Green IT
UPS Efficiency and Cost of Ownership

by

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Executive Summary – For IT operations energy costs are an increasing concern. UPS efficiency has not been a focus in product specification and selection in the past. With new highly efficient true UPS becoming available such as Toshiba's G9000 Series it has become important to consider not only performance and first cost, but also efficiency. A Toshiba G9000 225 kVA UPS is used in this paper for a comparison versus traditional UPS designs. The surprising finding is that both at full load and at 20% load points on the UPS, the savings in operating cost over the product life is over $150,000. The savings realized actually justify replacing relatively new UPS systems of many manufacturers with a system such as the Toshiba G9000 high efficiency, high performance design. Also reasons for the typical data center UPS being less than fully loaded are presented.

Green IT – UPS Efficiency and Cost of Ownership

Energy costs are rising and it is unlikely per unit cost will decrease in the future. IT operating costs have become prominent as corporate and government users realize the high cost of IT operations. Focus has mostly been on server power supply efficiency, however, UPS efficiency is a worthy area of concern also. This paper addresses that concern regarding UPS systems and their effects on IT power usage.

Most data centers have one or more UPS systems. In normal operation utility power is delivered to the UPS input, converted to DC, reconverted to AC and delivered to the load by the UPS. That is the process that makes a UPS what is known as a "true on-line UPS". In a 480 volt building the voltage is stepped down to 120/208 via a transformer at some point. (As an aside, that step down is best done separate from the UPS which should always have the same input and output voltage. The IT center wants the stepdown external to the UPS to allow bypassing of the UPS in a failure or maintenance mode.) The process of converting the utility AC to DC and back to AC allows the UPS to develop and supply pure clean AC power, a primary benefit of a good UPS. A data center wants this clean power process even though there are losses in the process. More power must go into the UPS than comes out of the UPS otherwise a UPS would be a perpetual power device. If the AC-DC-AC process is 90% efficient, for every kW of load supported the UPS will require 1.11 kW of utility power input. The extra 0.11 kW becomes heat which usually is cooled by air conditioning. Cooling that 0.11 kW of heat typically calls for approximately 35%

more energy so the true energy required to deliver the 1 kW would be 1.15 kW. This is just an example of the efficiency process and calculation.

To provide real world figures, look at the new state of the art Toshiba G9000 UPS which is an industry leader in terms of performance and efficiency. A 225 kVA G9000 system has an efficiency at full load of 96.5%. Importantly, at partial load it maintains high efficiency. Real world loading of many UPS systems is relatively low as we'll address later in this paper. The 225 kVA G9000 when supporting only 20% load has an efficiency of 94.9%. The G9000 also is a technology leader and has very low inherent input current distortion of 3% at full load. Most industry UPS in this size range use a highly distorted 6 pulse SCR rectifier that has 30% distortion. To reduce the distortion those designs typically offer a capacitive input filter that wastes input power while reducing distortion typically to a 7 to 12% range at full load. The input distortion level is important for two reasons. First, UPS input distortion dirties up building power going to non UPS loads in a building. It can affect the air conditioning motors/drives, elevator motors/drives and electronics such as copiers. Second, input current distortion drives standby generators crazy. It is this distortion that causes the requirement to oversize generators for those types of UPS. I have brought up the input filter many UPS require as it affects energy need. This type of input filter typically has losses of 0.5%.

Published efficiency numbers for typical UPS at 225 kVA (a model 610 225 kVA) will be used as a real world comparison. At full load, without the input filter, the efficiency is published at 94%. Published input filter loss is up to 0.5%. Comparing the two systems at a 225 kVA/180 kW load using these published efficiency figures shows losses by the Toshiba at 6.5 kW and the losses by the comparison UPS at 12.5 kW. Adding real world air conditioning costs for cooling the heat finds Toshiba overall losses of 8.8 kW and the comparison UPS of 16.9 kW. The net savings using the more efficient Toshiba G9000 is 8.1 kW. That may not seem a large number but analysis shows it is a very significant number when operating cost is the concern. The typical life of a UPS is 15 years. Using 10 cents per kw-hr and 5% simple energy cost inflation per year results a savings of over $153,000 by using the higher efficiency G9000 UPS. In the first three years the savings is over $22,000.

Typically, data center UPS are not fully loaded. Therefore a comparison at light load is also required. The Toshiba G9000 has an efficiency of 94.9% at 20% loading. Most UPS manufacturers do not publish partial load efficiencies, likely because the numbers are significantly lower than full load values. A paper done by Pacific Gas and Electric Company reported measured efficiency of typical UPS at 20% load to generally be in the 75 to 85% range. For purposes of this paper we'll use 83% efficiency as the comparison value to be in the higher end of the range reported. The 20% load point based upon the Toshiba G9000 202 kW output rating would be 40 kW load. Efficiency losses of the Toshiba G9000 UPS at this load would be 2.1 kW. For the better than typical industry standard UPS the losses would be 8.2 kW. Adding in the cost of cooling the efficiency losses finds overall losses for the Toshiba of 2.8 kW and the typical UPS of 11.1 kW. The savings would be 8.3 kW. Thus at light loading the savings using the more efficient UPS is over $156,000 over a normal 15 year life. This actually is even more than at full load! What a surprising result!

The astounding finding above is that the operational cost savings when comparing 20% and 100% load points between a state of the art high efficiency Toshiba G9000 and a typical industry UPS ends in the same dollar savings. Over the product typical life, a savings of over $150,000 in operating cost will occur whether the system is fully loaded or only 20% loaded. Certainly that is not expected intuitively, but an engineering analysis shows that is the case.

What this means is, not only is it the wise decision to purchase the high efficiency system when looking for a new UPS, but also another realization can be made. Even if one has a brand new UPS such as the one used in this comparison, they will be ahead of the game if they replace that unit with a high efficiency unit such as the Toshiba G9000. The savings realized will quickly pay for the new UPS and the company will be dollars ahead in operating cost for years to come after the savings have already paid for the new high efficiency UPS!

(Pause to let that surprising fact sink in. The high efficiency UPS operating savings makes replacing a lower efficiency brand new UPS worth it!)

Even though the above shows loading may not affect the savings, it still is prudent to consider what are real world load levels for UPS systems and realize why they are the low? Most UPS are selected to carry future unknown load requirements. As servers and computers become more powerful the performance per kW increases with each generation of computer. Thus the future computing power does grow significantly but the electrical power need does not. A second reason for light loading is power system configurations which feed dual power supply servers. To have redundant UPS each server power inlet is powered from a different UPS. In a UPS or power supply failure situation each UPS has to carry all the server load. By design each UPS is less than half loaded in this configuration, and typically much less than half loaded. A third reason is parallel module configurations, in which a UPS plant has multiple UPS modules connected in parallel to add up to the required power levels. It is typical to have at least one module as redundant in what is known as an N+1 or N+2 design. The modules share the load in normal operation. Simple math shows the maximum loading in an N+1 configuration to be 50% and in an N+2 to be 66%. Again the actual load is usually much less. Further causing over sizing is that the person choosing UPS size, whether IT personnel or consultant, simply does not want to be responsible for an undersized UPS so it is natural that over sizing is done. One more cause is UPS are sometimes selected based upon adding up nameplate ratings from the IT equipment served. Actual draw is usually much lower than nameplate on IT equipment.

Conclusion

In conclusion, high efficiency and high performance are now available in the UPS industry. Individually tens of thousands of kw-hrs and dollars can be saved by their selection and use. As green product selection matures, new UPS systems can significantly help reduce user and world wide energy use. The surprising result of analyzing UPS efficiency differences is that a new UPS, such as the Toshiba G9000, results in so much savings that not only would it be a wise new purchase decision, but its savings makes it economically smart to change out even relatively new existing UPS modules of lesser efficiency.

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