Containerized Power and Cooling Modules for Data Centers

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by Dennis Bouley

Executive summary

Standardized, pre-assembled and integrated data center facility power and cooling modules are at least 60% faster and 20 - 30% cheaper to deploy than traditional data center power and cooling infrastructure. Facility modules, also referred to in the data center industry as containerized power and cooling plants, allow data center designers to shift their thinking from a customized “construction” mentality to a standardized “site integration” mentality. This white paper compares the cost of both scenarios, presents the advantages and disadvantages of each, and identifies which environments can best leverage the facility module approach.

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When data center stakeholders are faced with the challenge of deploying new data center power and cooling infrastructure (i.e., chillers, pumps, CRACS, CRAHS, UPS, PDUs, switchgear, transformers etc.), is it better for them to convert an existing room within the building (if this is at all an option) or to construct an extension to house additional power and cooling equipment? Or is it more cost effective and technically feasible to source the power and cooling from a series of facility modules?

Facility modules are pre-engineered, pre-assembled / integrated, and pre-tested data center physical infrastructure systems (i.e., power and cooling) that are delivered as “plug-in” modules to a data center site. This contrasts with the traditional approach of provisioning physical infrastructure for a data center with unique one-time engineering, and all assembly, installation, and integration occurring at the construction site. The benefits of facility modules include cost savings, time savings, simplified planning, improved reliability, improved agility, higher efficiency, and a higher level of vendor accountability.

Deployment of facility modules results in a savings of 60% in deployment speed, 22% in first cost, and 18% in Total Cost of Ownership (TCO) when compared to a traditional build out of the same infrastructure (see Figures 1 and 9). TCO cost savings are even more dramatic (greater than 30%) when the traditional data center is overbuilt in capacity and provisioned upfront with typical power and cooling systems and controls.

Traditional 40 ft by 20 ft (12 m by 6 m) ISO shipping containers are the most recognizable form of facility module. However, facility modules can also be built on a skid or delivered as multiple form factor modular buildings. For this reason, this paper will use the term “facility modules” and not “containers” when describing the various modular solutions. This paper provides data center professionals with the information needed to justify a business case for data center facility power and cooling modules.

Facility modules are faster and cheaper to deploy than a “same physical infrastructure” traditional approach for a number of reasons. Figure 1 compares both first cost and TCO savings over a 10 year period.

![Figure 1](https://via.placeholder.com/150)

**Figure 1**
TCO differences between the traditional and the facility module approach
The analysis depicted in Figure 1 is based on the following assumptions:

- 500 kW capacity with initial load at 30% of capacity, and final load at 80% of capacity
- 5% cost of capital (discount rate) for energy and maintenance costs incurred yearly
- Packaged chiller with economizer mode
- St. Louis, MO, USA climate
- No core & shell cost savings included
- No white space infrastructure included (air distribution, power distribution units, racks)
- Identical physical infrastructure for both the facility module and traditional approaches in order to ensure fair comparison of material costs

Facility power and cooling modules offer substantial savings (a difference of $4 vs. $5/watt first cost) because they offer a standardized means for building and installing the data center physical infrastructure. The standardization of components enables dramatic economies of scale in the production, delivery, and installation of data center power and cooling capacity. The traditional approach, on the other hand, is highly customized with the majority of the work being performed on site. Disparate components from multiple vendors are custom engineered into one unique facility. As can be seen in Figure 1, the majority of savings are derived from the “design / field install” and “energy” categories.

The following sections provide a description of each category in Figure 1 to illustrate why facility modules are less costly. “Material” and “design / field install” represent capital costs while “maintenance” and “energy” represent operational costs. The first cost plus the operational costs equal the TCO over the 10 year period. Figure 1 illustrates higher facility module material costs and similar maintenance costs for both approaches. The largest TCO savings on the facility module side are visible in the categories of “design / field install” and “energy”.

Material costs

The "materials" cost includes the mechanical and electrical room physical infrastructure equipment (switchgear, UPS, panel boards, heat exchanger, chiller, pumps, filters, lighting, security management, fire suppression). These costs are 20 - 25% higher for facility modules, because of the cost of the additional materials (the container shell) and the cost of pre-assembling / integrating the systems together.

Design and Installation costs

“Design / field install” costs represent the costs to engineer the design of components to fulfill the power and cooling needs. In the case of facility modules, this cost is rolled into the material cost. In a traditional situation, design / field install costs include all work performed in the field to assemble, install, integrate, and commission the system for operation.

What is modularity?

The terms “modular”, “modular-based”, “modular-oriented”, “modularized”, “modular pods”, “coupled”, “container”, “modular container” are all vague and represent a host of different concepts. In fact, a distinction should be made between the three elements of modularity: device modularity, sub-system modularity, and linked modularity. These terms are described as follows:

Device modularity: modular devices are made up of modular components (e.g., an APC Symmetra UPS with hot swappable power modules and battery modules)

Sub-system modularity: a sub-system is a functional block made up of multiple devices of the same type (e.g., a UPS sub-system is considered to be modular if it is comprised of multiple similar UPS devices)

Linked modularity: a linkage is defined between the deployment of modules of different sub-systems (e.g., linkages may be as simple as rules of deployment, or they can be enforced by pre-engineered and pre-manufactured sets or "kits" of deployment).

Given these distinctions, modularity is defined as a technique that builds large systems out of small sub-systems, where the sub-systems have well defined rules for interfacing with each other. This modularity also suggests a simplified approach to installation or replacement, ideally with a “plug in” of modular elements that require simplified commissioning.
The facility modules are designed in a research and development area, are tested, and then released to manufacturing. Once in manufacturing, the design is “stamped out” and shipped to the end user. In the traditional approach, multiple parties play a role in developing the design. Numerous meetings are held as electrical contractors, mechanical contractors, designers, end users, facilities departments, IT departments, and executives are all involved. Design points are argued back and forth, politics plays a significant role, and decisions often have to be made serially (i.e. one contractor has to wait for another contractor to complete his work before he can continue to move the project forward).

Since professional services field work is more costly and time consuming than comparable work in the factory, facility modules offer substantial savings. For example, a worker on the assembly line in the factory who installs a pre-engineered standard set of electrical wire in a module costs less than the combination of an electrical engineer and electrician in the field who are tasked with building a “one off” electrical design for that particular project.

Although not illustrated in the Figure 1 analysis, another benefit of the facility module approach is the reduction or elimination of on site “brick & mortar” facility construction to house the physical infrastructure. Not only is this costly (on the order of $100-$150 per sq ft or $1076 - $1,614 per sq m), it is disruptive to normal facility operations (see Figure 2 and Figure 3).

With facility modules, the construction work is less invasive and less complex as no core and shell needs to be built and field installation is significantly reduced.

Figure 4 illustrates a facility module being placed on-site on a cement pad with a crane. Once in place, electrical power is connected to the main switchgear, to the cooling facility module, and to the IT space, and chilled water piping is connected to the air handlers in the IT space.)
In a scenario where facility power and cooling modules will be supporting the data center, much of the traditional up-front design and construction management burden shifts from the data center owner / end user to the solution provider (see Figure 5). The manufacturer designs and then “stamps and repeats” data center power and cooling modules for multiple customers. The data center power and cooling physical infrastructure becomes part of the manufacturing supply chain instead of an on-site custom build. This has a significant impact on the installation expense.

Note that in a traditional approach, the owner / end user is responsible for either developing the design, assembling the components of the solution, engaging the various vendors for equipment acquisition, or for hiring and managing contractors to perform this work. In
contrast, since facility power and cooling modules are pre-built in the factory, the owner / end user avoids time consuming tasks (no need to chase down the individual pieces of equipment needed, one or few delivery schedules to manage, very few, if any, construction contractors to interface with).

**Figure 5**

*In the traditional approach, the data center owner is burdened with either performing or contracting out much of the planning and solution assembly work.*

**Maintenance costs**

**Figure 1** conservatively illustrates maintenance as equal for both the facility modules and the traditional approach. However, the potential exists to reduce facility module maintenance costs. As maintenance personnel are trained to handle all of the various components within the facility module, the end user would save by contracting for “one stop shop” container maintenance. Rather than having to write up an assortment of terms and conditions with different vendors, only one contract could be drawn up to support the one or two “big box” facility modules.

In such a scenario, one organization would be held accountable for the proper function of the facility module. This is a simplified approach as the data center owner no longer has to preoccupy himself with trying to track down which organization is responsible for resolving a mishap. In a traditional data center, many of the parts and pieces (plumbing, electrical, power system, cooling system, and racks) are supported by different suppliers and finger pointing is a common occurrence.

The cost savings could also extend to software / management upgrades. Instead of custom written code for a large assortment or products, the data center facility power and cooling modules could make available to the customer one set of standard firmware upgrades.

**Energy costs**

Traditional mechanical and electrical rooms consume 37% more energy than comparable power and cooling facility modules. This situation exists for two principal reasons: 1) traditional infrastructure is more oversized 2) the pre-engineered design of the modules allows for better integration of power and cooling system controls (this advantage is especially pronounced when it comes to the cooling system). An explanation of how these two characteristics influence energy consumption follows.
Rightsizing
Traditional designs incorporate excess capacity because the real-life data center performance and the loads to be supported are uncertain. On the other hand, since facility modules are designed and tested in the factory, they can be sized more precisely to the required load. They also can be scaled quickly when rapid changes to the data center occur (as within private cloud environments). The unpredictable nature of growth makes it necessary to build excess capacity upfront in a traditional setting.

In the Figure 1 analysis, the facility modules are installed upfront. Therefore, savings are conservative because no scaling occurs. Traditional cooling components are sized larger to account for the uncertainty of performance previously discussed. Later in this paper, a data center analysis is presented which explores the cost impact of a data center which is scaled over time, and the impact on the overall data center PUE is demonstrated.

Integration of controls
In most data centers, significant energy is wasted as a result of poor coordination of controls. Consider the example of controls for a chiller plant. The programming required to properly coordinate chillers, cooling towers, pumps and valves, for example, is extensive. Adding economizer modes increases the complexity. In fact, often times, economizer modes are disabled in designs because of this complexity, which results in added energy expense.

The American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) publishes a Coefficient of Performance (COP) standard of 12 for chiller plants. A higher COP indicates a better overall system performance. Although the individual parts that make up the chiller plant may achieve this standard, most chiller plants only achieve an actual COP of 2 or 3. This is a symptom of problems encountered when attempting to integrate the controls of the various components involved. In the Figure 1 analysis, it is assumed that the traditional approach, when compared to the facility cooling module, achieves only ¼ of the hours of economizer mode operation. This is due to the ineffectiveness of custom designed / integrated controls implemented in the field.

Cooling system controls within a traditional data center are comparable to a sizeable orchestra where all the “players” have to be highly coordinated to produce quality music. The facility module, on the other hand, can be compared to a simple quartet; the number of components that need controlling are fewer and the integration (the proper adjustment of settings based on cause / effect relationships) is performed ahead of time, so that the container “behaves” in an efficient manner once under operation.

The complexity of the controls makes it difficult to predict Power Usage Effectiveness (PUE) within a traditional setting. The PUE of a facility module is predictable, however, because the equipment has been extensively pre-tested using standard components and the controls have been coordinated ahead of time. Consider the PUE of a traditional 1 MW data center located in St. Louis, Missouri, USA at 50% load with an average density of 6 kW per rack, raised floor, chillers, variable frequency drives (VFD), water control, and economizers. In such a data center a PUE of about 1.75 would be typical. Comparable container configurations have been tested and analyzed and a measured PUE of 1.4 or better is expected. That difference translates into an electrical bill reduction of 20%.

The confined area within a facility module allows the operation to be more tightly controlled because the influence of other systems (like building air comfort cooling systems) is non-existent. This help to avoid situations of overcooling. In addition, the facility modules are free of “parasitic” loads such as a shared chiller or shared lights.

The facility module is designed for infrequent human interaction. Traditional buildings, on the other hand, are designed with humans in mind. For this reason, rooms inside of a building can be specified to consume 4 to 5 times the floor space in order to meet local code require-
ments. This extra space then requires more energy and more water to cool, heat, and ventilate the space.

A closer look at the impact of scaling and rightsizing

The analysis presented earlier in Figure 1 focused on the benefits of standardizing, pre-assembling, and integrating the electrical room and mechanical room infrastructure into modules. However, significant additional savings can be achieved. The modular nature of facility modules enables scaling and rightsizing to actual data center loads. This, in combination with superior power and cooling distribution technologies, can result in a TCO savings of nearly 30% over a traditional data center (27.2% CAPEX and 31.6% OPEX).

Figures 6 and 7 highlight the CAPEX and OPEX differences between a data center with traditional infrastructure and operational practices, and a data center with facility modules and design and implementation of best practices. The “waterfall” charts break out how the 27.2% CAPEX and 31.6% OPEX delta in savings are derived.

![Figure 6](image-url)

Figure 6
Breakout of major CAPEX cost savings when comparing traditional to modular
Figure 7
Breakout of major OPEX cost savings when comparing traditional to modular

The key assumptions for the data centers illustrated in Figures 6 and 7 are listed in Table 1. The data for this analysis is derived from the same cost models that support the Data Center Capital Cost Calculator and Data Center Design Planning Calculator TradeOff Tools.

Table 1
Key assumptions of two data centers compared

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Traditional Data Center</th>
<th>Modular Data Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>St. Louis, MO USA</td>
<td>St. Louis, MO USA</td>
</tr>
<tr>
<td>Density</td>
<td>7 kW/rack</td>
<td>7 kW/rack</td>
</tr>
<tr>
<td>Initial load</td>
<td>1 MW</td>
<td>1 MW</td>
</tr>
<tr>
<td>Final maximum load</td>
<td>5 MW</td>
<td>5 MW</td>
</tr>
<tr>
<td>(projected on day 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final actual load</td>
<td>4 MW</td>
<td>4 MW</td>
</tr>
<tr>
<td>Day 1 Capacity</td>
<td>5 MW</td>
<td>1.5 MW</td>
</tr>
<tr>
<td>Year 10 Capacity</td>
<td>5 MW</td>
<td>4 MW</td>
</tr>
<tr>
<td>Module size of data center</td>
<td>n/a</td>
<td>500 kW</td>
</tr>
<tr>
<td>Cost of capital</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Cooling architecture</td>
<td>Chiller, cooling tower, no</td>
<td>Packaged chiller, economizer</td>
</tr>
<tr>
<td></td>
<td>economizer, perimeter air</td>
<td>with integrated controls,</td>
</tr>
<tr>
<td></td>
<td>handlers with raised floor</td>
<td>row coolers</td>
</tr>
<tr>
<td>Power architecture</td>
<td>Traditional, non-scalable</td>
<td>97% full load efficient,</td>
</tr>
<tr>
<td></td>
<td>UPS, traditional distribution</td>
<td>scalable UPS, 415V</td>
</tr>
<tr>
<td></td>
<td>(480V to 208V)</td>
<td>distribution</td>
</tr>
<tr>
<td>Design/install approach</td>
<td>Upfront build, custom designed,</td>
<td>Scaled &amp; rightsized,</td>
</tr>
<tr>
<td></td>
<td>field installed &amp; integrated in</td>
<td>standard, pre-assembled</td>
</tr>
<tr>
<td></td>
<td>traditional brick &amp; mortar</td>
<td>&amp; integrated in shipping</td>
</tr>
<tr>
<td></td>
<td></td>
<td>container</td>
</tr>
</tbody>
</table>
Avoided overbuilt capacity and scaling the design over time contribute to a significant percent of the total savings. White Paper 143, *Data Center Projects: Growth Model* provides additional information on the significance of a growth strategy. Other drivers include the architecture deployed and the design/installation approach. The following sections further explain the waterfall diagram cost savings categories.

**Avoided overbuilt capacity** – When a data center is built out upfront, the designer plans for a worst case final load because of cost and operational penalties for running out of capacity midstream in the data center’s life are too steep. In reality, the final load rarely hits the projected number. This analysis assumes that the actual final load is the average of the minimum and maximum final load projected. Significant CAPEX and OPEX savings accrue if the traditional data center is built out to 4 MW instead of 5 MW.

**Scaled build over time** – Scaling data center infrastructure over time results in increased savings because capital costs and maintenance costs are deferred until they are needed to support the load. Furthermore, the system runs at a higher percent load each year, resulting in energy savings.

*Figure 8* compares the PUE of a design built upfront to one that scales as the load is increased. Early in the data center’s life, when the load is small, a big efficiency penalty is incurred for the upfront build. Right-sizing has the potential to eliminate up to 50% of the electrical bill in real-world installations. The compelling economic advantage of right-sizing is a key reason why the industry is moving toward modular, scalable physical infrastructure solutions.

![Figure 8](image)

*Figure 8*

Scalable modules allows for rightsizing which improves overall data center efficiency.

**Row cooling, 415 Volt distribution, no raised floor** – Row cooling reduces energy cost (shorter path for cold air to be transported to servers), 415 Volt distribution eliminates step-down transformers that are needed in traditional power distribution schemes, and raised floor costs can be avoided when close coupled cooling is deployed and power and cable distribution is run overhead.
Packaged chiller with economizer – The packaged chiller / economizer approach avoids upfront costs and reduces operational costs. Although a packaged chiller (also known as an air-cooled chiller) is less efficient when compared to a water-cooled chiller with cooling tower, the addition of an economizer operation reduces energy costs by utilizing outside air (indirectly) to cool the data center. This reduces annual chiller use. See White Paper 132, *Economizer Modes of Data Center Cooling Systems*, for further information regarding the benefits of economizer modes.

Factory assembled with integrated components and controls (Figure 6 only) – This pre-built standardized architecture reduces CAPEX because (1) components are assembled and integrated by one vendor and (2) factory assembly is less expensive than building from a collection of multiple vendors’ parts in the field. In addition, the time involved in calibrating cooling system controls through integration of fans, pumps, loops, chillers, water towers etc. is drastically reduced when standard modules are deployed.

Smaller core and shell (Figure 6 only) – The compact nature of pre-engineered, pre-manufactured modules means that more equipment is packaged into a smaller overall physical “envelope”. At a typical cost of $100-150 / sq ft ($1076 - $1,614 per sq m), this can result in significant savings.

Efficient UPS (Figure 7 only) – New UPSs approach efficiencies of 97% when operating at full load compared to 89% efficiency for traditional UPSs at full load. This contributes to the energy savings of the improved design.

Standard, integrated cooling controls (Figure 7 only) – As discussed earlier in the paper, cooling controls impact the effectiveness of the cooling plant and the operation on economizer mode. A design with standard integrated controls will optimize the operation of the cooling plant.

Additional facility module benefits

Beyond the CAPEX and OPEX advantages of facility modules, data center owner have additional reasons for pursuing the facility module approach:

- **Predictable efficiency** – The facility module approach allows the consumer to specify and for the manufacturer to publish expected efficiencies based on real measurements of the design. This predictability is attractive for businesses with a focus on energy efficiency initiatives.
- **Portability** – If portability represents a high value, then the facility modules may make some sense. Consider the example of a business that needs to deploy data center power and cooling but whose lease runs out in 18 months. If their lease is not renewed, they can physically move their data center physical infrastructure (power and cooling) investment with them instead of leaving it behind.
- **Hedge against uncertainty** – Facility modules are a viable option if a high degree of uncertainty exists regarding future growth. The flexibility of scaling and rightsizing helps to minimize risk.
- **Speed of deployment** – Traditional data centers can take nearly two years, from concept to commissioning, for delivery. Speed of implementation is oftentimes critical to a business. Cost of time is important to organizations that place a high value on early delivery (e.g., companies who want to be first to market with new products).

In the case of a public institution like a university, for example, a substantial upgrade to an existing facility can be a long, drawn out affair. Decisions have to be approved by the Board of Trustees and the state government also has to issue approvals. That process alone can take upwards of a year. Data centers built with facility modules can be deployed in less than half the time from concept to commissioning (see Figure 9).
The following is a list of some typical facility module applications:

- **Colocation facilities seeking faster, cheaper ways to “step and repeat” computer power and support systems for their customers.** Facility modules provide colos with a solution to cost effectively upsize and downsize in large kW modular building blocks when demand for their services fluctuates as a result of market conditions.

- **Data centers that are out of power and cooling capacity or out of physical space.** The facility modules can quickly add cooling and power capacity so that additional servers can be placed into existing racks, creating a higher density per rack, which can now be handled by the supplemental power and cooling.

- **New facilities with tight time constraints.** Traditional data centers can take nearly two years, from concept to commissioning, for delivery. Speed of implementation is oftentimes critical to a business. Cost of time is important to organizations that place a high value on early delivery (e.g., companies who want to be first to market with new products).

- **Data center operators in leased facilities.** For example, if a business needs to deploy data center power and cooling but their lease runs out in 18 months, they don’t want to pour money into a fixed asset that they would have to leave behind. If their lease is not renewed, they can physically move their data center physical infrastructure (facility power and cooling modules) investment with them.

- **IT departments whose staff is willing to manage power and cooling** (not relying on the stretched resources of corporate facility departments that are more focused on the management of the entire building, for example) can leverage facility modules to control their own chilled water supply. The number of internal and external signoffs required for acquisition of power and cooling resource is significantly reduced when compared to traditional custom build.

- **Data center facilities saddled with infrastructure characterized by poor PUE.** These facilities may only be marginally improved within the constraints of their existing physical plant. Adding facility modules provides an alternative to help solve problems inherent to the inefficient data center design they may have inherited.

**Figure 9**

Comparison of deployment time estimates (modular vs. traditional)
• **An organization with vacant space** (i.e. warehouse space - see Figure 10) can populate the space with a series of prepackaged modules. They leverage utilization of the space and avoid the delays and construction costs of building a new brick and mortar wing.

![Figure 10](image)

*Empty or underutilized warehouse space can be used to house facility power and cooling modules*

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**Facility module drawbacks**

If facility modules offer flexibility, shorter time of deployment, and cost advantages, then why aren’t facility modules a solution for everyone? Consider some of the challenges that facility modules can present:

**Distance between the facility modules and the internal data center** – In cases where outdoor facility power and cooling modules supply an indoor data center, distance is an important factor. If the indoor data center is located next to an outdoor perimeter wall or a roof, expense to connect the data center to the facility modules is minimized. However, if the data center is located deep within the building, the cost of running cable and piping (breaking through multiple walls, floors, and/or ceilings) could quickly become prohibitive.

**Physical Risks** – Facility modules can be exposed to outside elements such as severe weather, malicious intent, vehicle traffic (if placed in parking lot), and animal / insect infestation. Risks for a particular site should be assessed before choosing to deploy facility modules.

**Arrangements for power provisioning and network connectivity** – When facility modules are installed, arrangements for additional power distribution (additional breakers / switchgear) and fiber connections need to be established.

**Restrictive form factor** – Facility modules are big “chunks” of power and cooling capacity and, although mobile, they do present some challenges when it comes to relocation. The blocks are heavy and may be too heavy to place on the roof of a building. The 20 foot by 40 foot (12 m by 6 m) dimensions of a typical shipping container means that data center owners who experience growth may be confined by width, height, and length restrictions unless they have enough ground space to add more facility modules.

**Human ergonomics** – Facility modules are designed for remote operations and are less human friendly than traditional brick and mortar data centers. Space inside is very limited.
(for maintenance personnel for example) and airflow is geared towards equipment and not for the comfort of humans.

**Serviceability** – Service personnel who work in traditional data centers are accustomed to access to the front and back of equipment in a protected indoor environment. Some facility power and cooling modules, on the other hand, have doors located on the outside which are the means by which service people can access the back of the equipment. When these doors are open, the physical infrastructure equipment is exposed to heat, moisture, dust, cold and other potentially harmful outdoor elements.

**Local code compliance** – Since facility modules present a new technology, local municipalities may not yet have established guidelines for restrictions on modules. Inconsistencies could exist regarding how different municipalities classify power, cooling, and IT modules. Local codes impact the level of module engineering and customization required to secure Authority Having Jurisdiction (AHJ) approvals.

**Transportation** – The Transportation Security Administration (TSA) stipulates width (11.6 feet, 3.5 meters) and length limitations in the United States in order for truck and train loads to pass over curved roads, under bridges, and through tunnels. Outside of North America, roads can be even smaller, further restricting the mobility of containers. Non-standard wide loads require special permits and in some cases escorts which increases the cost of transporting the facility modules.

**Table 2** illustrates several factors that need to be taken into consideration when data center owners are determining whether facility modules are the best fit. **Table 3** summarizes the differences between a traditional data center build out and facility modules across various factors. (Note that the shaded cells indicate the best performer for each factor.)

<table>
<thead>
<tr>
<th>If ...</th>
<th>Then you should ...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Go traditional</td>
<td>Consider facility modules</td>
</tr>
</tbody>
</table>

### Table 2
*Traditional or facility modules?*

- Your existing data center is located deep within the facility infrastructure (i.e., more than 500 ft / 152 m away from outside walls or roof).
- You have adequate space in parking lots or other perimeter spaces outside of the facility.
- You require mobility and/or reuse of “temporary” data center physical infrastructure.
- Your are restricted by the capacity (generally up to 500 kW modules) and scalability offered by the facility modules.
- You have no room in your parking lot and the roof of your facility cannot bear the weight of facility modules.
- You are comfortable with running a true “lights out” data center (no human beings working inside).
## Table 3

**Summary comparison of traditional and facility module approaches**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Traditional data center build out</th>
<th>Facility module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to deploy</td>
<td>12 to 18 months represents a typical timeframe</td>
<td>Can be designed, delivered, installed, and operational within 34 weeks or less</td>
</tr>
<tr>
<td>Cost to deploy</td>
<td>High up front capital cost with extensive field assembly, installation, and integration</td>
<td>Allows data center to be built out in large kW building blocks of pre-manufactured power and cooling capacity</td>
</tr>
<tr>
<td>Regulatory roadblocks</td>
<td>Regulatory approvals on an ad-hoc basis for the various steps of the infrastructure layout. This approach often results in delays that impact the initiation of downstream construction. The end user is responsible for securing approvals.</td>
<td>Data center owners who choose to install facility modules should check with local authorities prior to installation. Permitting processes may vary greatly across different geographies.</td>
</tr>
<tr>
<td>Security</td>
<td>Physical security is enhanced when assets are located deep within the building, away from the outside perimeter</td>
<td>Location of physical infrastructure assets outside of the building increases exposure to outside physical security and weather threats</td>
</tr>
<tr>
<td>Installation</td>
<td>From a physical infrastructure perspective, a retrofit can be more complex and more invasive than a build out of a new data center. Infrastructure components need to be installed individually, started up individually and then commissioned.</td>
<td>Specialized equipment (such as a crane) is needed to maneuver 20 and 40 foot pre-configured facility modules. A &quot;docking station&quot; needs to be configured for connection to building pipes and electrical. Started up as one integrated unit.</td>
</tr>
<tr>
<td>Tax implications</td>
<td>Recognized as permanent part of the building</td>
<td>Reported as temporary structure which can be more attractive from a tax perspective (see Schneider-Electric White Paper 115, Accounting and Tax Benefits of Modular, Portable Data Center Infrastructure)</td>
</tr>
<tr>
<td>Safety</td>
<td>Data centers are recognized as human occupied space and must meet safety and environmental criteria for human beings</td>
<td>Facility modules are designed to be unmanned; Limited human interaction lessens the chances for the occurrence of accidents involving humans.</td>
</tr>
<tr>
<td>Reliability</td>
<td>The solution is assembled on site from various parts and pieces provided by multiple vendors. This increases the need for coordination and therefore, creates more chances for human error.</td>
<td>More predictable performance because components are pre-wired and are factory acceptance tested before shipping. Smaller modules reduce risks of human error: If a failure occurs, the entire data center doesn’t go down.</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Existing structures often limit the electrical efficiencies that can be achieved through optimized power and cooling distribution; complex custom configured controls often result in suboptimal cooling operation, reducing efficiency</td>
<td>Facility modules can utilize standard modular internal components and can be specified to a target PUE.</td>
</tr>
<tr>
<td>Carbon footprint</td>
<td>Construction materials utilized are high in carbon emissions. Brick, insulation and concrete are all carbon emission intensive materials. Concrete is often used for floors, walls and ceilings.</td>
<td>Steel and aluminum produce about half the carbon emissions of concrete. Concrete is only used to pour a support pad. 80% less concrete is needed for facility modules as opposed to a comparable “building shell” data center.</td>
</tr>
<tr>
<td>Serviceability</td>
<td>Traditional data centers have more room for service people to maneuver. All servicing is protected from any harsh weather elements.</td>
<td>Servicing is more limited with facility modules because of space constraints. In some cases equipment can only be accessed by opening a door from the outside and exposing equipment to outside elements (heat, moisture, cold).</td>
</tr>
</tbody>
</table>
Some facility modules are packaged in traditional 20 and 40 foot (6 and 12 meter) freight containers (Figure 11a) and some are packaged as more customized add-on pre-fab “plants” or modular add-ons to existing buildings (Figure 11b). Still others are packaged and delivered as skids. Modules could be placed inside of a warehouse for rain protection. Tent-like canopies can be set up to further protect the modules, much like a car port can protect a car that is not garaged.

Classic ISO (freight) containers and skids

Facility cooling module – These units house modular air-cooled chillers, pumps with variable frequency drives (VFDs), a fluid storage tank, monitoring software, sensors and physical security cameras and can support up to a 500 kW capacity per container (see Figure 12).
Facility power module – These units house UPS and batteries, a step-down transformer, switchgear, panel boards, physical security (access security, cameras, sensors, monitoring software), VESDA fire protection and alarms and in row cooling. The facility power module also features hookups for utility power, 'on-site' power, backup (generator) power and data. A UPS and generator design (with day tank and ATS switch) can also be configured (see Figure 13).

Modular indirect evaporative cooling modules
When ASHRAE expanded the recommended server inlet temperature range to 27°C (80.6°F), they did so with the intention of allowing more economizer operating hours. A modular indirect evaporative cooling module is designed to live outside the data center and can automatically switch between two forms of economized cooling:

- Air-to-air heat exchange - Brings in hot IT air in from the data center through the modules' electronically commutated fans. This air is then passed through internal channels of the indirect evaporative cooler (IEC). After the IT air is cooled, it leaves the IEC and passes through a cooling coil and returns to the data center.
- Indirect evaporative heat exchange - When ambient temperatures can’t support an air-to-air heat exchange, cooling occurs through indirect evaporative cooling which removes heat from the IT air by evaporating water on the outside of the heat exchanger channels. The unit prevents the outside air from coming in contact with the data center air, regardless of which cooling mode is used (air-to-air or indirect evaporative).

Though temperate environments will realize the quickest ROIs, nearly all geographies can attain some level of “free cooling” utilizing these cooling modules. An example of a cooling module that applies this cooling method is the Schneider Electric EcoBreeze™. Each module has the capacity to cool approximately 50kW and up to 8 x 50 kW modules can be configured in one frame (see Figure 14). Schneider Electric White Paper 132, “Economizer Modes of Data Center Cooling Systems” provides further detail as to how this cooling system compares to other systems with economizer modes.
The introduction of facility power and cooling modules presents an alternative to the traditional “craft industry” approach of designing and building data centers. New economic realities make it no longer possible to bear the brunt of heavy upfront costs and extended construction times for building a traditional data center. The availability of pre-engineered facility modules allows the planning cycle to switch from an onsite construction focus to onsite integration of pre-manufactured, pre-tested blocks of power and cooling. The result of this change in focus is a lower cost, and faster delivery solution.

The ideal application for facility modules can be described as follows:

1. Data centers whose owners are uncertain about their growth and covet the business value of early delivery.
2. Data center owners who are constrained by space and power / cooling capacity, and can’t afford to build a new data center from scratch.

Facility modules can power and cool traditional data center IT rooms that are out of power and cooling capacity. They can also be used to power and cool IT modules (containers of IT equipment). Among leading edge corporations, a migration from brick and mortar to facility module “parks” will take place. Cloud computing business models will also accelerate the deployment of rapid facility module provisioning.

**Figure 14**
*Illustration of air side economizer made up of containerized modules*

**Conclusion**

Dennis Bouley is a Senior Research Analyst at Schneider Electric’s Data Center Science Center. He holds bachelor’s degrees in journalism and French from the University of Rhode Island and holds the Certificat Annuel from the Sorbonne in Paris, France. He has published multiple articles in global journals focused on data center IT and physical infra-structure environments and has authored several white papers for The Green Grid.
Resources

Click on icon to link to resource

Accounting and Tax Benefits of Modular, Portable Data Center Infrastructure
White Paper 115

Economizer Modes of Data Center Cooling Systems
White Paper 132

Data Center Projects: Growth Model
White Paper 143

Data Center Capital Cost Calculator
TradeOff Tool 4

Data Center Design Planning Calculator
TradeOff Tool 8

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

Data Center Science Center
DCSC@Schneider-Electric.com

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