Determining the Power, Cooling, and Space Capacities when Consolidating Data Centers

White Paper 177

Revision 2

by Wendy Torell and Patrick Donovan

Executive summary

When planning the consolidation of multiple data centers into existing data center(s), it is often difficult to establish the various capacities and capabilities of each site's physical infrastructure. This information is a key input to deciding which site(s) will become the "receiving" data center(s). This paper describes how to specify these requirements in standard terms and how to establish current conditions and future capabilities of each data center involved in a consolidation project.

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Introduction

When preparing for a data center consolidation project, there are steps that need to be taken in order to make good judgments about how much can be consolidated and which sites make the most sense for becoming receiving data centers. Just as IT assets, network bandwidth, compute power, and the level of virtualization are determined as part of the consolidation analysis, it is also critical to have an accurate understanding of each site's physical infrastructure capabilities. This paper specifically addresses facility power, cooling, and the physical space.

Not properly accounting for this can lead to serious problems including gross over-provisioning of resources or, conversely, not having enough power, cooling, or space capacity to meet user needs. The current capacity, utilization, and scalability for future growth need to be understood before deciding which data center(s) will become the receiving host. In many cases, however, this information is unknown. And since there can be wide disparities in the size, architecture, and management and reporting structures amongst the data centers involved in a given project, specifying these capabilities may seem to be a daunting task. **This paper describes a simple, cost-effective standardized approach to establishing current conditions and future capabilities of each data center.**

Determining capacities in existing data centers

Assessing the power, cooling, and space capacities of an existing data center is a key step in understanding the suitability of a site to become a "receiving" data center in a consolidation effort. However, the majority of data center operators today have a difficult time answering simple questions like:

- What is the design rating (kW) of my data center?
- What is the current space capacity of my data center?
- How much bulk power and cooling is available in my data center?
- How much power and cooling distribution is available in my data center?
- What is constraining my data center from adding more IT load?
- What density is my data center running at?

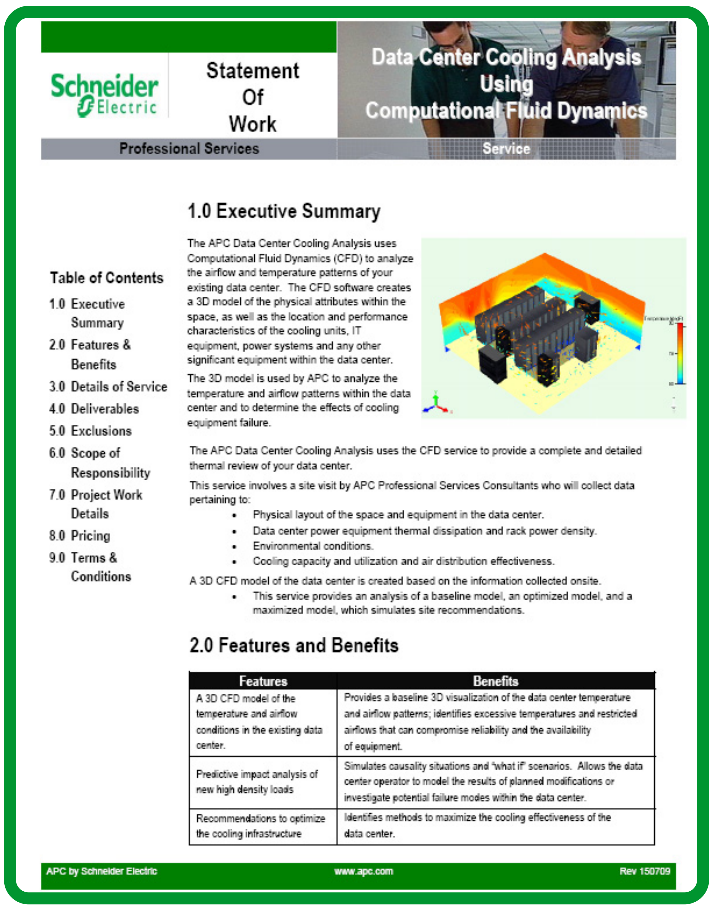
Much of this difficulty stems from the fact that there is no standard language for talking about capacity of the physical infrastructure in a data center. And further, there is no standard process for comparing one site to another to make rational decisions. Consider two data centers – One has excess bulk power (UPS) and cooling (heat rejection) capacity but is experiencing severe hot spots in the white space due to poor cooling distribution, and the other is maxed out on bulk power and cooling but has effective air distribution and plenty of available white space. Which is the better candidate to become the receiving data center?

Low-cost data center power and cooling assessments and computational fluid dynamics (CFD) analyses can assist in answering these questions. However, most data center assessments are expensive, unique, and do not provide results that can be compared across a population of data centers. A repeatable assessment using a standardized statement of work and a standardized report format simplifies the process, reduces costs, and provides data in a form that can be compared across data centers. The next section describes a standardized method for assessing power, cooling, and space capacities of an existing data center. This method also assesses other variables pertinent to selecting which facility (or facilities) is most suited for being the receiving data center in a consolidation project.

A standardized approach for assessing sites

To completely characterize the power, cooling, and space capacities, as well as the density capabilities of each data center, the following should be included in an assessment:

- Evaluate critical infrastructure capacity and current utilization using the standard terminology defined below
- Determine cooling distribution effectiveness
- Assess condition of power and cooling equipment
- Make recommendations to optimize capacities of existing equipment
- Establish feasibility of expansion for future growth
- Determine current maximum density capability through 3D CFD analyses of temperature and airflow (see **Figure 1** for sample statement of work) when capacity management software is not in place
- Make recommendations to optimize density capabilities of existing equipment



Schneider Electric | Statement Of Work | Data Center Cooling Analysis Using Computational Fluid Dynamics

Professional Services | Service

1.0 Executive Summary

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The APC Data Center Cooling Analysis uses Computational Fluid Dynamics (CFD) to analyze the airflow and temperature patterns of your existing data center. The CFD software creates a 3D model of the physical attributes within the space, as well as the location and performance characteristics of the cooling units, IT equipment, power systems and any other significant equipment within the data center.

The 3D model is used by APC to analyze the temperature and airflow patterns within the data center and to determine the effects of cooling equipment failure.

The APC Data Center Cooling Analysis uses the CFD service to provide a complete and detailed thermal review of your data center.

This service involves a site visit by APC Professional Services Consultants who will collect data pertaining to:

- Physical layout of the space and equipment in the data center.
- Data center power equipment thermal dissipation and rack power density.
- Environmental conditions.
- Cooling capacity and utilization and air distribution effectiveness.

A 3D CFD model of the data center is created based on the information collected onsite.

- This service provides an analysis of a baseline model, an optimized model, and a maximized model, which simulates site recommendations.

2.0 Features and Benefits

Features	Benefits
A 3D CFD model of the temperature and airflow conditions in the existing data center.	Provides a baseline 3D visualization of the data center temperature and airflow patterns; identifies excessive temperatures and restricted airflows that can compromise reliability and the availability of equipment.
Predictive impact analysis of new high density loads	Simulates causality situations and "what if" scenarios. Allows the data center operator to model the results of planned modifications or investigate potential failure modes within the data center.
Recommendations to optimize the cooling infrastructure	Identifies methods to maximize the cooling effectiveness of the data center.

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Figure 1

Example of a CFD analysis statement of work to determine density capability

Figure 2 provides an excerpt from a report illustrating the cooling capacity assessed using the methodology described above. Below are two case studies illustrating the usefulness of such assessments.

Case study 1: Assessment of 5 Department of Defense data centers

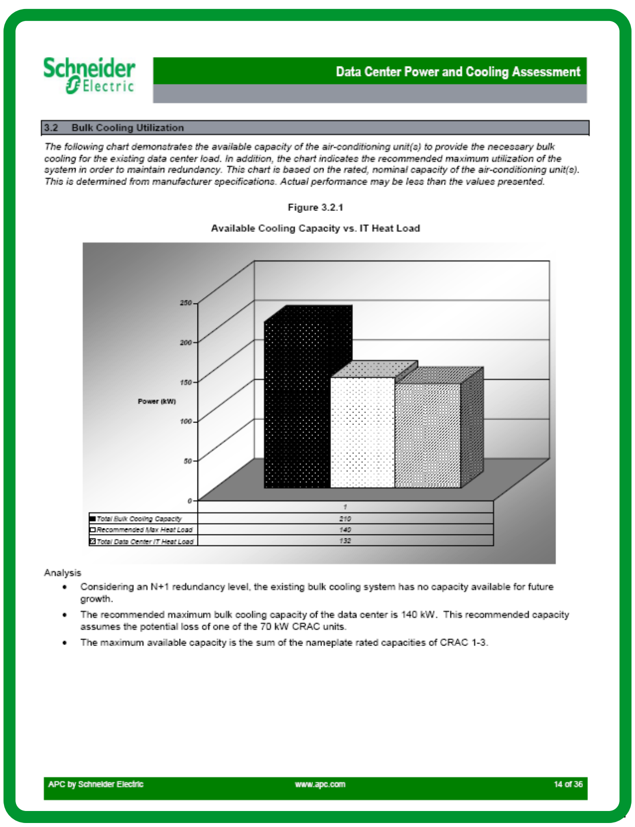
In August 2011, Schneider Electric was tasked with evaluating the infrastructure systems, operational configuration and physical layout of five Department of Defense data centers to identify changes to the data center that would realize energy savings, operating expense reduction and increased availability. Four of the five sites were determined to be cost prohibitive for further expansion or upgrade, and it was recommended to consolidate all five locations into a newer site that was part of the study. Schneider Electric's standardized assessments made it possible, through common language and methodology, to accurately compare the capabilities of the five locations.

Case study 2: Assessment of EPA data center at Potomac Yard

Link to resource
Green Grid Assessment

Assessment of EPA Mid-Tier Data Center at Potomac Yard

The EPA and The Green Grid signed a memorandum of understanding (MOU) in April 2008 to establish a working agreement for the assessment of a small to mid-sized EPA data center. Schneider Electric participated with the Green Grid in conducting the actual assessment. The intent was to provide specific recommendations for energy efficiency improvements in the subject data center but also to share the results, methodologies, and recommendations across the EPA and related governmental agencies. Pre-assessment PUE was 2.9 and the assessment concluded that a potential PUE of 1.8 was possible. However, it was determined that the capital improvements needed to achieve this PUE had a poor ROI and payback period. Instead, it was recommended that efficiency be built into every change and addition to the data center on an ongoing basis.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Data Center Power and Cooling Assessment

3.2 Bulk Cooling Utilization

The following chart demonstrates the available capacity of the air-conditioning unit(s) to provide the necessary bulk cooling for the existing data center load. In addition, the chart indicates the recommended maximum utilization of the system in order to maintain redundancy. This chart is based on the rated, nominal capacity of the air-conditioning unit(s). This is determined from manufacturer specifications. Actual performance may be less than the values presented.

Figure 3.2.1

Available Cooling Capacity vs. IT Heat Load

Power (kW)

	1
Total Bulk Cooling Capacity	210
Recommended Max Heat Load	140
Total Data Center IT Heat Load	132

Analysis

- Considering an N+1 redundancy level, the existing bulk cooling system has no capacity available for future growth.
- The recommended maximum bulk cooling capacity of the data center is 140 kW. This recommended capacity assumes the potential loss of one of the 70 kW CRAC units.
- The maximum available capacity is the sum of the nameplate rated capacities of CRAC 1-3.

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Figure 2

Example of a capacity assessment report

Standard terminology

The following terms provide a basis for communicating and assessing the capacities and capabilities of different data centers:

Data center capacity – This is the maximum IT load that the data center can support.

Spare capacity – This is the current actual excess capacity that can be utilized "right now" for new IT equipment.

Stranded capacity – This is capacity that cannot be utilized by IT loads due to the design or configuration of the system. The presence of stranded capacity indicates an imbalance between two or more of the following capacities:

- Floor and rack space
- Power
- Power distribution
- Cooling
- Cooling distribution

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

Determining spare and stranded capacities of existing sites requires different levels of abstraction for different subsystems in the data center. For example, bulk power and cooling equipment such as facility-level UPS, generator, or chiller would be described and measured at the room level, whereas equipment like cooling and power distribution equipment such as PDUs or row or rack-oriented cooling systems would be described and measured at the pod, row, or rack level. White Paper 150, *Power and Cooling Capacity Management for Data Centers*, provides further explanation of these terms.

Standard metrics to characterize capacity and density capability

Table 1 represents a recommended list of standard metrics to include when evaluating the physical infrastructure capacity, ensuring a fair assessment from site to site. These metrics provide insight not only into the overall capacity of the data center, but where the bottlenecks in capacity exist.

Table 1

Proposed standardized capacity metrics

Metric	Definition	Notes
Bulk power capacity	The usable IT capacity (kW) of bulk power subsystems: facility-level UPS, generator, switchgear	Identify bulk power subsystem with lowest usable IT capacity
Bulk cooling capacity	The usable IT capacity (kW) of bulk cooling subsystems: heat rejection components (i.e. chiller, cooling tower)	Identify bulk cooling subsystem with lowest usable IT capacity
Power distribution capacity	The usable IT capacity (kW) of power distribution subsystems: PDUs, branch circuit	Identify usable IT capacity; assessed per row or pod and summed for total
Cooling distribution capacity	The usable IT capacity (kW) of cooling distribution subsystems: Perimeter/row/rack CRACs/CRAHs	Identify usable IT capacity; assessed per row or pod and summed for total
Data center capacity	The maximum usable IT load (kW) that can be supported	Minimum kW value of above 4 capacities
Total current max IT load	Max IT load (kW) measured (for dynamic loads, need to track over period of time)	Commonly assessed from PDU outputs and summed for total

It's important to understand that nameplate ratings of the various subsystems of the data center *do not* reflect the capacity available for the IT equipment. To determine the usable IT capacity of each system, the following should be deducted from the nameplate:

- Safety margin de-rating
- Redundancy requirement
- Non-IT loads on the sub-system

Link to resource
White Paper 120
Guidelines for Specification of Data Center Power Density

In addition to power and cooling capacity, the density capability is crucial to evaluating which sites can be easily adapted to future IT needs. The cooling distribution architecture and configuration has a big impact on how dense the IT racks in the space can get. And the density capability of the site directly influences space capacity. Even if there is not a lot of IT space currently available in a particular site, when the cooling distribution architecture is one that can handle higher densities than what exist in the IT racks today, the site can be adapted to higher density zones allowing space to be freed up for additional IT racks. **Table 2** illustrates additional metrics needed for each site to compare the density capability and space capacity. White paper 120, *Guidelines for Specification of Data Center Power Density*, provides more information on how peak and average density help specify the density of a data center. With the information from **Table 1** and **Table 2** for each site, an apples-to-apples comparison can be made on capacity and density capability.

Table 2

Proposed standardized density metrics

Metric	Definition	Notes
# of racks	Total number of racks in IT space currently in place	# of racks per row or pod and summed for room total
U-space availability	U-space available in existing racks	Used to determine if space is a constraint for adding physical server hosts
Available unused IT floor space	Total number of racks that can be added to existing IT space	Based on defined space / rack based on aisle widths and support infrastructure required
Average power per cabinet	The current average power density per rack (kW/rack)	Assessed at pod and room level
Peak to average ratio (%)	The max expected or allowable rack power divided by the average value	This affects how much stranded capacity exists in power and cooling distribution
Max power per cabinet	The max average density capability of existing infrastructure	This helps determine density growth potential of existing infrastructure

Other decision criteria

Once the current and the immediate post-consolidation capacity and density specifications are determined, there are other factors to consider before deciding which site(s) is chosen to receive IT assets from other data centers.

Link to resource
White Paper 143
Data Center Projects: Growth Model

Expansion for future growth – If the growth plan suggests that the required future data center capacity will exceed the current capacity, the site should be assessed for constraints that could prevent expansion. White paper 143, *Data Center Projects: Growth Model*, shows a simple and effective way to develop a capacity plan for a data center

Age of physical infrastructure – Older systems may not be scalable, are likely to be less efficient, and may be nearing the end of their useful lives requiring expensive and possibly interruptive service or replacement.

Link to resource
White Paper 154
Electrical Efficiency Measurement for Data Centers

Efficiency – The cooling architecture plays a large role in how efficient the infrastructure is. A large difference in efficiency might outweigh some of the potential benefits a data center might have. White paper 154, *Electrical Efficiency Measurement for Data Centers*, describes a standard language and method for measuring data center efficiency.

Link to resource
White Paper 122
Guidelines for Specification of Data Center Criticality / Tier Levels

Redundancy – The required level of power and cooling redundancy may also impact the decision on which data center to consolidate into. White paper 122, *Guidelines for Specification of Data Center Criticality / Tier Levels*, describes how to choose an appropriate level of criticality as well as guidance on how to maintain your selected level of redundancy.

Facility management software capability – A site with an effective management system might be ranked higher because it's better able to manage the infrastructure resources in dynamic, denser IT environments. White paper 150, *Power and Cooling Capacity Management for Data Centers*, describes the principles for achieving effective management.

Link to resource
White Paper 82
Physical Security in Mission Critical Facilities

Physical security –Post-consolidation security requirements should be determined and compared against the existing systems. White paper 82, *Physical Security in Mission Critical Facilities*, describes the systems and best practices for physical security in a data center. Closely related to physical security is the assessment of location risks that could affect data center operations.

Conclusion

Having a standard set of metrics and a standard method of assessing all data centers in a consolidation effort is crucial to effective migration planning. Simple, standardized, cost-effective assessment services exist to help establish existing data center infrastructure capacities and capabilities as well as expansion for future growth, efficiencies, risks, and improvement opportunities. Properly assessing the physical infrastructure will reduce surprises, avoid wasteful backtracking, and assure a predictable outcome.

About the authors

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Resources

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