

TCO Analysis of a Traditional Data Center vs. a Scalable, Containerized Data Center

White Paper 164

Version 2

Energy Management Research Center

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Executive summary

Standardized, scalable, pre-assembled, and integrated data center facility power and cooling modules provide a “total cost of ownership” (TCO) savings of 30% compared to traditional, built-out data center power and cooling infrastructure. Avoiding overbuilt capacity and scaling the design over time contributes to a significant percentage of the overall savings. This white paper provides a quantitative TCO analysis of the two architectures and illustrates the key drivers of both the capex and opex savings of the improved architecture.

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Introduction

Power and cooling systems available now are more modular, more standardized, and more efficient than those installed in the majority of data centers today. Whether upgrading an existing data center or building a new one, data center managers will minimize both capital and operating expenses by specifying physical infrastructure with the following attributes:

- Standardized, pre-assembled, and integrated components
- Modular infrastructure that can scale as the load increases over time
- Efficient power and cooling components
- Cooling design with integrated economizer mode
- Pre-programmed controls

White Paper 163, [Benefits and Drawbacks of Prefabricated Modules for Data Centers](#), describes how standardized, pre-assembled, and integrated modules (sometimes referred to as containers) save deployment time and upfront cost compared to the same electrical and mechanical infrastructure implemented in a “stick built” manner with custom engineering and considerable onsite work.

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 current power and cooling distribution technologies, results in a TCO savings of nearly 30% over a traditional data center (27.2% capital cost and 31.6% operating cost).

Cost comparison

Figure 1 and Figure 2 illustrate a CAPEX difference of 27.2% and an OPEX difference of 31.6% between a data center with traditional infrastructure and operational practices, and a data center with facility modules designed and implemented with best practices. The “waterfall” charts break out how the 27.2% CAPEX savings and 31.6% OPEX savings are derived.

Figure 1
Breakout of major CAPEX cost savings when comparing traditional to modular

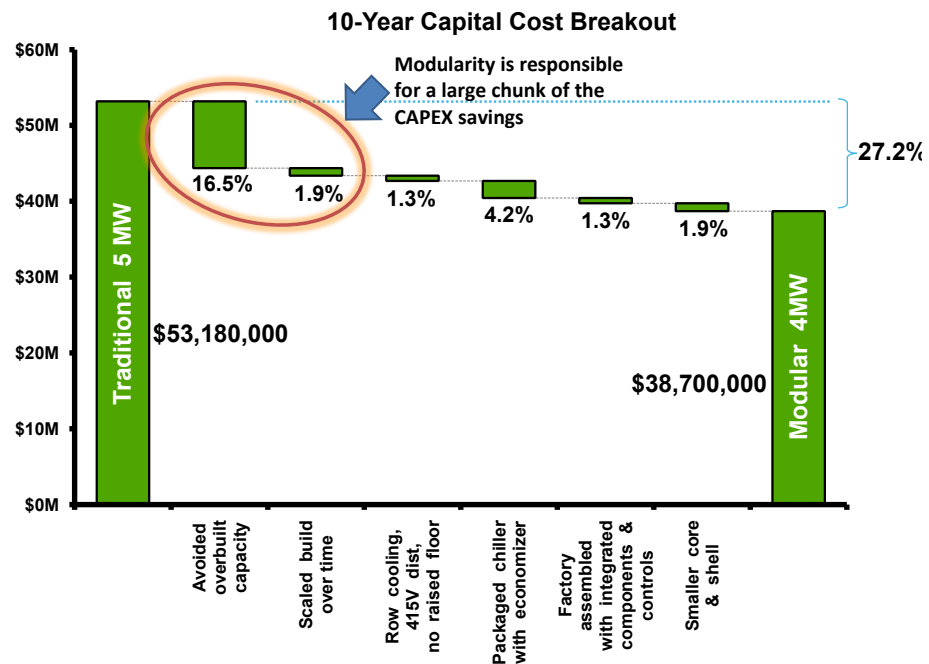
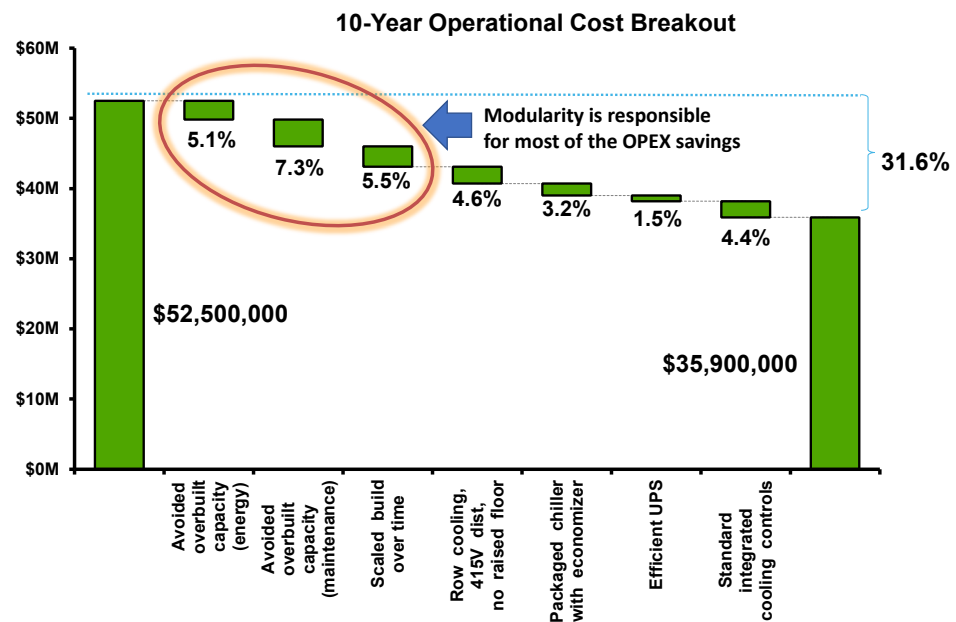


Figure 2

Breakout of major OPEX cost savings when comparing traditional to modular



Avoided overbuilt capacity and scaling the design over time contributes to a significant percentage of the total savings. White Paper 143, [Data Center Projects: Growth Model](#), provides additional information on the importance 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.

Avoided overbuilt capacity – When a data center is built out upfront, the designer plans for a worst-case final load because the 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 when the data center is built out to 4 MW instead of 5 MW. As the OPEX chart shows, there are both energy and maintenance cost savings. Note, although beyond the scope of this paper, there is additional value that can be quantified by implementing a predictive maintenance plan for prefabricated modules. See TradeOff Tool, [Prefabricated Data Center Service Contract ROI Calculator](#), to illustrate this value.

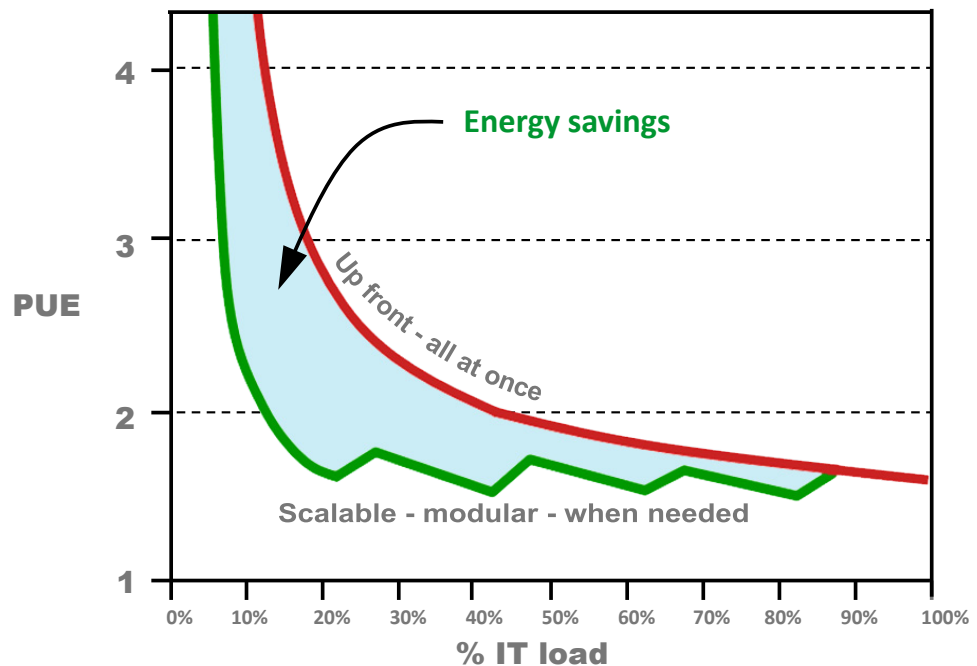
White Paper 37, [Avoiding Costs from Oversizing Data Center and Network Room Infrastructure](#), shows how the single largest avoidable cost associated with typical data center and network room infrastructure is oversizing.

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. As can be seen from **Figure 2**, there is capital cost savings of approximately 2% due to the cost of capital.

Figure 3 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 rightsizing is a key reason why the industry is moving toward modular, scalable physical infrastructure solutions.

Figure 3

Scalable modules allows for rightsizing which improves overall data center efficiency, measured as Power Usage Effectiveness (PUE)



Row cooling, 415 Volt distribution, no raised floor – Close-coupled cooling reduces energy cost (short cold air path to servers), 415 Volt distribution eliminates multiple 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 majority of medium and large data centers today rely year round on water-cooled chillers with cooling towers for cooling their data centers. The “packaged chiller with economizer” cooling architecture 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. White Paper 132, [Economizer Modes of Data Center Cooling Systems](#), describes in more detail the benefits of economizer modes.

Factory assembled with integrated components and controls (Figure 1 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, cooling towers, etc. is drastically reduced when standard modules are deployed.

Smaller core and shell (Figure 1 only) – Traditional buildings are designed with humans in mind. For this reason, electrical and/or mechanical rooms inside of a building may be specified to consume 4 to 5 times the floor space in order to meet local code requirements, compared to the facility module which is designed for infrequent human interaction. This extra space then requires more energy and more water to cool, heat, and ventilate the space. 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 per square foot (\$1076 - \$1,614 per square meter), this can result in significant savings.

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

Efficient UPS (Figure 2 only) – New UPSs approach efficiencies of 97% when operating at full load compared to 92% efficiency for typical UPSs at full load. This contributes to the energy savings of the improved design.

Standard, integrated cooling controls (Figure 2 only) – Cooling controls impact the effective-ness of the cooling plant and the operation on economizer mode. A design with standard integrated controls makes the operation of the cooling plant more predictable and reliable. Traditional cooling components are generally sized larger to account for the uncertainty of performance that result from unique systems with custom controls.

Assumptions

The key assumptions for the data centers illustrated in **Figure 1** and **Figure 2** 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 Capacity & Growth Planning Calculator](#) TradeOff Tools.

Attributes	Traditional Data Center	Modular Data Center
Location	St. Louis, MO USA	St. Louis, MO USA
Density	7 kW/rack	7 kW/rack
Initial load	1 MW	1 MW
Final maximum load (projected on day 1)	5 MW	5 MW
Final actual load	4 MW	4 MW
Day 1 capacity	5 MW	1.5 MW
Year 10 capacity	5 MW	4 MW
Module size	n/a	500 kW
Cost of capital	5%	5%
Cooling architecture	Chiller, cooling tower, no economizer, perimeter air handlers with raised floor	Packaged chiller, economizer with integrated controls, row coolers
Power architecture	92% full load efficient, non-scalable UPS, traditional distribution (480V to 208V)	97% full load efficient, scalable UPS, 415V distribution
Design/install approach	Upfront build, custom designed, field installed & integrated in traditional brick & mortar	Scaled & rightsized, standard, pre-assembled & integrated in shipping container

Table 1

Key assumptions of two data centers compared

Conclusion

Traditional designs almost always intentionally incorporate excess capacity upfront because subsequent expansion of power and cooling capacity is extremely difficult and costly in a production data center. This often has the effect of people being overly conservative in capacity planning which then results in higher upfront capital costs and a chronically inefficient data center. The proper deployment of facility modules, on the other hand, eliminate this wasteful oversizing tendency, because its standardized, modular architecture makes adding or reducing capacity to meet real-world, dynamic demand much easier. This, in conjunction with efficient, integrated power and cooling technologies results in TCO savings of 30% compared to a typical oversized data center operating today.

About the author

Wendy Torell is a Senior Research Analyst at Schneider Electric's Data Center Science Center. In this role, she researches best practices in data center design and operation, publishes white papers & articles, and develops TradeOff Tools to help clients optimize the availability, efficiency, and cost of their data center environments. She also consults with clients on availability science approaches and design practices to help them meet their data center performance objectives. She received her Bachelor of Mechanical Engineering degree from Union College in Schenectady, NY and her MBA from University of Rhode Island. Wendy is an ASQ Certified Reliability Engineer.

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