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The Impact of UPS Efficiency

White Paper #7

Introduction

There is a lot of talk these days around efficiency. Replace your furnace, air conditioner, windows, water heater or car with a more efficient system and save big money. Perhaps Big brother is watching and he wants to tax you based on carbon footprint. The fact is there are a lot of reasons to replace old technology; parts availability, rising maintenance cost, yes efficiency, and of course reliability. After all, nothing last forever and especially something that runs 24/7 x 365, it will wear out, it will break, the only question is when. Although these are all good reasons the reality of our situation is that no one can open up the purse with out a good return on investment to justify the purchase. Unless you have a catastrophic failure and a system cannot be repaired there are always hoops to jump through, and shown your leadership the bottom line is always going to be the major hurdle. Our hope is that this document lets you know that you are not alone in this and that we understand what it takes to help you make your case to the decision makers.

UPS Efficiency

UPS systems have seen significant energy efficiency improvements over the past decade. Technology has not only improved efficiency and reliability but it has also reduced footprint. These advances can make it difficult to ignore the potential return on investment from upgrading a legacy UPS when the total cost of ownership is identified. This paper will look at a few of the efficiency advancements and provide cost saving examples. It is important to remember that the results do vary depending on site-specific variables such as power and installation cost. For the simplicity of this paper we will stick solely to electrical operational cost.

Historically, the flaw with UPS efficiency publications is the fact they are most often published at their 100% load rating. This is not an accurate way to view efficiency, because very few UPS systems operate at 100% load. The fact is even the most basic UPS is specified initially at the 50% load with the idea it can have load increases up to 80% before one should consider upgrading or adding on. In today's Mission Critical World chances are the system will be installed in a redundant design. In that case the UPS will never see more than 50% load in normal operation, most will run at 30% to 40% load. However, since most systems reach their peak efficiency at 100% load the manufacturers use that number to advertise with. What you need to know is what will the efficiency of that system be with YOUR load on it.

In figure 1 we have a chart which displays typical efficiency curves of older legacy UPS systems (UPS A), typical of systems built in the past 10 years. Then we have a “Semi-State of the art” (UPS B) modern design and finally the most recent State of the Art Transformer less Technology UPS (UPS C).

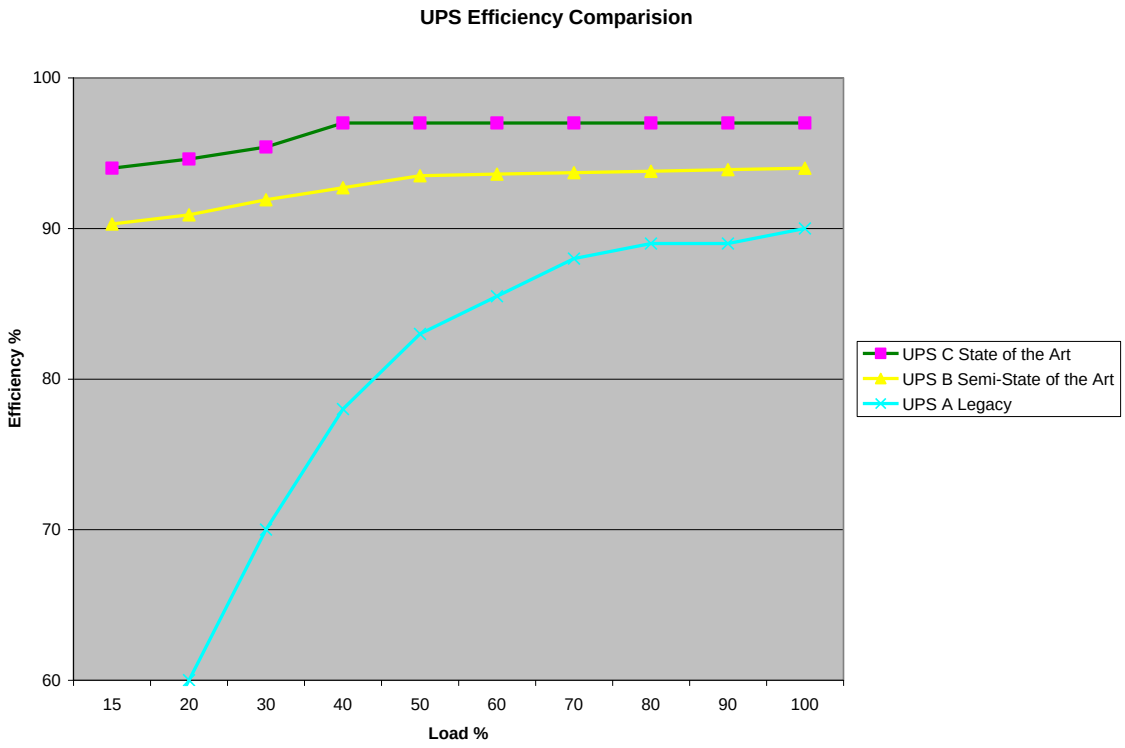


Fig 1

Note 2&3

Most of the legacy systems consisted of 6 pulse & 12 pulse rectifier technology and SCR or Transistor pack inverters. The technology that many OEM’s (Original Equipment Manufacturer) used with in the past 10 years consisted of the same 6 & 12 pulse rectifier with IGBT (Isolated Gate Bipolar Transistor) technology being infused into the inverter assembly of the UPS. However, there have been a few manufacturers that have been utilizing full IGBT technology in the rectifier and inverter of their UPS systems going back to the early 1990s.

If your UPS is made of typical legacy technology you can see that at 50% load there is almost a 10% delta in efficiency from a modern state of the art system. If you have a typical redundant legacy system you may be running in the 30% load range and your efficiency delta increases to almost 20%.

If the typical life of a data center is 10 years the efficiency of the UPS system being installed should be considered during the evaluation process. The fact is your UPS will have a higher operating cost than capital cost. With rising energy costs this decision could not only save you money but it may help you meet sustainable goals. Many times a 5% efficiency gain can have a savings of 18% to 84% annually depending on the load percentage of the UPS, the technology it is replacing and the local utility rates. The cheapest purchase price is not always the least expensive and it requires the buyer to be knowledgeable of the technology they are purchasing along with the return on that investment. Total cost of ownership and understanding all the components that make up that cost are essential to the purchasing decision.

Electrical Operational Cost Example:

Here are three different systems to compare. UPS A is a legacy system typical of most technology as new as 2008 and as old as 1990. UPS B is an example of a Semi-State of the art design utilizing an output isolation transformer. UPS C is a state of the art transformer-less design.

- UPS A = 225kVA .8 output power factor legacy UPS with 7% input harmonic filter and 6 pulse rectifier with input isolation transformer.
- UPS B – Semi-State of the art 225kVA .8 output PF UPS
- UPS C = State of the Art 225kVA .9 output PF UPS.

UPS A

The typical 225kVA / 180kW legacy UPS at 50% load (90kW) (See Fig 3) is operating in around 85% efficiency. The kWh/Y used by the UPS to support the load on this system comes to 927,529.41. Then you need to consider the kWh/Y for cooling, which will add another 371,011.76 kWh/Y, for 1,298,541.18 kWh/Y. (Note: A typical rate for estimating cooling power is, for each kW of power consumption used it takes 400w of power to remove the heat. In other words 40% of kWh consumed by the load)

This means that the electrical operation cost of the data center loads in this situation amount to $129,854.12 per year if the utility rate is $.10 per kWh. Of that amount $19,478.12 is wasted money on the UPS energy loss's due to the efficiency. (See Fig 2)

Note 9

UPS B

The same load on a 225kVA/180kW Semi-State of the Art UPS, will still be operating at 50% load (See Fig 3). However the efficiency is now improved to 92.7%. This system using the same calculations will bring your total electrical operational cost down to $119,076.96 per year with a savings of $10,786.16 per year since the UPS efficiency loss now only makes up $8,691.96 of the total electrical operational cost. (See Fig 2)

Note 9

UPS C

The same load on a 225kVA/202.5kW State of the Art UPS, will still be operating at 44% load (See Fig 3). Now you have added head room and the efficiency is improves to 96.5%. This system using the same calculations will bring your total electrical operational cost down to $114,379.27 per year with a savings of $15,474.84 per year since the UPS efficiency loss now only makes up $4,003.27 of the total electrical operational cost. (See Fig 2)

Note 9

Fig 2

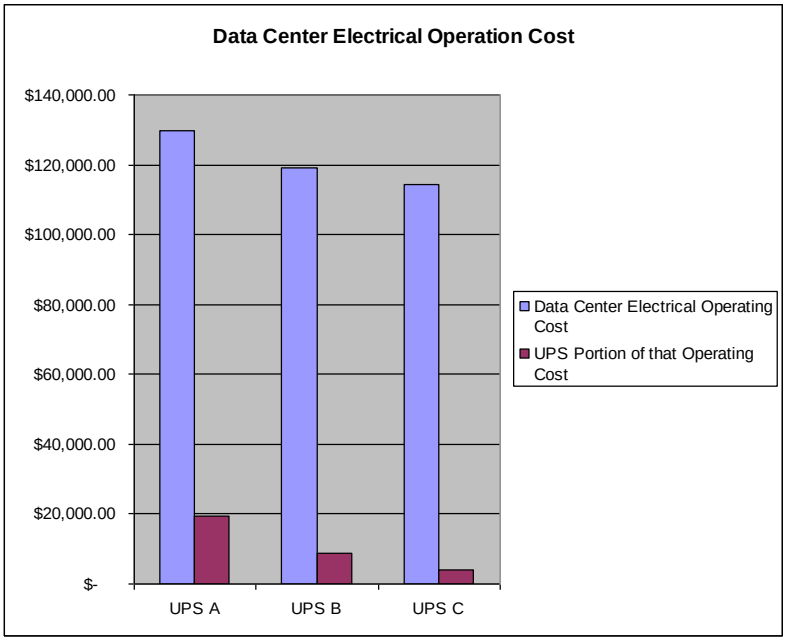


Fig 3 Capacity Vs Usage per UPS

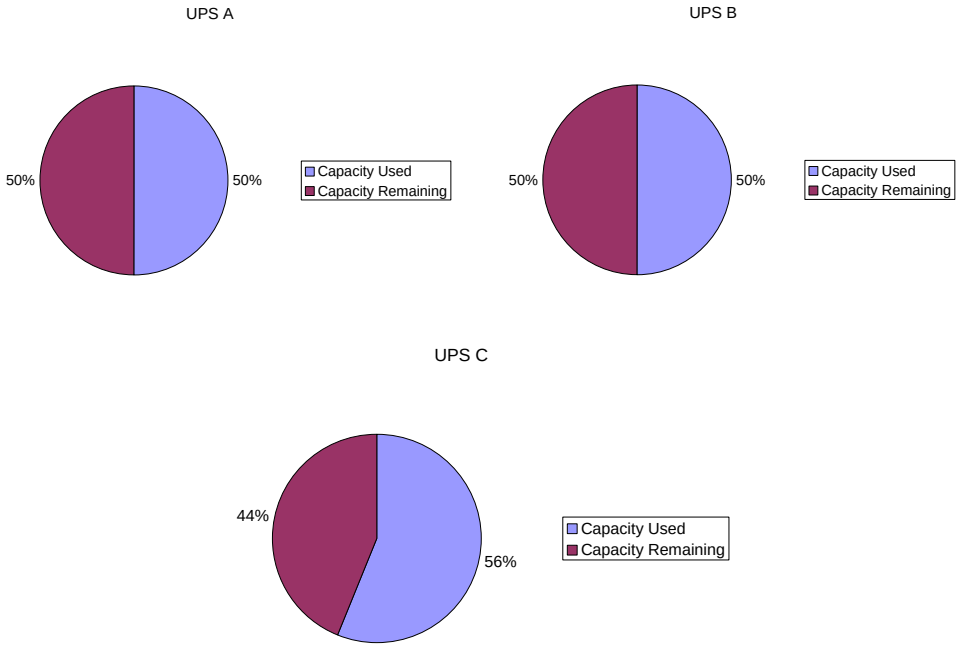
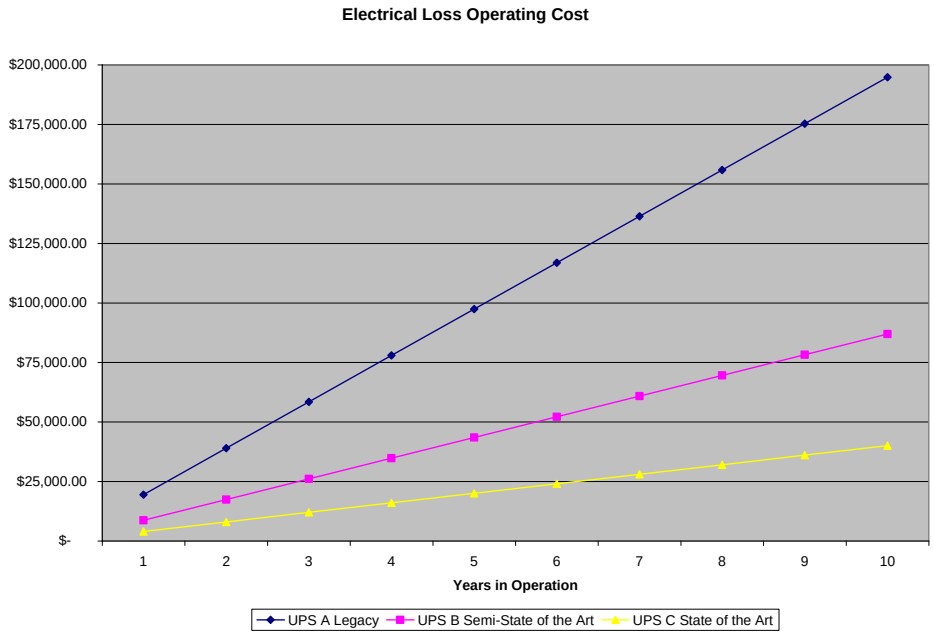


Fig 4: Ten Yr TCO on Electrical Operational Cost



Note 4 & 7

Total Cost of Ownership

The electrical operational cost while impressive still leave out the rest of the equation when it comes to justifying the investment in new technology. Things that need to be considered are any repair/maintenance items needed to keep the legacy system running. Here is a list of some of the basic items that need to be considered on your existing UPS system.

Fig 5: Legacy UPS Needs from CPSI TCO-ROI Tool

Pending Repairs and Maintenance Cost	
Cap Replacement	
Battery Replacement	
Fan Replacement	
Immediate Repair needs	
Total Repairs	$ -
	Existing UPS Contract $
Existing Full Service Contract Cost	
PM only Contract Cost	

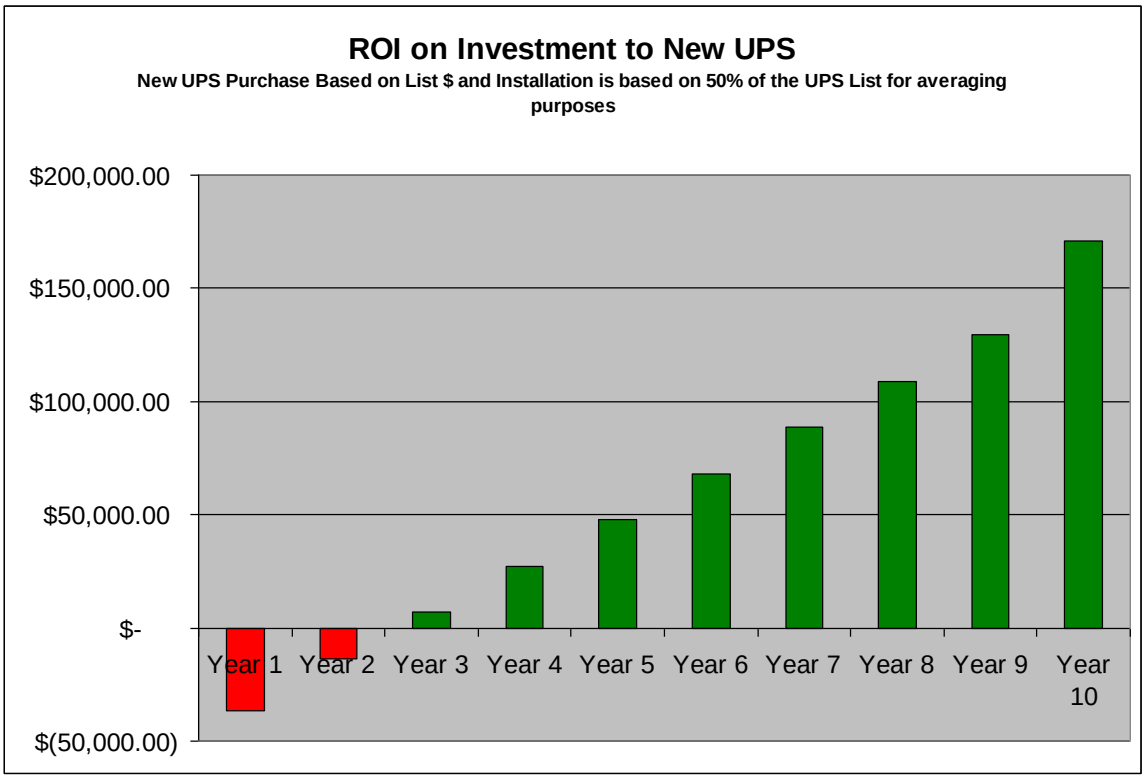
Then there are the things to consider with the purchase of the new UPS system.

Fig 6: New UPS Cost Factors from CPSI TCO-ROI Tool

New UPS Cost & Rebates	
New UPS Price	
Batteries	
Optional Maintenance Bypass	
DC Disconnect Option	
Parallel Switch Gear Option	
Communications Options	
Start Up Service	
Optional Acceptance Testing	
Installation	$ -
One Time Tax Rebates	
Energy Credits from Utility	
New UPS Installed Cost	$ -
	New UPS Contract $
PM only For Warranty period	
Full Service Post Warranty	

Hopefully when all is done and said what you should end up with is something that looks like this (Fig 7) which has factored in the maintenance contracts, repairs, purchase price, warranty, electrical operational cost, installation cost, rebates from utilities, tax breaks and if possible depreciation of assets that may be in place from a stimulus package.

Fig 7:



Note: This chart is from CPSI TCO-ROI tool and was an example for a customer looking to replace a legacy system which was grossly oversized with a right size solution of the latest State of the Art Technology 225kVA UPS. This was a very conservative estimate and in reality we expect they will see a cash positive ROI after the first year since this is replacing a 500kVA system.

Conclusion

In most cases the UPS will pay for itself two or three times over during the course of a 10 year period based on this electrical rate of $.10kWh. Based on our experience most returns on investment are met within 2.5 years or less with customers who have upgraded from legacy technology. An interesting perspective I found doing this exercise is the significant savings between the Semi-State of the Art system which was the energy efficient leader and the latest State of the Art Technology. There is a 3.8% efficiency gain but that resulted in 50% less wasted energy. Even when two high efficient machines compete with each other you can see the long term savings are significant. However great care should always be placed on reliability, quality and support for a product. Note 8

There are many reasons to consider replacing your legacy UPS, rising maintenance and service fees due to availability of parts, reliability, growth issues, load reduction issues. However, if you can identify the lost income that your system is costing you then you have evidence to move forward with replacement.

This example is based on conservative numbers we have had customers who down sized their older oversized legacy UPS systems that have seen ROI that turn a profit within a year in some situation. Every UPS installation is unique and will yield different results. In our experience it is worth evaluation.

Reference Notes:

1. Mitsubishi Document 2004/04/19 ALN_H0824_IGBT.doc
2. Efficiencies of legacy units and modernized conventional units are based on averages of multiple brands and do not represent any one brand. Information was gathered from specification guides, brochures, and 3rd party field engineer service reports and site survey forms.
3. Mitsubishi numbers are based on an efficiency calculation tool provided on their engineering disk
4. Further gains are also made with the new IGBT converter technology UPS units due to the input power factor improvements over legacy UPS systems. Those gains are not taken into consideration for this paper.
5. This paper is not intended to endorse any one brand over another.
6. CPSI is an authorized value added reseller and service provider for many brands of UPS, Power Distribution, Parallel Switch Gear, HVAC & Generator products.
7. This chart only represents electrical cost savings, for total cost of ownership maintenance & repair cost and options should be considered.
8. The type of load being supported always needs to be considered when choosing the proper technology of a UPS system. Certain loads may warrant technology that is not as efficient but can handle their unique demands.
9. The typical way of calculating UPS efficiency is to measure the true input kW consumed versus the output kW delivered to the UPS. The difference is the loss kW which is represented in heat output. For the purposes of this paper a calculator tool designed by Mitsubishi was utilized to provide the values used in the example portion of this paper for the State of the Art Technology UPS and the Semi-State of the Art Technology.