Analysis on the Impact of the Cooling Water **Temperature on the HPC System and Facility Case Study: Oakforest-PACS System and Facility** 

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# Abstract

Hot water cooling approach has been established as one of the standard techniques to improve the energy efficiency of modern HPC/Data Centers. However, to fairly evaluate its efficiency, there is a need to take into consideration not only the energy reduction of the cooling facilities, but also some possible negative impacts on the HPC system side. In this poster, we present some preliminary results of an investigation using the Oakforest-PACS (OFP) system and facility using three temperature cases (9°C, 12°C, and 18°C). We could confirm that better PUE (1.25  $\rightarrow$  1.20  $\rightarrow$ 1.18) and COP (4.26  $\rightarrow$  6.23  $\rightarrow$  8.72) can be obtained by using higher temperature. The impact on the HPC system side, such as performance degradation and energy consumption, remains as future work.



#### Running benchmark applications on three different cooling water temperature (High [18°C]; Low [9°C]; Regular [12°C])



### **Benchmark applications**

- Intel MKL (LINPACK, MP-LINPACK, HPCG)
- GeoFEM (parallel FEM application)

#### **Energy consumption**

3-hour period (highlighted in green color)

## Water cooling: Racks **Air cooling: Storage & Others**



12°C region, and was not utilized for the comparison purposes

# **PUE (Power Usage Effectiveness) and COP (Coefficient of Performance)**

1) PUE =

1.26

1) PUE is used to measure the energy efficiency of HPC/Data Centers, and as lower is the PUE value, better is the energy efficiency.

2) COP is used to measure the energy efficiency of cooling and heating equipment, and high COP values represent high efficiency.

**Note:** Hourly power consumption data was used for estimating the energy consumption (for the 3hour period marked by rectangles on the lower right side graphs in the previous section).





### **Conclusions and Future Works**

We have been conducted a systematic investigation on the Oakforest-PACS system and facility trying to better understand the efficiency of the hot water cooling on such HPC site. As a preliminary analysis result, we could confirm that better PUE and COP values can be obtained by using higher water temperature set points. However, we could also observed some performance degradation on the HPC system nodes, due to the frequency throttling mechanism, when using higher temperature settings (18°C). A detailed investigation is part of the future works, and also include the impact on the energy consumption of the HPC system.

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