Building blocks of data center construction

Data center demands continue to skyrocket, forcing organizations to build new facilities with little funds. Future-proof your investments and avoid costly construction mistakes.

BY STEPHEN J. BIGELOW
Site selection and planning

Before any construction process can begin, stake out a location that has everything you need.

Corporate data needs are changing, and companies are responding by breaking ground on new data center facilities. Although the push to build a new data center is compelling, the process can be long and laborious.

Corporate decision makers need to start a construction initiative by selecting the best physical space. But site selection isn’t simply about finding a sweet real estate deal. It also requires attention to utility and connectivity availability, safety and security concerns, access to quality staff and local government incentives. These directives can help you properly prepare for one of the most critical decisions in your data center construction project.

PLAN FOR TODAY AND TOMORROW

Where to build a new data center is not just a matter of building costs. Choosing the right site is a decision fraught with tangible and intangible issues. Some considerations are obvious. The new data center must provide adequate physical space and security for equipment and personnel. For example, it requires at least one highly available source of affordable power and WAN connectivity—multiple redundant providers are often preferred.

But don’t overlook the less-tangible facets of the project. The location should be geologically stable and relatively guarded from any effects of a storm. Avoid facilities that may be geographically close to airports or nuclear power plants that could force you to shut down or evacuate the facility in the event of an emergency.

Each of these factors must be weighed today and throughout the data center’s entire operational life. The costs for all of these considerations may be offset by compelling financial incentives like state and federal tax credits.
BRUSH UP ON YOUR READING

Jumpstart a site selection by consulting one of many industry “site books.”

- **Business Facilities** magazine examines trends in facility and data center site selection. Its Online Site Seekers’ Guide has contact information for most major economic development agencies in North America and a few international agencies.

- **Site Selection** magazine covers corporate real estate strategies and area economic development trends.

- **The Conway Data New Plant Report**, also from the publishers of **Site Selection**, has a database of plant and expansion records going back to 1989.

- **Area Development** covers news, reports and trends in site and facility planning, including energy and employment topics.

- **Foreign Direct Investment** (fDi), a unit of the **Financial Times**, gives a globalized look at business trends.

ECONOMIC STATUS AND DEVELOPMENT

Examining business-related factors for each state can help you narrow the field of potential locations for your facility. State governments include departments of business development; a little online research can provide you with a lot of information.

For example, the North Carolina Department of Commerce Economic Development Intelligence System (EDIS) lets you compare North Carolina to all states to glean raw data—from the number of business failures to the percentage of college grads among residents over age 25. Logon credentials must be requested from the state for this site. By comparison, the Massachusetts Office of Housing and Economic Development provides a variety of resources, including a site-finding serv-
ice to connect businesses with available locations.

States also have public and private development efforts designed to attract new investments. Team Pennsylvania, which also operates PA Site Search, provides details on real estate that’s available for development in that state. Since this resource is aimed at drawing in business opportunities, read this data with a bit of skepticism. Still, it can be useful to narrow down the initial field of possible locations.

**UNDERSTAND TAX OBLIGATIONS**

Taxes are unavoidable, but how much you’ll need to pay and what tax incentives are available can vary dramatically from state to state. Economic development information can give you some tax insights, but other resources can help as well.

The National Tax Credit Group LLC has a free Site Locator tool that helps businesses identify state and federal tax credits. After entering some details about your business type and location preferences, you’ll receive data comparing labor, infrastructure and other costs of doing business at that location. A free 10-day trial of the group’s TaxOvation software can help identify tax incentives or rebates based on a property’s address. The Tax Gateway from Ryan Inc. can also generate useful tax and legislative information for each U.S. state.

Keep in mind that there may be some tax advantages to building a new data center outside of the U.S. For example, in 2007, the corporate tax rate in Iceland was about 18%, compared to about 39% in the states.

**GUARDING AGAINST POTENTIAL DISASTERS**

Even the most generous tax incentives and dirt-cheap real estate prices won’t make up for the fact that a location is vulnerable to natural disasters. Carefully evaluate locations near earthquake fault lines, flood plains, storm-ridden coastal areas and regions with high incidences of tornadoes or lightning.

Similarly, building a facility outside of the U.S. carries a long list of potential problems. There are the obvious exposures to natural disasters and power disrup-
tions that should be considered anywhere, but other countries can vary dramatically in their licensing requirements, taxation laws and other conditions negotiated with the host country. Don’t discount the political climate of the host country and region—good relations can change quickly in the face of civil unrest or a military coup, for example.

And economic climates can also vary widely. SearchDataCenter.com’s Data Center Decisions: 2009 Purchasing Intentions Survey of 920 IT managers showed that U.S. IT budgets took a bigger hit than those in non-U.S. data centers. In the U.S., 20% of IT shops faced a decrease of more than 10%, compared with only 11% of non-U.S. IT shops. Additionally, just 32% of U.S.-based data centers saw an increase in IT budgets, versus 44% globally.

**AVAILABLE AND SKILLED IT PROS**

The most sophisticated and automated data center is nothing but an expensive building without skilled IT professionals to man it. You may have highly skilled data center workers in your current data center. But you can’t expect all of them to pack up and move to a new data center across the country—or across the world.

When embarking on a new build, make sure that trained technical workers are available in that general area. State economic development resources will try to tout their educational prowess and worker-training levels, but you may need to dig a bit deeper to ensure that there are sufficient numbers of adequate talent.

Look for communities that strive toward technological development, have active schools with concentrations in IT as well as a population and environment that encourages such professionals. The International Economic Development Council (IEDC) offers a range of guidelines that can help you understand the principles of economic development and site-selection data standards.

Consider the number of permanent staff that will be required to man the data center as well as essential educational benchmarks. For example, most prospective IT hires should have at least an associate’s degree in computer science with a variety of entry-level industry certifications like CompTIA’s Security+. Senior staff
should hold at least a bachelor’s degree and advanced industry certifications such as Cisco Certified Network Administrator (CCNA). Available educational resources and current economic climate in a given area will directly affect your ability to fill open positions.

### BUYING THE LAND

Once you’ve zeroed-in on the most desirable area, it’s time to think about the actual property. Commercial online resources, like LoopNet and FastFacility, are just two of many property databases that can lead you to an existing property that is up for sale—both inside and outside the U.S. However, state economic development offices often have the best listings.

Optimally, you should navigate to the main economic development agency website for the state in which you’re most interested in building. Refer back to the agency for assistance in finding viable real estate.

### WHEN YOU CAN’T BUILD, GO RETRO

Experts generally agree that it’s easier and less risky to build a new facility than it is to retrofit an aging data center. But some companies simply cannot justify the financial or strategic problems involved in a new build and are forced to grapple with the challenges of an upgrade.

These challenges can include a complete replacement of power and cooling infrastructures. Renovations can also involve costly upgrades to the building’s superstructure, such as reinforcing the floor. All of those upgrades must be completed while the data center is still actively in service.

An alternative to building an entirely new data center may be to use ones that are housed in cargo trailers such as the Sun Microsystems Modular Data Center S20 or the SGI Ice Cube Modular Data Center. These “containerized” data centers tout high density, fast deployment, easy redeployment and lower capital outlay.
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Data center conceptualization and cost analysis

Hiring a knowledgeable design firm can help realize your data center plans and give you a true-cost reality check.

How do you select and work with a data center design firm to ensure they build the facility that your organization needs? Before a data center appears on the landscape, it takes shape as a comprehensive plan that must include near- and long-term business requirements.

Formulating a design serves two purposes. It illustrates how the facility will ultimately look and operate, and it produces cost estimates that the business can work with. In nearly all cases, professional design firms are engaged to generate the design, deliver the cost estimates and lead the construction process. Picking the right design firm is a pivotal choice in all data center projects.

In years past, data centers were perceived as little more than specialized office space, and they were cost-estimated accordingly. Those estimates usually relied on cost-per-square-foot measures—where primary costs involved building space and utilities like lighting and air conditioning. Often, putting computers and ancillary equipment into that space was a secondary consideration.

But times have changed and so have cost models, which are now driven by radically different needs for power and cooling systems. Infrastructure essentials such as power requirements and cooling systems support can account for 90% of a new data center’s construction costs.

Even if you ignore today’s energy-efficient hardware designs, servers are larger and demand more power. Data centers also house more servers, high-density blade servers, storage systems and other networking equipment.

All of this equipment is housed in denser enclosures and often creates more energy and generates more heat. Such complex heating situations are changing the requirements for cooling and power distribution designs. For example, using a
computational fluid dynamics model of a data center design is essential in order to fully understand the nuances of high-efficiency cooling behavior.

These new paradigms render the traditional cost-per-square-foot model obsolete, giving way to a modeling scheme that focuses on total load, represented by watts per unit area or watts per standard rack unit. Different experts will recommend different models.

SELECTING A DATA CENTER DESIGN FIRM

Shifting cost models have a direct impact on which data center design firm you decide to hire. Be wary of engineers who aren’t familiar with how energy needs and space issues can affect the facility’s bottom line. Not all engineering firms—often called MEPs because they are experts in mechanical, electrical and plumbing—focus on power, cooling and space issues when they’re designing a new data center.

This is more common than you might think. Some design firms got out of data center design back in 2001 with the collapse of dot-com businesses; a few are just now re-entering the market. Technologies have dramatically changed since then, so avoid firms that have not actively or continuously been engaged in designing data centers. Identify firms that have endured throughout all economic climates.

Be certain that the firm—and the team members they intend to assign to your project—have successfully completed projects of the same scope.

The prospective design team’s experience with specific construction environments is important as well. Whether it’s a greenfield project—building from scratch on an empty plot—or a data center renovation, the MEP firm should demonstrate solid experience in such situations. Hiring a firm that has worked on projects similar to yours will pay off in the end.

GET THE RIGHT ENGINEERS FOR THE JOB

Make sure that the correct design and construction team has been appointed to your project. There are two positions that you’ll need to focus on: the project man-
The project manager is part of the design firm; it’s his or her job to create the high-level budgets and schedules for the project based on parameters that you have supplied. The results here aren’t necessarily concrete, but they should reflect your needs and budget limitations. The project manager should have demonstrated experience in this field.

The lead engineer will oversee or even manage the design. He or she could be part of the design firm or an objective third-party firm brought in to ensure compliance. In some cases, the project manager and lead engineer will be the same person.

Regardless, the lead engineer—not the architect—should be your primary design contact. The rationale for this is the value of the engineer’s contacts. An experienced data center engineer will know fire suppression and security experts, for example. Equally experienced general contractors must also know these details to assemble the building. Architects and designers then report to the lead engineer.

Don’t underestimate the value of a good working relationship among design team members. Data center design experts suggest that 60% of team members assigned to your data center project should have previously successful joint projects under their belts. The fact that a firm has worked on your type of project before means little if the actual staff they put on your project hasn’t done this type of work. It means even less if those same workers don’t have a rapport with one another.

When the design process is complete, you should have a total design document package that includes construction plans and a narrative, or the basis of a design, which clearly describes the operational and physical specifications of the proposed building. Once the design is ready, it’s time to select your construction contractor. But, as you’ll see in the next segment, it may be wiser to have a contractor lined up before your design is finished. In many cases, the general contractor is selected before the design phase is complete.
Negotiating with contractors

General contractors can add value to the early phases of your construction project and can help keep an eye on costs.

Managing general contractors (GCs) and subcontractors on a data center project can be a huge challenge. How do you select the contractor and when do you bring him onboard? Should the contracting firm be separate from the data center design and architecture firm?

Once the design of a new data center is underway, it’s time to consider which general contractor will ultimately build the facility. Aside from the actual criteria in choosing the best contractor for a new data center build-out, businesses must also determine the best point at which to involve a contractor and keep a close eye on the budget as a project begins.

Advanced planning and teamwork

Most construction projects follow a set of traditional steps or phases: needs assessment, design development, request for proposal (RFP) circulation and contractor bid collection and evaluation. Bids are then “leveled” to ensure that each encompasses the full scope of the RFP and is priced similarly.

At this point in a traditional construction cycle, a winning bid is selected and contracted. However, complex construction projects like data centers often benefit from involving a GC much earlier in the construction cycle.

The issue for many GCs is money—general contractors typically obtain construction projects by submitting the lowest bid. But those contractors will invariably subcontract some of the underlying construction tasks such as materials procurement or wiring to other third-party subcontractors. Those subcontractors must adjust or lower their own bids to participate in the project.

This is how the GC makes more money, though the quality of the subcontractors
can suffer. Facilities experts can cite numerous instances when inexperienced or poorly qualified subcontractors arrived to execute a job. Unfortunately, there is little (if any) time to find alternative subcontractors once a construction job is underway. The client bears the consequences of unsatisfactory work.

To prevent that from happening, one solution is to have an experienced project manager review and evaluate all bids and then level the contractors’ bids. But it can burden project managers to assess and compare the nuances of multiple bids.

A better solution, and one that GCs are increasingly accepting and data center facility project managers are recommending, is to select and bring your GC onboard early—even during the project’s design phase. Essentially, you’ll benefit from making the GC part of your design team because the contractor uses an “open book” approach. This allows you to see his cost and profit on everything, even bids from subcontractors.

Rather than hiring the GC for the lowest fixed price, you are engaging him in a consulting role. The GC is, in a sense, given a seat at the design table along with your company’s representatives—IT, the firm you’ve chosen to design the data center, any project manager from outside the MEP firm, and if needed, the architect.

This approach is called CM-at-risk, meaning the construction management (CM) firm—actually the GC—joins your design team and provides continual cost updates as your design evolves. The GC takes on the risk of delivering services at the initially promised price.

Since the lowest price is no longer the sole factor for choosing that firm, you’ll be able to see how your design changes will affect the bottom line. The GC subsequently provides bids based on general terms, conditions and profit margins that may be a percentage of the construction cost or a fixed amount above cost. Al-
though this process eliminates bidding between GCs, businesses gain valuable knowledge into their contractor and subcontractor choices, as well as the cost associated with any design decisions.

**GC BIDDING AND SELECTION**

Traditional construction bidding pushes businesses to select contractors based on the lowest bid, making experience and qualifications a secondary concern. With the CM-at-risk model, this dynamic is reversed. A business with insight into a contractor’s pricing and subcontractor bids has more freedom to select a GC based on his or her data center construction background, terms and anticipated profit.

Look for experience and a demonstrated pattern of success in previous data center construction projects. Comprehensive references are a must; try to arrange a tour of a recently completed project to view the contractor’s finished work firsthand.

If you pay particular attention to local projects, you should get a good idea of the GC’s working knowledge of local codes, practices and building regulations. If you plan to meet industry-recognized certifications with the new space, examine the contractor’s expertise with high-availability infrastructures as well as certifications.

In addition, a general contractor that truly specializes in data center construction will likely use an MEP specialist that’s familiar with MEP design drawings and can supervise those crucial aspects of the build. The GC MEP can also coordinate with the design firm’s MEP. Meetings that bring these two specialists together early in the project can raise red flags on potential problems. Any such issues can compromise your build schedule and budget long before the actual construction even begins.
DON’T LOSE SIGHT OF YOUR BUDGET

Final costs for a data center construction project can vary dramatically depending on location, size, features, power and cooling demands and many other considerations. However, experts note that new data center constructions on a greenfield site—undeveloped land—can break out in relatively predictable ways.

Plan on spending 65% to 75% of your budget on data center MEP infrastructure: generators, copper wires, uninterruptible power supply (UPS) units, batteries, chillers, pumps, piping, etc., as well as labor associated with installing these items.

The fees to design the data center will only come to 3% to 5% of the total project cost. The general contractor's fees will account for 6% to 8% of the project budget. The remaining 12% to 26% of your budget will go toward basic construction costs—concrete, steel, excavation and labor.

Be cautious when blending design and construction tasks. These design-build options can provide tremendous convenience and cost efficiencies because it’s one-stop shopping—a single firm provides the design and construction resources for the project. However, the tendency to let a single firm handle everything can backfire. Experts suggest that the design-build option is best left to companies that implement new data centers regularly and use the same firm repeatedly—so they know what to expect.
Wrapping up your construction project

Choosing a commissioning agent is the final decision in your construction project, but it's not an easy one.

Data center commissioning—the closing stage in a construction project—is a rigorous, systematic process that ensures that you get the data center design, equipment interoperability and system redundancy you purchased. The central role of the commissioning agent firm is to advocate your data center needs and requirements.

The commissioning stage tests data center design, subsystems, equipment interoperability and system redundancy to check that designers, architects and contractors have delivered the facility as contracted. Likely, a commissioning agent will spearhead testing and advocate for all of your agreed-upon requirements.

Look externally to maintain objectivity

It’s not uncommon for the design firm to perform commissioning activities. Many companies are comfortable with this approach because it offers singular accountability if problems arise—especially in a design-build scenario.

Successful commissioning, however, requires uncompromised objectivity. Having a design firm that’s also the commissioning agent can raise objectivity concerns. Experts lament many cases where the commissioning process simply rubber-stamped engineering activities. In such cases, the onus is on the design firm to demonstrate its objectivity.

A data center construction project is challenging, costly and represents significant risk. Companies may want to rely on the objectivity of an outside agent to review the design, construction and equipment installation to mitigate risks.

Engaging the services of an independent third-party engineering firm is the
preferred approach to commissioning agents. That firm might be a runner-up for the project’s design contract or a separate firm that specializes in data center commissioning. The biggest challenge in using an independent agent is the potential for mistakes in the interpretation of design documents. The design firm may also be reluctant to share information—further complicating the process.

As with design firms and contractors, take the time to perform due diligence on your prospective commissioning agent. Look at the agent’s documentation and scripts for previous clients and see how they’re written.

A lack of previous examples could signal a lack of experience. Check with past clients to find out how long it takes to get results from the agent—responses should be thorough and timely.

Your company will also need to budget for the additional cost of retaining an outside firm, along with the time required for commissioning. Then weigh those costs against the potential risks of not getting a second expert opinion.

**COMMISSIONING PROCESS OVERVIEW**

The commissioning phase starts early in the construction process when custom subsystems are ordered or key subsystems are installed at the work site. The process continues through building completion and system integration. Although there is no single approach when commissioning a new data center, experts stress the importance of thorough system testing and operation before signing off on the completed project.

For example, schedule overruns can curtail late-phase testing, so it’s important to test backup generators or air conditioning systems for 100 hours to shake out premature failures. By the time the data center is complete, much of the commissioning testing and verification should already be completed. This allows errors or problems to be corrected earlier, and you can take possession of the building sooner. In actuality, many engineering firms loosely adhere to the general American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) guidelines for commissioning buildings.
To be sure that nothing is overlooked during the commissioning process, use these four steps as guidelines:

1. **Review the preparation of key mechanical components.** It may be appropriate for commissioning agents to observe and review the fabrication of large mechanical components intended for the new data center. This would happen before construction starts.

   This step is only recommended when the construction involves prototype or custom products that are critical for subsequent construction. A review can ensure that the product manufacturer delivers the correct components in good working condition from Day 1.

2. **Verify the installation of key mechanical components.** As critical equipment and mechanical components—air conditioners, pumps and chillers—are installed, the commissioning agent should verify correct installation. Contractors and subcontractors may be inclined to install switches, piping, wiring runs, valves and other operational elements in the wrong place. A commissioning agent will assume an active role in these installations and regularly provide feedback and corrective requests.

3. **Test each subsystem under load conditions.** After a subsystem installation is complete, the commissioning agent will test each system under load to ensure proper operation. At a minimum, the agent will start every UPS and power distribution unit to verify that they work, run step-load changes on each UPS and conduct battery runtime tests. Air conditioner testing often occurs later in the construction process because the room must be clean and particulate-free to avoid damaging equipment.

4. **Perform full system integration testing.** As the project nears completion, the commissioning agent will verify interoperability of the entire system by testing all equipment under full load. In most cases, the agent will use a test protocol that
includes normal operating situations as well as a series of problem scenarios to verify redundant or failover features. This type of testing normally involves large simulated loads instead of real servers.

**DON’T MAKE THESE TYPICAL COMMISSIONING MISTAKES**

Getting a commissioning agent actively involved in the build early makes it easier to identify and correct construction oversights before they get out of hand. Waiting to commission the data center until it’s finished is ineffective, often resulting in significant schedule and cost overruns.

Don’t rush the commissioning process. Budget appropriately and give the agent time to work properly. The commissioning process is rarely ever flawless. If you marginalize commissioning, you compromise the entire process and open the door to serious problems down the line. For example, contractors often overlook the importance of emergency power-off (EPO) switches, but an agent can ensure they operate properly without requiring costly fixes. An attentive commissioning agent can help to identify and fix such flaws before they become more serious issues once the data center is operational.

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