Data center lifecycle and energy efficiency

SIEMENS

White Paper

Lifecycle management, thermal management, and simulation solutions enable data center energy modernization

Introduction

Data centers are coming under increased scrutiny for their voracious energy appetite. Internally, efforts to increase efficiency are desired for the cost savings potential, but corporate responsibility and a will 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 IT organizations currently possess.

Establishing a “Green IT” culture in an organization can be a difficult and, at times, an unnatural change. However there are tools coming to market today that can aid in smoothing the transition and improving the uptake 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 – including the facility, mechanical systems, and IT assets – from design to simulation, building, testing, repairs, and retirement. This consolidation of information simplifies the next fundamental requirement: the benchmarking, metering, and reporting of energy usage per square foot plus calculation of the power usage effectiveness (PUE) and carbon dioxide equivalent (CO_2e) impact of the data center.

This paper describes how the lifecycle management, thermal modeling, and cooling simulation capabilities within Siemens PLM Software combine to present significant energy efficiency opportunities, and how one European computer data center realized more than €70,000 in energy cost savings within one year of deploying the solution, thus fully recovering the costs of software and services. (Due to a confidentiality agreement, the data center cannot be identified by name.)

Data centers face diverse energy challenges

In 2009, a large computer data center located in Germany set out to significantly reduce its energy consumption and associated costs by implementing modern efficiency measures. The data center, operated by a major European IT services organization, identified several business and technology challenges in its equipment, systems, and facility infrastructure that were limiting energy efficiency in its operations, including the following:

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 use per device was rising, leading the IT team to struggle to control power consumption growth in the dynamic environment.

Information isolation The IT team needed greater awareness of cooling costs, energy usage, increasing cooling requirements, and how to grow capacity by leveraging existing cooling systems. Lack of centralized information limited the ability to share this knowledge and limited collaboration between IT and facility personnel. They believed that if the information were contained within a single product lifecycle management (PLM) system, each inventory item 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 capacity. Additionally, it had been observed that cooling costs were rising significantly faster relative to their equipment costs annually. The ability to increase the computer room air conditioner (CRAC) set point temperature by just one degree 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 availability of service 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 enterprise-wide 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 method to track and report PUE, a metric that represents the ratio of total energy used by the data center to the energy actually consumed by servers over time. Timely PUE measurements would reveal how much of the power is used by the servers themselves versus the amount used for cooling IT hardware, removing the heat generated, and managing the power quality. Additional efficiency metrics needed to be captured, including energy usage per square foot and CO2e levels, and compared to industry standard metrics such as ASHRAE's 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 the data center's disparate and distributed systems. A comprehensive PLM system, which encompasses all aspects of product design, manufacturing, and 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 awareness increasing about the consequences of uncontrolled CO2e emissions on the public health and welfare, the demand for containing and managing 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 to be able to document gains and achievements in efficiency initiatives. It needed the tools to simplify this process.

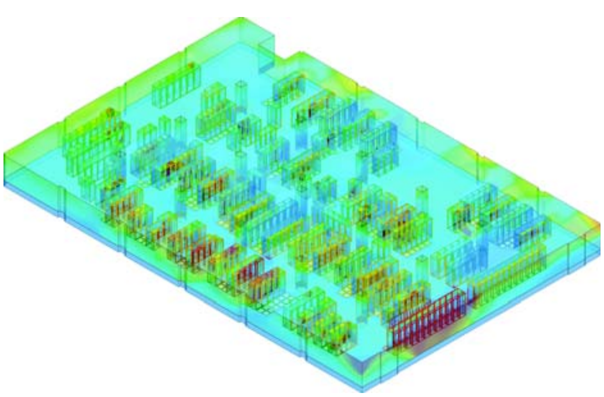

Figure 1: Servers and cabinets are visible in the virtual data center, as are the hot spots.

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

Requirements management The IT team sought to capture a Bill of Requirements in the system as a historical record of change drivers, and use it to track the fulfillment of cost, regulatory, efficiency, and other customer requirements through the design and build process.

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

Build processes Design engineers and builders executing the design changes had separate information stores for their respective tasks. Having a single repository of record for the information required 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 design, engineering, and build 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 an expedient 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 energy efficiency objectives:

1. Select and standardize on a PLM software system that provides the means to design, build, and support the data center products and to manage all the data throughout the product lifecycle.
2. Adopt advanced virtual design techniques to visualize and prototype desired capabilities, assess

impacts, and digitally validate components before implementation.

3. Deploy airflow-and-cooling planning strategies using simulations based on computational fluid dynamics (CFD).
4. Select cost-effective cooling systems that are engineered to ensure optimal performance while preventing overheating and avoiding the risk of equipment malfunctions or disruptions in service.
5. 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.

Siemens solution provides operational benefits

The IT organization chose to implement a suite of Siemens PLM Software solutions to resolve its efficiency challenges. Included in its selections were Teamcenter® data center management software for end-to-end lifecycle management and simulation, and NX™ software for digital product development. The solution approaches energy efficiency and cost savings from both the infrastructure and asset management perspective, and encompasses the entire data center lifecycle, including concept, design, management, and optimization for the life of the equipment.

Through use of the Siemens PLM Software solutions, the IT group was able to achieve the following benefits:

- The IT team no longer uses 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 in a single operating environment.
- Infrastructure assets, from CRACs to PDUs, racks to individual server components, are inventoried in a common system, with unique properties attributable to individual or groups of devices.
- Collection histories of data such as temperature, kilowatt-hours, and other sensored metrics are stored in a common system, which can then be fed to downstream processes such as modeling and simulation.
- 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 in a managed process to easily-manipulated and common formats such as Microsoft Excel or Word documents.
- Server temperature history, both real-time and virtual CFD-based predictions, is now tracked within Teamcenter, allowing for other integrated tools (e.g. CAD) to leverage that data in its native format.
- The thermal/flow analysis is integrated within Teamcenter for Simulation with NX Electronic Systems Cooling for CFD in a managed environment, instead of a separate standalone silo.
- Having a constantly, and automatically, up-to-date virtual model of the data center air flow analysis is possible with Siemens PLM Teamcenter management platform.

Virtual modeling and simulation

With the NX digital development system and Teamcenter for simulation, virtual data center models can be created and simulations applied in an efficient and timely manner. The simulations produce a graphical representation of how the products will perform in a physical environment, with suggestions on how to improve the design. NX validation checking provides automated assurance that the design complies with efficiency requirements and continues to do so for the life of the product.

Teamcenter and NX simplify 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. The IT team can monitor the temperature distribution and identify and quickly respond to threats and hot spots in the design.

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 form a consensus. 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.

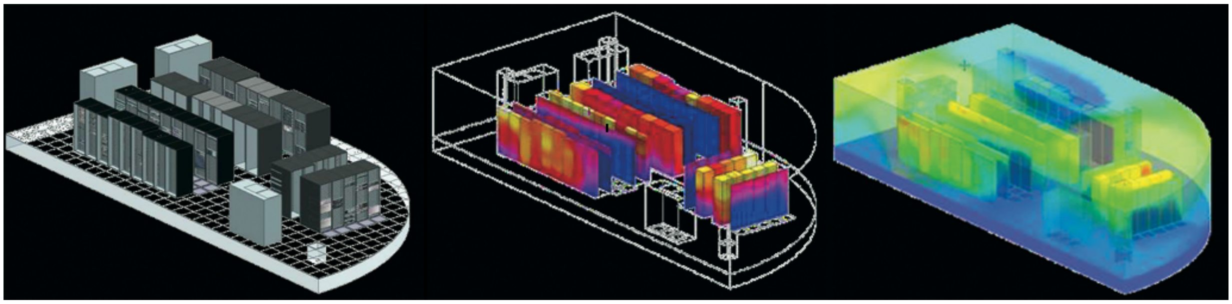

Figure 2: Energy efficiency is designed, simulated, and optimized in Teamcenter.

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, the addition or removal of perforated tiles, and the trial of ducting systems. With hot spots eliminated before construction begins, the IT team can evaluate whether the setpoint 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 to the designed plan from a controlled workflow of changes developed within Teamcenter.

As a result of CFD simulation, the data center was able to safely increase its CRAC setpoint temperature from 18° Celsius to 23° Celsius for 392 kilowatts of energy to dissipate with 100 kilograms per second of air:

- Step 1 simulated the initial configuration with the highest temperature and hot spots identified.
- Step 2 correlated to temperature measurements, increasing confidence in the CFD simulation.
- Step 3 reduced hot spots from the original server configuration by moving the servers within hot spots to the coldest area of the data center.
- Step 4 simulated the case with setpoint temperature increased by the difference between the initial configuration and 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:

- Step 1 simulated the initial configuration with the average raised floor temperature.
- Step 2 simulated to remove 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 data center's air temperature was measured and correlated with CFD-simulated air temperature, the results were excellent throughout the entire data center. On average, only 1.1° Celsius difference was recorded (with ±0.5° Celsius accuracy on measurements).

The models, which use the existing library of servers with manufacturer's data, are scalable and repeatable. Simulation data management allows visualization of the link between a product, model, and analysis. Having a simulation database speeds future simulations by reducing the time to find and re-use data and allowing automation of CFD model creation.

Additional green IT initiatives

With the operational and design wins facilitated by implementation of the Siemens PLM Software solution, the European IT organization was able to redouble its efforts and work toward even larger design goals.

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

Sizeable savings gained

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

- The data center logged more than €70,000 in energy cost savings, achieving full return on investment for the Siemens PLM Software deployment within one year.
- The data center is experiencing 37 percent less power consumption per server with the newly optimized system changes in place.
- Waste heat recovery brought the data center from 1.8 PUE to 1.52 PUE and delivered associated energy cost reductions.

About Siemens

Siemens AG (NYSE: SI) is a global powerhouse in electronics and electrical engineering, and operates in the industry, energy and healthcare sectors. For more than 160 years, Siemens has built a reputation for leading-edge innovation and the quality of its products, services and solutions. With 405,000 employees in 190 countries, Siemens reported worldwide sales of $102.9 billion in fiscal 2010. With its U.S. corporate headquarters in Washington, DC, Siemens in the USA reported sales of $19.9 billion and employs more than 60,000 people throughout all 50 states and Puerto Rico.

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