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Regenerative thermoelectric heat pump for the HVAC systems

Hello everyone!
First of all, do not be surprised by the female voice of the speaker, at my request the presentation is voiced by my PC assistant Cortana.
In this presentation, I would like to introduce you to preliminary estimates of the feasibility of using thermoelectric heat pumps in the 4,5th Generation District Heating Technologies.

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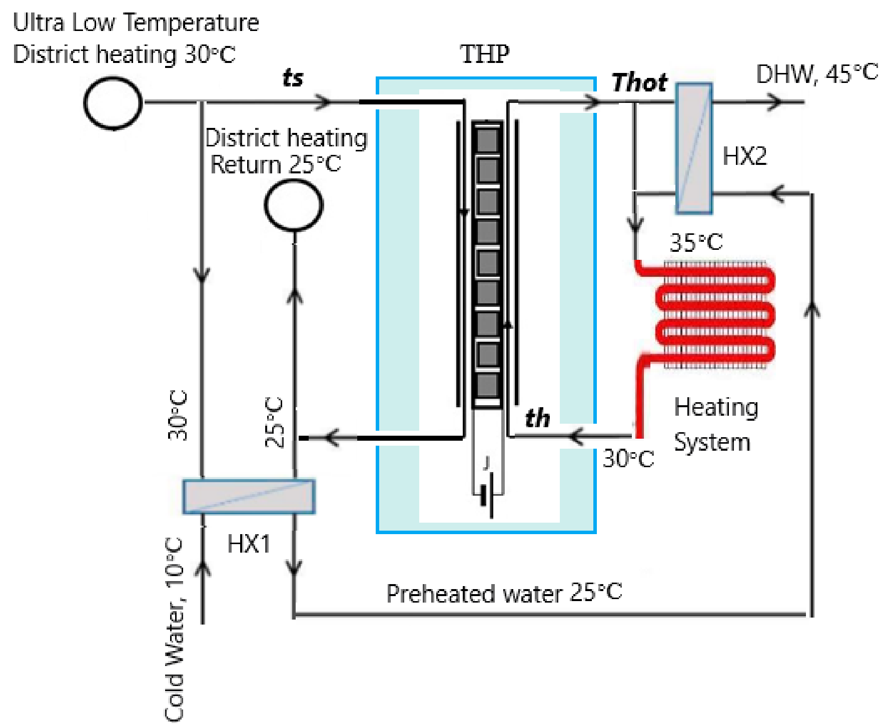
Are there any problems with 4,5GDH?

There is no doubt about the prospects of low-temperature district heating systems.
However, they have one problematic bottleneck that has yet to be resolved.
I mean the problem of transforming the temperature potential of the heat carriers to the level required by the end-user. If the temperature of the carriers in the 5GDH systems is determined at the level of 30°C, then the heating systems require at least 35°C, and the DHW systems 45°C. For 4GDH, this problem is less acute, but it also exists.
The solution to the problem of temperature potential transformation relies on heat pumps. The works, devoted to this problem consideration, apply to large scale heat pumps.
As a rule, the conducted analyzes do not give an unambiguous conclusion about the advantages of such a heat supply scheme in comparison with the traditional ones. It is shown that the large scale HP is appropriate in the case of use in the system of waste heat CHP or other thermal waste.
In other cases, the feasibility of using HP depends on the level of capital expenditures and the ratio of prices for fuel, electricity, and CO_2 emissions.
This is not surprising - such an approach devalues all the advantages of low-temperature distributed power systems because it's practically returning to the 3GDH.

The solution exists

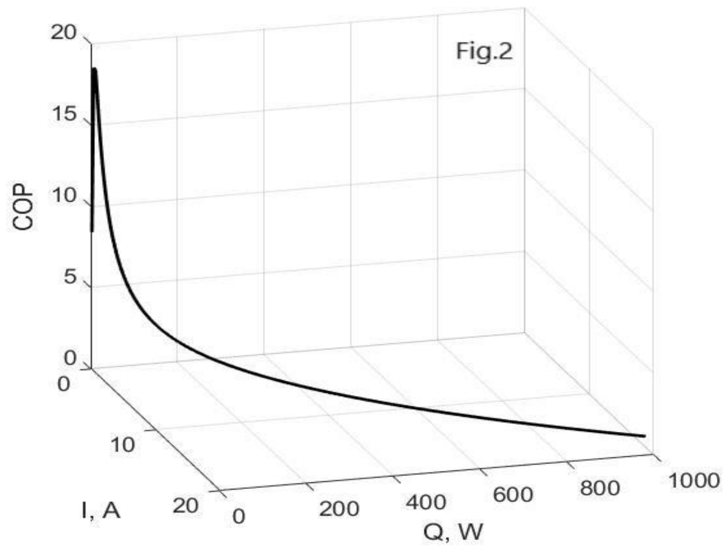
Taking this opportunity, today I would like to present a concept that could potentially make a breakthrough in solving the problem under consideration. I mean a district heating low-temperature system with distributed thermoelectric heat pumps (THP), which implement the ideal Lorentz reverse cycle with heat recovery. This slide shows a general view of this circuit.



Unlike systems with the central powerful heat pump this circuit is very simple, extremely flexible and effective. The main element is a thermoelectric heat pump designed to provide a separate consumer. It performs all the functions of the HVAC system - heating, air conditioning and hot water supply throughout the year. Very easy and precisely regulated, perfectly compatible with local energy storage systems and control systems such as "Smart House". The characteristics of this heat pump break the established ideas about the possibilities of THP.

The low-temperature heat carrier ***ts*** and the coolant of the heating system ***th*** enter the thermoelectric heat exchanger according to the counter-current scheme. Here ***th*** heated to ***Thot*** = 35°C and enters the heating system, where it is cooled to an initial temperature of 30°C. In the DHW mode, the coolant is heated to a higher temperature ***Thot*** ≈55°C, and in the heat exchanger HX2 heats the DH water to a given temperature 45°C. The DH water is preheated in the heat exchanger HX1. All modes are regulated by selecting the optimal temperature ***Thot*** by changing the supply current of the THP. The efficiency of the circuit reaches COP ≈ 8.

How does it work?



The basis of the proposed innovation is the technical possibility of creating an integrated counter-flow heat exchanger, which combines thermoelectric modules (micro-heat pumps) in a series circuit for heating (or cooling) of the heating system coolant.

Fig 2 presents the real characteristics of the separate standard thermoelectric module in such conditions. A Pareto set of the module in the coordinates {*I, Q, COP*} is shown. Adjustments of the current *I* allow you to select the optimal ratio of power *Q* and the *COP* in a wide range. The required power is achieved by sequentially connecting the required number of modules and setting the required coolant flow.

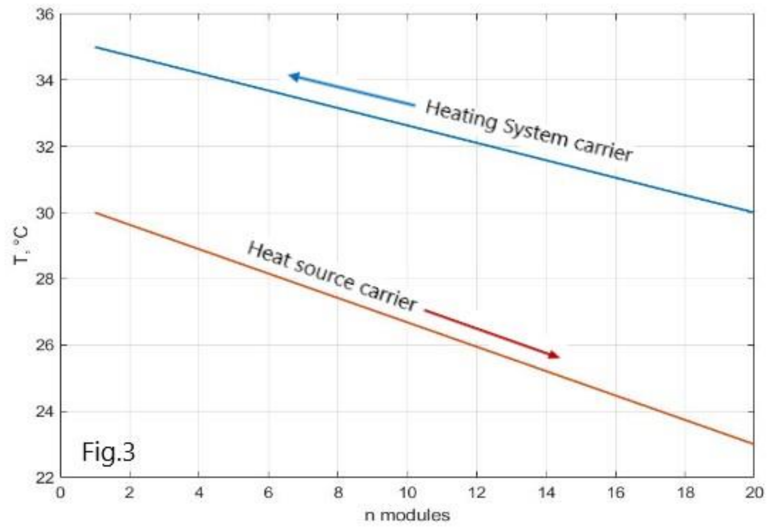


Fig.3

Fig 3 shows the temperature distribution of coolants along the channel of 20 thermoelectric modules. The temperature difference between the inlet and outlet of the heating system usually does not exceed 5°C. Therefore, on each individual micro-heat pump it can be very small (***ts-th***< 5°C). So that each individual module operates with high efficiency. In practice, such a scheme simulates an ideal Lorentz cycle because heating and cooling of coolants occur at variable temperatures with a constant small difference between them. The power of such heat pump is easily regulated within 0 <Q <10 kW, the efficiency within 1.5<COP<15. This provides an opportunity to optimize the modes of the heating system according to changing external conditions.

Advantages of the centralized heat supply system with distributed thermoelectric heat pumps.

Preliminary analysis of the considered system allows to define its potential advantages:

- High efficiency.
- High reliability
- Part-load performance.
- Flexible performance.
- Net zero water consumption.
- Net zero CO2 emission.
- Compatibility with smart control systems.
- Reduced size and weight.

The current technical level of development corresponds to TRL3.

THANK YOU FOR THE ATTENTION

It is impossible to explain all the features in a short presentation.
If you are interested in the topic, please contact us.
Proposals for cooperation are welcome.

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