

# High COP Heat Pumps for Commercial Energy Applications

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## Problem Statement

Utilizing CO<sub>2</sub> as a refrigerant in heat pumps for commercial applications which have simultaneous heating and cooling loads such as data centers, hotels and hospitals.

## Approach

- A data center on campus (Mathematics Department data center) is used as a case study to examine the savings with the proposed CO<sub>2</sub> heat pump system.
- The conventional electric and steam driven chillers which provide chilled water to the data center are replaced by the proposed heat pump system.
- Heat emitted by the electronic equipment in a data center is used to heat the buildings instead of rejecting it to the environment.
- Simulation for annual data with various design parameters is carried out.

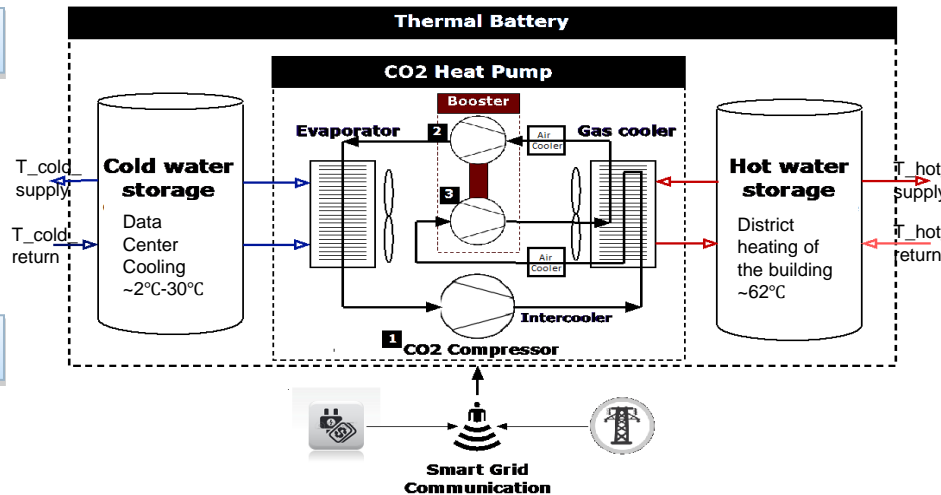
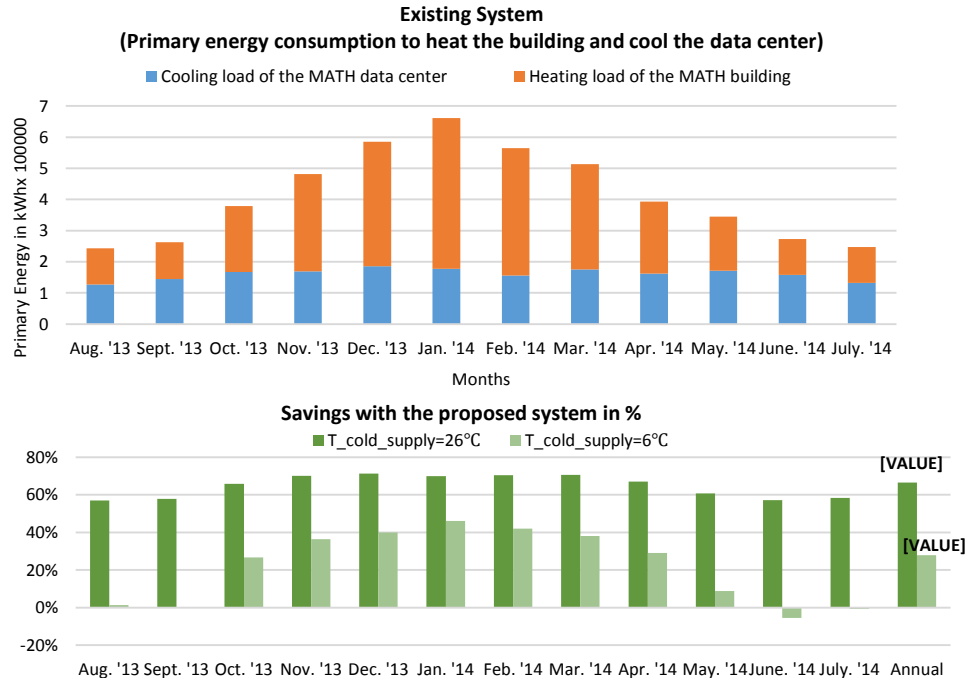


Figure 1: Schematic Diagram of the proposed system



## Impact

- Energy Savings =28-66% (depending on supply temperature)
- Pay back period=3.5 - 4.5 years
- Thermal battery(TB) allows the system to be operated with Smart Grid technologies: More economical and effective means of energy storage.
- TB can easily be optimized to handle part load heating and cooling demands as well as intermittent renewable onsite power generation.

## Selected Publications

Dharkar, S., Kurtulus, O., Groll, E., & Yazawa, K. (2014). Analysis of a Data Center Using Liquid-Liquid CO<sub>2</sub> Heat Pump for Simultaneous Cooling and Heating. In *15th International Refrigeration and air conditioning conference* (pp. 1–8).

Liu, Y., Groll, E. A., Kurtulus, O., & Yazawa, K. (2014). Study on Energy-Saving Performance of a Novel CO<sub>2</sub> Heat Pump with Applications in Dairy Processes. In *15th International Refrigeration and air conditioning conference* (Vol. 1, pp. 1–10).

Houbak-jensen, L., Holten, A., Blarke, M. B., Groll, E. A., Yazawa, K., & Shakouri, A. (2013). Dynamic analysis of a dual-mode CO<sub>2</sub> heat pump with both hot and cold thermal storage. *ASME 2013 International Mechanical Engineering Congress & Exposition*, 1–9.