Considerations regarding the Recovery and Utilization of Residual Heat from Data Centers

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Abstract: *In the context of the acceleration of the need to store and process data and digital telecommunications, which leads to an increase in global electricity consumption and greenhouse gas emissions, the need for research to find reliable, efficient, and cost-effective solutions to reduce energy consumption and the recovery of the residual heat produced by the data centres is an increasingly urgent one. The article presents aspects that refer to the recovery of residual energy from data centres and its use for the preparation of domestic hot water, but also for the preparation of the thermal agent necessary for heating installations in buildings and respectively modern heating systems, with the mention that the latter work at a low temperature regime.*

Keywords: *Waste heat recovery, data centres, heating systems, district heating, domestic hot water*

1. Introduction

The rapid increase in the need for data storage and processing and digital telecommunications have recently generated a massive development of the data center (DC) industry. Although the digitization of various fields of human activity brings major benefits to the quality of his life, the secondary effects that appear because of this trend must also be assumed and solutions found to reduce the negative effects. Considering the exponential increase in human dependence on IT devices and services, an increase in energy consumption for manufacturing and powering these devices is also generated [1].

Taking into account the fact that DC operation is continuous, 24/24 h, 365 days per year, and it assumes as operating characteristics high requirements for safety in operation, high heat flow density, high energy consumption and carbon emissions, it is essential to make energy consumption more efficient and to recover residual heat and reuse it, a fact that leads both to the reduction of energy consumption and to the reduction of the carbon footprint [2,3].

Another problem that needs to be addressed concerns the applications in which the potential of recovered thermal energy can be used so that the technical solutions are as reliable, efficient and profitable as possible.

2. General characteristics of DC and the prediction of their development in the future

DC are spaces with a special destination within a building where IT systems and associated components are located that together carry out data processing, storage and distribution operations, they may include: server complex, data storage systems, storage systems backup, network infrastructure, electricity supply, fire alarm systems, security system and systems for maintaining the indoor climate at the parameters corresponding to the DC class.

According to the ASHRAE thermal guides for data center operating, DCs are classified according to the climatic parameters that must be maintained in the respective space in order to maintain high reliability and energy-efficient operation. The classes in which DCs falls are shown in Fig.1 [4].

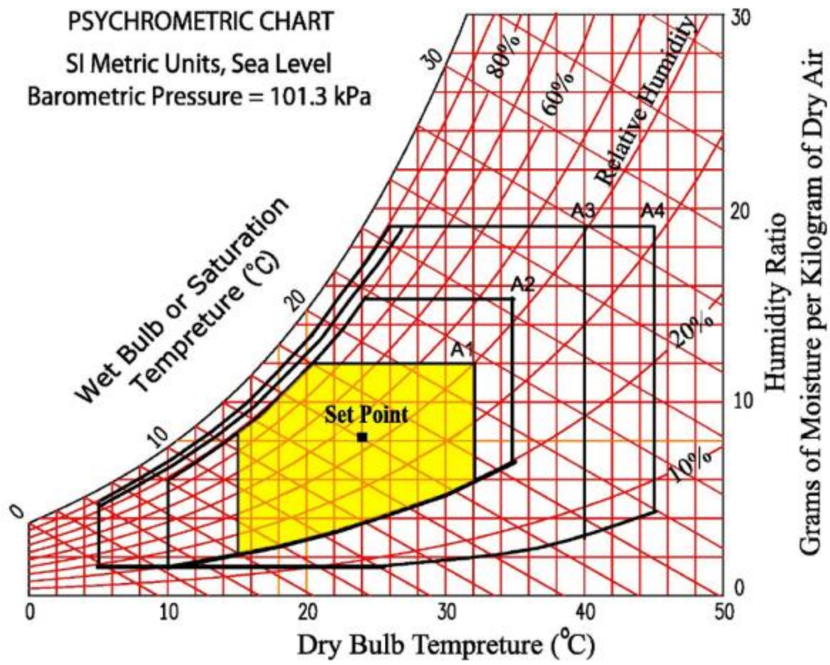

Fig. 1. ASHRAE thermal guides for data center operating [4]

A rapid increase in the needs for data processing, data storage and digital telecommunications is expected, which will normally lead to an increase in energy consumption in this sector and also in greenhouse gas emissions. Currently, DCs energy consumption is estimated at 3% of global electricity consumption and greenhouse gas emissions at 4% [5]. Recent reports predict an increase in DC of 12–14% over the next two to five years, thus resulting in an increase in consumption of up to 1/5 of global electricity consumption by 2025 [5,6].
Considering these expectations, the energy efficiency of the DCs has recently become the main concern of operators, ahead of availability and security aspects. Even when running in idle mode, the servers consume a significant amount of electricity, so other measures must be considered, such as shutting them down for the idle period or consolidating the workload. Of course, these measures to reduce energy consumption will lead to a reduction in system performance, so a balance must be found in the process of determining suitable technical solutions [7].

3. Applications for the use of energy recovered from DC

Considering that the potential of recoverable energy from DC residual heat varies depending on their size, the characteristics of the equipment used and the classification class of the DC, the applications for its subsequent use will be of two types, namely: local use, by integrating the energy under the form of hot water in the own heating installation and hot water supply for consumption and centralized use by providing thermal energy, as a prosumer, to the city's district heating system.

3.1 Local use of recovered energy

The local use of recovered energy is chosen as a technical solution for situations where the amount of thermal energy recovered is less than or equal to the total thermal energy required to cover the needs of the buildings in which the DC is located, for space heating in the winter and the production of domestic hot water in the summer.
For the recovery of residual heat from DC, an air-water heat exchanger connected to the primary circuit of a water-water heat pump can be used, which will raise the temperature of the heating agent so that it can still be used as needed in the thermal heating installation or for the production and accumulation in a hot water tank (HWT) of domestic hot water. The functional scheme of the

waste heat recovery installation and the production of thermal energy in the form of hot water is presented in Fig. 2.

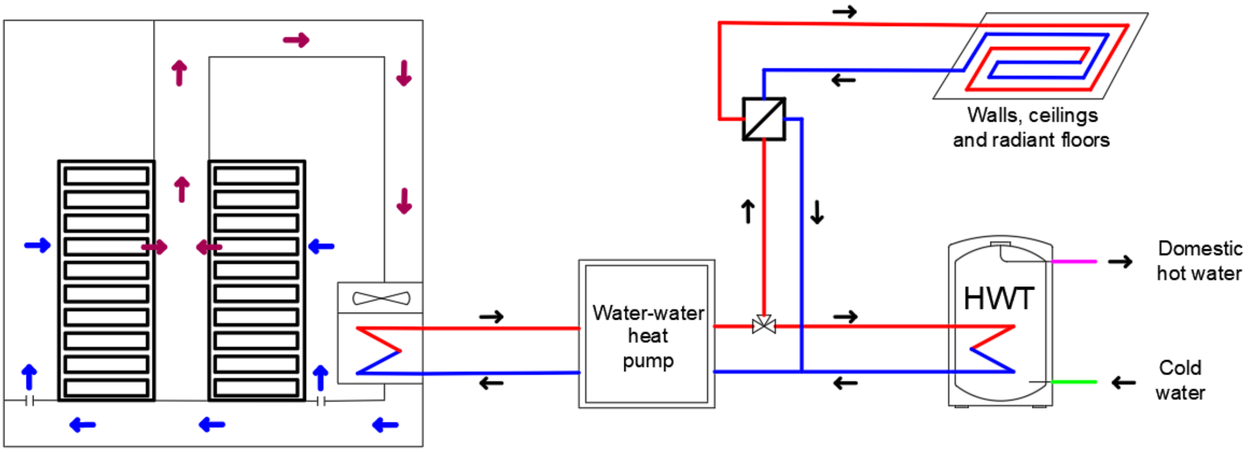

Fig. 2. Functional scheme of the recovery and local use installation

3.2 Introducing the recovered energy into the heating system

Traditional district heating systems are composed of thermal plants that produce and pump hot water or steam through pipes to provide heat to metropolitan areas. A heating system incorporates a heat generating unit, a transmission and distribution network, substations and heat consumers.
Most district heating systems use various energy sources, including coal or natural gas and waste incineration, or incorporate renewable energy sources (RES), such as geothermal, solar, or energy recovered from waste heat produced from various sources such as wastewater, industrial surplus energy or residual heat from DCs.
Today, district heating systems enable the long-distance distribution of thermal energy and the use of an increasing percentage of renewable energy, thus increasing the fight against global warming and the energy crisis. For this reason, sustainable heating systems will have to ensure planning structures, low costs linked to efficient operation and strategic investments, an aspect illustrated in Fig. 3 [8].

Fig. 3. The concept of 4th Generation District Heating [9]

The heating systems are also classified mainly according to the source of energy used, the temperature regime of the thermal agent and the efficiency of the equipment used in the process of production and distribution of the thermal energy supplied to the final consumers.

We thus identify a transition of heating systems starting with the first generation characterized by a high temperature regime of the thermal agent up to 200ºC towards the following generations which are characterized by a decrease in the temperature of the supplied thermal agent and the use of a wider range of energy sources among where RES are also found (Fig.4).

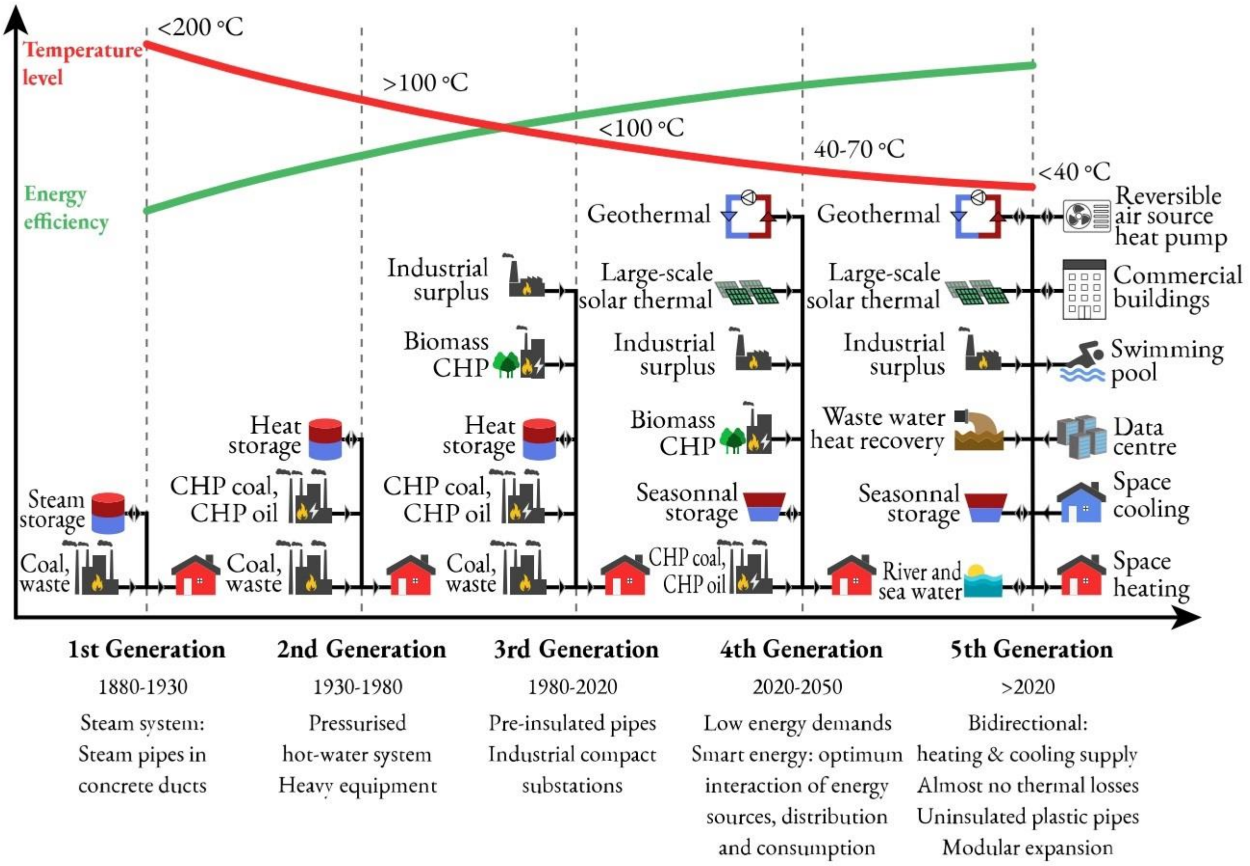

Fig. 4. The evolution of the district heating systems generations [10]

An important aspect that must be taken into account when we talk about RES integration is the fact that the temperature of the thermal agent produced by these sources is lower than in the case of the classic ones, so that the use of additional equipment is required to raise the temperature of the agent to the necessary value to it could finally be used by the consumers of the heating system, in most cases using water-to-water heat pumps (Fig. 5).

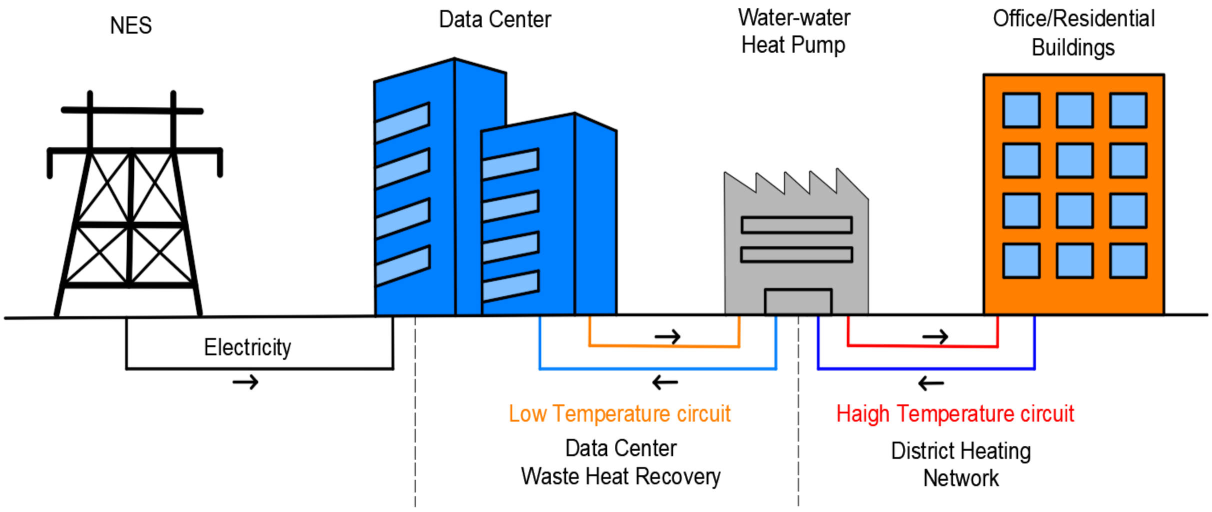

Fig. 5. Integration of thermal energy recovered from data centers in the district heating systems

4. Conclusions and future directions

The residual energy potential in the EU presented in specialized literature is estimated to be approximately 2860TWh/year [11] of which approximately 56TWh/year comes from the DC sector [12]. So, the residual energy potential recoverable from DC is a source for the preparation of hot water in various applications: domestic hot water, thermal agent for heating installations with walls, ceilings and/or radiant floors and thermal agent for heating systems ready for transition from in the 4th to 5th generation. Thus, the residual energy recovery systems and the applications for which the recovered energy is used, can be based on a temperature between 35ºC and 70ºC [13].

As future directions, we propose the realization of a pilot installation in a server room for the purpose of evaluating the residual energy potential that can be used and identifying the optimal solutions for applicability.

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