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Saving energy and efficiency increase by enabling free-cooling mode for cooling system in Data Center

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ABSTRACT

Modernization of the cooling system for the Data Center is a strategic task aimed at increasing efficiency and reducing costs. The proposed maximum use of the freecooling mode had a positive effect on the operating parameters. The results of the cooling system operation in a transitional climate over two years are discussed.

Keywords: Data Center, chiller, freecooling, COP, compressor mode, experimental data

1. INTRODUCTION

Concern for minimizing energy consumption by the cooling system in the data center is the overriding goal of automating and optimizing the hardware configuration and the cooling system control algorithm [1, 2, 3]. The modernization carried out in 2015, described in detail in [1], was subjected to long-term tests in subsequent years. This paper presents a period of 2 years (summer 2016-summer 2018) in order to analyze the functioning of the cooling system with its own control algorithm.

2. CONTROL STRATEGY

The POLCOM Data Center is located in Małopolska, where the climate is characterized by a temperature variation during the year ranging from -20 to 35°C. Below the 10°C threshold, 57% of the temperatures in the two-year scale in question occur. This means that refrigeration equipment can use the freecooling mode. More, below 12°C, 65% of temperatures occur, which allows achieving significantly higher COP values. The variability of the outside temperature in the discussed period of time is presented in Figure 1.

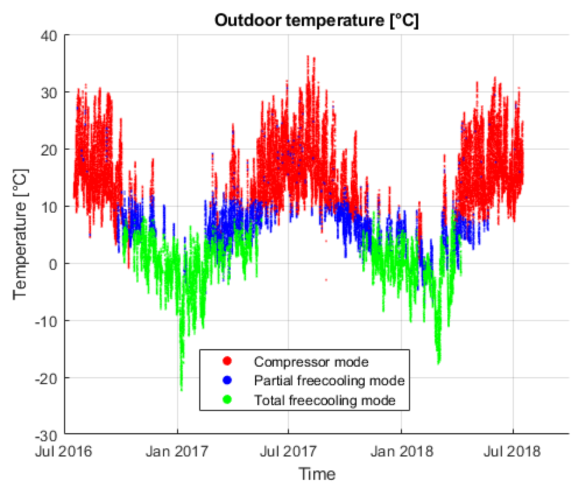

Fig. 1. Outdoor temperature

In this elaboration, the data is color-coded according to the different operating modes of the refrigeration system. The cooling system is equipped with an individual control algorithm, which, based on the experience carried out in 2014/2015, switches the modes of compressor operation and free-cooling using the features of the climate. The switching temperature was set at 10°C and the hysteresis width at 1.5°C.

Figure 2 shows the cooling capacity achieved by the cooling system. Over the course of two years, the efficiency of the system has increased from approximately 800kW to 1000kW. The reason was the increase in the number of IT equipment collocated in the server room, and thus the increase in thermal power.

The cooling system consisted of three chillers: chiller B, chiller C and Turbocor. They worked in parallel to ensure continuous production of cooling energy. The refrigeration system worked in three operating modes: compressor (each unit worked in the compressor mode), partial freecooling (at least one unit worked in freecooling mode) and total freecooling (all units worked in freecooling mode.

Chiller B and chiller C units are old type units, built on the basis of screw compressors. These aggregates could work in the free-cooling mode. The Turbocor unit is a modern internal unit with centrifugal compressors using magnetic bearing technology. It has been combined with a high-performance drycooler to maximize freecooling time.

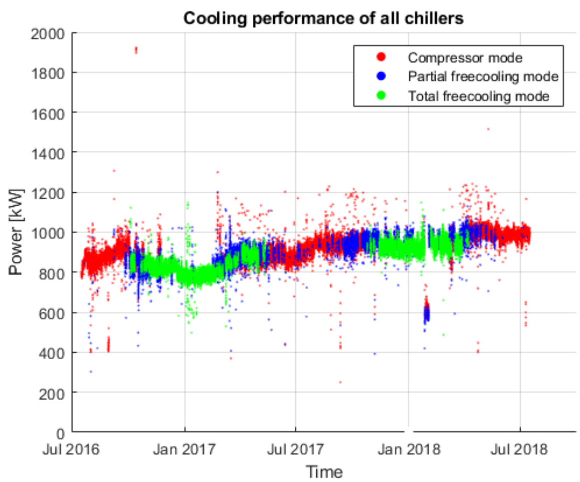

Fig. 2. Cooling performance

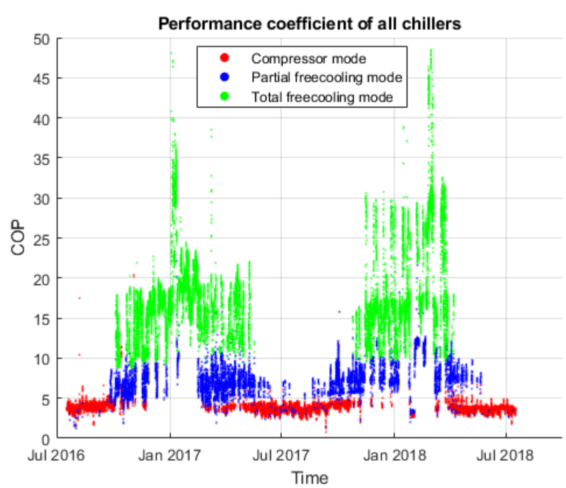

Fig. 3. Performance coefficient

The operating parameters of chillers B and C are presented in Figures 4÷7. They show the COP of the aggregates as a function of time and outdoor temperature. Areas corresponding to compressor and free-cooling work can be observed. In the case of chillers B and C, the COP for compressor operation ranges from 1.9 to 5.9, for freecooling from 5.9 to 22. Chiller B freecooled 41% of the time and 59% in compressor mode respectively. Chiller C 30% in freecooling mode and 13% in compressor mode, and was off 57% of the time.

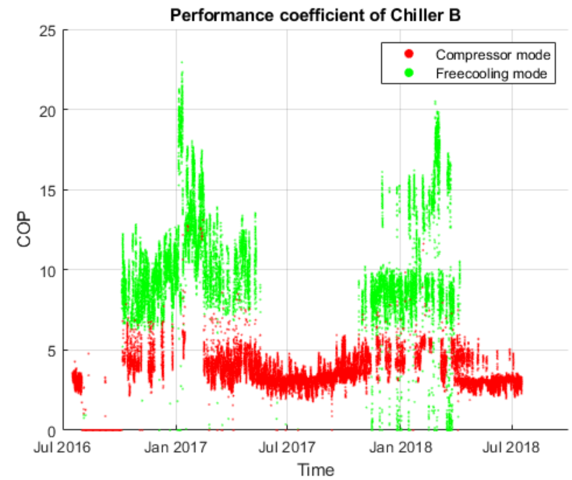

Fig. 4. Performance coefficient of Chiller B

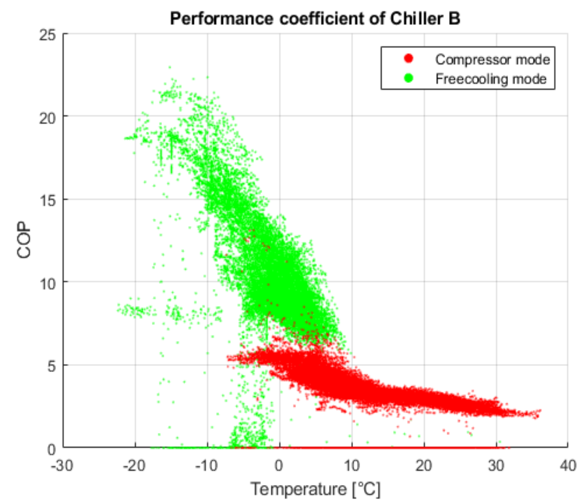

Fig. 5. Performance coefficient of Chiller B

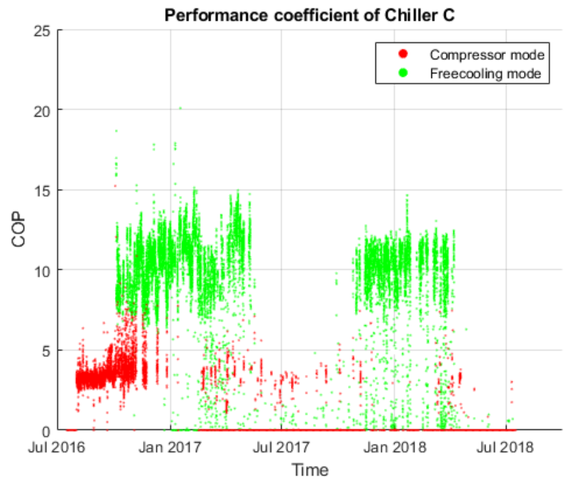

Fig. 6. Performance coefficient of Chiller C

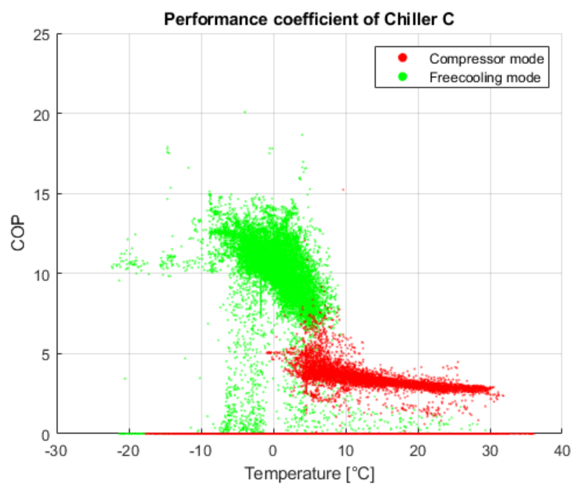

Fig. 7. Performance coefficient of Chiller C

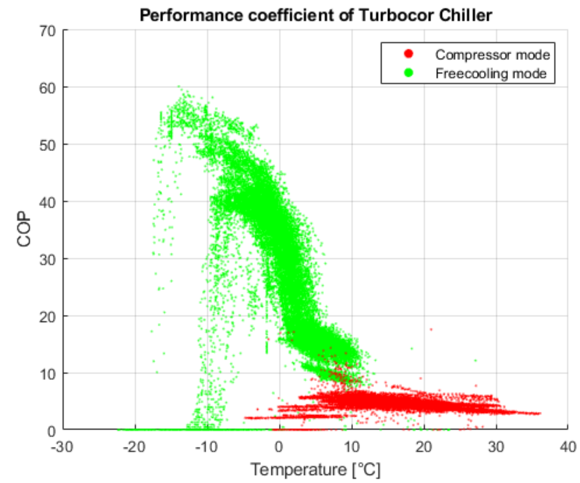

Fig. 8. Performance coefficient of Turbocor Chiller

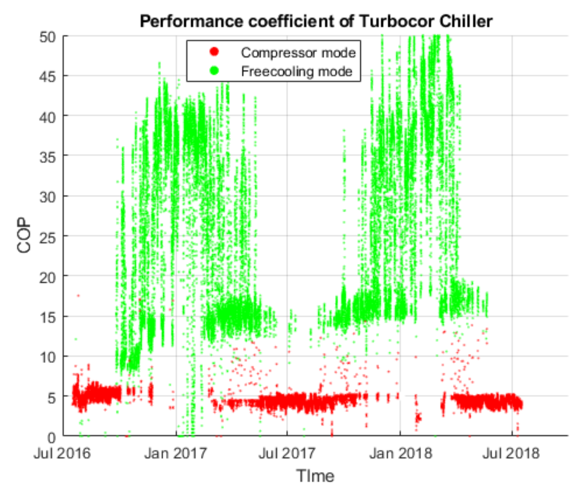

Fig. 9. Performance coefficient of Turbocor Chiller

3. ANALIZA KORZYŚCI Z WYKORZYSTANIA TRYBU FREECOOLING

The modern Tubrocor refrigeration unit in combination with the highly efficient drycooler achieved a COP for compressor operation in the range from 3 to 6.7, and for freecooling operation from 8 to 60. The COP distribution during the year is shown in graphs 8 and 9. The unit worked in freecooling mode for 50 % of the time and in compressor mode also 50%. The comparison of the operating modes of the old and the new solution (see table 1) shows the clear advantage of the Turbocor unit in terms of operating efficiency. The percentage increases in the efficiency of the new Turbocor unit compared to the old solution based on Chillers B and C.

Agregat	Chiller B	Chiller C	Both Chillers	Turbocor
Aggregate	4.0	5.0	4.5	7.1 (+58%)
Average COP in FC mode	10.6	10.4	10.5	22.3 (+112%)
Average COP in CP mode	3.3	3.3	3.3	4.3 (+30%)

Tab. 1 Performance coefficient of chillers

The new solution achieved higher rates of work efficiency in all operating modes (especially in the free-cooling mode), which translated into a higher average COP.

Considering that in 2018 the Turbocor chiller also achieved a higher cooling capacity compared to chillers

B and C (see Figures 10÷12), the modernization resulted in a measurable energy gain.

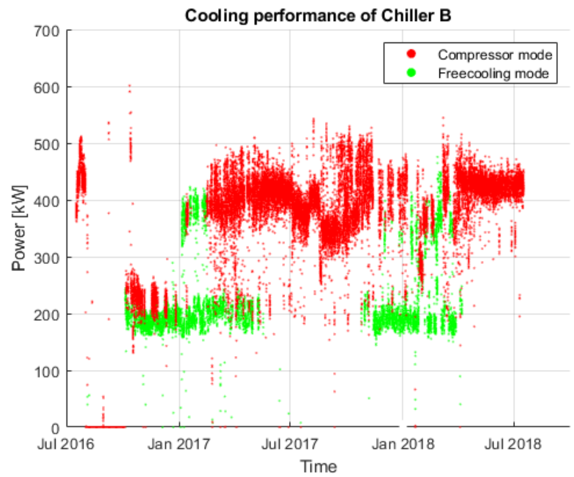

Fig. 10. Cooling performance of Chiller B

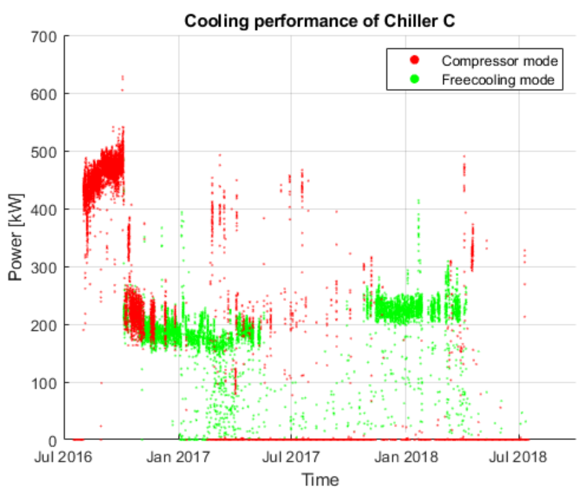

Fig. 11. Cooling performance of Chiller C

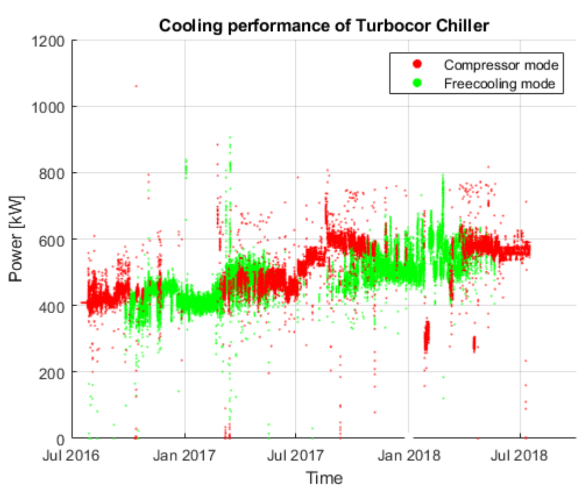

Fig. 12. Cooling performance of Turbocor Chiller

Chiller B and C units produced 28.6 GWh of cooling energy in two years, while consuming 6.7 GWh of electricity. In the same period of time, the Turbocor unit produced 34.6 GWh of cooling energy, while consuming 4.9 GWh of electricity. Taking into account the average COP achieved by both solutions, it can be determined that the modernization made it possible to achieve an energy gain of 2.8 GWh of electricity over two years, which corresponds to a 19% reduction in electricity consumption.

CONCLUSIONS

The investment in the modernization of new aggregates has brought the expected results. The use of the freecooling mode significantly increased the efficiency of the cooling system. An increase in cooling capacity was achieved with a simultaneous reduction in electricity consumption. As examined in [1], temperature fluctuations forced the use of hysteresis due to the stability of the operation of cooling devices, which directly results in a loss of working time in the free-cooling mode by 7%. Further research work on increasing the efficiency and full use of the possibilities offered by the freecooling mode should be focused on the optimization of the control algorithm in terms of the switching temperature and the width of the hysteresis loop.

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