Engineering Simplicity

DAY ONE GREEN:
HOW TO EFFECT DATA CENTER EFFICIENCY AND A LOWER CARBON FOOTPRINT

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By David Owen

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How to Effect Data Center Efficiency and a Lower Carbon Footprint

Juniper Networks has been actively addressing the carbon challenge and its impact on climate since its founding and has focused on leading the industry in power per bit (Watts per Gb) networking bandwidth and features. As networking and computing became pervasive, the projection of power growth and the required ability of the power grid to support it, became known via the work done by Jonathan G. Koomey. During the 2010s, the Juniper power team became actively involved by participating in meetings hosted at LBNL Berkley, joining as an early sponsoring member of the Emerge Alliance (hVDC), participating in Green Grid as a sponsoring member, and attending many green energy conferences to understand various power distribution architectures already being adopted in the industry to reduce power consumption and carbon emissions.

While there are volumes of information available as well as professional services to conduct audits and help get you on the right path to reducing your carbon footprint, a good starting point being the Data Center Maturity Model (DCMM) which is developed and maintained by The Green Grid. The DCMM model is a good resource to audit existing infrastructure and find out where a facility is within the multi-stage roadmap to improved energy efficiency. The model covers all the multiple aspects of data centers such as power, cooling, compute, storage, and network. Evaluating this model can lead to a plan to improve energy while keeping the highest level of performance suitable for the needs of your organization and its available resources.

Okay, given my background in power engineering, let's look at a few best practices at how your power efficiency can be improved. Let's assume you just bought a company and the company came with an existing data center. You're asked to audit the data center to see if it meets the company's high levels of DCMM power efficiency.

You visit the DC site and find it contains multiple isolation transformers due to an infrastructure approach of continuing to add to existing structure and not having the ability to rebuild from a completely new design. This can be very common. The problem is that each isolation transformer has an efficiency loss associated with it and having multiple transformers in a series can lead to compounded loss. Even if the isolation transformers are not in a series connection, often they are operating at low load or unbalanced load. These small details can lead to lower efficiency. It is quite possible to have an efficiency of <90%. Table 1 provides efficiency data for transformers rated with an Energy Star rating or better. Low efficiency can easily occur in a Data Center that is expanded without careful planning and knowing beforehand the operating load and power balance in each transformer.

Table 1 *Knowing the expected loading of the transformer will determine the final efficiency.*

KVA (Three Phase)	NEMA TP-1 (Energy Star) Federally Mandated	NEMA PREMIUM CSL-3* Not Federally Mandated	DOE 2016 Standards Federally Mandated
15 kVA	97.0	97.90	97.89
30 kVA	97.5	98.25	98.23
45 kVA	97.7	98.39	98.40
75 kVA;	98.0	98.60	98.60
112.5 kVA	98.2	98.74	98.74
150 kVA	98.3	98.81	98.83
225 kVA	98.5	98.95	98.94
300 kVA	98.6	99.02	99.02
500 kVA	98.7	99.09	99.14
750 kVA	98.8	99.16	99.23
1000 kVA	98.9	99.23	99.28

Note: All efficiency values are at 35 percent of nameplate-rated load.

See NEMA TP-1 (or Energy Star labeled). On May of 2010, the NEMA CSL-3 standards were introduced with higher efficiency ratings than NEMA TP-1. The benefits of CSL-3 transformers are reduced electrical and heat losses, lower total cost of ownership (TCO), greater energy savings and green/LEED design.

Another best practice and important component in the data center power architecture is the Uninterruptible Power Supply or UPS. There are many types of UPS and the efficiency can range in early generations at 85% and up to 98% for newer generations. The efficiency depends on the UPS type and mode used and the characteristics of the downstream loads connected to the UPS.

Because the UPS has power loss, it is important to have only critical loads operating from the UPS. Basic lighting, air-conditioning, and other electrical needs for facility power and human comfort should not be powered from the UPS to avoid unnecessary power loss. It should only be used for critical loads, such as networking, server power, or equipment cooling.

It's recommended to use an Advanced ECO-Mode UPS, however it may not be possible to take advantage of the Advanced ECO-Mode UPS capability due to critical load transient behavior and ratings. A more modern Advanced ECO-Mode UPS can provide 94% conversion efficiency even in a full conversion mode that protects against voltage dips/sags, transient and interruption on the electrical grid/building inlet. There's more detail concerning Advanced ECO-mode UPS benefits and risks here: https://www.sourceups.co.uk/ups-eco-mode-the-benefits-and-risks/
Up until now the focus has been on a data center with sub-optimal efficiency, so what happens when you find the data center is already designed to be highly efficient. For instance, all the critical loads are powered by dedicated transformers and all non-critical loads, lighting, office air-conditioning, etc., are operating on separate transformers with the ability to minimize power use when not needed. A highly efficient data center is accomplished using networking connected power monitoring and power distribution equipment that is monitored in real-time and can be programmed to be turned on and off based on the need. So with this in place, the focus can be turned back to optimizing the critical loads' efficiency.

There are a few best practices to optimize these critical loads. One is to move to higher distribution voltage from 208/120 VAC to 415/240 VAC. This is well-documented in a white paper at Servertech. The idea is to take advantage of the end equipment power system rating that supports 100-240VAC input voltage. Efficiency gains are typically 2% from eliminating the PDU transformer and an additional 2% to 3% from running compatible IT devices at a higher voltage. Moving to 415/240 VAC can be done by limited engineering resources as discussed in the Servertech white paper.

Taking it a step further, companies with power engineering resources and with the ability to develop their own power solutions embedded into their server racks can use a few different strategies to eliminate the UPS and embed the backup into their server racks, as listed in Table 2. Some popular solutions are to use 480/277 VAC directly to the racks with 12VDC to the IT loads and internal battery backup to replace the UPS. Another is to use 48VDC followed by direct conversion from 48VDC to lower voltages required by CPUs or other chips. And yet another solution is to bring 3ph directly to the rack and into power supplies that convert to 12VDC or 48VDC to the IT loads. And a growing choice is to distribute 240VDC or 380VDC (hVDC) with battery backup at the 240V/380VDC rectifier and then distribute it throughout the data center to the IT equipment.

Table 2 *Juniper Networks advanced universal input PSM use cases*

PSM Input Source		Configuration	Availability	Efficiency	Comments
A	B				
208 VAC	208 VAC	Source A & B both Eco Mode UPS Full Conversion	Highest	UPS 94%, PSM 94% Combined 88%	Lowest Risk
240 VAC	240 VAC	Source A & B both Eco Mode UPS Full Conversion	Highest	UPS 94%, PSM 94% Combined 90%	Lowest Risk
240 VAC	240 VAC	Source A Eco Mode UPS Full Conversion Source B Advanced Eco Mode	Highest High	UPS 94%, PSM 96% Combined 90% UPS 97-98%, PSM 96%, PSM 96% Combined 93.5%	PSMs on Source B will experience a few milliseconds of distorted voltage with grid outage.
277 VAC	380 hVAC	Source A Advanced Eco Mode UPS Source B 380 hVAC with Battery	High HIghest	UPS 97-98%, PSM 96%, PSM 96% Combined 93.5% 380VDC hVDC 97-98% Combined 93.5%	PSMs on Source A will experience a few milliseconds of distorted voltage with grid outage.
380 hVAC	380 hVAC	Source A 380 hVAC with Battery Source B 380 hVAC with Battery	Highest Highest	380VDC hVDC 97-98% Combined 93.5% 380VDC hVDC 97-98% Combined 93.5%	Low Risk. 380 hVDC arc'ing resistance detection needs to be provided.

Juniper Networks supports these advanced design choices by using power supplies that support universal input voltage and can operate from 200-240VAC, 277VAC (hVAC), and 240/380 VDC (hVDC). By using a universal input power supply, administrators can operate routers and switches based on their choice of power distribution. Note uses 80Plus Standard Titanium efficiency: see https://en.wikipedia.org/wiki/80_Plus.

To summarize, for any serious discussion about data center efficiency optimization you should:

- Use the Data Center Maturity Model for evaluating an existing data cente.
- Understand the architectures and steps needed to move from a sub-optimal efficiency to a higher efficiency.
- If you are part of a large, dedicated DC power team, there are popular, purpose built, power architectures that can be adopted.
- Speak to your Juniper Networks account manager or Professional Services rep about universal input PSM use cases to support your preferred architecture to improve data center efficiency.

3100046-001-EN-Nov.2022