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Mission Critical Facilities

PAYGO for Data Center -- Modular Infrastructure

Introduction

The infrastructure costs for Data Centers are increasing at a significant pace. Construction costs and their environmental impact are also soaring. The traditional Data Center infrastructure solution is not practical for all clients and needs. This white paper explores an alternative to traditional Data Center infrastructure. The application of a modular M/E Plant can provide a cost effective solution that reduces risk to the client while maintaining system availability. This white paper will also discuss the topology of the Data Center infrastructure approach and various system options. This approach to modular infrastructure can be applied to traditional white space or containerized IT equipment.

Mechanical

The mechanical system infrastructure for a typical large-scale Data Center usually consists of water-cooled centrifugal chillers piped in parallel, complete with a primary/ secondary CHW distribution system. The condenser water system typically consists of cooling towers, constant volume pumps, and a reliable source of make-up water. Chemical treatment and filtration of the condenser water are also critical components relative to the maintaining the reliability of this system. For most applications, the mechanical infrastructure needs to be developed and/or installed to accommodate the final build-out capacity for the Data Center. That is to say, the equipment room space must be reserved, and full-size distribution headers must be provided complete with necessary valving to facilitate the installation of future equipment on a live system. This can result in an initial Capital Expense (CapEx) that far exceeds the initial demand of the facility.

Traditional centrifugal chiller plant

Using a modular approach to the mechanical system infrastructure, several advantages can be immediately realized. Perhaps most importantly, this modular approach allows the Owner to purchase only the infrastructure needed to support the current load. As the load increases over time, additional infrastructure can be provided independent of the existing configuration – reducing the risk of live tie-ins within an active Data Center.

By utilizing a modular air-cooled chiller configuration, the entire condenser water system can be eliminated (i.e., cooling towers, condenser water pumps and associated piping and valves, make-up water, filtration system, chemical treatment, and controls). Furthermore, the building footprint can be dramatically reduced by minimizing the amount of space needed for mechanical equipment. By utilizing modular air-cooled chillers with integral Variable Speed Primary (VSP) pumps, the resultant mechanical room space required is a mere fraction of that required for a conventional water-cooled central plant.

Operational Expenses (OpEx) can also be reduced by maximizing system efficiencies. Despite the higher chiller IPLV ratings (when comparing modular air-cooled chillers to water-cooled centrifugals), it is important to analyze the energy demand for the entire chilled water/ condenser water system. The modular approach eliminates the need for the following motor energy demand: tower fans, condenser water pumps, condenser water make-up, and side stream filtration. In addition to this reduction of equipment, the modular chiller packages can also be provided complete with integral free-cooling modules. Typically, these chillers are capable of producing 100% of the design capacity without the need for compressors whenever ambient temperatures are below 45F db.

For large chilled water systems with primary / secondary pumping, the chillers, cooling towers, condenser water pumps, and primary CHW pumps are not typically on UPS power. Instead, only the secondary CHW pumps and CRAH units are fed from UPS power to maintain some level of continuous cooling (in conjunction with a CHW storage tank) in the event of a utility outage, while the larger equipment remains de-energized until the engine generators have started and restored power. For smaller systems, the use of standard air-cooled chillers is often done at the expense of continuous cooling. As this white paper will continue to point out, the proposed modular approach to the system infrastructure will eliminate this need for complexity. Instead, a loss of power will trigger a single generator to energize, and with this simplified configuration, back-up power will be available within a matter of seconds, restoring power to the chillers and pumps. Unlike typical air-cooled chillers which could require a delay of up to 3 minutes before restarting, the modular chillers being proposed are capable of restarting as quickly as 15 seconds.

Electrical

The electrical solution to modular Data Center requires simplifying the costly and failure prone components in the electrical infrastructure. The modularity of the electrical infrastructure should be scaleable and flexible, to provide the availability and capacity needed for the modern Data Center. The major components for electrical distribution are conditioned power source for the IT equipment, on site generation for prolonged outage, and distribution system to deliver power to the key components such as HVAC and IT load.

Modular chiller plant

To increase the reliability of the system, the philosophy of “less is better” should be applied. Every additional component that is added, above that which is required, adds some level of additional risk of failure. The modular Data Center approach simplifies the distribution from the UPS to the critical load by providing 230V to the rack and eliminating the Power Distribution Unit (PDU). The failure components associated with the PDU such as mis-operation of overtemp, EPO, improper coordination due to magnetization current, etc., can be eliminated altogether with this design approach. The output of the UPS directly serves the IT equipment via distribution breakers and panelboards. The elimination of PDUs in the data center also helps to decrease the CapEx and OpEx.

The conditioned power is provided from the UPS source in the module. The nominal UPS size of 1000KW (recommended useable of 900KW) is provided in the module. The output of the UPS module shall be 400/230V AC to maximize power supply efficiency. The higher voltage to the server power supply increases the efficiency of the electrical system. The increased efficiency at load is significantly amplified back to the utility grid. The UPS is provided with minimum runtime flywheel technology. The flywheel will provide sufficient power to allow for single (non-parallel) generator to come up to speed.

The generator shall be sized to meet the critical load and supporting mechanical/ building/structure loads. The generator source shall be provided with fuel capacity for extended outage. Since the generator is not paralleled and shall comply with NFPA 101 for emergency use, the generator will be in operation within 10 seconds, thus providing continuity to the UPS and the critical load.

The distribution system for the modular mechanical system will be provided in the same module as the UPS system. The output distribution to the mechanical system shall be 480/277V to the chiller and supplemental air handlers in the building/structure housing the IT equipment. The utility source shall be provided by pad mounted transformers to the UPS/Distribution Module. The utility metering shall be on the secondary side of the transformer at 480V/277V.

The Power Block (PB) is comprised of a generator module and UPS/Distribution Module. Each PB can deliver up to 900KW of critical load. The PB system is a standalone system, but scalable to allow for multiple PBs to be added to a site to increase capacity and/or redundancy.

The reliability and maintainability of the infrastructure is established at the system-level (not for individual components). Failure of a single component can affect the PB, but the system reliability is provided via redundant power blocks. This redundancy simplifies the complicated engineering design of the electrical system and minimizes field construction failures. The modules can be fabricated with standard “off the shelf” products, without the need for costly or complicated customization. The maintenance of the system is also simplified by having consistency between the modules.

The modular M/E Plant can be installed where 480V or 400V voltage is available from the utility company. The design solution and infrastructure capacity can accommodate national and international installation (becomes a shipping box). The block architecture of the modular system allows for flexibility in capacity growth and/or redundancy. The availability is provided via system-level redundancy, not component-level.

Conclusion

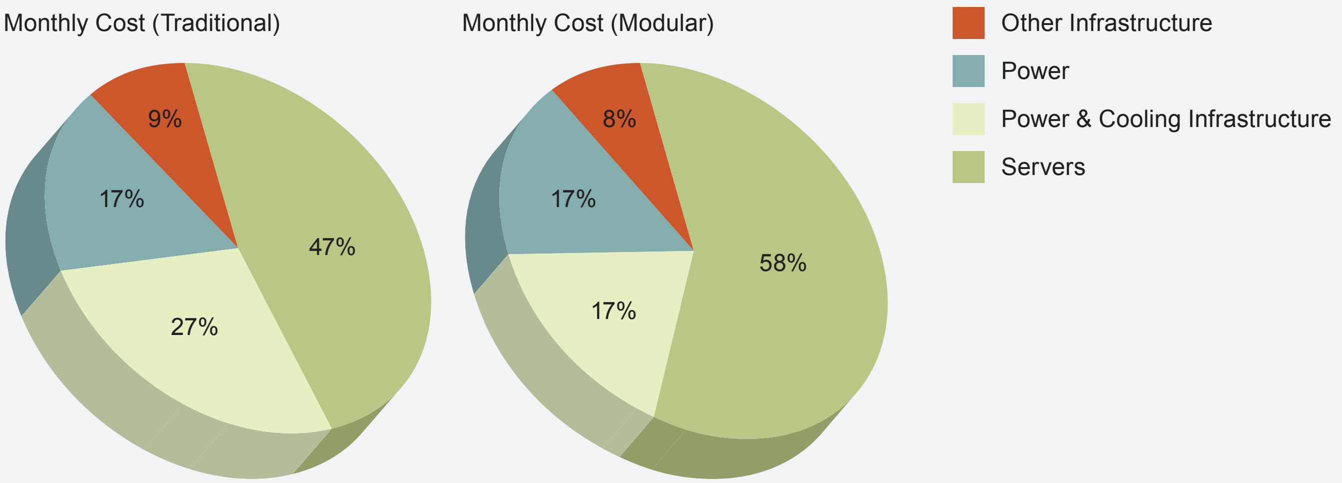
The construction risk is reduced by taking the most expensive parts of the Data Center infrastructure (equipment) and taking advantage of standardized off the shelf product. The modular infrastructure has benefits over traditional infrastructure space such as: reduced initial CapEx, reduced OpEx, and increased Energy Efficiency.

The CapEx is reduced by providing higher voltage distribution without transformation, less real estate within the building for infrastructure, and reduced installation labor at the site. The CapEx is further reduced by using “off the shelf” products, resulting in reduced complexity in design, and easier constructability. The connection between modules is limited to twisted pair for communication and limited power connection. The PB operates as a standalone unit without complicated controls and customization that is evident in most modern Data Centers. The ease of scalability also allows the Owner to buy only the infrastructure he needs, when he needs it – Pay As You Go (PAYGO).

The OPEX can be reduced by increasing the energy efficiency of the mechanical and electrical infrastructure and eliminating the need for such major components as PDU’s, cooling towers, condenser water and secondary CHW pump, etc. The use of standardized products and simplified control strategies also greatly reduce the mean time to repair and general maintenance requirements.

The efficiency is increased by utilizing free air cooling with higher temperatures for the UPS Module(s), in addition to the integral free-cooling modules within the modular air-cooled chillers. With the combination of efficiency gains from higher voltage distribution to the rack and higher inlet temperature to the rack, the PUE can be as low as 1.3.

Overall Data Center Costs 2700KW



1. 3 Year Server and 15 Year Infrastructure Amortization
2. 2700KW Critical Load

Modular Data Center Summary

Redundant Configuration

Pod Size (KW)	PUE Design	PUE Average	Site Load (KW)	CAPex ($ thousand)	Opex* ($ thousand)	Total** ($ thousand)
900	1.90	1.42	1797	$11,733	$130	$272
1800	1.92	1.45	3628	$18,345	$214	$498
2700	1.78	1.38	5089	$24,956	$261	$776
5400	1.90	1.46	10809	$46,580	$505	$1,356
6300	1.92	1.47	12695	$57,416	$617	$1,609
7200	1.92	1.48	14570	$63,643	$692	$1,826
8100	1.93	1.49	16478	$69,870	$768	$2,043

*Estimated Infrastructure Monthly Cost
**Total Monthly Cost For Data Center

About BKM Mission Critical Facilities

Established to meet the demands of mission critical facilities, BKM Mission Critical Facilities (BKM-MCF) is dedicated to the advancement of critical systems for data centers, network operation centers, and readiness centers. From a small LAN closet to a large Tier IV facility responsible for millions of dollars in corporate revenue, BKM-MCF understands the critical nature and value of keeping a company or agency online 24x7, 365 days a year. BKM-MCF provides energy conscious design for facilities with a need for high reliability. This engineering passion is expressed through the firm's elegant design solutions to solve the challenges faced by its clients.

About the Authors

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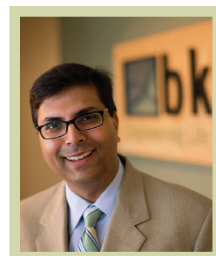

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