Eco-mode: Benefits and Risks of Energy-saving Modes of UPS Operation

White Paper 157

Revision 3

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Executive summary

Many newer UPS systems have an energy-saving operating mode known as "eco-mode" or by some other descriptor. Nevertheless, surveys show that few data centers actually use this mode, because of the known or anticipated side-effects. Unfortunately, the marketing materials for these operating modes do not adequately explain the cost / benefit tradeoffs.

This paper shows that eco-mode provides a reduction of approximately 2% in data center energy consumption and explains the various limitations and concerns that arise from eco-mode use. Situations where these operating modes are recommended and contra-indicated are also described.

Schneider Electric

Introduction

The growing financial and environmental costs associated with the energy use of data centers and industrial applications has given rise to an appropriate drive to improve the efficiency of data center power and cooling systems.

Efficiency improvements – reductions in PUE for data centers – can be accomplished at a number of levels in the data center:

- Overall system architecture
- Scalable, right-sized system design
- Better efficiency of individual devices
- Operational decisions ⬅ Eco-mode is a benefit / risk decision here

This paper will focus on a particular technique for improving the operating efficiency of a double-conversion UPS by operating it in eco-mode. Eco-mode is a method of operating the UPS at reduced power protection in order to obtain improved electrical efficiency and save energy, and is marketed by vendors under a variety of names (see box, left).

This paper will address the following subjects

- What is eco-mode, and how does it work?
- What efficiency gains are possible and expected?
- Loss of protection and reliability associated with eco-mode
- Operational considerations

Eco-mode will save energy, although the amount saved is surprisingly small. In addition, the energy saved comes at some reduction in electrical protection and reliability. This penalty will vary depending on the design of the electrical architecture such as in a data center and on the UPS vendor's specific design approach used in implementing eco-mode functionality. Some data center operators or plant owners will decide the energy savings are worth the risks and potential problems, and some will not.

> ## > Eco-mode has many names
>
> **Technical names**
> - Bypass
>
> **Vendor names**
> - ECOnversion™ – Advanced Eco Mode
> - ESS – Energy Saving System
> - SEM – Super Eco-Mode
> - VFD – Voltage and Frequency Dependent
> - Maximum energy saving mode

Eco-modes described

Eco-mode is very similar to the basic mode of operation used in an offline UPS where it is called "standby" or "line interactive" mode[1]. In these traditionally smaller, single-phase UPSs, the inverter/rectifier circuits are "offline" or are not part of the normal power path. In normal operation, therefore, the load is exposed to essentially raw mains power from the Utility. This mode of operation is similar to what occurs with a double-conversion online UPS that is operating in traditional eco-mode.

All large double-conversion online UPSs are equipped with a "static bypass" path, which provides multiple features including acting as a source of redundancy for the UPS power inverter. This is shown schematically in **Figure 1**.

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[1] See White Paper 1, *The Different Types of UPS Systems*
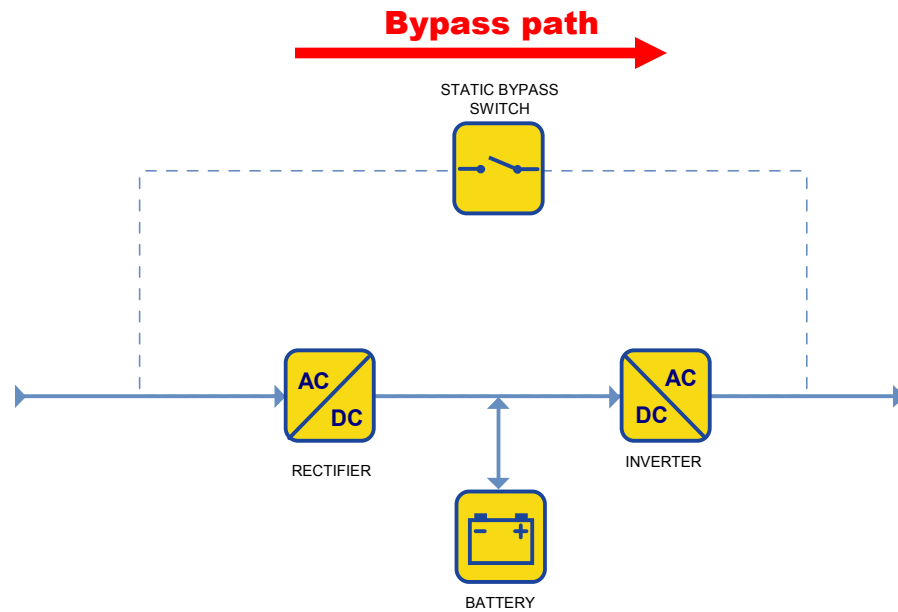
Bypass path

There are two main paths that can supply the load, the online (double conversion) path and the bypass path. Note that the load is connected to the raw[2], unconditioned mains power when the bypass is active. The following table shows when each path is used in both online and eco-mode operation:

Table 1

Power path used by a UPS showing differences of Eco-mode

	Online mode	Eco-mode	Comment
Normal operation	**Rectifier/Inverter**	**Bypass**	**Eco-mode exposes the load to raw mains**
During a power Disturbance	**Inverter**	**Inverter**	**Online mode requires no path change during power disturbances**
During a fault condition	**Bypass**	**Bypass**	**Extremely rare event**

Note that in online operation the UPS uses the bypass path only when there is a fault. In the life of the UPS, this is an infrequent event and may actually never happen. **Therefore, in online mode the critical load is not subject to power disturbances, even during a mains power problem**. In eco-mode, any mains power abnormality causes the UPS to switch power paths between bypass and inverter.

In online mode, the UPS continuously regenerates the output voltage. In eco-mode the load is normally powered by the bypass path, allowing raw mains power to supply the load, and the UPS inverter is engaged only when the utility mains fails. In eco-mode the UPS inverter

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[2] The term "raw mains" in this context means power that has the same voltage, waveform, frequency, grounding system, and impedance as the mains. Note the mains itself may have some parallel protection such as surge suppression. In some cases a transformer is added to the bypass path, which changes the ground system and impedance, but not the waveform or frequency. A UPS may also have output capacitors present between the voltage phases or between phase and ground; such capacitors do provide some filtering of high frequency noise, but do not correct frequency, voltage, or waveform; in fact they can actually make voltage distortions worse by adding resonances like those seen in the later **Figure 2**.

operates in a "standby" mode. In principle, this is a simple change in the control software of the UPS. However, the reality is considerably more complex as explained in the later sections of this paper.

The benefit of eco-mode is that the efficiency of the bypass path is typically between 98.0% and 99%, compared to the base UPS efficiency of 94% to 97%. This means there is a pickup in UPS efficiency of between 2-5% in UPS efficiency when eco-mode is used.

The cost of eco-mode is that the IT load is exposed to raw utility mains power without the conditioning normally provided by the double-conversion, online UPS. The UPS must continuously monitor the mains power and quickly switch to the UPS inverter when a problem is detected, before the problem can affect the critical load. This may sound simple, but actually is quite complicated and entails a number of risks and has some potentially undesirable side-effects, as explained later in this paper. An example of an output voltage waveform of an actual UPS with eco-mode responding to a power failure is shown in **Figure 2**.

Figure 2

Output voltage waveform of a 275 kVA UPS in standard eco-mode responding to a power failure

Upper waveform is output voltage, lower waveform is output current
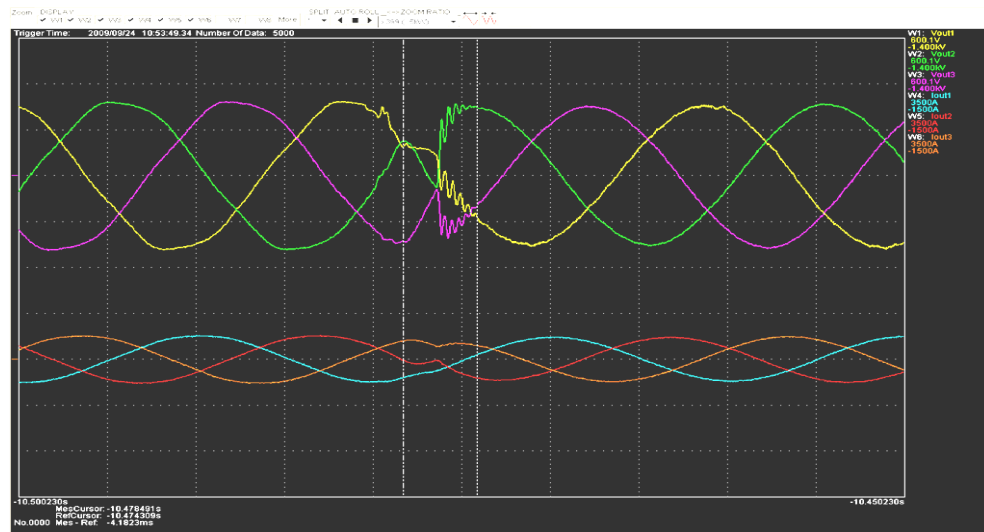
Note that this vendor claims a detection and transfer time response of 1.2 milliseconds to a power failure – performance that is clearly not attained in this example.

It is important to note that different vendors implement eco-mode differently. There are variations in the way the system operates the standby inverter. There are variations in the way the mode is enabled, where it will revert to normal UPS mode under various conditions. Some vendors claim to have special patented ways to control their transfer switch. But they all have the same basic concept of exposing the critical load to unconditioned power and transfer events in return for a small percentage gain in efficiency. However, depending on how eco-mode is implemented by the vendor, the degree to which the load is exposed to raw mains can be significantly minimized.

Advanced eco-mode

In standard or "classic" eco-mode, as described above, the UPS inverter is essentially off. If there is a utility power failure when the inverter is in standby, then both the UPS's output voltage and current waveforms will be negatively affected as shown in **Figure 2**. It takes time for the UPS to detect the failure, turn on the inverter, and supply clean power to the load from the batteries. This transfer time is what, in large part, allows the input disruption to briefly reach the output of the UPS. However, it has been possible to greatly reduce this and other negative effects of standard eco-mode. Advances in firmware control schemes and electrical

design has led to the creation of what is known as "advanced eco-mode". This form of eco-mode is available in varying degrees from a few UPS vendors today.

In advanced eco-mode the primary power path during normal operation is the same as standard or classical eco-mode: through the bypass path. But with advanced mode, the inverter remains "on", operating in parallel with the input without actually handling the load current. Since the inverter is already "on", it can more seamlessly take over the supply to the output where there is a mains failure. **Figure 3** shows an example comparison of the output voltage waveforms between standard and advanced eco-modes. It clearly shows the reduction in disruption that any connected loads would be exposed to in the event of a power failure.
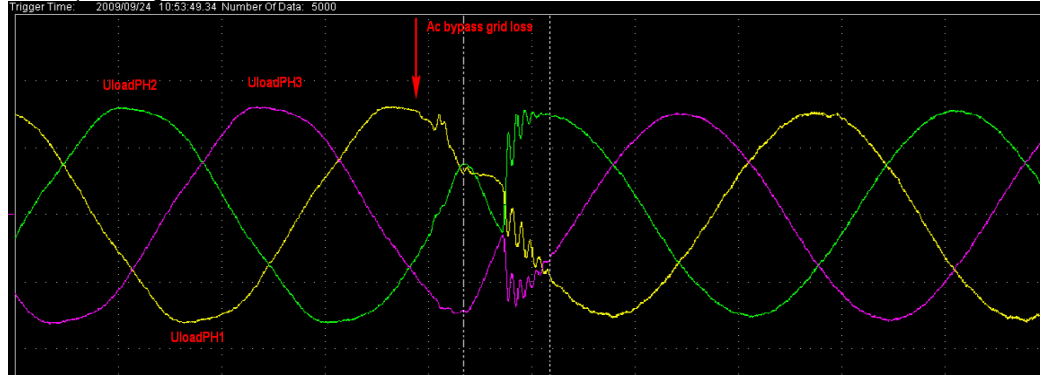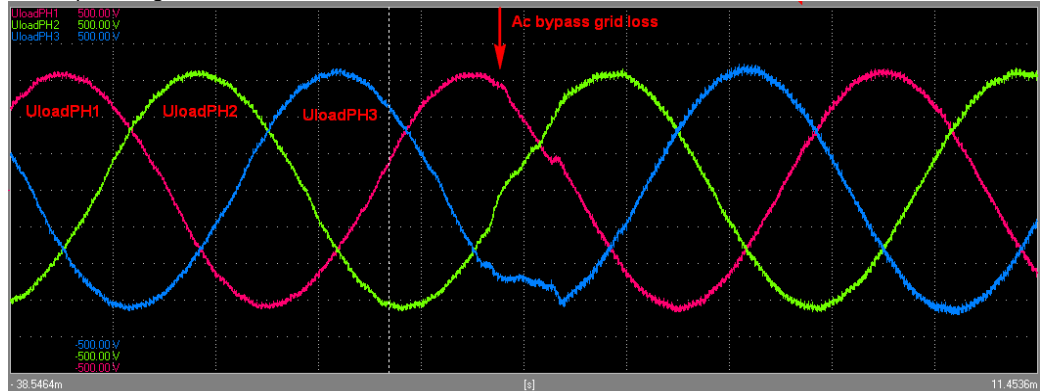
UPS operating in **standard** eco-mode…

Figure 3

The top image shows the output voltage waveform of a 3 phase UPS operating in standard eco-mode at the time of a power failure. The bottom image shows a 3 phase UPS operating in advanced eco-mode during the same power failure event.

UPS operating in **advanced** eco-mode…

Advanced eco-mode can offer other advantages over standard eco-mode. A known feature of double-conversion UPSs operating in online mode is the ability to shield the utility mains supply from harmonic currents generated by the loads. This reduces the harmonic injection back into the utility mains or other source such as a standby generator. In the case of generators, lower harmonic currents will reduce voltage waveform distortion, and may allow the generator to operate reliably at a higher kW load. This "filtering" function of a double conversion UPS is not present in   standard eco-mode as the load current (including any harmonics) is passed directly back to the input. However, in advanced eco-mode the inverter is on and connected to the output and can be controlled to absorb the harmonic currents of the loads even though it is not processing the load power. In principle, this harmonic filtering function could filter harmonics to nearly the same level and quality as the filtering provided by a double-conversion UPS not operating in eco-mode. Various vendors of UPS systems with eco-mode implement this type of capability differently and to different degrees of performance.

While advanced eco-mode offers advantages over standard eco-mode, it does come with a tradeoff. Since the inverter circuit is "on" in the advanced mode, the overall efficiency of the UPS is less than it would be if it operated in standard eco-mode. The difference is small, however, having been observed to be in the 0.5% - 1.0% range typically. **So while advanced eco-mode efficiency is less than standard eco-mode, it is still better than traditional online mode.**

Most UPS systems offering eco-mode do not require its use. This is a mode that can be enabled and configured either by the customer or, in some cases, a certified technician. And in cases where the UPS offers an advanced eco-mode, it is likely that the user can choose between three modes: online mode, standard eco-mode, and advanced eco-mode. This provides the customer more flexibility in choosing an operations model that fits their risk profile and efficiency goals. **Figure 4** shows an example UPS offered by Schneider Electric that offers both standard and advanced eco-modes of operation.

Figure 4

Example of a UPS that can operate in double-conversion, eco-mode, and advanced eco-mode (Galaxy VM with ECOnversion^{TM} mode by Schneider Electric)


Efficiency improvements

The UPS system is one of many contributors to the overall inefficiencies (electrical "losses") of a hospital, factory, or data center. For example, a UPS's typical contribution to a data center's PUE is shown in **Figure 5**.

Figure 5

PUE of a typical data center, showing how energy consumption of UPS and other systems contribute to the total PUE

Legend:
- UPS cooling
- UPS
- all other power
- all other cooling
- lighting
- IT load
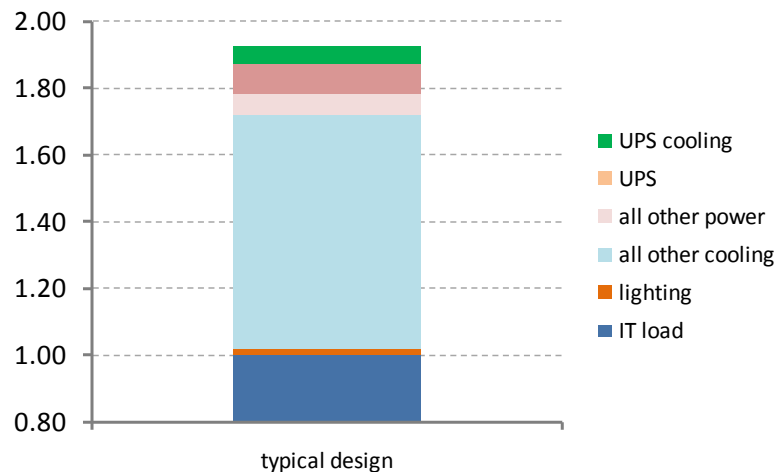
Note that the vertical axis of the graph begins at 0.8 – not at zero – to show detail. The IT load always contributes exactly 1.0 to a PUE value.

Continuing with the example above, the contribution of the UPS to the PUE is in two parts: the energy used by the UPS itself at around 9%, and the energy used to cool the heat produced by the UPS at approximately 5%. The PUE contribution of the UPS electrical losses is equal to the UPS loss expressed in a percent of the IT load. The PUE contribution of the UPS cooling load is equal to the UPS loss divided by the marginal Coefficient of Performance[3] (COP) for the cooling plant. To illustrate how these UPS-caused losses contribute to a typical PUE value, these losses are the topmost two segments of the bar in **Figure 5**.

The above figure represents the installed base of data centers, with a typical PUE of 1.93. However, the installed base is comprised of older equipment that does not represent the current generation of devices used in data centers. Using current-generation equipment in a higher density data center design we achieve a better PUE as shown in **Figure 6**.

Figure 6

Typical PUE of data centers, showing improvement of PUE of current designs compared with installed base
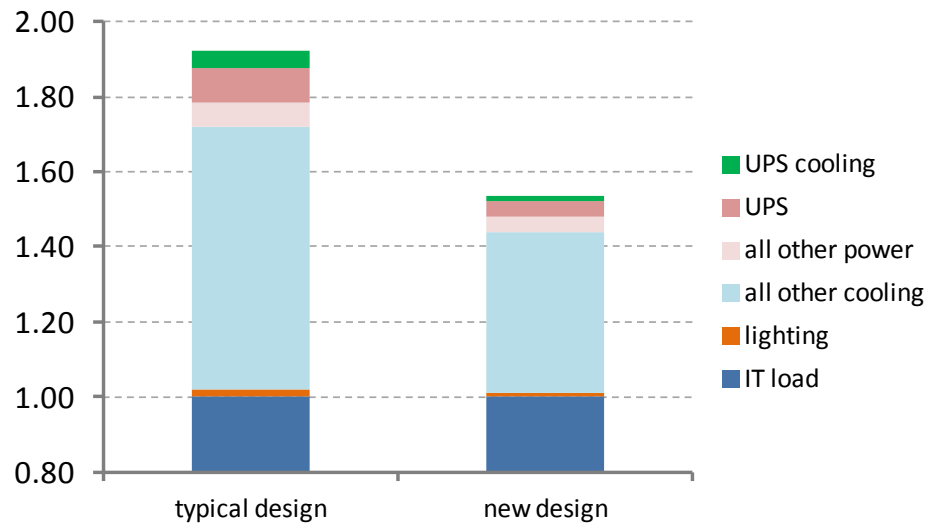
Note that a new data center with a PUE of 1.54 is significantly better than the installed base value of 1.93. In fact, the energy bill for a given IT load is directly proportional to the PUE, so we can say that **a current generation data center will typically have a 20% reduction in energy use for the same IT load, when compared with the typical installed base.** We can now add a third entry to the chart to show the PUE improvement of using eco-mode, as shown in **Figure 7**.

When eco-mode is engaged, the UPS loss drops from 4% to 1.5% (corresponding to an efficiency improvement from 96% to 98.5%), but the PUE only falls from 1.54 to 1.50. This represents a savings of total energy use of 2.3%[4]. In this analysis, it is assumed that the data center is operating at 50% load using modern UPS systems. The result is that, as a rule:

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[3] The marginal COP is the incremental cooling capacity in watts created per incremental watt of power needed by the cooling plant. Typical values range from 2-6 and are typically much better (larger) than the overall cooling plant COP, which is reduced by the presence of fixed loads such as fans and pumps.

[4] Total energy use savings of 2.3% was computed from the PUE values of 1.536 and 1.500 derived from the losses in the bar charts. Example of incorrect analysis quoted in "Raising UPS Efficiency with Eco-mode", UPSonNet.com: "The gain in Eco-mode is quite tempting. In average about 3.5% power saving is gained, just considering UPS efficiency. Taking in account also cooling requirements, close to 9% of output power can be spared." In fact, a 3.5% power savings in UPS efficiency will only translate to about a 3.2% savings in total energy.

The energy savings associated with the use of UPS eco-mode (standard) is approximately 2.3%, corresponding to an energy savings of about US $10,000 per year for a 1 MW rated data center at 50% load with an electric rate of $0.10/kWh.

The energy savings from the UPS only, equates to 2.54% which applies to all applications including hospitals and factories.

The actual energy saved will depend on the specific equipment and architecture chosen, the loading of a particular data center, and the local cost of electricity, but the above is a reasonable estimate of the savings that applies to a typical situation.

Figure 7

Typical PUE of data centers, showing improvement of PUE of current designs compared with installed base
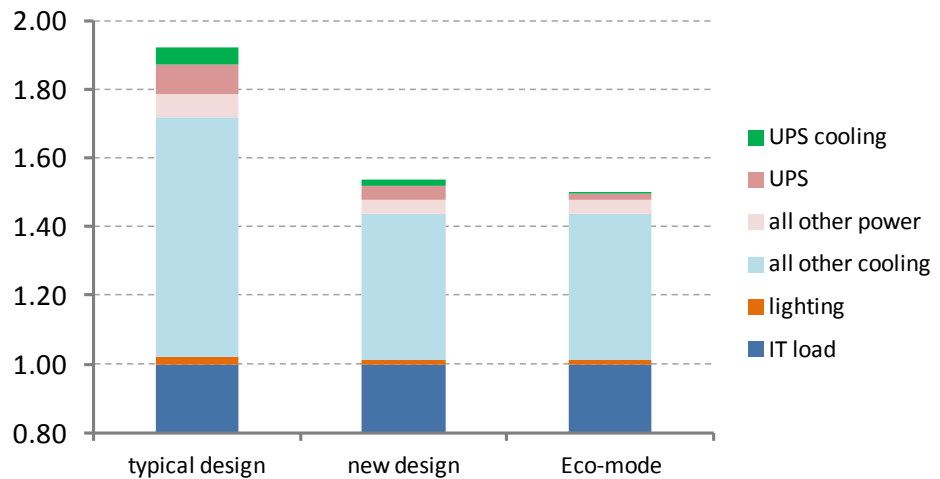
Note that the estimated 2.3% energy savings is for a system operating 100% of the time in standard eco-mode. If the system operates only part of the time in eco-mode, then the savings are proportionally reduced. If the system utilizes advanced eco-mode, then the UPS has additional losses depending on the implementation of advanced eco-mode and the presence of load harmonics. The savings in advanced eco-mode are likely to be approximately 0.5% less when compared with standard eco-mode, or around 1.8%.

It is interesting to see that, in general, **the percent savings in total energy for a data center will be slightly less than the percent UPS efficiency improvement**. Many discussions of eco-mode suggest that the total energy savings will be much more than the UPS efficiency improvement, but these analyses have made incorrect assumptions about how UPS losses contribute to the PUE, and how UPS losses contribute to air conditioner energy use.

While 2.3% is not a major efficiency pickup, it is valuable. Unfortunately, there are consequences associated with operation in eco-mode, which must be fully comprehended in the decision to use this mode and gain its efficiency improvement. These considerations are:

- Reduction of electrical protection
- Reliability impacts
- Operations issues

These factors frequently cause operators to decide against using eco-mode, and will be discussed in the following sections.

Loss of protection

A key function of a UPS system has historically been to regenerate "clean" electrical power without the variations of voltage, variations of frequency, or transients that are present on raw utility mains power – the central concept being that such variations would interfere with the operation of sensitive critical loads.

However, remarkable improvements have occurred in the characteristics of most power supplies, including IT equipment, such that virtually all equipment sold today is immune to mains frequency variations and designed to accommodate any variations of mains voltage within a specified operating range. It is a fact that IT equipment power supplies today, in order to run reliably, requires less power conditioning than in prior decades.

In the case of the modern personal computer or server, it will operate reliably if it can be assured that mains voltage does not drop more than 20% for more than about 8 milliseconds, and that damaging surge voltages are filtered. In principle, this can be achieved by a standby–type desktop UPS, which is essentially a UPS permanently running in eco-mode. Naturally, this suggests that an entire data center might be run in such a standby or eco-mode. However, the load in a data center or hospital, or industrial plant is not like a large personal computer. The UPS load in a data center is a complex system of circuits including many different types of IT equipment and transformers, possibly including other complex devices such as static switch PDUs, fans, and pumps. **While a personal computer or server can be well characterized regarding its response to power fluctuations, it is much more difficult to assure the performance of a complete data center or other industrial application**.

Eco-mode takes time to respond to power problems

Eco-mode cannot predict the future. It must respond to a problem that already exists and switch to the inverter. This means that a mains power problem can get through the UPS to the critical load until the following four things happen:

1. The power problem is detected
2. The UPS determines whether and how to respond
3. The UPS inverter is energized (Note: in advanced eco-mode, it is already energized)
4. The static bypass switch is actuated (opened)

In practice these events may take from 1 to 16 milliseconds, during which the critical load is subjected to the power problem. Consider some of the following situations:

- While the loss of 1-16 milliseconds of power may not affect the typical 2U server, the loss of power for 8 milliseconds to a power transformer can cause that transformer to saturate when voltage is restored, tripping breakers.

- The loss of power for even a few milliseconds on a circuit feeding a PDU equipped with a static switch will cause a state change on that switch. This can lead to an undesirable state change of the overall power system, including overloads and dropped loads.

- The loss of power for less than 16 milliseconds can cause protective devices on pumps and fans to operate, creating an unexpected and undesirable state change of the system.

- There are non-server IT devices, such as switches and other auxiliary devices that may not be as robust as servers are in handling dips and sags in the range of 1-16 milliseconds.

- The static switches used in standard eco-mode UPS systems can only transfer when the mains voltage is lower than the inverter voltage or at a zero crossing of the mains voltage. There are conditions such as loads with reactive power factor where the static

bypass switch cannot clear for up to 8ms[5], so it is not possible to assure a gap in supply of less than 8ms. With advanced eco mode it is possible for the UPS inverter to be commanded to absorb the reactive current of the load, which can eliminate this problem and allow shorter gaps in power. This mode of operation is provided in the UPS illustrated in **Figure 4**, but is not present in all implementations of advanced eco-mode. If interruptions shorter than 8ms are required, then a detailed analysis of the eco-mode of the specific proposed UPS is essential.

- A typical static bypass switch cannot open if power is flowing to the load, so a UPS in eco-mode cannot protect the load from sub-cycle mains overvoltage, even if the UPS detects it immediately.

Harmonics and eco-mode

A separate issue involves harmonics. In a conventional UPS – and to a large degree in a UPS using advanced eco-mode - the load is isolated from the harmonic content of the mains **voltage**, and conversely the mains are isolated from the harmonic content of the load **current**. In standard eco-mode, both of these functions are defeated. While it is true that IT loads today have a low harmonic current content at rated load, they do have significant harmonic content during energy saving modes, which may affect the overall power system if not considered. Data centers, hospitals, and industrial applications are also notorious for having large motor drives for chillers, fans, and pumps that may cause harmonic voltage on the mains that should not be passed to the critical load. Harmonic issues will not be a factor in most data centers, but the use of eco-mode may require that they be studied or mitigated.

Use of eco-mode requires additional care and analysis

All of the problems in this section are all problems that can be technically overcome. However, it is very difficult to ensure that they will not be a factor in a specific installation, unless all aspects of the electrical design are very well characterized and analyzed. The reduction in power protection of using eco-mode may be acceptable, but certainly cannot be ignored. Most applications are a complex arrangement of devices whose interactions are not well characterized and it is not feasible to assure that the system can reliably operate with the reduced power protection of eco-mode. Highly standardized and pre-engineered electrical architectures, where all of the issues can be studied and tested, are therefore best suited for the use of eco-modes.

Reliability impacts

In the previous section the reduction in power protection resulting from eco-mode was discussed. This section discusses issues that can affect system reliability.

Thermal shock and cycling

A system operating in eco-mode will need to start the inverter and transfer in response to detected power events. The frequency of occurrence of transfer events will depend on a number of factors, including the sensitivity settings on the UPS, the mains power quality, and power disturbances created within the facility by other equipment. Whether this happens

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[5] When loads have reactive power, there are times during the AC voltage waveform when the load current is negative but the load voltage is positive. If the input mains fails as a low impedance phase fault condition during any of these times, the silicon controlled rectifiers in the static bypass will remain closed (even if commanded off) and will hold the output to the (faulted) input voltage. The UPS inverter will see this as a fault condition and all the UPS output current will backfeed the mains instead of supplying the load. The condition will persist until the next zero crossing of the AC line, which could be 8.3ms (60Hz) or 10ms (50Hz), at which time the static bypass will open and the inverter will supply the load.

once a month or once an hour, the step change in power applied to the UPS inverter creates a step of load current applied to the inverter which causes a thermal event and shock to the system. It is well known that thermal transients are a primary cause of failure of electronic power systems.

To make this situation worse, the thermal transient is applied at precisely the time when the UPS is needed the most and there is no alternative. Therefore we are concentrating the risk of failure at the exact time when the system is needed the most.

In normal UPS operation without eco-mode, there is no thermal shock or transient when the mains power fails. If the UPS inverter experiences a random failure, it will almost certainly be at a time when mains power is present so the UPS will go to bypass with no load drop.

Component wear

The lifetime of many electrical components is affected by operating temperature and current stress over time. When a UPS is operated in eco-mode, the UPS rectifier and inverter and associated capacitors and other devices are essentially bypassed and not providing significant power to the load. This decreases the temperature of these devices which will increase their life and reduce failure rate.

However, it is important to recognize that failure rate of a UPS is not directly related to loss of UPS function or interrupting the critical load. Failures of the UPS inverter or rectifier do not typically drop the load because they mainly occur when the mains is present and the UPS protects the load by switching to bypass. Therefore, while reduced component wear is a benefit of eco-mode, it does not necessarily offset or balance the risks due to thermal shock and cycling described in the previous section.

Battery life

There are two interesting factors regarding eco-mode and battery life, which are battery wear and battery operating temperature.

The transfers to inverter operation will typically cause momentary operation on battery, even if mains power is present and the battery charger is able to function. This means eco-mode operation will require a transfer to battery much more often than the same UPS operated in double conversion mode. This may be of no consequence if such events happen only once every few months, but may create unnecessary battery wear if these events happen multiple times per day. This extra battery wear depends on the implementation of eco-mode, the local power quality, and the eco-mode settings. It may be difficult to predict battery wear in advance, so it needs to be established over time with real-world experience at a particular site.

In principle, eco-mode is more efficient so the UPS creates less heat. This could mean that batteries run cooler, and therefore last longer. However, the reality is that this effect cannot be assumed and the battery temperature will be strongly affected by the UPS design. For example, if the batteries receive cooling from the UPS fans and those fans are off in eco-mode, then the batteries may actually operate at higher temperatures in eco-mode. If the batteries are in isolated cabinets from the UPS power electronics, then there may be no effect from eco-mode. Therefore, no general assumption of the affect on eco-mode on battery life is possible, and eco-mode impact on battery temperature must be established on a case by case basis.

Fault clearing

A UPS in its normal setting detects output faults and switches to bypass to obtain the extra fault clearing current needed to rapidly open downstream protective devices. This is a valuable feature that can prevent downtime of IT loads during a fault condition. However, when the UPS is in eco-mode, it can be very difficult to distinguish an output fault from a loss of input power. During an output fault a UPS in eco-mode may detect a drop in input voltage that causes a switch to inverter, which will extend the fault clearing time and possibly expose the critical load to a momentary loss of power. Some vendors, such as Eaton, claim to have sophisticated control and detection algorithms in their eco-mode UPS to reduce this problem. Nevertheless, this is an additional factor that should be considered as the efficiency gains of eco-mode are balanced against the various costs and risks.

Effect on operations

Using eco-mode will have consequences on operations that can be important to recognize and plan for. These are discussed in the following sections.

Testing

The behavior of eco-mode is site specific. It will be affected by mains power quality and the effect on the mains by other loads within the facility. For this reason it is important to do testing to determine if eco-mode is compatible with the installation, and to determine the appropriate eco-mode settings. This will involve commissioning testing, as well as ongoing measurements to determine if it is operating as intended.

Verification of the reliable operation of eco-mode in a real data center or hosptial is difficult. There are many types of power transients and events that are very difficult to simulate during testing.

Eco-mode settings

All eco-mode UPS systems have various settings that can be adapted to the site or user preferences. Typically this involves adjusting sensitivities or delays associated with eco-mode. If the eco-mode sensitivity is too high, it may overreact to small mains disturbances and activate the inverter too often. If the sensitivity is too low, eco-mode may take too long to react to an important power problem. The UPS also typically has a feature where it disables eco-mode for a while if it sees a power problem, and re-enables it after a certain period of time of stable power. There may be settings associated with this function as well. These settings are not standardized across different UPS vendors, and may go by different names or operate differently.

Some vendors offer the capability of scheduling times when eco-mode is on. For example, eco-mode can be programmed to be on during nights and weekends when IT reliability may be less critical.

Eco-mode settings may need to be adjusted over time, and the current settings and the settings history should be documented.

Procedures

A operations managers should consider whether to establish procedures regarding the use of eco-mode. For example, establish a procedure to disable the eco-mode feature if frequent transitions are observed (which might, for example, be caused by nearby construction

activities). Another possibility is to establish a procedure to disable eco-mode when storm activity is impending, in order to improve the resilience of the system[6].

Power forensics

In high availability applications like data centers and hospitals, there is often a need to identify the root cause if an actual load drop or failure is experienced. Power meters with recording and forensic capabilities, such as PowerLogic™ ION series meters and software, can record the details of power during failure events for later analysis and are typically used for this purpose. Some customers rely on the isolation of the UPS system to reduce the need for power forensics in the data center, or may forgo this capability for cost or other reasons. However, when eco-mode is used, the exposure of the critical load to unconditioned power, along with the increase in the frequency of occurrence of mode switching in the UPS, significantly increases the need for power forensics when there is a desire to identify root causes of power problems.

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[6] Some vendors have even discussed automating this function through software weather alerts communicated to the UPS.

Conclusion

Eco-mode represents a potential way to save energy in data centers, hospitals, and other UPS applications. Data Center operators can expect to see savings on the order of 2-3% in total energy if eco-mode is enabled. Higher percent savings are possible if the data center is operated at very light electrical loads. The energy savings associated with eco-mode are getting smaller as newer generation UPS systems improve in efficiency.

The use of eco-mode entails risks. Eco-mode introduces a number of new modes of operation of the data center, and reduces power protection. Current power supplies and IT equipment is much more resilient to power variations than similar equipment of prior generations, suggesting that this equipment should operate reliably using eco-mode. However, complex systems comprised of a mix of IT equipment, transformers, transfer switches, and other possible non-IT loads are less predictable in their response to infrequent and unusual power events, and their compatibility with eco-mode is less certain. These considerations have greatly limited the use of eco-mode in real data centers in the past, and are likely to continue to do so.

However, the advent of advanced eco-mode has significantly reduced these (already rare) risks and has done so at only a small cost in efficiency compared to standard eco-mode. Advanced eco-mode provides energy savings while offering better protection for connected loads than when operating in standard eco-mode. Different vendors implement advanced eco-mode differently and there are significant variations in fault response, harmonic mitigation, and other characteristics between different UPS products.

The operation of eco-mode is like the hand-off of a baton in a relay race. It is critical that it works correctly, each hand-off is a little different, and on very rare occasions there may be a problem. For this reason, eco-mode should be used in situations where the number of hand-offs are as few as possible, e.g. where power quality is excellent.

As data center, hospital, and industrial designs become more standardized, equipment continues to improve, and real world experience using eco-mode accumulates, predictability and confidence in eco-mode will improve.
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✎ About the author

Neil Rasmussen is a Senior VP of Innovation for Schneider Electric. He establishes the technology direction for the world's largest R&D budget devoted to power, cooling, and rack infrastructure for critical networks.

Neil holds 25 patents related to high-efficiency and high-density data center power and cooling infrastructure, and has published over 50 white papers related to power and cooling systems, many published in more than 10 languages, most recently with a focus on the improvement of energy efficiency. He is an internationally recognized keynote speaker on the subject of high-efficiency data centers. Neil is currently working to advance the science of high-efficiency, high-density, scalable data center infrastructure solutions and is a principal architect of the APC InfraStruXure system.

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For feedback and comments about the content of this white paper:

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If you are a customer and have questions specific to your data center project:

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