WHITE PAPER

Raising the Bar for **Commercial Cooling System Performance**

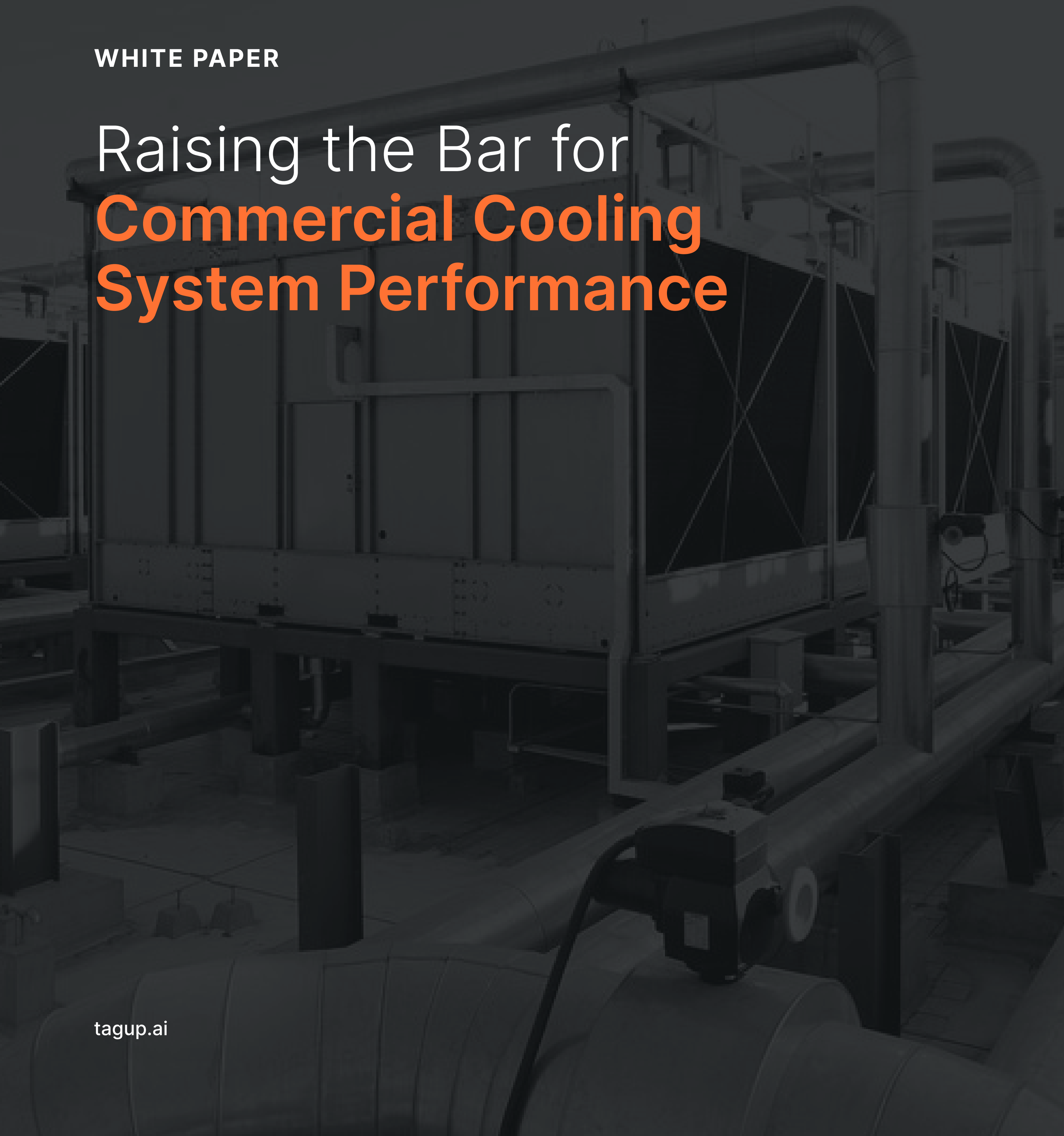

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Table of Contents

Introduction

Commercial cooling systems are critical to the way we work and live, but they're often tremendously inefficient - wasting priceless resources on a warming planet. In the United States alone, commercial cooling will consume 153 billion kWh of electricity in 2023 at a cost of $25.5 billion, resulting in over 66 megatons of CO_2 released into the atmosphere. With the help of machine learning, commercial cooling systems can be optimized, and resources can be saved.

Commercial buildings generate three things: traffic, revenue, and heat. A combination of external weather conditions, office and facility operations, and a steady flow of people leads to a building that's almost always heating up. How this heat is managed is often the difference between wasted energy (and sky-high utility bills) and a sustainably cooled, comfortable building.

The Traditional Approach to Commercial Cooling

In medium and large-sized buildings, chilled water systems are as common as the cooling problem they solve.

The process starts with the air handling unit, circulating cool air throughout the building. The air accumulates heat as it travels, then returns to the air handling unit to be cooled via the chilled water loop. There, the air meets pipes flowing cold water and transfers its heat—leaving the air cooler and the water warmer. The warm water flows to a chiller where its heat is transferred to the condenser water loop. Once in the condenser loop, the heat originally generated in the building is exhausted to the atmosphere via a cooling tower, and the process repeats.

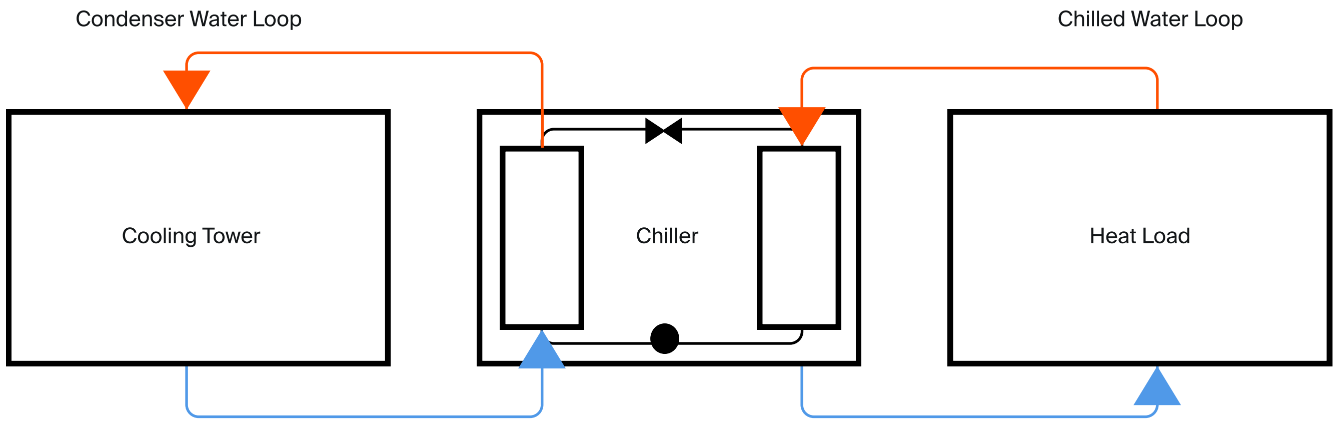

Figure 1. Diagram of a typical chilled water cooling circuit

The HVAC Optimization Paradox

Reducing energy use and operating costs is a priority for commercial building owners, but HVAC optimization isn't easy to attain or maintain.

The equipment in the condenser loop represents the lion's share of energy consumption and operating costs, and the system's efficiency depends on variable factors and the complex interactions between each piece of equipment.

Temperature control settings are a prime example. At higher temperatures, air can hold more moisture; thus, when the condenser water loop is operated at a higher temperature, the cooling tower can evaporate more water—and transfer more heat—with less airflow. Reducing the tower fan speed will decrease airflow, increase operating temperature, and reduce the power consumption at the tower. On the other hand, operating at higher temperatures can reduce chiller efficiency and lead to greater power consumption overall.

The True Cost of the Status Quo

The most common control strategy among condenser loops is called “fixed setpoint”. Here, a single cooling tower exit temperature is fixed and never changes. Stakeholders who prefer a more flexible control strategy often opt for what’s called a “fixed approach”. Taking a set value (or “approach”), like 7°F, a fixed approach controls the cooling tower exit temperature at the current wet bulb temperature plus the approach. This strategy tends to produce better system performance than a fixed setpoint strategy, but it still leaves much to be desired for stakeholders seeking optimization.

In some cases, a fixed approach control strategy can create a reasonable balance between the competing needs of the tower and the chiller. However, the approach that minimizes total power can vary by more than 5°F depending on the load on the system, atmospheric conditions, and several other factors. This discrepancy means that a fixed approach controller, no matter how well-tuned, can still leave as much as a 10% reduction in power consumption on the table.

Historically, condenser loop optimization required employing expensive engineering firms with many hours dedicated to a single site. As thorough as they may have been, the results often led to a deterministic control strategy—one that inevitably grew obsolete as time passed.

Complications Facing Real-World Cooling Systems

- Changes to cooling tower fan speed impact chiller power consumption and also affect the rate of evaporation and the amount of water consumed, which can be a major driver of the overall cost.
- Weather, cooling load, and even the price of electricity and water can vary day-to-day and throughout the day, affecting operating costs and performance.
- Many systems expose more channels for optimization, including variable-flow pumps or variable-speed chillers.
- Larger systems may take a long time to reach a steady state, meaning optimization must consider future load and atmospheric conditions.

Each piece of equipment can have unique characteristics to its efficiency curves, which can drift over time as the asset ages. Capturing the underlying system dynamics while accounting for all these complications is an insurmountable task for deterministic control logic. The optimal solution learns from the observed data and improves over time—one powered by machine learning.

Machine Learning for Cooling Optimization

Now, with Tagup's Manifest platform, cooling systems can be optimized in real-time to adapt to changes in operating conditions. Our machine learning technology delivers value from day one using pre-trained control logic, before further adapting to the idiosyncrasies of each system over a period of days or weeks. The system never stops tuning for performance, ensuring that any drift in operating characteristics is detected and corrected.

Manifest's optimization technology gathers data from cooling system sensors and uses machine learning models to predict how changes to operational parameters will impact system performance. Manifest can operate as a recommender – with an operator in the loop to approve each decision – or as a controller, automatically implementing recommendations.

Equipped with accurate flow rates, internal temperatures, atmospheric conditions, and power and water conditions, Manifest's machine learning models simulate your cooling system's performance and energy consumption under various conditions. Optimized settings are sent to operators for review or applied autonomously.

A Real-World Example

As an example, Manifest is deployed at a medium-sized office building with a cooling loop comprising one chiller, two condenser water pumps, and one open-loop evaporative cooling tower. Manifest interfaces with the tower fan controller and adjusts the temperature setpoint for water leaving the tower. Over the evaluation period, cost savings totaled 10% compared to baseline operation, with a high daily savings of 15%. Building and weather data collected over an extended period shows that Manifest can reduce annual operating costs by up to 20% and deliver peak savings of as much as 30% under certain load and environmental conditions (Figure 2).

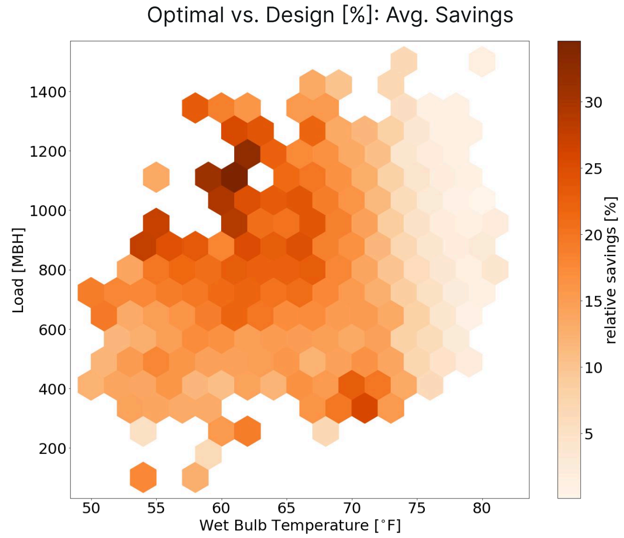

Figure 2. Projected relative savings with autonomous optimization through Manifest compared to a fixed setpoint control strategy, based on 15 months of actual weather and cooling load data for a medium-sized office building.

The Opportunity for Autonomous Optimization

By leveraging the power of machine learning, Manifest creates real-time system models and simulates performance in any condition with precision. Building operators around the world can use Manifest's recommendations to optimize control settings with confidence, or have their cooling system's performance optimized autonomously.

Manifest enables efficient, sustainable HVAC performance—for now, and for the future.

About Tagup

Tagup is a Boston-based defense technology company founded at MIT that is redefining logistics superiority with next-generation AI. The company's platform, Manifest, combines human expertise with proprietary Generative Reinforcement Learning™ to optimize complex, high-stakes decision-making across the public and private sector, delivering a decisive operational advantage in mission-critical environments.

For more information:

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