Renewable Energy Sources was the first in Ukraine to start production of heat pumps in 2007. We have thousands of operating systems on heat pumps in various sectors of the economy.
Our clients are PJSC Kyivvodokanal, Motor Sich, Mykolaivoblteploenerho and many others.
We export heat pumps to neighboring countries (except Russia).

Associations

RES is a co-founder and member of the National Association of Ukraine for Heat Pumps, the Refrigeration Association of Ukraine, the Association of Engineers of Sustainable Energy Technologies. Thus, for the implementation of large-scale projects it is possible to involve our colleagues in heat pumps and industrial refrigeration.

UNHPA
Ukrainian National Heat Pump Association

ХОЛОДИЛЬНА АСОЦІАЦІЯ УКРАЇНИ ГРОМАДСЬКА СПІЛКА

АСОЦІАЦІЯ ІНЖЕНЕРІВ СТАЛИХ ЕНЕРГЕТИЧНИХ ТЕХНОЛОГІЙ УКРАЇНИ
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