# Data Center Projects: System Planning

## White Paper 142

Revision 2

by Neil Rasmussen


## Executive summary

Planning of a data center physical infrastructure project need not be a time consuming or frustrating task. Experience shows that if the right issues are resolved in the right order by the right people, vague requirements can be quickly translated into a detailed design. This paper outlines practical steps to be followed that can cut costs by simplifying and shortening the planning process while improving the quality of the plan.




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## Introduction

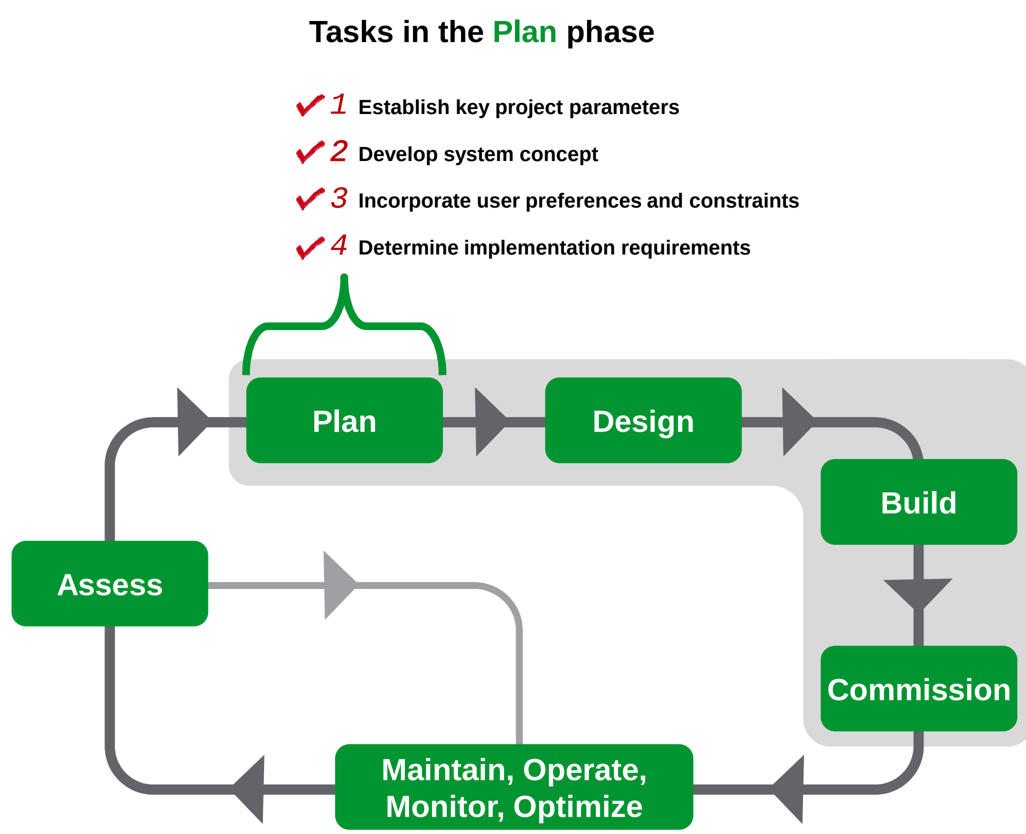
The planning of projects to build or upgrade data centers remains a major challenge for many IT departments. Plans are often poorly communicated among the various business stakeholders within the organization. Decision makers may be presented with proposals that are described in excruciating technical detail, yet still appear to lack the information they need to make good business decisions. Seemingly small upfront changes in plans can have major cost consequences downstream when the data center enters the construction / build stage. The planning and approval process can consume a significant part of the calendar time of a project, and it is common that unwelcome surprises or changes occur late in the planning process, causing planning rework that results in significant delay in project completion.

Our experience with many data center projects suggests that many of these problems can be avoided if the right decision makers are given the right information in the right sequence.

This paper lays out a methodology for planning a data center project to improve the quality and speed of the results. This structured planning methodology describes a sequence of steps to be taken and the key decisions that come out of each step. By following this process and making the process visible to all stakeholders, project managers can improve the transparency of the process, make the stakeholders feel their time is more efficiently used, and improve the buy-in on the project. **Figure 1** shows where planning occurs in the context of a data center life cycle. The "Plan" phase is broken out as the four main tasks of the system planning sequence. The planning sequence described in this paper establishes the design requirements for the detailed engineering design of the data center's **physical infrastructure**, which powers, cools, houses, and protects the IT systems). This planning sequence is separate from IT planning and assumes that another IT planning process is going on in parallel or has already taken place.

**Figure 1**

*The Plan phase in the context of the data center life cycle, showing the four key Plan tasks*



The phases of the life cycle highlighted in grey in **Figure 1** represent the entire data center project. The **PLAN** portion of the life cycle lays the foundation for everything that follows. The plan phase should take the least time and result in the lowest expense, but will have the greatest impact on the performance and cost of the data center. The planning phase sets up the details of both the physical **system** to be created and the **project process** that will create it. For more information about the project process, see White Paper 140, "*Data Center Projects: Standardized Process*". For more information on the data center life cycle, see White Paper 195, *Managing the Data Center Life Cycle*.

## The system planning sequence

The system planning sequence is the logical flow of thought, activity, and data that transforms the initial project idea into a compact set of requirements and documents that should control the performance and cost of the built data center. In Schneider Electric's implementation of the standardized project process, system planning is sequenced into four tasks that take place during the **Plan** phase of the project as illustrated in **Figure 1**.

The process flow described in these four tasks contains some key ideas that we have found to be an effective best-practice in data center planning and form the basis for the method described in this paper. These key ideas are:

**Separation of system concept from detailed design:** We have found that it is very efficient to choose a system concept before generating a detailed technical specification, working on detailed design, or debating long lists of user preferences or requests. Revelations regarding performance or cost that occur after detailed design has begun, may cause a change in the fundamental system concept and create large amounts of rework and schedule slip. **The early parts of the design process need to focus exclusively on ensuring a shared understanding of the most important capabilities of the data center and its cost, and avoid investing in work on detailed design and specification.** Deciding on a system concept involves high level decision makers determining high level objectives and making early tradeoffs between performance, cost, size, location, and schedule for the data center involved in the project. This approach attempts to avoid the problem frequently encountered where key stakeholders are not aware of fundamental design characteristics or costs until detailed designs begin to emerge later in the process

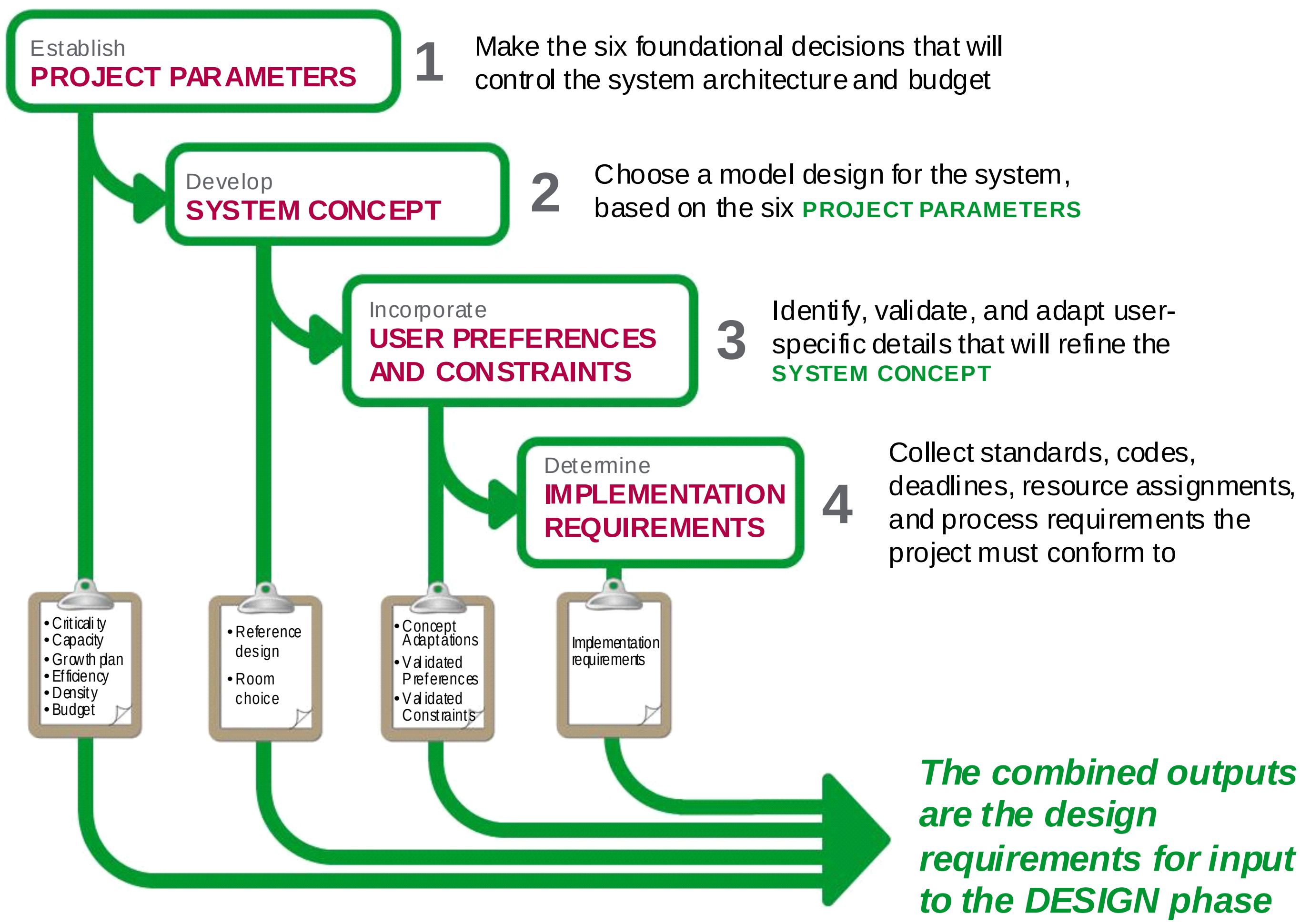
**Separation of key project parameters from user preferences and constraints:** We have found that there is a small set of high-level key project parameters that are necessary and sufficient to support a choice of a system concept. We have found that some of these key parameters include concepts such as density and growth plan that don't historically have clearly defined and unambiguous methods for quantification. **The early planning should focus on establishing a consensus on these parameters and postpone dealing with user preferences and most constraints, in order to efficiently reach an early decision on the system concept.** This ensures that high level decision makers focus on the most important decisions early and do not get drawn into discussions of details.

### The 4 Plan tasks

Each of the four core planning tasks of **Figure 1** takes information as input, transforms it or adds more detail to it, and sends it along to the next task. **Iterations are to be expected within each step, but the goal of an effective process is to try to minimize re-work, and especially to eliminate mistakes that cause the process to need to go back two or more steps.** This progression can be modeled using the flow illustrated in **Figure 2**. The data that is flowing and being transformed is the developing description of the system. In **Figure 2**, data is shown as pages on a clipboard traveling from task to task (the green rectangles) with a new page of data that serves as additional input to each subsequent step along the way. Each task adds more information and the sum of this content becomes the design requirements for the subsequent process of detailed engineering. The implementation requirements (Task 4), when combined with the outputs established in the prior three tasks, together become the complete design requirements and serve as a “rulebook” for the detailed design engineered in the subsequent design phase (not discussed in this paper).

**Figure 2**

*The four tasks of the “system planning sequence”*




## Task #1: Establish project parameters

This task starts with the general idea of a business need that requires a change to the organization’s IT capability. From there, Task #1 involves determining the following project parameters: **criticality**, **capacity**, **growth plan, efficiency, density, and budget**. The key stakeholders that should be involved at this stage include the finance executive, the CEO, a key IT executive, IT operations manager, and other individuals who understand the core business needs and objectives. The six project parameters set the high-level goals of the data center project, which are used later to develop the physical infrastructure system concept for the data center.

These key project parameters are defined as follows:

1. **Criticality** –Level of system availability to be achieved in terms of standard industry norms.
2. **Capacity** – Maximum IT load (in kW) that the data center physical infrastructure can support
3. **Growth plan** – Description of the ramp-up to the maximum power requirement, incorporating uncertainty (see White Paper 143, *Data Center Projects: Growth Model*)
4. **Efficiency** – Energy efficiency goal for the data center infrastructure systems
5. **Density** – The average and peak power that IT cabinets are expected to consume (kW/rack) and the amount of floor space required (see White Paper 155, *Calculating Total Space Requirements and Power Density for Data Centers*) along with information regarding density uncertainty
6. **Budget** – The money planned for the capital costs[1] of the project

Many planning failures, throw-away design work, and schedule slips are traceable to:

- Failure of the stakeholders to have a shared understanding and agreement about these key parameters early in the process
- Stakeholders were not fully aware of the tradeoffs between these parameters
- Stakeholders were not fully informed about how the design was going to perform against these parameters until after detailed design is underway or even completed, when it may be too costly to make corrections

An important goal of this task is to assure that scarce executive time is applied to the most important decisions. An effective approach is to break this task into two steps:

First, meetings must be held involving the project lead and each individual stakeholder (e.g., finance executive, IT executive, facilities executive) to explain the process, provide common language for the 6 project parameters, validate the appropriate member(s) from their team to participate in the process, and prepare them individually for a future joint meeting where all six of these key project parameters will be agreed upon. This allows each member of the team to have a shared understanding of the plan and think about these issues ahead of time and to validate their needs and concerns.

Second, organize a workshop for the stakeholders focused on establishing the 6 parameters. This is expected to be an iterative process where the choice of one parameter (like criticality) may cause another parameter (like cost) to be unacceptable, which drives a change in one or more other parameters. For example, choosing to over-specify kW capacity requirements for possible future IT expansion may drive the project over the target budget and require a savings achieved by reduction of criticality.

Stakeholders in that workshop can consider tradeoffs between the key project parameters in real time by relying on a knowledgeable expert participating in the discussion or by using a mathematical model such as the Data Center Planning Tool (example in **Figure 3**). This allows stakeholders to consider "what if" scenarios and understand trade-offs between capital cost, power sizing, efficiency, and capacity. Such a planning tool can be used in a workshop as stakeholders develop a shared understanding of how their particular area of interest (like finance, for example) affects the other areas of the project (like data center capacity).

The goal of these planning sessions is to produce a realistic data center budget, capacity, growth plan, efficiency, density, and criticality targets. It may not be possible to establish the 6 parameters in a single executive workshop, because some participants may need to take

[1] The budget for planning is the project budget and does not include the operating expense budget. However, operating costs are a consideration that is used in trading off parameters during the selection of the system concept.

more time to consider or analyze trade-off decisions that have been identified. However, in many cases quality decisions can be made in a few days, and that should be the target for the duration of this step.

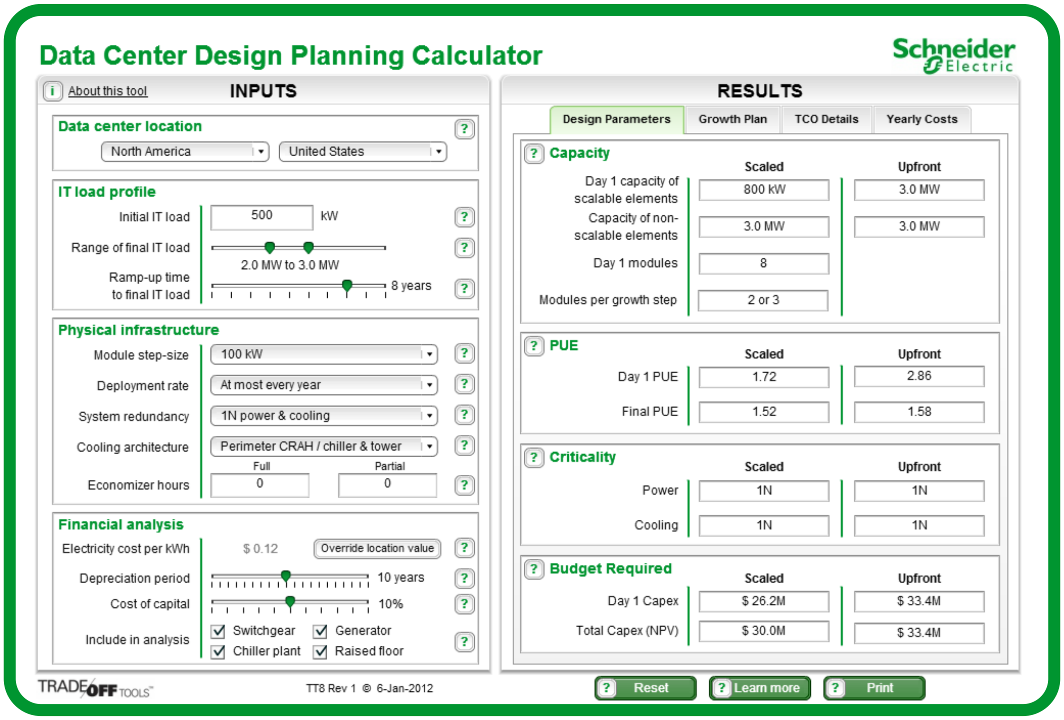
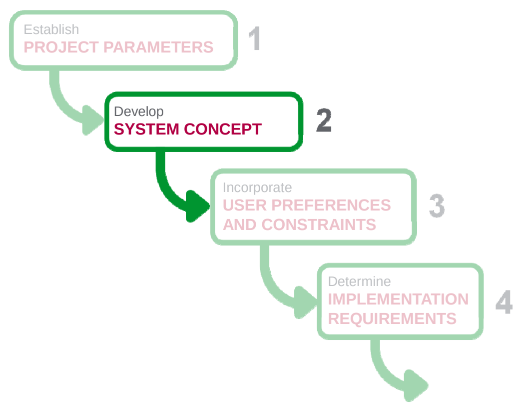



**Figure 3**

*Screenshot of a Data Center Planning Tool*

# Task #2: Develop system concept

This task takes the foundational project parameters from the previous task – **criticality**, **capacity**, **growth plan, efficiency, density, and budget** – and uses them to choose a general concept of the physical infrastructure system. The key stakeholders involved at this stage should include IT operations, the IT executive, facilities executives, facility engineer, and a consultant with experience in system planning for data center projects. The corner-stone of this task is the selection of a **reference design**, which embodies the desired criticality, capacity, efficiency, density, and budget and has a scalability that will support the growth plan. In addition, it is important by the end of this step to have decided upon the specific site (room, building, or site) for the data center.




Compared to the traditional "blank piece of paper" data center design approach, reference designs serve as a good initiator for moving the design phase forward. A reference design is an example model design that embodies a specific combination of attributes including criticality features, power density, equipment technologies, scalability features, and instru-mentation level. An effective reference design also includes system level performance specifications such as weight, footprint, etc. and includes a detailed list of materials or components that comprise the system. A given reference design has a practical range of power capacity for which it is suited and provides a immediate way to effectively evaluate alternative designs without the time consuming process of actual specification and design. High quality decisions can be made quickly and effectively. For more information on reference designs see White Paper 147, *Data Center Projects: Advantages of Using a Reference Design*.

While there are virtually unlimited numbers of possible reference designs, the six key project parameters will quickly rule out most of them and allow the process of reference design selection to become a simple choice between a few options instead of the long process of having a design created to satisfy the parameters starting from a “blank piece of paper”.

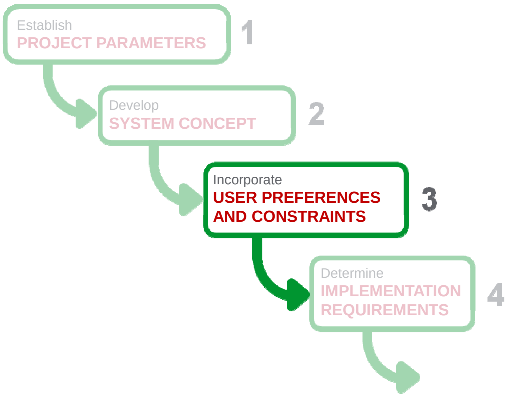
Once a number of reference design options are identified, those alternatives can then be reviewed for additional considerations, such as logistics, vendor reputation, customer references, etc.

In many cases the proposed location for the data center is already known, or is limited to a few choices. Selecting a reference design early provides the information needed to rapidly assess whether the design concept is compatible with a given location. When incompatibilities are noted, the choice of reference design, site location options, and project parameters can be examined together immediately and trade-offs can be made to find a satisfactory combination. In a traditional design process, incompatibilities may not be recognized until detailed design has begun, losing valuable time and forcing management to go back and re-consider decisions that they thought were already made. All of this means rework which ultimately translates in project delays and additional costs. This ability to make the most important trade-offs early and quickly is made possible by distilling the important decisions down to three elements: 1) the 6 project parameters, 2) a limited list of reference designs, and 3) a list of site options.

If the project manager prepares effectively for this task, it may be completed in a single executive workshop meeting. For smaller projects, tasks 1 and 2 can be completed in a single workshop.

## Task #3: Incorporate user preferences and constraints

User preferences and constraints include **technical design requirements** that are not included in the six key project parameters and not explicit in the system concept or location choice. Given the choice of system concept from the earlier task, this task collects and evaluates user preferences and constraints to determine whether they are valid, or should be adjusted in some way to reduce cost or avoid problems. **The central idea here is that the user preferences and constraints should be adapted so that they work with the system concept already chosen.**




It is our experience that it is much more efficient to validate and adapt the user preferences and constraints after the design concept is chosen, rather than collecting these as requirements up front and attempting to use them to drive the overall design. It is the user preferences and constraints that often unwittingly drive data center designs away from standard designs and drive up cost, drive up deployment time, and reduce quality.

The key contributors involved at this stage should include IT operations, network engineers, facilities engineers, other personnel dealing with the day-to-day data center activities, and a consultant with experience in system planning for data center projects.

User preferences and constraints are defined as follows:

- **Preferences** are the desires of the users that are subject to change or adjustment after consideration (or reconsideration) of cost and consequences. User preferences sometimes change when the users are presented with new information.
- **Constraints** are obstacles that cannot be overcome, or can only be changed at great expense or with unacceptable consequences. Constraints are pre-existing conditions that are difficult or impossible to change.

Preferences are characteristics that are viewed as desirable by the operators or organization based on their goals or their experience, but are not constraints. Examples of user preferences include the following:

- We prefer overhead power cabling
- We need visitors to be able to see the data center on site tours
- We want security cameras to see every inch of the data center space
- We don't ever want to need to do electrical wiring or plumbing in the IT room after it is turned on.
- We prefer wide IT racks to provide more cable space
- We want to physically separate the IT cabinets by IT customer
- We want a display on the wall showing the energy performance summary of the data center

Constraints are dictated by circumstances and are not under the control of the data center designer. Constraints include facility limitations, regulatory limitations, or unchangeable business requirements. Consultants are required to assess whether decisions that impact the facility's physical plant conform to national and local codes.

Examples of constraints include the following:

- A physical characteristic of the facility (i.e. ceiling slab height, floor load bearing capacity, room geometry, existing columns or walls, roof mounting requirements for outdoor devices)
- A law or code that requires compliance
- A standard that you are committed to meeting (such as TIA 942)
- Work rules (i.e. access hours, union rules )
- A physical characteristic of the delivery path (such as the weight capacity of the elevator that will be used to transport equipment to the room)

Once they are validated, the user preferences and constraints are reviewed for compatibility with the selected system concept. Where they are found compatible they are passed on to become part of the design requirements. Where a validated preference or constraint is incompatible with the design concept, then reconciliation is attempted by making adjustments to either the preference or constraint, or by appending small change requirements to the system concept (i.e. concept adaptations). This process may require some iterations as there may be trade-offs and interaction between different preferences and constraints, as shown in **Figure 4**. **The goal here is to make concept adaptations to avoid the need to return to reconsideration of the system concept unless absolutely necessary.** It is our experience that almost all preferences and constraints can be satisfactorily incorporated to work with a chosen system concept.

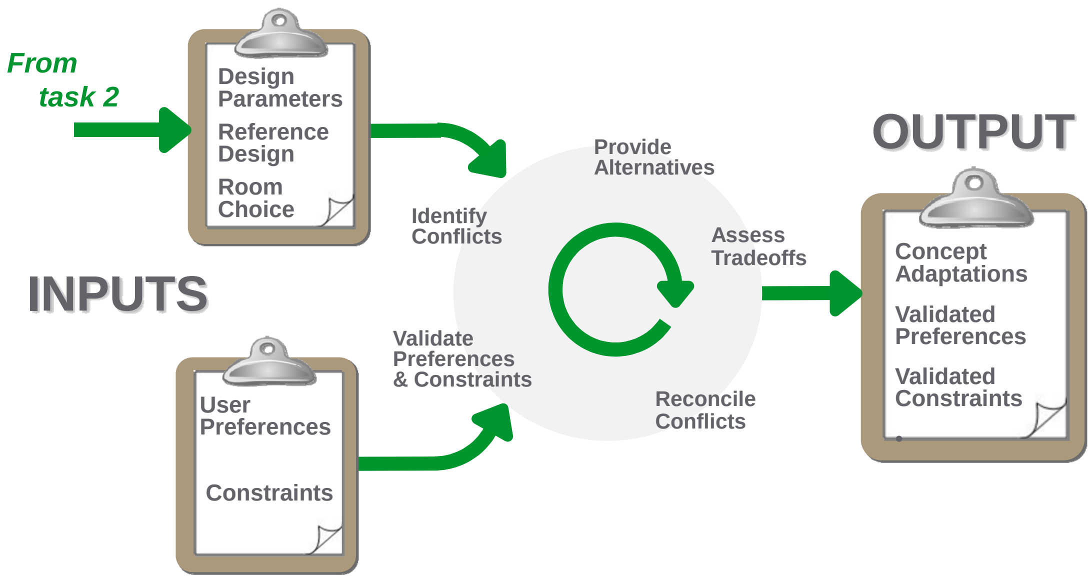



**Figure 4**

*Task detail for incorporating user preferences and constraints*

It is important to make sure that a constraint really is a constraint. Here are two examples of a work-around for a constraint:

> *Constraint*: The existing data center is not allowed to be turned off (to perform the upgrade).
> *Possible work-around*: Put up a temporary wall to separate the running system from the work area for the new installation, and bring in a separate utility feed to run both systems at once during changeover.
>
> *Constraint*: We can't use air-removal units that duct into the dropped ceiling, because the ceiling has a non-fire-rated plenum duct and the fire inspector won't allow a hookup.
> *Possible work-around*: Spray the duct with fireproofing.

In most cases a few iterations are required to arrive at a final set of user preferences and constraints. This task is complete when the preferences and constraints have been reconciled with the system concept and summarized as concept adaptations, validated preferences, and validated constraints. This process task can be accelerated if user preferences and constraints are collected in parallel with the previous tasks. Note that many constraints cannot be determined until the site is selected. This may require the prior task, "Develop system concept", to take place before the constraints can be collected.

## Task #4: Determine implementation requirements

The implementation requirements serve as a set of rules to be followed when creating a detailed system design, above and beyond the outputs established in the previous 3 tasks. The implementation requirements consist of the following elements:

1. **Standard requirements** that do not vary from project to project. Standard requirements generally appear in the form of standard specifications that comprise the major portion of the data center specification. Examples of standard requirements are any special regulatory compliance standards, compatibility of subsystems, safety, or best practices that need to be made explicit to engineers or installers[2].

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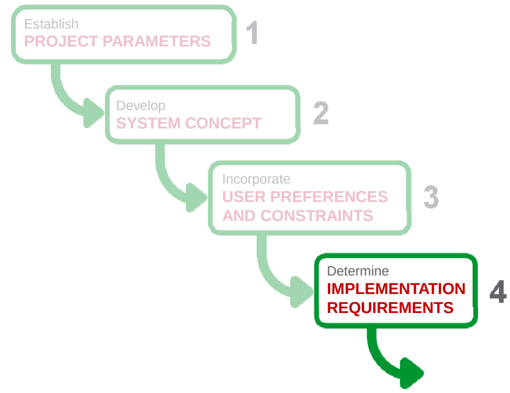
[2] Engineers and architects are assumed to be aware of and comply with local mandatory code requirements; those do not need to be made explicit. This step is to identify special voluntary, internal, or industry standards that are to be complied with *above and beyond* mandatory local requirements.

2. **Project requirements** that define the user-specific details regarding execution of the project. These include special deadlines, human or equipment resource assignments or limitations, vendors that must be used, or special procurement or other administrative processes that the project must adhere to.

Separating the implementation requirements into those that are common to all systems (the standard requirements) and those are particular to *this* user's project (the project requirements) simplifies the job of creating and maintaining the detailed system design, because most of the review and decisions can be focused on the subset of the project-specific requirements. Further guidance is provided in the *System Specification and Project Manual Volume 1: Small and Medium Data Centers.*




The implementation requirements, when combined with the outputs established in the prior three tasks, together become the complete design requirements and serve as a "rulebook" for the detailed design engineered in the subsequent design phase (not discussed in this paper). In the later design phase, the design requirements established by the planning process outlined in this paper guide system and project engineering. It is in this later design step that the engineering specifications are developed, including:

1. Detailed component lists
2. Exact floor plan of racks, including power and cooling equipment
3. Detailed installation instructions
4. Detailed project schedule
5. Actual "as built" characteristics of the design (efficiency, density, and expandability)

The use of a reference design as the means to establish the design concept, as recommended in this paper, greatly simplifies the detailed system design created in the design phase, if the reference design has been provided with sufficient detail. Effective reference designs already include much of the content in the above list so that it does not need to be recreated. Reference designs typically include one-line diagrams for the electrical, mechanical, and IT spaces, provide floor layouts, a Bill of Materials (BOM), and provide expected system level performance characteristics, all of which can often be directly incorporated into the detailed design with minor adaptations and minimal additional analysis or engineering.

## Conclusion

Despite its crucial importance to the success of the project, system planning has historically been considered unstructured and difficult, carried out as art rather than science, with opportunities for missteps, wrong assumptions, and miscommunication that can have serious consequences in later phases of the project. This phase often takes much longer than anticipated or required. Much of the difficulty can be removed by viewing system planning as a standardized process, consisting of an orderly sequence of tasks that progressively develop and refine the system concept, to ensure that the final system fulfills the original business need.

This paper outlines a process for data center planning comprised of four tasks, each of which refines or transforms the system concept as it progresses from idea to design requirements. The principle of this process is to ensure that the right people are making the right decisions in the right order in order to maximize efficiency. The sequence starts with:

A **Business Need**, from which is established
**Project parameters**, from which is developed a
**System Concept**, supplemented with validated
**User preferences and constraints**, which are added to
**Implementation requirements**

Together the outputs of these steps become a package of design requirements, which are at the right level of detail to allow shared stakeholder understanding and buy-in, while providing the necessary and sufficient guidance to ensure the subsequent engineering and build phases of the project will achieve the agreed-to results.

Planning process standardization, when combined with a common language for describing requirements, can bring most data center planning into the realm of predictable, repeatable science. Following an organized process allows the project manager to avoid oversights and misinformed decisions during the early planning phase of a data center project and ensure stakeholders are using their time effectively.

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## About the author

**Neil Rasmussen** is a Senior VP of Innovation for Schneider Electric. He establishes the technology direction for the world's largest R&D budget devoted to power, cooling, and rack infrastructure for critical networks.

Neil holds 25 patents related to high-efficiency and high-density data center power and cooling infrastructure, and has published over 50 white papers related to power and cooling systems, many published in more than 10 languages, most recently with a focus on the improvement of energy efficiency. He is an internationally recognized keynote speaker on the subject of high-efficiency data centers. Neil is currently working to advance the science of high-efficiency, high-density, scalable data center infrastructure solutions and is a principal architect of the APC InfraStruXure system.

Prior to founding APC in 1981, Neil received his bachelors and masters degrees from MIT in electrical engineering, where he did his thesis on the analysis of a 200MW power supply for a tokamak fusion reactor. From 1979 to 1981 he worked at MIT Lincoln Laboratories on flywheel energy storage systems and solar electric power systems.

# Resources

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

Data Center Projects: Standardized Process
White Paper 140

Data Center Projects: Growth Model
White Paper 143

Data Center Projects: Advantages of Using a Reference Design
White Paper 147

Calculating Total Space Requirements and Power Density for Data Centers
White Paper 155

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