Building Data Centers - Key Considerations

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In this article, the authors explore several key construction-related considerations for employers commissioning data centers, which also apply to other stakeholders in a data center investment program.

The successful construction of a modern data center requires seamless coordination of expertise in both design and construction, covering a wide range of disciplines including utilities, power distribution, electrical systems, cooling and heat rejection, telecommunications networks and security systems. Building a data center today is therefore a complex task involving careful planning, specialist engineering expertise and navigating an ever-evolving regulatory landscape.

This article explores several key construction-related considerations for employers commissioning data centers, which also apply to other stakeholders in a data center investment program.

OVERVIEW OF THE HISTORIC DEVELOPMENT OF DATA CENTERS

The first data centers were built by the United States military in the 1940s and 1950s (referred to as "mainframes" at the time). They were essentially large rooms that housed complex cable networks and the large computer systems of the times. Data centers as we know them today -industrial-scale, standalone facilities housing large and complex IT infrastructure - began to take shape during the dot-com bubble in the late 1990s as companies began to require fast internet connectivity and around-the-clock operation to establish their online presence.

Today's data centers are a far cry from the mid-20th century mainframes and their successors from the dot-com bubble era. The exponential development and proliferation of technology, increasing dependence on cloud computing (both by individuals and organizations), advent of cryptocurrency mining and advancements in artificial intelligence have all contributed to a significant rise in the demand for data centers of increasing scale, complexity and performance requirements as well as

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an increase in power and cooling generation needs.

CHOOSING THE RIGHT CONTRACT FORM: D&B OR EPC?

Given the specialist nature of data centers, data center owners and investors commissioning data centers typically look to employ a contractor with data center engineering expertise to act as a single point of responsibility to deliver both the design and the construction of the facility. Most large-scale data centers to date have been built under a design-build (D&B) contract for this reason, but there is now a growing appetite for engineering, procurement and construction (EPC) contracts as data center owners and investors look to shift more risk onto contractors and achieve faster delivery times (speed to market is discussed in more detail later in this article).

The typical factors that dictate whether a construction project should proceed under a D&B contract or an EPC contract also apply to the construction of data centers:

- *Is the Contractor Responsible for Specialist Equipment/Components Needed to Achieve the Required Performance Output Levels?* In essence, is the contractor (i) simply building a data center "shell" (i.e., a building with an HVAC system) into which the data center owner will install its own IT systems, or (ii) is it providing a full turnkey solution (including specialist IT equipment that can operate according to the required specifications)?

- *Will the Contractor Be Required to Achieve Certain Performance Output Levels, and Will There Be Associated Performance Liquidated Damages and Termination/Rejection Rights?* In the context of data centers, these performance levels may include continuous data processing and storage capacities, internet connection speeds, power consumption, IT equipment cooling, and ambient temperature and humidity levels. Performance liquidated damages and termination/rejection rights may be appropriate if failure to meet the performance levels will impact the commercial viability of the project.

- *Are the Data Center Owners and Investors Comfortable With Limited Influence Over the Design and Construction Processes, and Paying a Higher Price, in Exchange for Reduced Administrative Burden?* Again, this depends on who is commissioning the data center and for what purpose - for example, an experienced tech company building an enterprise data center for its own use may wish to retain a greater level of involvement over the design and construction of the facility to ensure the data center is custom-built for its modes of operation, including requirements relating to security of information and equipment. Conversely, a retail data center business may prefer a hassle-free turnkey solution as long as they receive a data center that can be operated according to their desired specification by a third-party operation and maintenance company.

- *Is Fast Project Delivery a Critical Driver in the Project's Success?* Whilst both the D&B and EPC forms of contract can achieve faster delivery times than a traditional design-bid-build contract by allowing certain construction activities to

begin prior to finalization of design, the better-defined project deliverables and less collaborative nature of design development typically found in the EPC contract give it a slight edge. Other ways to speed up delivery of data centers are discussed in more detail later in this article.

If the answer to one or more of these questions is a "yes," an EPC contract may be an appropriate choice. However, it is also possible to formulate a D&B contract that specifies performance output levels (and consequences for shortfalls) and/or specialist equipment, whilst allowing the data center owners and investors to maintain the usual level of involvement in, and control over, the design and construction processes found in D&B contracts.

Design-build-operate contracts are generally not used for the construction and operation of data centers due to the specialist nature of the business and operations of data centers. This may of course change as the market and the key players mature, with contractors taking on greater roles in the value chain, similarly to what has happened in the energy sector.

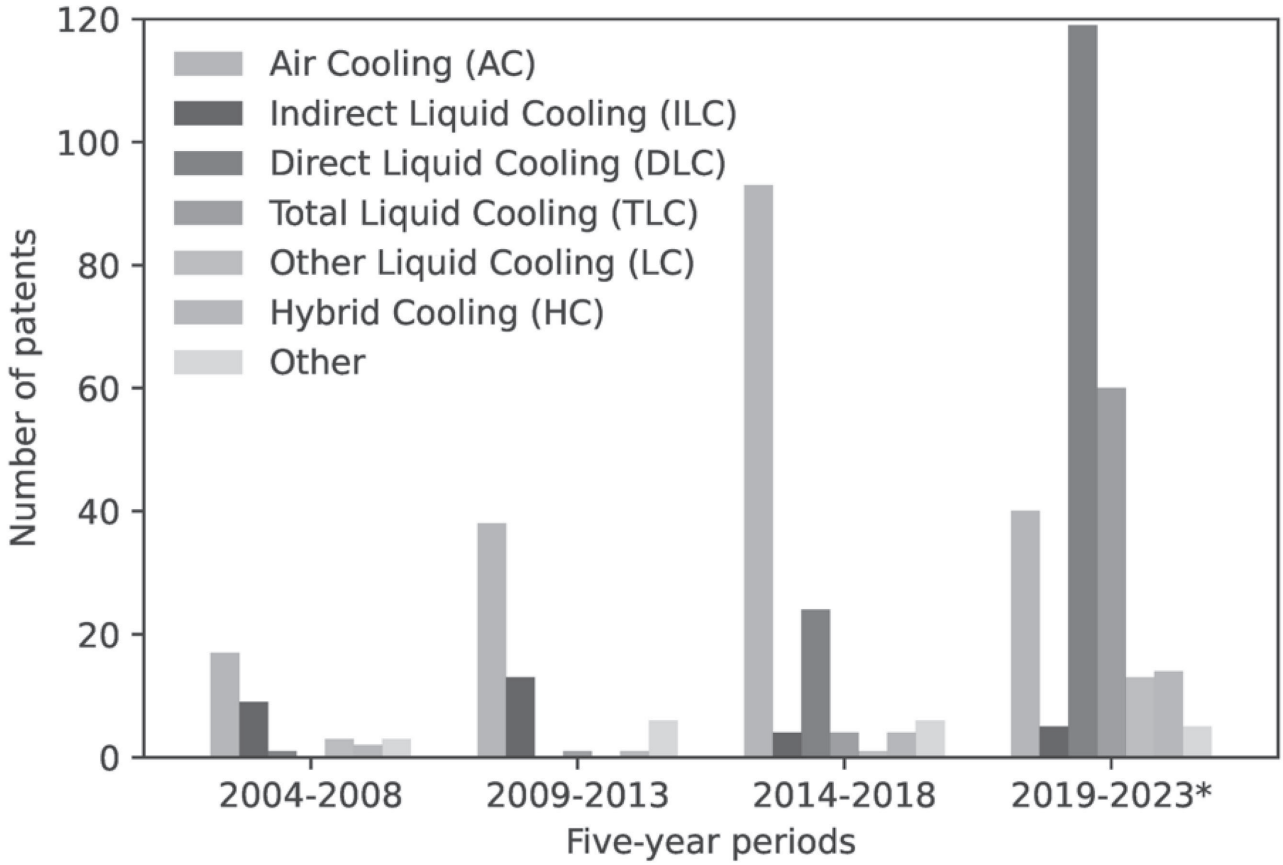
In our experience, a construction contract for a data center will need to be tailored on a case-by-case basis, to accommodate the specific requirements and risk appetite of the data center owners and investors whilst also reflecting market positions and the latest technical developments, with input from commercial, technical and legal advisors with real-world experience unique to the business and operations of data centers. There is no simple "one size fits all" solution, and each contract must carefully consider the specific project at hand and the parties involved.

SELECTING THE RIGHT PERFORMANCE CRITERIA

The specialist nature of data centers requires unique performance criteria in data center construction contracts (to the extent the contractor is commissioned to guarantee performance output levels, rather than to simply construct based on data center owner design). These include:

- Equipment Cooling: The high-capacity, high-speed data processing requirements of modern data centers translate to extremely high temperatures in the IT equipment which, if not managed properly, can lead to performance degradation and equipment failure. The energy demand of cooling equipment in data centers can account for up to 50% of its total energy demand (excluding the energy demand of the IT equipment), making efficient cooling technology key to improving the data center's overall energy efficiency. The increased demand for data centers in recent years has been accompanied by a corresponding increase in global patent registrations in the field of data center cooling, as can be seen in Table 1.

Table 1 — Patents in the field of data center cooling by technology in five-year periods, between 2004 to 2023.[1]



The increased demand for data centers has also led to capacity issues and extended lead times for cooling equipment suppliers. Given how important effective cooling equipment is in the performance of data centers, data center owners and investors need to ensure that they have a robust cooling equipment procurement strategy in place prior to making other contractual or financial commitments, and that producers' lead times are factored into their overall construction programmes.

- *Ambient Temperature and Humidity*: According to widely-accepted industry standards, the recommended ambient temperature for data centers is between 8 to 27 degrees C (64.4 to 80.6 degrees F) and the recommended ambient humidity is a dew point temperature range of -9 to 15 degrees C (15.8 to 59 degrees F), with relative humidity ranging from 50% to 70%. Ambient temperature is important for aiding the cooling of the IT equipment, and humidity control is important as high humidity levels can cause condensation whilst low humidity levels can generate static electricity, both of which can cause critical equipment failure.
- *Power Consumption*: Many data centers require upwards of 100MW of power, with some hyper scale data centers now

reaching upwards of 1GW, and these numbers are increasing year on year. Such increasing energy demand of data centers is driven mainly by the increase in data center size and capacity, which require (i) increasing numbers of servers and cooling equipment, and (ii) higher performance servers. In addition, modern data center equipment requires such power supply to be provided on a 24/7 basis, with little to no voltage fluctuations. To offset the enormous amounts of energy required by the IT equipment, data centers should be designed to try to minimize energy consumption in the rest of the facility. This is not only to bring down operation costs, but also to ensure the constant availability of sufficient power to the IT equipment. The data center industry uses a metric called Power Usage Effectiveness (PUE), which is calculated by dividing total energy consumption of an entire data center facility by the energy consumption of its IT equipment. Modern data centers should aim to have as low a PUE ratio as possible, and ideally below 2.

SITE SELECTION

Site selection for a data center involves a rigorous assessment of a variety of factors. Key considerations include:

- Utilities connections, in particular to a stable energy grid;
- The physical environment, in particular temperature and humidity;
- Network latency (the "ping rate") based on proximity to local end users who require high-speed data flow for machine-to-machine communications;
- Availability of land to accommodate expansions (and any captive power generation systems);
- Physical security which, in conjunction with the cybersecurity measures, provide the highest levels of data protection possible;
- Transport connections, for ease of shipping data center hardware as well as for workers' transportation;
- Remoteness from affiliate data centers and end users to reduce the risk of disasters, blackouts, etc. causing total data loss or IT service outage;
- Availability of qualified contractors and workforce; and
- Favorable political and legal environment.

A robust site survey should be an essential part of the prefeasibility study for any data center project.

SPEED TO MARKET AND SUPPLY CHAIN MANAGEMENT

There is increasing focus on speed to market in data center development projects, as businesses try to keep up with their unrelenting data processing needs and stay ahead of the competition. Simultaneously, the number and scale of new data center projects is on an exponential trajectory, with many developers now developing multi-facility campuses, multi-site data center networks and/or hyperscale facilities, leading to increased competition to secure top tier contractors and critical IT equipment manufacturers/suppliers. There are a

number of ways in which data center owners and investors can look to achieve fast project delivery in such a market environment:

- Entering into framework agreements with contractors and engineers (particularly if planning to build multiple data centers), to remove the need to negotiate multiple bespoke agreements, especially if multiple projects are being delivered. This also helps create (and maintain) competitive tension between multiple contractors and suppliers;
- Opting for an EPC contract (rather than a D&B contract), with well-defined deliverables and a full turnkey solution;
- If a proven design is available, keeping the design uniform from project to project as much as possible; and
- Establishing supply chains for critical IT equipment by directly entering into agreements with the suppliers on a framework basis. This will allow the data center owner to procure the equipment themselves then either (i) provide the equipment to the build contractors as free-issue materials, or (ii) designate the suppliers as nominated subcontractors (which will also require corresponding provisions in the framework supply agreements).

COMPENSATION MODEL

In our experience, smaller data center projects, such as data centers for commercial cloud services with construction cost of less than 500 million USD, tend to be procured on a guaranteed maximum price model whereby the contractor absorbs all additional costs of beyond a pre-agreed maximum price. Large-scale AI and/or hyperscale data center projects in the five to ten (plus) billion USD range, on the other hand, may use a combination of pricing structures for different contract packages. For example, the most critical parts of the data center (where the hyperscaler has more experience (and in-house capability) and wants more transparency) could be procured on an open-book global maximum price basis, while associated civil works and other ancillary infrastructure could be subject to lump sum payments pricing.

Another model that we see gaining traction is the "build-to-suit lease." In this case, the landlord builds (to the tenant's specifications) and leases the data center facility. The construction costs are built into the periodic lease payments to be paid by the tenant under the lease. The lease is usually long-term (i.e., 15–20 years) to enable the recovery of the construction costs through the rent payments, including post-commercial operation.

NOTES:

[1]Analysis of Cooling Technologies in the Data Center Sector on the Basis of Patent Applications. Energies, Ott, B.; Wenzel, P.M.; Radgen, P.,2024, https://doi.org/10.3390/en17153615.