

# How Data Center Infrastructure Management Software Improves Planning and Cuts Operational Costs

## White Paper 107

Revision 3

by Torben Karup Nielsen and Dennis Bouley

### > Executive summary

Business executives are challenging their IT staffs to convert data centers from cost centers into producers of business value. Data centers can make a significant impact to the bottom line by enabling the business to respond more quickly to market demands. This paper demonstrates, through a series of examples, how data center infrastructure management (DCIM) software tools can simplify operational processes, cut costs, and speed up information delivery.

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## Introduction

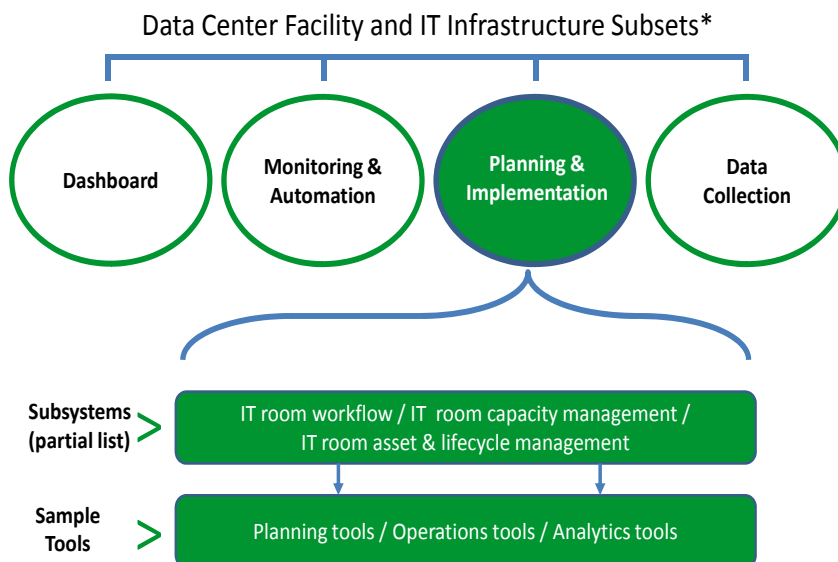
According to the Uptime Institute (a division of the 451 Group) the market for data center infrastructure management systems will grow from \$500 Million in 2010 to \$7.5 Billion by 2020.<sup>1</sup> IT and business executives have realized that hundreds of thousands of dollars in energy and operational costs can be saved by improved physical infrastructure planning, by minor system reconfiguration, and by small process changes.

The systems which allow management to leverage these savings consist of modern data center physical infrastructure (i.e., power and cooling) management software tools. Legacy reporting systems, designed to support traditional data centers, are no longer adequate for new “agile” data centers that need to manage constant capacity changes and dynamic loads.

Some data center operators do not use any physical infrastructure management tools. This can be risky. One operator who only managed 15 racks at a small manufacturing firm, for example, felt that the data center operations “tribal knowledge” he had acquired over the years could help him handle any threatening situation. However, over time, his 15 racks became much denser. His energy bills went up and his cooling and power systems drifted out of balance. At one point, when he added a new server, he overloaded a branch circuit and took down an entire rack.

New management software Planning & Implementation tools (see **Figure 1**) improve IT room allocation of power and cooling (planning), provide rapid impact analysis when a portion of the IT room fails (operations), and leverage historical data to improve future IT room performance (analysis). These three types of Planning & Implementation tools—planning, operations, and analysis—are each explained in the following sections this paper. Data center facility software tools (e.g., building management systems) are not discussed. For a description of data center physical infrastructure software tools that exist within other data center facility and IT infrastructure subsets and subsystems see White Paper 104, *Classification of Data Center Management Software Tools*.

 [Link to resource](#)  
**White Paper 104**  
*Classification of Data Center Management Software Tools*



**Figure 1**  
 The software tools discussed in this paper belong to the Planning & Implementation subset

\* See APC White Paper 104, *Classification of Data Center Management Software Tools* for a comprehensive description of OT subsets and subsystems.

<sup>1</sup> Andy Lawrence, The 451 Group, *Data Center Infrastructure Management: Consolidation, But Not Yet*, December 7, 2010

Some data center managers were never sold on first generation physical infrastructure management tools because the tools were limited in scope and involved considerable human intervention. These first generation tools would generate a pre-loaded list of devices and warn that a CRAC unit inlet temperature had exceeded an established threshold. The operator would have to determine on his own what equipment was affected by the error. The tools were not capable of generating a correlation between physical infrastructure device and server. Nor were these tools capable of initiating actions to prevent downtime, such as speeding up fans to dissipate a hot spot.

Newer management tools are designed to identify and resolve issues with a minimum amount of human intervention. By correlating power, cooling and space resources to individual servers, DCIM tools today can proactively inform IT management systems of potential physical infrastructure problems and how they might impact specific IT loads. Particularly in a highly virtualized and dynamic cloud environment, this real-time awareness of constantly changing power and cooling capacities is important for safe server placement. These more intelligent tools also enable IT to inform the lines of business of the consequences of their actions before server provisioning decisions are made. Business decisions that result in higher energy consumption in the data center, for example, will impact carbon footprint and carbon tax. Charge backs for energy consumption are also possible with these new tools and can alter the way decisions are made by aligning energy usage to business outcomes.

## Planning: Effect / impact of decisions

Newer planning software tools illustrate, through a graphical user interface, the current physical state of the data center and simulate the effect of future physical equipment adds, moves, and changes. This capability provides answers to some common planning questions (see **Figure 2**). For example, modern planning tools can predict the impact of a new physical server on power and cooling distribution. Planning software tools also calculate the impact of moves and changes on data center space, and on power and cooling capacities.

**Figure 2**

*Common planning  
questions*

### Common questions answered by planning tools:

- Where does the next physical or virtual server get placed?
- Will I still have power or cooling redundancy under fault or maintenance conditions?
- Do I need to spread out my blade servers to get reliable operations?
- How will a new server impact the existing branch circuit?
- What will the impact of new equipment be on my redundancy and safety margins?
- Does the existing power and cooling equipment have the capacity to accommodate new technologies?

### Symptoms of poor planning

The following examples illustrate the kinds of issues that develop as a result of poor planning:

- A recent power and cooling assessment at a data center revealed numerous hotspots at the floor level where it should have been cold. Other areas were cold where they should have been hot. Why? Although the data center had enough kilowatts of capacity, no real planning had taken place when it came to the placement of equipment. The air distribution was insufficient, even though the bulk capacity was available.

- A rack of servers was lost when an IT administrator unintentionally overloaded an already maxed-out power strip.
- Drives and memory removed from servers which had been purchased for an install project were misappropriated for another manager's project. No asset management tool was in place to record activity such as removal of equipment from a rack. Since no automated tracking of rack assets occurred, the project planning was flawed. When the day of the install arrived project resources had been flown in at significant expense. Unfortunately, most of the day was wasted trying to locate misappropriated equipment.
- A large manufacturing firm virtualized their data center and consolidated their most critical business applications to a cluster of servers. Because they were using the fail-over mechanism of their virtualization platform (ability to migrate their VMs), they felt protected from hardware failure. Unfortunately, in their planning, they had not recognized that each of the servers was dependent on the same UPS. This meant that when the UPS failed, no UPS protected servers were available to migrate the affected loads to.

## Understand the impact of failures and changes

Business executives and data center operators share the goal of maintaining operational integrity even when failures occur in the data center. Insight into the impact of potential failures helps business management feel secure about business process availability. More importantly, this insight can help data center operators prepare for problems to shorten recovery times, or even avoid them in the first place. Simply put, planning tools help maintain business continuity while providing peace of mind.

Modern planning software tools perform the following functions:

- Provide graphical representations of IT equipment and its location in the rack (This frees the operator from having to either pour over spreadsheets to find this information or to physically have to be present in the data center.)
- Visually display the impact of pending moves and changes on power capacity and cooling distribution (see **Figure 4**). (This spares the operator from having to engage in complex mathematical calculations and from potentially committing some serious errors that result in unanticipated downtime.)
- Simulate the consequences of power and cooling device failure on IT equipment for identification of critical business application impacts (This provides an up-front assessment of risk, based on scientific calculation, rather than by making decisions based only on "gut feel".)
- Proactively manage within rack and floor tile weight limits (This avoids the disruptive situation of compromised rack integrity or having a rack crash through a stressed out raised floor.)
- Simulate cooling scenarios in the data center with CFD approximation (This produces an airflow analysis much faster than a traditional CFD study.)
- Generate recommended installation locations for rack-mount IT equipment. The location selection is based on available power, cooling, space capacity, and network ports. (This helps to avoid the problem of overloaded branch circuits or hot spots.)

“Business executives and data center operators share the goal of maintaining operational integrity even when failures occur in the data center.”

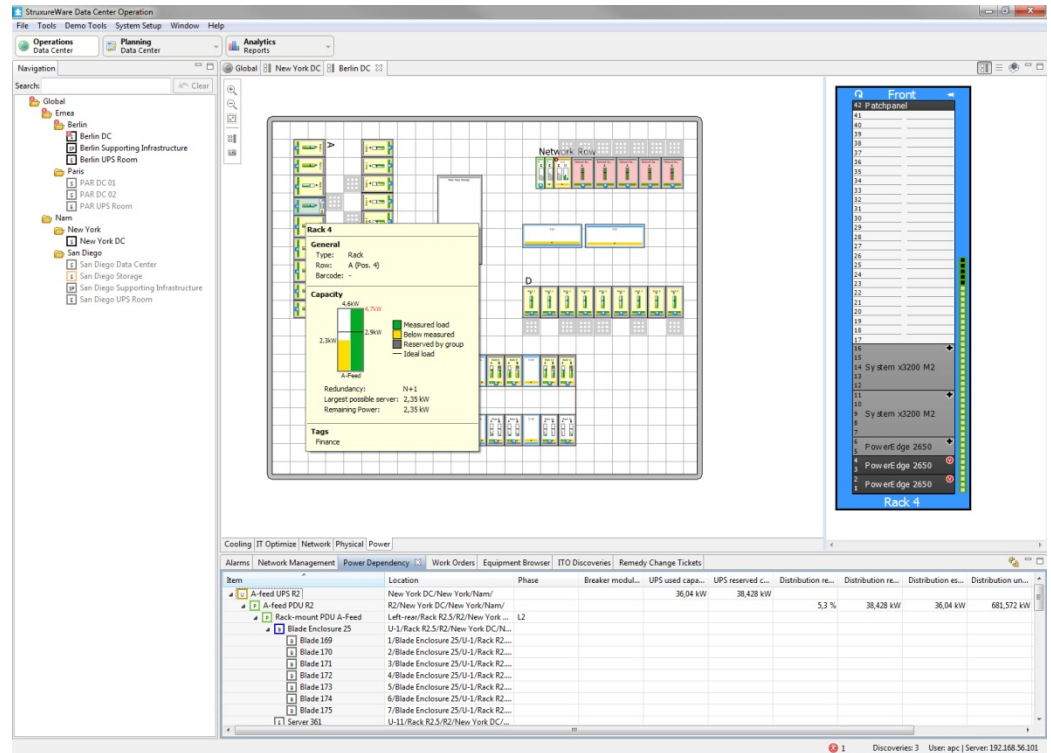
Planning tools improve data center operational efficiency and create an environment for process improvements. Consider the traditional scenario where an operator is trying to determine whether power capacity that was just exceeded on a rack is only an anomaly or a developing trend. They go on "gut feel" and leave it alone. If they are wrong, a breaker will trip the next time power capacity in that rack is exceeded. When this happens all the servers downstream of that breaker that might be running mission critical applications would be suddenly shut down. Planning tools, on the other hand, can proactively simulate the allocation of the workloads in the rack to see if a user-defined threshold might be breached before

a change or move is made. The power usage of each device in the rack is measured so that load balancing decisions can be made based on science rather than intuition.

Physical infrastructure tools available today send out an alarm from the rack prior to a breaker tripping. This early warning system provides the operator with the opportunity to make adjustments before downtime occurs. Reports are generated for minimum, maximum, and average usage over time for that rack and for each rack in the data center (see **Figure 3**). If a rack gets close to an overcapacity threshold, predictive simulation options can be generated and reviewed to determine the best way to alleviate the situation. Planning implies the ability to simulate outcomes, to capacity plan, and to manage inventory and workflow.

**Figure 3**

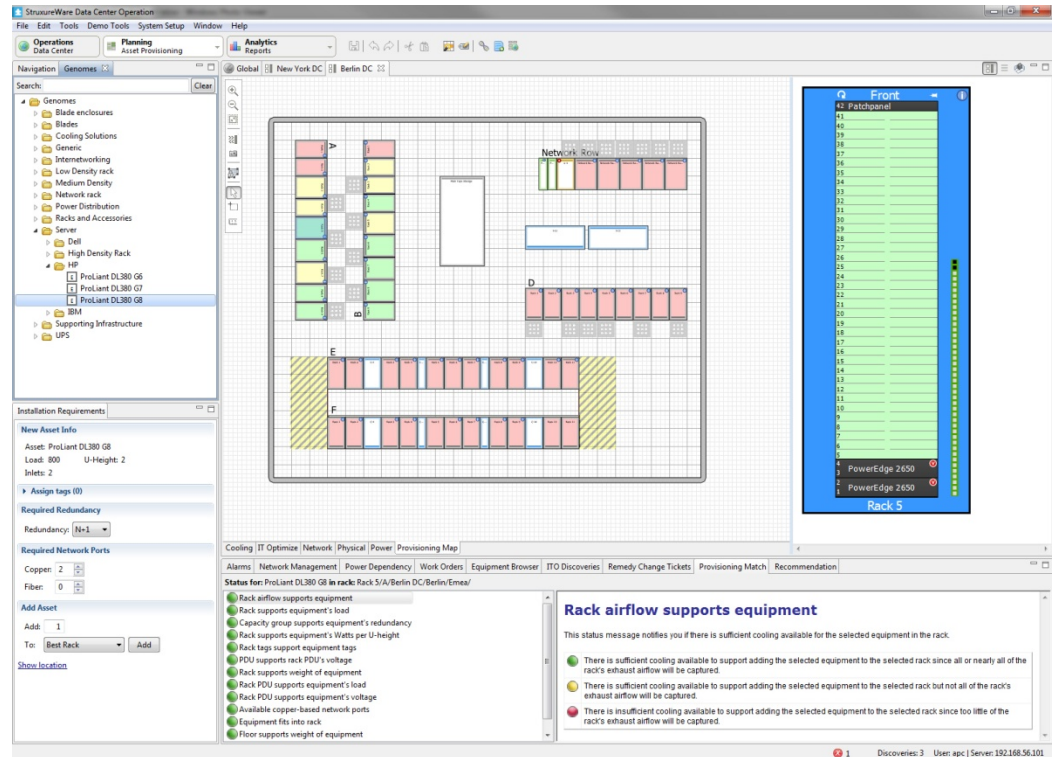
Collection of data for real-time simulation (sample screen extracted from the Schneider Electric StruxureWare Data Center Operation)



Consider the scenario of how an operator determines where to place the next physical server. In the traditional data center the operator would perform a manual check on racks for some free space and a network port. They might feel behind the rack to check if it's too hot. They would then take their new server, place it in the rack, plug it in, and hope for the best.

Figure 4

Planning tools can be used to analyze the impact of moves and changes on the data center power and cooling (sample screen extracted from the Schneider Electric StruxureWare Data Center Operation)



As operations management tools are constantly collecting data from the various devices in the racks, the tools are capable of utilizing the collected data to perform real-time simulation of server placement based on power, cooling, space, port availability and weight requirements of the server (see **Figure 4**). The tools then generate a work order to place the server in the correct rack.

“The deployment of modern planning tools can result in hundreds of man hours saved per year and thousands of dollars saved in averted downtime costs.”

The deployment of planning tools can save time and money by helping to avert downtime. These benefits extend to highly virtualized, cloud-based environments. Host selection and deployment are critical to capitalizing on the benefits of a cloud infrastructure. With numerous virtual machines and applications running on any single host, the health and availability of each physical machine becomes that much more critical. The use of planning tools better ensures that each physical machine has the power and cooling necessary to remain operational.

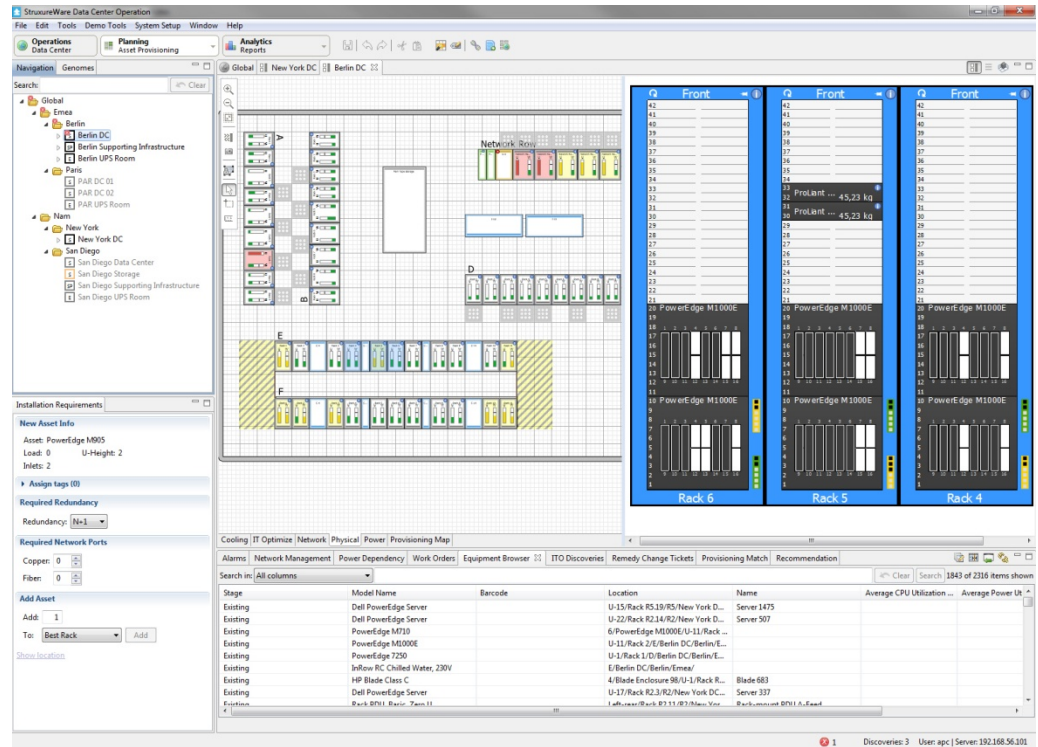
While planning software helps to improve the efficiency and effectiveness of operations, access to data center planning data can also help convince senior management that an upgrade to a data center can be justified (see the “Analytics: Identifying operational strengths and weaknesses” section of this paper). Newly available reporting capabilities from recently released management systems can help justify expenditures for data center improvements. Use of advanced planning tools can also help data center professionals prepare for audits and other forms of compliance.

New graphical user interfaces make the management tools easier to work with. Now racks can be viewed in three dimensions or from top down or from rack front (see **Figure 5**). The management tools correlate data between CRAC units, the PDUs, and the UPSs. The entire chain is monitored. The tools relate the rack being cooled by a CRAC unit to the IT equipment within those racks. Therefore, the impact of a physical infrastructure failure (such as a failing CRAC unit) on the housed IT asset can be predicted.



**Figure 5**

Front view of row of IT racks within the IT room (sample screen extracted from the Schneider Electric StruxureWare Data Center Operation application)



## Operations: Completing more tasks in less time

New automated workflow tools allow operators to assign work orders, reserve space, track status, and extract an audit trail for complete visibility and history to the change cycle when equipment goes in and out. **Figure 6** highlights the types of operational questions answered by modern physical infrastructure management tools.

### Symptoms of poor operations

The following examples illustrate the kinds of issues that can develop as a result of poor operation planning and implementation. Today's infrastructure management tools can help make data center operators more effective and improve existing processes.

- In a large financial data center, the provisioning and installation of servers became so complex that only highly paid engineers were able to perform the task
- A veteran data center manager based in New York was concerned about the provisioning of a server in his new London data center. He felt the employees based in London were relatively inexperienced and that they would not know where to properly place the server. He flew from New York to London in order to place a Post-It® note on the rack position he wanted reserved, just to make sure no mistakes were made. He wanted to make sure the power and cooling systems could support the additional servers.
- One owner of a mid-size data center located in Florida had been intentionally oversizing his cooling capacity for years in order to ensure that the data center would not run out of cooling. He also could not account for the origin of a number of servers in his data center. It was determined that he was over cooling even more than what he had originally thought and that 10% of his servers being cooled were at very low utilization.
- A finance industry data center operator was tasked with installing nine new servers. He located a rack in the data center that was nearly empty, and installed the servers into the rack. He checked that all the servers turned on, and when they all initialized, he considered the installation a success. It wasn't until the next day that he noticed the UPS which was feeding the new servers had switched to bypass. As it turned out, the

overnight load on the newly installed servers had peaked thereby overloading the UPS and placing hundreds of servers at risk.

- At a large healthcare industry data center containing both low density (with no redundancy) and high density (with 2N redundancy) configurations, a low density server was inadvertently installed in a high density rack. This error wasn't discovered until the time came to decommission the server. In the end, running the server ended up costing about 20 times more in electrical costs than was necessary.
- A large engineering firm had virtualized a large percentage of their workload and applications as part of a cloud-based computing model they had adopted. In order to better respond to constantly fluctuating demand and maintain availability, they allowed the VM manager to automatically create and move VMs based on compute requirements. In one case, applications ran out of processor power so the VM manager moved them to another physical host in a different rack that had processor capacity. The server ended up crashing because the PDU was overloaded.

### Common questions answered by operation tools:

- What is my current workflow?
- The data center has hot spots, how can I address this?
- What is the overall health of my data center?
- I lost a fan on my CRAC, what do I do now?
- My power capacity is exceeded on a rack, what can I do?
- What is my PUE?

**Figure 6**

*Key operations questions*

Newer operations software tools perform the following operations-related functions:

- Track single and three phase equipment power draw, ensuring all three phases on the power system carry a balanced load (This means an operator becomes less reliant on a vendor or on an electrician to determine power system load balances.)
- Illustrate power path—from UPS to rack to individual devices—within the rack, measured load, and rack capacity (Rather than discovery through trial and error, this helps the operator to immediately identify which servers will be affected if a particular rack or UPS happens to fail.)
- Report average and peak power usage by rack (This helps to justify decisions when determining where to locate a new server.)
- Generate an audit trail for all changes to assets and work orders for a specified range of time, including a record of alarms raised and alarms removed (When trying to determine why a system failed, rather than relying on various individuals' opinion of which equipment was moved and when, the operator can use the system to provide the factual evidence.)
- Identify excess capacity and indicate which devices can either be decommissioned or used elsewhere (This can help save energy costs by reallocating underutilized IT room assets.)
- Generate a Power Usage Effectiveness (PUE) value on a daily basis and track historical PUE (This allows the operator to analyze whether management's cost cutting, energy saving strategies are actually working.)

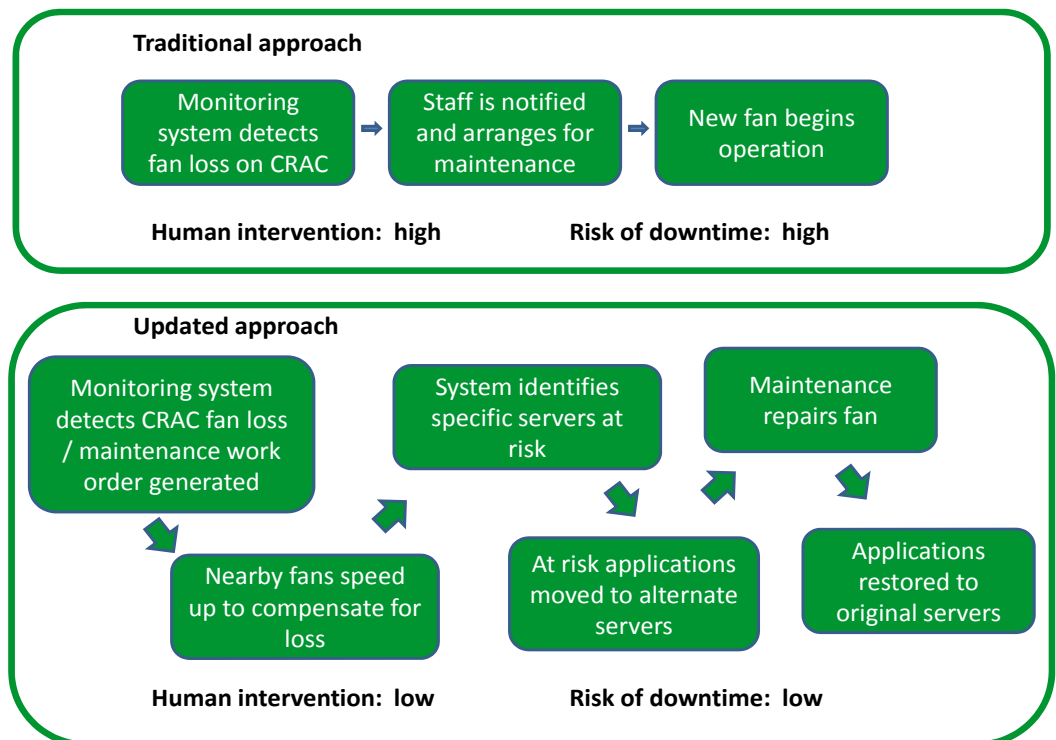


 [Link to resource](#)  
**White Paper 118**

*Virtualization and Cloud Computing: Optimized Power, Cooling and Management Maximizes Benefits*

- Some tools exist that can communicate power, cooling, rack and other physical infrastructure information directly to a VM manager. Such cooperation can ensure virtual machines and their respective applications and workloads only exist on physical hosts that have “healthy” power and cooling resources. This increases IT reliability while possibly reducing the need for physical infrastructure redundancy. To learn more about how a highly virtualized environment can impact the data center physical infrastructure, see White Paper 118, *Virtualization and Cloud Computing: Optimized Power, Cooling and Management Maximizes Benefits*.

Today's planning & Implementation software management tools allow for improvements to standard operational procedures. **Figure 7** compares both traditional and improved workflows regarding the loss of a fan on a CRAC unit. **Figures 8** and **9** illustrate examples of different approaches for managing data center energy consumption issues.



**Figure 7**

*Traditional vs. modern approach: CRAC fan loss*

In a traditional approach, the human operator reasons in the following manner: “I have three CRAC units and 15 racks. It’s CRAC number 3 that is malfunctioning, so I only have to worry about the last 5 racks in my chain.” This human tribal knowledge calculation/correlation might work when only a limited number of racks need to be managed. However, as the IT room environments grow, the situation becomes less and less manageable. Hot spots and overloaded circuits occur when operators rely on their last recollection and / or on a series of traditional assumptions. This is when problems begin to occur. At the higher levels of complexity, the management tools perform the task much more efficiently and accurately than the human brain.

The traditional method for tracking IT room equipment in/out logs involves either removal or installation of a device and then logging the device into a book (by a designated person). This procedure is followed for any device the size of a disk/tape and larger. All drive bays are audited nightly by security and if drives go missing, security reviews the access logs and server room security footage to see who might have taken them.

Operations software can provide data center inventory information from a hand held device while on the data center floor. An integrated barcode scanner simplifies the task of implementing work orders and identifying equipment. Using a wireless network, server locations are automatically synchronized, and device and asset attributes are detailed. Searches can be run by equipment vendor name, model, and type. Information can also be exported to an Excel format.

Consider a scenario where the data center operator is attempting to determine the overall health of the power and cooling physical infrastructure. In a traditional data center the operator would have to measure and interpret the health of each individual device. This measurement information would have to be kept on spreadsheets. The data would have to be manually aggregated for reporting.

Management tools are capable of 7x24 centralized device discovery, management, and monitoring. When problems occur, instant infrastructure alerts and alarms are triggered based on user defined thresholds and conditions. Reports and graphs are quickly generated to help diagnose the nature of the problem.

### Issue: Energy efficiency management

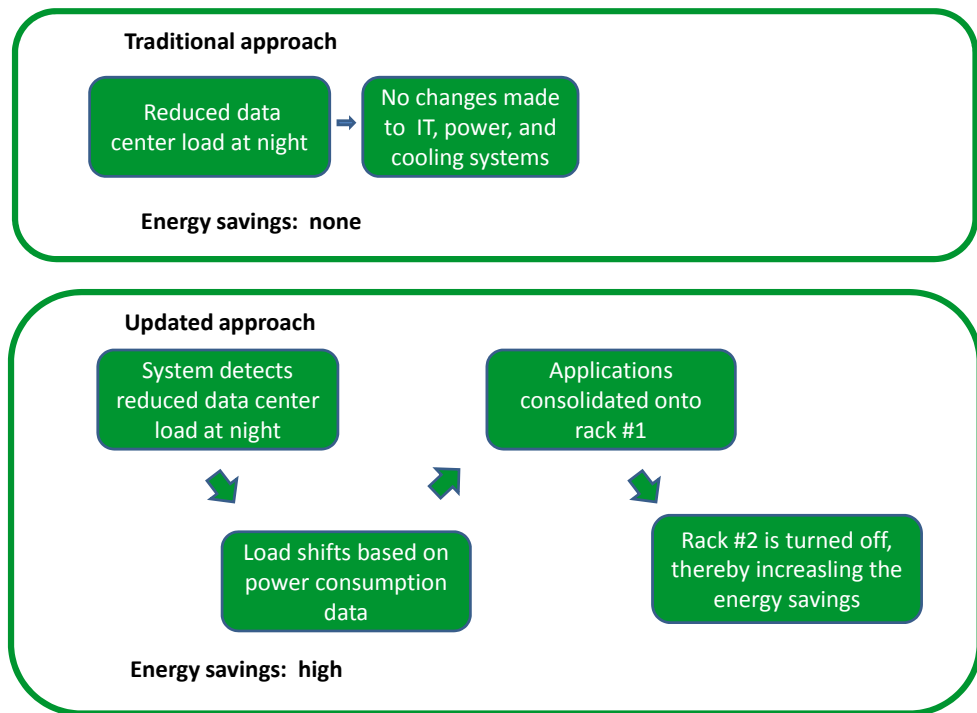
Typical data centers are excessive consumers of energy. Historically, data center design and operations have been focused on reliability and capacity. This has led to the unfortunate situation where data centers have not been optimized for efficiency. In fact, it is difficult to identify any one place where a data center is engineered for efficiency, because independent decisions of equipment designers, system integrators, control programmers, installers, contractors, IT managers, and operators all contribute substantially to overall energy performance.

Studies show that energy use is a substantial cost of IT operations, in some cases exceeding the cost of the IT hardware itself<sup>2</sup>. This cost pressure, and the realization that data centers can be much more efficient in their use of energy, have influenced many data center operators to lower energy consumption. Operators have traditionally been ill equipped to measure energy consumption even though they are becoming accountable for it. New energy management tools are making their way into the suite of IT room management systems.

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<sup>2</sup> US Department of Energy, "Creating Energy Efficient Data Centers", U.S. Department of Energy, May 2007

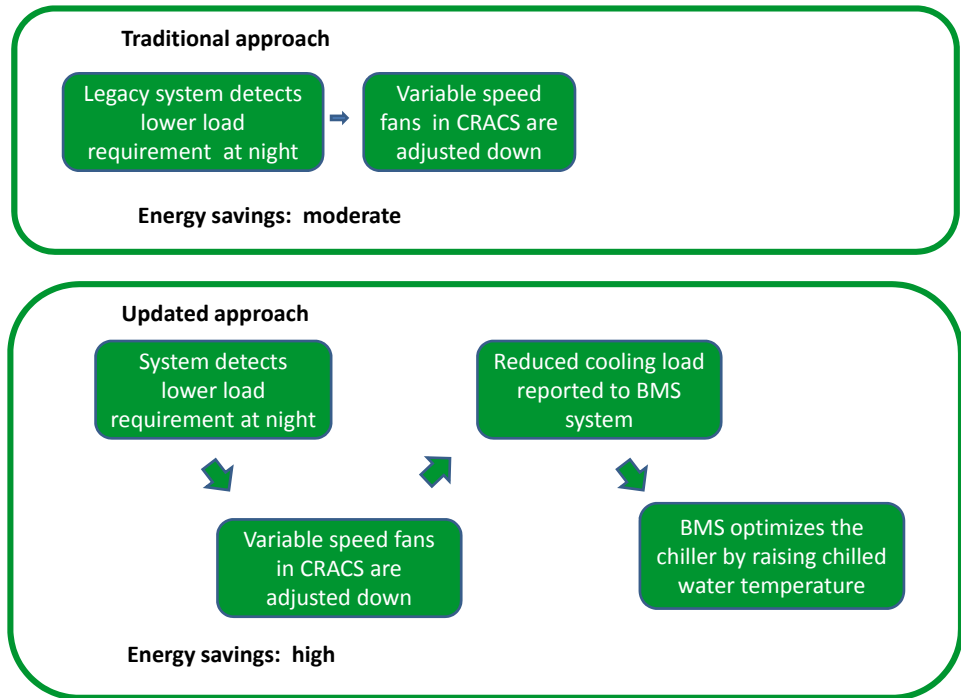
“Hot spots and overloaded circuits occur when operators rely on their last recollection and / or on a series of traditional assumptions.”



**Figure 8**

*Traditional vs. modern approach: Load shifting*

These new tools enable IT room operators to support load shifting (see **Figure 8**). In a virtualized environment, virtual machines, applications and their respective workloads can all be moved by the VM manager to other physical hosts when user-defined power thresholds are reached. In the energy-saving example shown in Figure 8, virtual loads are consolidated onto a single rack at night when demand is low. This allows the other rack to be turned off to save energy. It should be noted that generating real-time power consumption data requires metered rack PDUs or individual branch circuit monitoring equipment along with DCIM software to collect and report on measurements while correlating those readings to specific IT equipment. As described above, some DCIM tools even exist that can integrate directly with the VM manager to share power, cooling and other data. This integration ensures safe, automated placement of new and existing VMs. **Figure 9** provides another illustration of how software-driven energy management practices can reduce operational costs.



**Figure 9**

*Traditional vs. modern approach: Intelligent temperature setting*

## Analysis: Identifying operational strengths and weaknesses

The goal with analysis is to arrive at an optimal or realistic decision based on data. For example, an audit trail can be generated for all changes to assets within the computer room. If a spike in power demand seems to occur on the same rack at the same time every night, and the spike is dangerously close to tripping a breaker threshold, then a decision can be made to modify workflow so that the consumption peak for that rack can be reduced.

Analysis of physical infrastructure operational data can also determine the cause of problems (i.e., what is slow, what is costly). Combining analytics and predictive simulation is yet another way the data center can help to generate business value. **Figure 10** highlights the types of questions that can be addressed through the use of modern data center physical infrastructure management tools.

Performance reports track outages by rack, row, and power distribution zone. When servers fail more frequently in one area, an underlying reason can be determined. Without a frame of reference, the value of data center metrics is limited if the purpose of the operator is to raise efficiency and reduce data center cost.

**Figure 10**

*Key analytics questions*

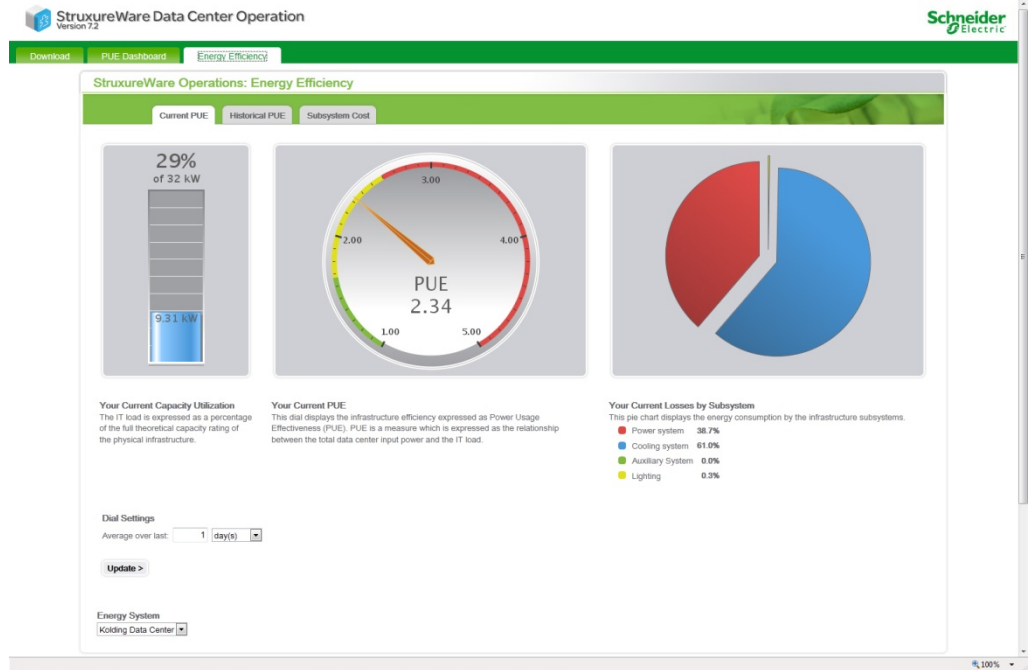
### Common questions answered by analytics tools:

- What do I have in my data center?
- Who has touched which equipment and when?
- Do I have stranded cooling and power capacity?
- When will firmware have to be updated?
- By what date will the data center run out of power and cooling capacity? What will run out first?
- When should batteries be charged on the UPS?
- When will the next large data center physical infrastructure investment be necessary?
- How can I predict the need for future infrastructure, investments and rollouts?

Modern analytics software tools perform the following functions:

- Identify discrepancies between planned energy usage, based on nameplate information, and actual usage, based on actual power data (This helps operators plan more accurate capacity forecasts which help influence budgeting and acquisition decisions.)
- Generate inventory reports organized by device type, age, manufacturer, and properties of the device (This enables the operator to quickly identify underutilized assets, assets out of warranty, and assets that need to be upgraded.)
- Generate energy usage reports (see **Figure 11**) by subsystem (This allows the operators to determine which racks or subsystems generate the most energy cost and to benchmark whether energy consumption is increasing as a result of recent changes to the IT room.)
- Provide energy use details that enable the linking of operating costs to each business unit user group which then allows for “charge backs”. (This also helps the operator to modify the energy consumption behavior of various business units and enables the business to make better decisions on which technologies they deploy.)





**Figure 11**


Energy consumption analytics (sample screen extracted from the Schneider Electric StruxureWare Operation - Energy Efficiency application)

When data center floor and rack space specifications are not coordinated with power, cooling, power distribution, and cooling distribution capacities, the result is stranded capacity. **This concept can best be illustrated by a CEO who walks around the data center, sees several racks that are only half full, and questions why the data center manager is claiming that the data center is “at full capacity”.**

Examples of stranded capacity in the data center include the following:

- An air conditioner has sufficient capacity but inadequate air distribution to the IT load
- A PDU has sufficient capacity but no available breaker positions
- Floor space is available but there is no remaining power
- Air conditioners are in the wrong location
- Some PDUs are overloaded while others are lightly loaded
- Some areas are overheated while others are cold

Stranded capacity is a frustrating capacity management problem for data center professionals. It is difficult to explain to users or management that a data center with 1 MW of installed power and cooling can't cool new blade servers when only operating at 200 kW of total load.

 Link to resource  
**White Paper 150**  
*Power and Cooling Capacity Management for Data Centers*

An effective capacity management tool not only identifies and highlights stranded capacity, but also helps prevent data center staff from creating the situation in the first place. For more information on how to manage stranded capacity, see White Paper 150, *Power and Cooling Capacity Management for Data Centers*.

## Conclusion

With the challenges of higher-density computing, dynamic workloads, and the need for more efficient energy consumption, organizations require software that allows them to plan, operate at low cost, and analyze for workflow improvement. Only higher visibility, more control and improved automation can help deliver on the commitment of producing business value.

Holistic management capabilities available today can enable data center professionals to maximize their capacity to control their energy costs and to advise the business on how to utilize IT assets more effectively. By sharing key data points, historical data, and asset tracking information, and by developing the ability to charge back users, the new Planning & Implementation tools allow users to take actions based upon data center business intelligence. In short, effective use of today's data center IT infrastructure management software will help make your data center more reliable and efficient while increasing its overall business value.



### About the authors

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## Resources

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### Classification of Data Center Management Software Tools

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### Virtualization and Cloud Computing: Optimized Power, Cooling and Management Maximizes Benefits

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