Data Center Lifecycle and Energy Efficiency

Lifecycle infrastructure management, power management, thermal management, and simulation solutions enable data center modernization.

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Introduction

Data centers are coming under increased scrutiny for their voracious energy appetite. Internally, efforts to increase efficiency are demanded to take advantage of the potential cost savings and demonstrate corporate responsibility. The desire to minimize environmental impact is becoming an equally prominent business driver. However, reducing the overall energy footprint and cost typically requires greater insight into the operation than most Information Technology (IT) organizations currently possess.

Establishing a “Green IT” culture in an organization can be a difficult and unnatural change. However, there are tools on the market today that can aid in smoothing the transition and improving the acceptance of this new paradigm. Among the most important is a single system of record that tracks and optimizes the entire lifecycle of the data center infrastructure – including the facility, mechanical systems, electrical systems, and IT assets – from design to planning, installation, operation, consolidation, and decommissioning. Gathering this data and information simplifies the next set of fundamental requirements: benchmarking, metering, and reporting.

This paper describes how the lifecycle management, thermal modeling, and cooling simulation capabilities within Datacenter Clarity LCTM* present significant energy efficiency opportunities and how data centers can realize more than 15 percent in energy cost savings within one year of deploying the solution, thereby providing a greater return on investment (ROI).

*Datacenter Clarity LC is a trademark owned and licensed by MAYA Heat Transfer Technologies Ltd.
A few years ago, a 52,000 sq. ft. data center, located in Munich, Germany, set out to significantly reduce its energy consumption and associated costs by implementing modern efficiency measures. The data center, operated by one of the top five European IT service organizations, identified several business and technology challenges in its equipment, systems, processes, and facility infrastructure that were limiting energy efficiency in its operations, including:

Rapidly-evolving environment
IT equipment in the data center was continuously evolving to incorporate technological advances, as well as increasing capacity demands. At the same time, the average power usage per device was rising, leading the IT team to struggle to control the increasing power consumption growth in such a dynamic environment.

Information isolation
The IT team needed greater awareness of cooling costs, energy usage, increasing cooling requirements, and how to accommodate the need for ever-increasing capacity by leveraging existing cooling systems. Lack of centralized information limited the ability to share this knowledge and restricted collaboration between IT and facility personnel. They believed that if the information was contained or collected within a single enterprise system, each inventory asset could be centrally tracked and its energy properties and history monitored, allowing more proactive energy management and purposeful equipment decisions.

Electricity costs
On average, more than 30 percent of the data center’s energy bill was going toward cooling the facility. Additionally, it had been observed that, each year, cooling costs were rising significantly faster relative to their equipment costs. The ability to increase the computer room air conditioner (CRAC) set point temperature by just 1.8° F would shave three percent or more off the data center’s annual energy bill.

Temperature management
The data center operations group realized a need for the ability to manage and predict temperature and its impact on server performance and, more importantly, on temperature-sensitive equipment, such as data storage systems. Having thermal management capabilities – from design to build-out, operations, and expansion or retirement – was necessary in order to actively control energy costs and consumption.

Performance control
Downtime caused by poor energy management had to be eliminated. When the data center faced reliability issues, its uptime and service availability could have been sacrificed, potentially stopping revenue-generating business in its tracks. Hot spots, blocked airflows, and failed or poorly-designed cooling systems increased the risk of performance degradation. Greater visibility into these conditions would allow for proactive corrections. It was deemed insufficient to only rely on power-per-unit floor area for decisions about IT server and data storage equipment locations. Sharing IT asset and facility information across the enterprise is now accepted as a key element of any efficient performance control system.

Reporting requirements
The data center determined it needed a more accurate, reliable, and consistent method to track and report industry standard metrics, such as Green Grid’s power usage effectiveness (PUE), a metric that represents the ratio of total energy used by the data center to the energy actually consumed by servers over time. Additional efficiency metrics that need to be captured include energy usage per square foot; carbon dioxide equivalent (CO2e) levels, or carbon usage effectiveness (CUE); water usage effectiveness (WUE); and the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) allowable ranges of temperature and humidity. Interoperability with third-party software, including energy consumption monitoring and benchmarking tools, was also desired.
Audit support
Internal and external energy audits were subject to the limitations of disparate and distributed systems of the data center. A comprehensive system, such as a Data Center Infrastructure Management (DCIM) system, which also encompasses all aspects of asset lifecycle management, would facilitate energy audits and assessments, including those performed in accordance with the U.S. Department of Energy’s Certified Data Center Energy Practitioner (DCEP) program.

External pressures
With increased awareness of the consequences of uncontrolled CO2e emissions on public health and welfare, the pressure to contain and manage emissions was growing from the general public, as well as through government legislation. The data center had a public and corporate image challenge – and a regulatory responsibility – to proactively address these concerns and document gains and achievements in efficiency initiatives. It needed the tools to simplify this process.

Design limitations
The process of adding, expanding, or changing the data center was hindered by information isolation and the lack of tools to effectively visualize the consequences of proposed changes. The IT team needed the ability to create virtual models with which to simulate various design considerations and analyze and optimize the design for maximum energy efficiency prior to procuring equipment and executing the design.

Management of requirements
The IT team sought to capture a historical record of changes to track cost, regulatory compliance, and other customer requirements throughout the entire data center lifecycle.

Engineering disparities
Varying engineering domains for mechanical, electronics, software, and electrical-interconnect technologies were limiting the design efficiency. Having a single, synchronized source of monitored data and process knowledge, as well as a common data model, would allow the various development teams to work collaboratively and expeditiously on efficient solutions.

Build processes
Design engineers and builders executing the design changes had separate sources of information for their respective tasks. Having a single repository of record for the required information would ensure that all stakeholders work with common goals and achieve the desired energy outcomes.

Approval chain
Tracking and validating the approval hierarchy – from concept through designing, engineering, and building – was cumbersome without a centralized system. The ability to easily capture and access or report on the chain of approvals and workflow for any set of data center improvements would increase the accountability of team members to ensure timely design and deployment of the IT organization’s operational goals.
Data center efficiency objectives

The European data center chose a multi-faceted approach to achieve its objectives:

- Select and standardize a DCIM solution that provides the means to design, build, and support the data center IT services and to manage all the data throughout the data center lifecycle.
- Adopt advanced virtual design techniques to visualize and prototype desired capabilities, assess impacts, and digitally validate components before implementation.
- Deploy airflow and cooling planning strategies using simulations based on computational fluid dynamics (CFD).
- Select cost-effective cooling systems that are engineered to ensure optimal performance while preventing overheating and avoiding the risk of equipment malfunctions or service disruptions.
- Utilize metering, monitoring, and control systems to aid in tracking where and how energy is used in order to detect and respond to spikes in energy usage and threats to business continuity.

The IT organization chose to implement Datacenter Clarity LC to resolve its efficiency challenges. The solution approaches energy efficiency and cost savings from both the infrastructure and asset management perspectives and encompasses the entire data center lifecycle, including concept, design, management, and optimization for the life of the equipment.

Through use of Datacenter Clarity LC, the IT group was able to achieve the following benefits:

- There was no longer a need to use disparate software solutions across the various functional groups involved in the data center’s efficiency operations.
- Temperature, electrical input, and power consumption calculations are performed, and the results are stored real-time in a single operating environment.
- Infrastructure assets – from CRACs to PDUs and racks to individual server components – are inventoried in a common system, with unique properties attributable to individual or groups of devices.
- Historical collections of data, such as temperature, kilowatt-hours, and other monitored metrics, are stored in a common system. This information is also used in downstream processes, such as modeling/simulation and upstream for dashboards, as aggregated data.
- Decision support is facilitated by easy reporting of desired attributes, such as server type, data center floor location, and average temperature. The collected data can be exported into easily-manipulated and common formats, such as Microsoft Excel or HTML documents.
- Server temperature history, both real-time and virtual CFD-based predictions, is now tracked within a centralized system, allowing for other integrated tools (e.g., 3D modeling) to leverage that data in its native format.
- Thermal and airflow analyses are integrated within DCIM in a managed environment instead of a separate standalone silo.
- Having a constantly up-to-date virtual model of the data center airflow analysis is possible with Datacenter Clarity LC.
Virtual modeling and simulation

The 3D digital modeling capability and the lifecycle asset management platform allow for virtual data center models to be created and simulations applied in an efficient and timely manner. The simulations produce a graphical representation of how the data center will perform in a physical environment, allowing the user to determine ways to improve the IT asset configurations. These virtual validations provide assurance that the configuration will meet the efficiency requirements and will continue to do so for the life of the data center.

Combining a 3D platform and an asset management system greatly simplifies CFD model creation and the simulation of changes. When data center changes are made virtually, the impacts can be assessed and adjustments made before implementation, thereby helping to contain costs and reduce planning time.

CFD modeling improves collaboration between facility and IT managers. When investigating expansion scenarios, comparing varying equipment layout scenarios highlights the differences in cooling efficiency, making it easier to quickly assess options and make smart decisions. In data center migration or consolidation situations, there are tools to map and virtually test the consolidated data center in order to optimize cooling and temperature distribution.

CFD simulations have allowed the European data center to quickly compare various means to eliminate data center hot spots, such as virtual server movement, blanking scenarios, and the addition or removal of perforated tiles. With hot spots eliminated before construction begins, the IT team can evaluate whether the set-point temperature can be raised without creating new hot spots and plan their data center cooling environment and consumption in advance. Additionally, CFD simulations are revealing air recirculation conditions and hot/cold air mixing areas, which the IT team resolves by testing virtual, incremental changes, such as moving tiles or adding baffling until recirculation and mixing is removed. The team then executes the designed plan from a controlled workflow of changes developed within Datacenter Clarity LC. As a result of CFD simulation, the data center was able to safely increase its CRAC set-point temperature from 18° to 23° C (64.4° to 73.4° F) by:

1. Simulating the initial configuration with the highest temperature and hot spots identified.
2. Correlating to temperature measurements, increasing confidence in the CFD simulation.
3. Reducing hot spots from the original server configuration by moving the servers within hot spots to the coldest area of the data center.
4. Simulating the case with set-point temperature increased by the difference between the initial configuration and the optimum configuration to see the overall impact. Special attention was paid to the storage equipment location due to the equipment’s higher sensitivity to temperature.

CFD simulations were also used to improve pressurization of the raised floor and decrease the CRAC volume flow rate by:

1. Simulating the initial configuration with the average raised floor temperature.
2. Simulating the removal of recirculation and the effect of blocking cable holes. The CRAC volume flow rate was reduced until the average pressure in the raised floor matched the initial configuration. When the air temperature of the data center was measured and correlated with the CFD-simulated air temperature, the results were excellent throughout the entire data center. On average, a difference of only 1.1 °C (or 1.98 °F) was recorded.

The models, which use the existing library of servers with data from the manufacturers, are scalable and repeatable. Having a simulation database speeds future simulations by reducing the time to find and reuse data and allowing automation of CFD model creation.
Additional green IT initiatives

With the operational and design successes that have been facilitated by the implementation of the DCIM system, the European IT organization was able to double its efforts and work toward even larger design goals.

The data center now utilizes on-site ground water instead of utility water for cooling, leading to lower costs and higher efficiency. Expanding its water-based cooling to in-rack water coolers allows for more efficient heat absorption than plenum-based air exhaust methods. Excess heat output from IT equipment has been routed to provide building heating, thus decreasing overall facility costs. All of these gains, and others, have led to the organization adopting energy efficiency as a required procurement decision criterion.

Sizable savings gained

As a result of its Green IT initiatives and new software solution, this particular data center reduced its energy consumption and associated costs while automating processes and improving operational performance.

• The data center logged more than 15 percent in energy cost savings within one year of deploying the solution, thereby providing a great return on investment.
• Waste heat recovery brought the data center from 1.80 PUE to 1.52 PUE and delivered associated energy cost reductions.

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