whitepaper

RUNNING A UPS IN ECO MODE

INTRODUCTION

With energy savings never far from the top of most data centre operators' and facilities managers' minds, UPS manufacturers continue to develop ever more efficient models.

Many modern uninterruptible power supplies can reach efficiency ratings of up to 97% even in double-conversion online mode. While most manufacturers now provide versions featuring "economy" operating modes offering enhanced efficiencies.

This whitepaper explores the broader concept of UPS efficiency before outlining how these ECO operating modes work.

It goes on to examine whether the energy savings they deliver are worth the corresponding trade-off in reliability and protection.

WHAT IS UPS EFFICIENCY?

UPS efficiency relates to the ratio of power entering the UPS to the power exiting to supply the load. Whenever current passes through the components of the UPS, a certain amount of energy dissipates as heat and sound, resulting in energy losses.

For example, a UPS with a 95% efficiency rating has 95% of the original input powering the load and connected equipment, with the remaining 5% energy "wasted" operating the UPS itself.

Advances in UPS design and technology over recent decades have seen efficiency ratings increase significantly. For example, typical online UPS efficiency has risen from 85-90% to more than 95%.

The efficiency ratings manufacturers publish tend to be based on running in online mode and depend on the peak of the efficiency curve, which can be anywhere from 30% through to 80% load.

As a general rule, as the load changes so too does the efficiency. Compared to UPS of the past, most modern transformerless models of today have a far flatter efficiency curve and are still capable of high efficiency (>95%) even at loads of just 20-25%.

Over the course of a UPS's service life (approximately 10-15 years), even a 1% or 2% improvement in operating efficiency can add up to substantial energy savings.

In addition to the financial benefits, higher UPS efficiency also has a positive environmental impact, helping to reduce CO_2 emissions and energy consumption.

WHAT IS ECONOMY MODE?

Virtually every double-conversion online UPS system today offers users the choice of a dedicated economy or energy-saving mode.

For the purposes of this whitepaper, we'll refer to this operating status as ECO mode, although it is also commonly referred to as "high efficiency mode", "bypass mode", "energy saving mode" or "active standby".

Standard ECO mode operates in a similar way to an offline/standby UPS, where the inverter is switched off and on standby while the bypass line (i.e. raw mains supply) powers the load.

If there's an issue with the mains, the load experiences a fractional break in supply while the automatic bypass transfers it back to the inverter.

The main benefit of running in ECO mode is a major boost to UPS efficiency, which means a reduction in electrical losses.

Typically, operating in ECO mode increases UPS efficiency to more than 99% compared to 93-97% for systems running in online mode. So that's a difference of anywhere between 2-6%.

Studies show that a data centre running their UPS in ECO mode can save as much as 2.3% of their energy per year. For a 1 MW data centre carrying a 50% load paying £0.10 kWh for electricity, that could equate to roughly £10,000 of savings a year.

Note that these calculations are based on the UPS running in ECO mode 100% of the time. If the UPS only operates in ECO mode for part of the time, the energy savings reduce proportionally.

In addition, some of the internal components inside the UPS's rectifier and inverter are less stressed during ECO mode operation, reducing natural wear and tear and increasing their lifespan.

DRAWBACKS TO USING ECO MODE

The major shortcoming with ECO mode is that the IT load is completely exposed to the raw mains utility without any of the power conditioning provided by double-conversion online UPS.

If there's a clean and stable mains supply and low harmonic generating loads, ECO mode works with relatively little risk. But if there's any issue with the quality of the mains, then it could cause big problems.

In ECO mode the UPS needs to continuously monitor the mains and quickly switch back to the inverter when it detects a problem.

Whenever there's an issue with the raw supply, the UPS must go through the following process:

- Detect the power problem
- Determine whether and how to respond
- Energise the inverter
- Open the static bypass switch
- Transfer the load onto the inverter output

All of this takes time. While in practice this process may only take between 1-16 milliseconds, that's vital time during which the critical load is subjected to the power problem.

And while a typical server may be able to override even a 16ms loss of power, just an 8ms loss to a transformer can cause it to surge when voltage is restored to normal levels, leading to it tripping breakers.

Similarly, power loss for even a few milliseconds on a circuit feeding a PDU with a static switch will result in a state change on that switch. This can lead to a wider state change on the overall power system, including overloads or dropped loads.

In addition, there are many devices, such as switches, pumps, or fans, that aren't as robust at handling short-term dips and sags as servers are. Finally, a typical static bypass will not open instantaneously. So even if the UPS detects a mains overvoltage, in ECO mode it can't protect the load.

As well as the loss of electrical protection, operating in ECO mode runs the risk of several other side-effects:

- **Harmonics** – in online mode, the UPS protects upstream loads and distribution elements from any harmonics on the mains supply, as well as isolating the mains from harmonics affecting the load. Running in ECO mode disables this function. Many data centres, hospitals, and industrial environments feature several motor drives for chillers, fans, and pumps that can cause harmonic distortion on the mains that shouldn't be passed to the critical load. Running in ECO mode also disables the power factor correction that an online UPS provides.

- **Thermal shock** – running in ECO mode requires the inverter to start in response to power effects. Whether this happens once a month or once an hour, the change in power to the inverter causes a shock to the system. Such thermal transients are one of the main causes of failure in electronic power systems. And in ECO mode, the thermal transient occurs at the exact time where the UPS needs to be at its most reliable.

- **Battery lifespan** – every time the inverter starts in ECO mode typically causes a momentary operation on battery. If these events occur every few weeks or months it wouldn't lead to any real problems. But if it's happening several times a day, that's unnecessary wear and tear on your batteries. And while in ECO mode the UPS should be generating less heat, that doesn't guarantee the batteries are running in cooler temperatures. If the UPS has internal batteries that are cooled by the fans, those fans are turned off in ECO mode so the batteries may actually face higher than normal temperatures. Obviously, this isn't an issue if the batteries are housed in separate cabinets to the UPS.

- **Fault clearing** – in online mode, the UPS quickly detects any faults on the output and switches to bypass to get the extra fault clearing necessary to open downstream protective devices. In ECO mode, however, it can be tricky to distinguish between an output fault and a loss of input power. For example, during an output fault, the UPS may detect a drop in input voltage and switch to inverter, which would increase fault clearing time and even expose the critical load to a momentary loss of power.

ACTIVE ECO AND SMART ACTIVE

In the last few years, advances in firmware control and electrical designs have led to the introduction of an additional operating mode: Active ECO (also known as Advanced ECO).

As with "standard" ECO mode, Active ECO sees the load powered through the bypass line i.e. the mains supply.

The big difference is that the inverter remains on at all times and runs in parallel with the input, without actually carrying the load current. Because the inverter is already "on", it can take over the load far quicker than standard ECO mode in the event of a mains failure.

Active ECO offers another advantage over standard ECO mode, namely power filtering. As mentioned previously, standard ECO mode doesn't offer any of the shielding from harmonics or power factor that you find in double-conversion online UPS mode. But with Active ECO, the inverter is on and connected to the output, enabling it to correct the waveform and power factor.

However, there is a trade-off when using Active ECO. Efficiency is reduced slightly by between 0.5-1% because the inverter circuit is on. Of course, this reduced efficiency is still higher than traditional online operating mode offers, so has come to be seen as something of a happy medium.

It's worth mentioning another operating mode that can help improve efficiency – Smart Active. This sees the UPS constantly monitor the incoming supply and automatically decide whether it's best to run in online or ECO mode depending on the state of the raw mains.

SUMMARY

ECO mode does have a role to play, but for mission-critical sites in particular, it should be used sparingly. A good example would be overnight or out of hours when a site's critical loads are inactive.

Another alternative use could be in a N+X parallel redundant installation. One of the UPS would operate in online mode as the primary unit, while the remainder run in ECO mode until they're required to actively support the load.

It's possible such advanced systems can increase their efficiency through cyclic recharging of the batteries, which allows the battery charge to degrade to a set level over a specific time period before applying a recharge.

In conclusion, running in ECO mode (or Active ECO mode) can undoubtedly deliver energy savings and reduce the overall Total Cost of Ownership (TCO) of the UPS.

There are some organisations, for example the non-profit industry body the Green Grid, which compare its use with that of free cooling within a data centre, taking advantage of low outdoor temperatures to cool the critical infrastructure.

However, ECO mode inevitably introduces a lower level of resilience into any critical IT environment, both in terms of inferior power quality for connected loads and slower transfer time to backup power in the event of a failure. This greater level of operational risk is why it isn't entirely fair to compare ECO mode to free cooling.

And with the risks seemingly outweighing any perceived rewards, many data centre operators and plant owners are still reluctant to use it. However, the introduction of more sophisticated alternatives such as Active ECO, which mitigate the risks whilst still delivering higher efficiencies, offers something of a happy medium.

Looking to the future, advances in UPS technology and efficiency are likely to reduce the energy savings associated with economy operating modes even further.

One example is the development of silicon carbide (SiC) semiconductors, which are far smaller and lighter than the silicon-based components typically used to manufacture UPS. SiC semiconductors are also capable of running at higher temperatures with less power and heat loss.

These qualities will enable UPS with SiC technology to achieve efficiency of up to 99% in true online double conversion mode across high and low loads alike.

Such performance will likely render ECO mode redundant as the UPS can deliver the same energy savings while also providing conditioned, reliable, and high-quality power.

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