Data Center Projects: Advantages of Using a Reference Design

White Paper 147

Revision 0

by Patrick Donovan

> Executive summary

It is no longer practical or cost-effective to completely engineer all aspects of a unique data center. Re-use of proven, documented subsystems or complete designs is a best practice for both new data centers and for upgrades to existing data centers. Adopting a well-conceived reference design can have a positive impact on both the project itself, as well as on the operation of the data center over its lifetime. Reference designs simplify and shorten the planning and implementation process and reduce downtime risks once up and running. In this paper reference designs are defined and their benefits are explained.

Contents

Click on a section to jump to it

Introduction

Link to resource
White Paper 142
Data Center Projects: System Planning

Strong incentives exist to plan, build, and commission data centers faster. However, the common reality of tighter budgets, less staff, uncertain and dynamic IT load, and an uncompromised need for high availability makes it difficult to do this optimally. Effective planning is the key. As noted in White Paper 142, *Data Center Projects: System Planning*, "[s]ystem planning is the Achilles' heel of a data center physical infrastructure project." Planning mistakes can magnify and propagate through later deployment phases, resulting in delays, cost overruns, wasted time, and ultimately a compromised system. **A data center reference design is a tool used during this planning process that helps avoid some of these potential mistakes.**

In general, a reference design is a system blueprint, list of attributes including system level performance specifications, and (ideally) includes a detailed list of materials or components that comprise the system. While a reference design can be directly implemented, more typically, it serves as a baseline design that is adapted to meet specific user preferences or constraints.

A reference design may be for a complete data center, or it may be limited to a subsection of the data center, such as an IT pod, IT room, power plant, or cooling plant. A catalog of various reference designs allows users to quickly find designs that best fit their requirements and require minimal adaptations for their specific project.

Reference designs are built upon recommended and proven best practices. Electrical component manufacturers often provide reference designs for their products to help their customers be more efficient and effective in their application. Home builders (see **Figure 1**) use model homes and existing architectural drawings as reference designs to not just highlight their overall capabilities, but also to encourage home buyers to use a proven and standardized construction architecture that can save time, effort, and money while offering predictable performance for both the builder and the homeowner. Reference designs also exist for data center physical infrastructure systems and can offer similar advantages.

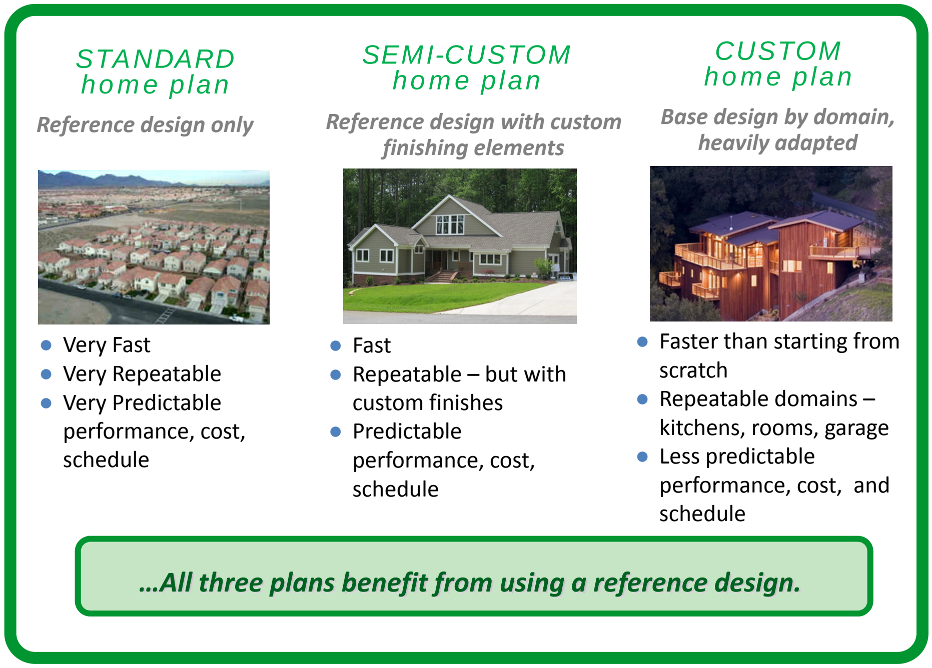
A data center reference design acts as a starting point offering a project team several valuable benefits including:

- Facilitating and simplifying the planning phase
- Reducing time to create buildable designs
- Reducing risk, offering predictable performance and improved reliability of the data center once operational

This paper describes what a data center reference design is, what it includes, and explains how the benefits listed above are achieved.

Figure 1

Reference designs are often used in home construction. Regardless of the level of customization, using a reference design can be beneficial, albeit to varying degrees.



Elements of a data center reference design

A data center reference design is a tested, validated, and documented plan for how the physical infrastructure systems are to be constructed and laid out, as well as for describing which specific components are used. For a reference design covering a complete data center, the electrical, mechanical, and IT room areas should all be covered by the plan. The design documentation typically comes in two forms:

- Graphical descriptions
- Written support documents

Graphical design descriptions

Perhaps the most useful of all the possible design documents are the **engineering "one-line"** (or "single-line") **diagrams** for the electrical, mechanical, and IT rooms. These documents provide detailed information about the architecture, the number and type of components installed, the flow of power and water through the various systems and components, as well as showing the electrical and plumbing connections to be made. It's these drawings that largely enable a reference design to be eventually buildable. **Figure 2** below shows an example of a one-line diagram illustrating the depth of detail provided.

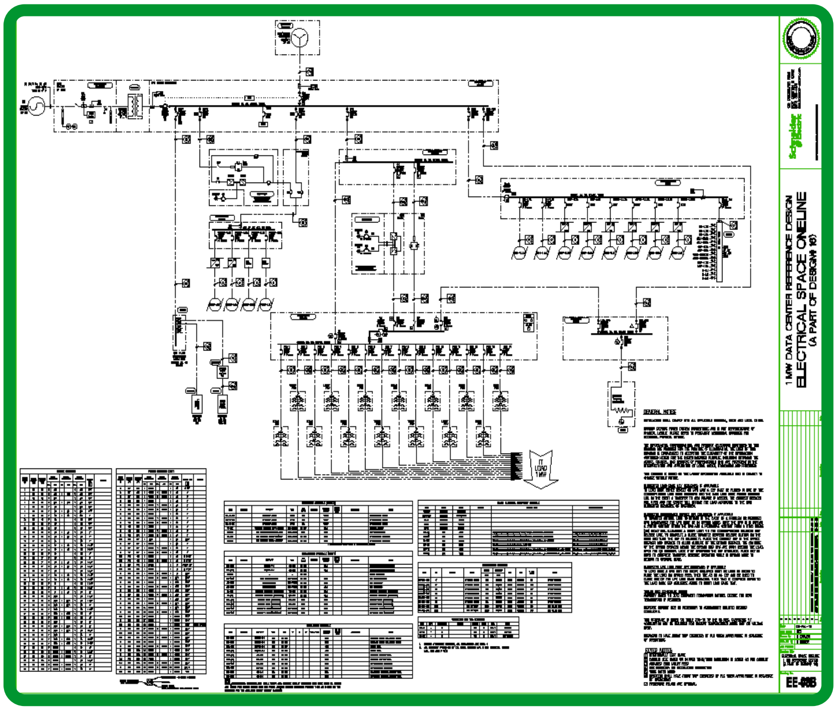


Figure 2

Example of an electrical room one-line diagram drawing from a Schneider Electric reference design

Floor layout drawings are another important graphical design description document found in data center reference designs. As their name implies, these drawings show the physical dimensions, arrangement, and clearances of all the system components. These components include such things as racks, PDUs, CRACs/CRAHs, UPSs, generators, switchboards, ATSs, etc. This critical information will quickly help answer big questions such as, “can I fit a 1 MW data center in my building?” Beyond conveying overall space requirements for all the various aspects of the design, the component and system layouts also are oriented in specific ways for specific reasons. These reasons include maximizing cooling efficiency, simplifying operations, maintaining good security and properly applying codes and standards related to spacing. **Figure 3** below shows an example of an IT floor layout drawing. Layout drawings should also exist for the electrical and mechanical rooms.

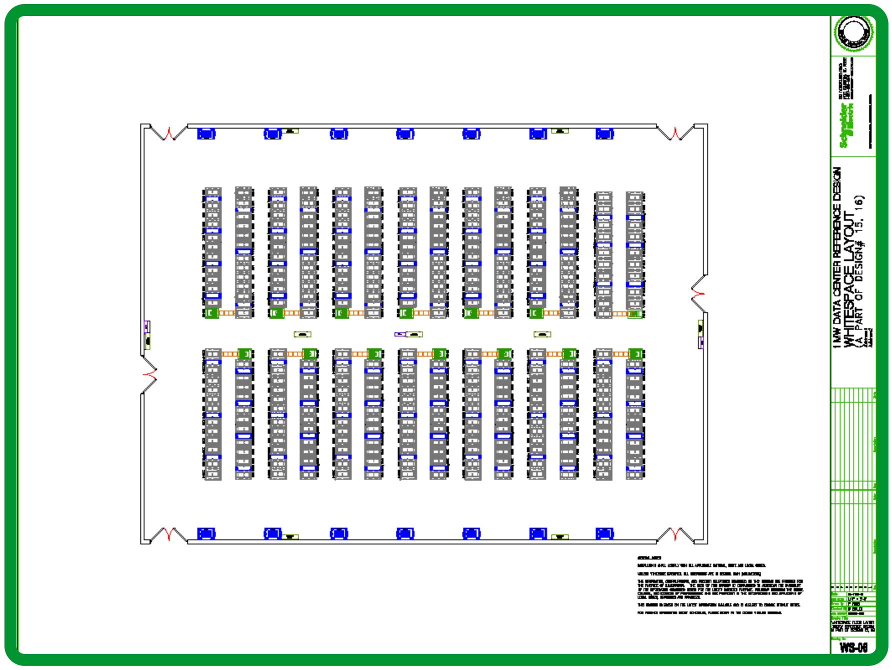


Figure 3a

Example of an IT floor layout drawing from a Schneider Electric reference design

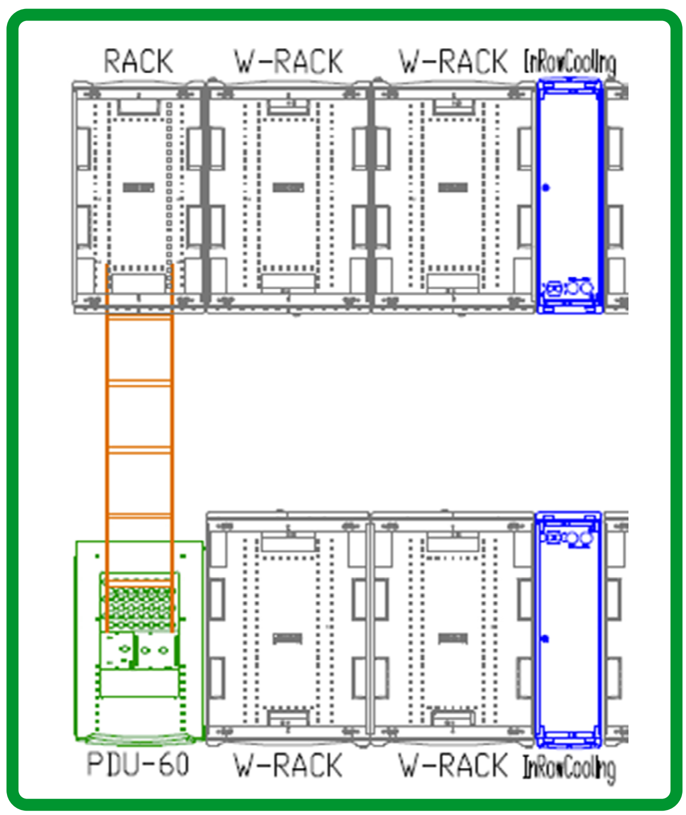


Figure 3b

Close-up view of the floor layout shown above in Figure 3a to highlight the detail provided

3D spatial views are yet another graphical design description document found in some reference designs. As **Figure 4** shows, these pictures provide a clear, high-level overview of what a given reference design will look like once built. All of the major system components can be easily identified and described. Although not necessarily useable from an engineering standpoint, these 3D views can be an effective way to help show, demonstrate, and promote a design to non-technical project stakeholders such as a CFO or supply chain manager. The beneficial role of reference designs in this communication with project stakeholders during the early planning process is described below in a later section.

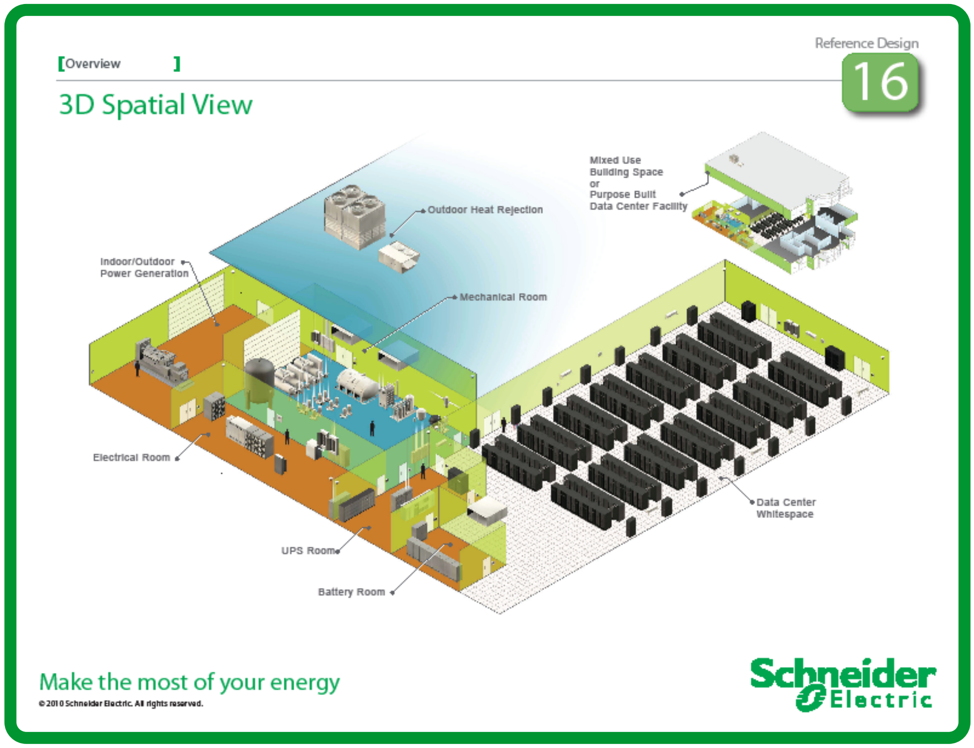


Figure 4

An example 3D spatial view document from Schneider Electric's Reference Design #16

Written support documents

An effective reference design also includes a high level summary of the design's attributes and system-level performance specifications. This would list basic specifications such as estimated cost, IT load capacity, estimated annualized PUE, density capability, level of redundancy for power and cooling systems, heat rejection method, and so on. This **standardized list of system attributes and performance specs** helps project teams to make fast and easy "apples-to-apples" comparisons of one proposed design with another. Also helpful when comparing designs is to have a document which explains the philosophy and specific benefits of a given design. This information can help explain why elements of the design are what they are; details that might be overlooked or misunderstood otherwise.

A **bill of materials (BOM)** as shown in **Figure 5** is another important and helpful element of a data center reference design. The BOM is a detailed list of all components that comprise what is shown in the reference design graphical documentation. The specific product name, description, part number, and quantity for each part are all identified. And in the example shown below, it is noted whether the reference design vendor supplies the part or not. Having this information early in the planning phase can help save time and reduce risk in the specification and procurement steps of building a data center.

Figure 5

Example Bill of Material (BOM) for the IT room from a Schneider Electric reference design

Equipment List

Equipment Designation	Type	Architecture Location	Product Description	Supplied by Schneider Electric	Quantity
Rack	Standard Rack	Whitespace Row	Netshelter SX 600mm Racks	Yes	260
W-Rack	Wide Rack	Whitespace Row	Netshelter SX 750 mm Racks	Yes	58
PDU-150	150kW PDU	Whitespace Row	480/277 : 208/120 Power Distribution Unit	Yes	13
PDU-60	60kW PDU	Whitespace Row	480/277 : 208/120 Power Distribution Unit	Yes	1
Metered Rack PDU	5.7kW r-PDU	In Racks, zero-U design	3 phase Rack Power Distribution	Yes	286
Metered Rack PDU	1.92kW r-PDU	In Racks, zero-U design	3 phase Rack Power Distribution	Yes	32
InRow Cooling	Chilled Water cooler	Whitespace Row	InRow RC100, 300m Half Rack Cooler	Yes	97
CDU	Piping	Wall of Whitespace	Cooling Distribution Unit	Yes	14

Limits of a reference design

As shown above reference designs can convey a lot of detailed design information providing a significant head start in the overall project. However, to have a full and accurate picture of what a reference design can offer, it is important to understand their limitations and boundaries. First off, before a project team can even begin to compare and contrast reference designs, they need to develop and agree on a list of basic requirements for the new data center. These requirements help determine which reference designs are appropriate for further review. While it is not the purpose of this paper to describe how to select and compare designs, it should be noted here that, at a minimum, the design can be selected based on three inputs:

Link to resource
TradeOff Tool 1
Data Center Power Sizing Calculator

- Total expected IT load
- Level of redundancy for power and cooling
- Density

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

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

With these three values the appropriate reference designs can be selected from a larger library of options. From there, designs can be compared and trade-offs analyzed. Defining a larger, more comprehensive list of requirements, however, can further simplify and more quickly narrow down the number of possible design options. For information on how to determine these three values, see the tool and white papers referenced on the left side of this page.

While it's possible for the data centers detailed in the reference designs shown above to be built exactly as illustrated, **engineering services will still be required**. The one-line diagrams still need to go through the process of being "stamped and approved" by local authorities. Designs need to be made legal (permitting, compliance with codes, etc) and localized (meet work practices and rules) for a given site. Also, to make them fully buildable, other design work will be needed to fill in the details unique to every site such as cable and pipe schedules, floor/roof loading constraints, or provisioning for proper water drainage. Not all designs may cover fire suppression and physical security systems, so those items may need to be accounted for through engineering services once a design is selected. Further, design and build elements related to the physical structure itself are not detailed by the reference design, unless the design is based on free-standing modules such as containers.

Customization

Additional engineering services will also be required if changes to a chosen reference design are preferred or required. While any design can be changed, the more standardized and modular the architecture, systems, and components are within the reference design, the easier and faster those changes can be made. And the impact of those changes will be less. White paper 116, *Standardization and Modularity in Data Center Physical Infrastructure,* delves further into the many positive effects of using a design that is both standardized and modular.

Link to resource
White Paper 116
Standardization and Modularity in Data Center Physical Infrastructure

As stated earlier, reference designs are built on best practices and experience. Components and sub-systems are designed to work together. The more these optimized systems are modified, the more likely its benefits will be reduced. Both project schedule and performance can be negatively affected with the ultimate result possibly being that the data center no longer resembles the original list of standardized attributes previously described above. That being said, it is possible that some changes could actually benefit the overall design or project. For example, a CE firm may have a particular expertise for a given system or approach that may differ from the original reference design. Or component substitution may be necessary due to availability issues in a certain region.

Benefits of using a reference design

The high level benefits of using a data center reference design as described above are:

- Facilitating and simplifying the planning phase
- Reducing time to create buildable designs
- Reducing risk, offering predictable performance and improving reliability of the data center once operational

Not all reference designs are equal. The sidebar shown to the left on this page lists some of the attributes that make one design more effective than another. The degree to which a design has these attributes impacts the extent and number of benefits achieved.

Facilitating and simplifying the planning phase

It's been said one of the biggest challenges in a new data center project is simply getting started. There's almost always some obvious need for the project: meet growing demand, add new applications or services that don't exist today or perhaps virtualization is allowing for massive consolidation of multiple locations into a smaller number to save energy and reduce operational costs. Whatever the driving need is, the challenge of getting started always involves, at least in part, translating the new IT needs (more servers, storage, etc) into a detailed, buildable design for the physical infrastructure required to support it. Even after the high level design parameters are established (e.g. power capacity, budget, etc.) there are many design preferences and constraints that must be reconciled through an iterative process. Reference designs can facilitate this by acting as a common platform and language for discussion.

The stakeholders typically involved in a data center project have very different backgrounds, perspectives, levels of technical knowledge, and goals. This can make the early planning steps particularly challenging. Being able to quickly jump from a few basic inputs (IT load, density and criticality as described earlier in this paper) to an applicable reference design that has already been validated, greatly simplifies this early planning process. It reduces the number of decisions that need to be made within the project team. It reduces the complexities of having to translate the inputs into design specifics and costs. Both speed up the overall planning process.

A reference design goes further in simplifying the process than just enabling a quick transition from basic high level requirements to a detailed design option. Their nature is such that they encourage or increase stakeholder involvement by being simple and easy to read by all parties. There are views and descriptions of a given design fit for an engineer and others that are fit for a lay person. And their standardized list of performance attributes enables the technical and non-technical project team members and stakeholders to speak a common language. All of this serves to assist in gaining alignment on project objectives. This alignment, explained later, is a key to not just having the project go smoothly, but also in helping the data center operate smoothly over its lifespan.

Reference designs provide a quick and easy way to accurately compare possible scenarios and design trade-offs. Project team members can rapidly visualize designs and immediately see the impact of changing the variables behind a given design. For example, how does redundancy affect cost? Is it cheaper to produce a single 10 MW data center or two 5 MW data centers? How does my density requirement affect the overall size of the data center? These types of questions could take months to understand and answer using the traditional, custom "one-off" design approach. With standardized reference designs it only takes minutes to make these comparisons.

> Attributes of effective reference designs

Modular, scalable – design is easily adaptable to different IT loads and different physical configurations; also can be expanded in the future.

Maximizes efficiency – minimizes waste in terms of both operations and electrical power usage.

Balanced capacities – power, cooling, and rack capacities are correctly balanced, and the power and cooling distribution systems are optimally sized, reducing unusable capacity and maximizing efficiency.

Detailed design – the more detailed a given design is, the less likely it will be for important items to be overlooked which would cause delay or operational problems later on; it also reduces the amount of engineering services required to make the design buildable for a given site saving time and money.

Reducing time to create buildable designs

Once initial requirements are developed, project objectives agreed to, and a reference design selected, the data center design team will be well on its way to having buildable designs. The time saved in the planning process as just described above combined with the level of detail found in the graphical design documents and BOM means that stamped and approved plans will be in hand sooner than with the traditional custom design approach.

Reducing risk, offering predictable performance, and increased reliability

Certainly, getting everyone on the same page and speaking the same language to agree on the project objectives is one way for these reference designs to help reduce risk. This increased participation and understanding makes it less likely that a project will suddenly and unexpectedly be re-scoped which costs time and money. But a reference design can also reduce risk beyond just the project itself. By offering predictable performance based on standardized, pre-validated designs, risk of downtime is less than in a traditional, custom designed data center.

A reference design is an embodiment of standardization. Being pre-engineered and validated means it has driven out the inefficiencies and error-prone complexity found in unique, custom designs. The real beauty of a reference design, however, is its role in sharing its inherent knowledge and prior experience with someone who has never conducted a data center project before. Normally, standardizing a design, operations, or any other business process requires doing these things through repeated trial and error to learn what the best practices should be. Only then can the benefits of standardization be realized. But, then these benefits wouldn't really be felt unless more data center projects were going to take place that would then use the best practices so painstakingly created. Reference designs enable project teams to immediately benefit from standardization even if they are only going to build one site or conduct a single project.

So, a reference design has been pre-conceived. It has been built before. Problems have been resolved. Components, systems, and sub-systems have been selected for their effective and efficient interoperability with each other. Nothing has been overlooked. Their operation has been measured before and so their future performance in a new build is predictable. New data centers built on such conditions are surely more likely to be built and commissioned faster and operate more reliably and predictably than traditional, fully customized data centers designed for the same IT requirements.

Evolution of reference designs

Today, reference designs originate from the end user or operator of data centers, as well as from physical infrastructure vendors such as Schneider Electric. There are companies that design and build a lot of their own data centers. And they might have some unique aspect of their business that affects the infrastructure architecture or, perhaps, they might have some special expertise with a given approach or design because they build so many. For these types of customers, it may very well make sense to develop their own internal standardized reference designs to better enable them to "step and repeat" their field proven designs. In some cases, there are organized efforts to share these designs and best practices with others in the industry to help promote energy efficiency. The Open Compute Foundation's "Open Compute Project" originally set up by Facebook is an example of this.

Reference designs offered by physical infrastructure vendors are available today as well. Their advantage exists in two areas. One, they tend to be involved in the design and building of more data centers than any one design firm or end user. So they have a higher level of experience to draw on. Presumably, the more experience a design is built on, the more likely it is for that design to be sound and reliable. Secondly, because the vendors own the design and manufacture many of the components and subsystems, it is more likely that they will be optimized to work together in a reliable and efficient way. Better interoperability can also make the detailed design and building phases proceed more quickly with less error. The value of a vendor-provided reference design increases when the vendor can simplify the supply chain by simplifying the order and delivery process. Pre-kitting of components, concurrently phased delivery of components, assured off-the-shelf delivery of reference design components, and components de-trashed and appropriately organized at the site could all be highly valuable benefits of a vendor-provided reference design. At the next level of maturity, a vendor-provided reference design would be pre-manufactured by the vendor and provided in pre-assembled skids, containers, or other forms in order to dramatically simplify and speed up the field installation of the system.

In the long run, however, data center reference designs are likely to mature and evolve into an open source format. Such designs would be comprised of modular architectures and subsystems governed by generic open standards. Infrastructure vendors would be incented to design their components and systems to meet these standards. Data center owners and operators would then be freed from the constraints of being beholden to a single vendor or designer's architecture. The existence of open source reference designs would greatly increase choice and flexibility for owners and operators without increasing complexity or decreasing reliability.

The force behind this evolution, of course, is the power of reference designs today to take an otherwise complex, highly customized data center project and simplify it while making it more efficient and predictable over the long run.

Conclusion

Using a reference design to plan a new data center saves time and effort while reducing risk and improving reliability. Starting a project with a clear and standardized menu of design options facilitates the planning process. It does so by using a common language to help align goals, encourage cooperation and participation across multiple functions, and makes it easier to evaluate the trade-offs between design goals. The contents of a reference design such as one-line engineering drawings, a BOM, and detailed dimensions provide a head start in getting to buildable, legal, and localized design plans. This head start shortens the design cycle and likely saves money in the process. Being built on pre-engineered systems intended to interoperate with each other, reference designs reduce risk and improve overall predictability and reliability as compared to using a custom, one-off design built from scratch. Using a reference design as a starting point in the planning process helps bring a new data center online faster and helps ensure there are fewer surprises and problems once it's operational.

About the author

Patrick Donovan is a Senior Research Analyst with Schneider Electric's Data Center Science Center. He has over 16 years of experience developing and supporting critical power and cooling systems for Schneider Electric's IT Business unit including several award-winning power protection, efficiency and availability solutions.

Resources

Click on icon to link to resource

Data Center Projects: System Planning
White Paper 142

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

Guidelines for Specification of Data Center Power Density
White Paper 120

Standardization and Modularity in Data Center Physical Infrastructure
White Paper 116

Specification of Modular Data Center Architecture
White Paper 160

Browse all white papers
whitepapers.apc.com

Data Center Power Sizing Calculator
TradeOff Tool 1

Browse all TradeOff Tools™
tools.apc.com

Contact us

For feedback and comments about the content of this white paper:

Data Center Science Center
DCSC@Schneider-Electric.com

If you are a customer and have questions specific to your data center project:

Contact your **Schneider Electric** representative at
www.apc.com/support/contact/index.cfm