KOHLER | UNINTERRUPTIBLE POWER

Cool Runnings – Achieving better energy efficiency in Data Centres

Achieving better energy efficiency in Data Centres

Data centres are estimated to be responsible for up to 3% of global electricity consumption today and are projected to touch 4% by 2030.

While data centres currently account for just under 2% of all greenhouse gas emissions, they are responsible for about 14% of Irish electricity use. The Irish government has adopted a set of principles to harness the economic and societal benefits that data centres bring, facilitating sustainable data centre development that adheres to its energy and enterprise policy objectives.

Renewable energy is now the cheapest source of power across two thirds of the globe and is driving the decarbonisation of heavy industry globally.

Removing fossil fuels and ensuring the agenda for energy efficiency requires a transformation of every sector of the global economy. It requires developments in mindsets, processes and technology.

In the data centre world, data centres are responsible for almost 1 per cent of global electricity demand and 0.3 per cent of all global CO_2 emissions. Energy efficiency has been brought into focus by the volatility of the energy market – but for most data centres, it has been on the agenda for a long time.

In Europe, the Climate Neutral Data Centre Pact, a movement representing 90% of Europe's cloud and data centre sector has attempted to head off any regulatory restrictions by submitting a self-regulatory initiative proposal to make the sector carbon neutral by 2030.

This is driving technology and processes in several areas which include smart operating modes for uninterruptible power supplies (UPS), engine optimisation for diesel generators, new approaches to more environmentally friendly maintenance, development of renewable fuels such as hydrotreated vegetable oil (HVO) and research into megawatt-scale batteries and hydrogen fuel cells. But these advances take time and have their own scalability and cost challenges.

In this white paper, we want to explore the improvements in the environmental performance of critical power protection for data centre applications and consideration of UPS in the near to medium future.

Maintaining critical power

With the amount of power and CO_2 emissions, data centres need to review and where possible, improve energy efficiency measures. It's good for the planet to do so but if steps aren't taken, the future growth as a business may also be impinged.

What does this mean for critical energy considerations?

Innovations in technology and processes are being implemented in several fields including engine optimisation for standby diesel generators, development of renewable fuels and research into the use of multi megawatt batteries. For sustainable UPS systems, there are three key considerations.

Reducing power loss
by choosing a high efficiency UPS

Size to actual load
by taking advantage of the correct load and smart running modes

Battery technologies
taking a wider view including management and recycling

As they consume more energy than UPS, data centre operators have for years been focussing on reducing the energy consumption of cooling systems. However, by considering the points above significant gains can – today – be made on UPS as well. And given all the power to data processing flows through a UPS this presents a great opportunity.

Measuring Energy Efficiency

Many data centres have had to react to fast-growing demand and in doing so have been replacing or installing newer equipment.

Integrating more efficient, modular systems and having a better understanding of the Total-Power Usage Effectiveness (TUE) or more traditionally until now, the Power Usage Effectiveness (PUE) has become the driving force behind the improvement in energy efficiency of data centre infrastructures and an integral piece in the wider 'green' jigsaw.

PUE can be defined as a measure of how efficiently power is used within a data centre – by measuring the ratio of total amount of power used to the amount of power delivered to computing equipment. Although originally an innovation by The Green Grid, the thinking behind what capacity is required for a given ICT load in a data centre has always been one of the first tasks of the designer. It is the de facto measurement for power currently although as wider energy efficiency is being aimed for, there are other measurements coming into play for consultants including Water Usage Effectiveness (WUE) and Carbon Usage Effectiveness (CUE) to name a few. The others, although valid are still being talked about rather than implemented including TUE, which can be a more effective metric at calculating a data centre's overall energy performance but requires a greater understanding of the IT hardware in place. It remains PUE that is the measurement needed for power consideration.

PUE

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TOTAL FACILITY POWER / IT EQUIPMENT POWER

Managing the load

What do we mean by managing the load?

Traditionally, UPS design involved a large framework system, which had to cover all the capacity required. Therefore, the system was always on at full power. Nowadays, we have modular designs where calculating and managing the load so there is always redundancy to provide a level of cover in the event of an equipment failure is the norm.

When working out energy efficiency, the review of what power is required is critical to the design of the data centre and its systems, as well as its ability to handle maximum load in the future. System engineers will now look to only fit and connect what is needed, so with smarter procurement, UPS designs can offer more longevity.

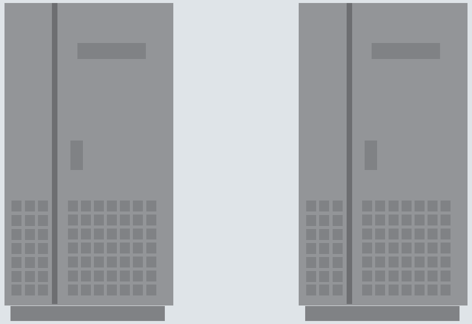
How can we manage the load?

Today, we manage by the load by understanding what level of power would be needed. We then build modular systems – which offer greater flexibility – and we size to cover redundancy.

For instance, if we knew we needed 250kW with N+1 redundancy today, we can make up that system with 6 modular UPS of 50kW, rather than 2 larger ones of 250kW to cover the critical power needed. The modular system offers a 50% reduction in UPS footprint as one UPS can be used to cover the power requirements, and the power doesn't all need to be on all the time.

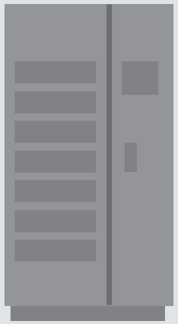
TRADITIONAL MONOLITHIC/STANDALONE

SIZING TO COVER REDUNANCY E.G. 250KW (N+1)



250kW + 250kW = 500kW

MODULAR DESIGN



6X50kW = 250kW N+1

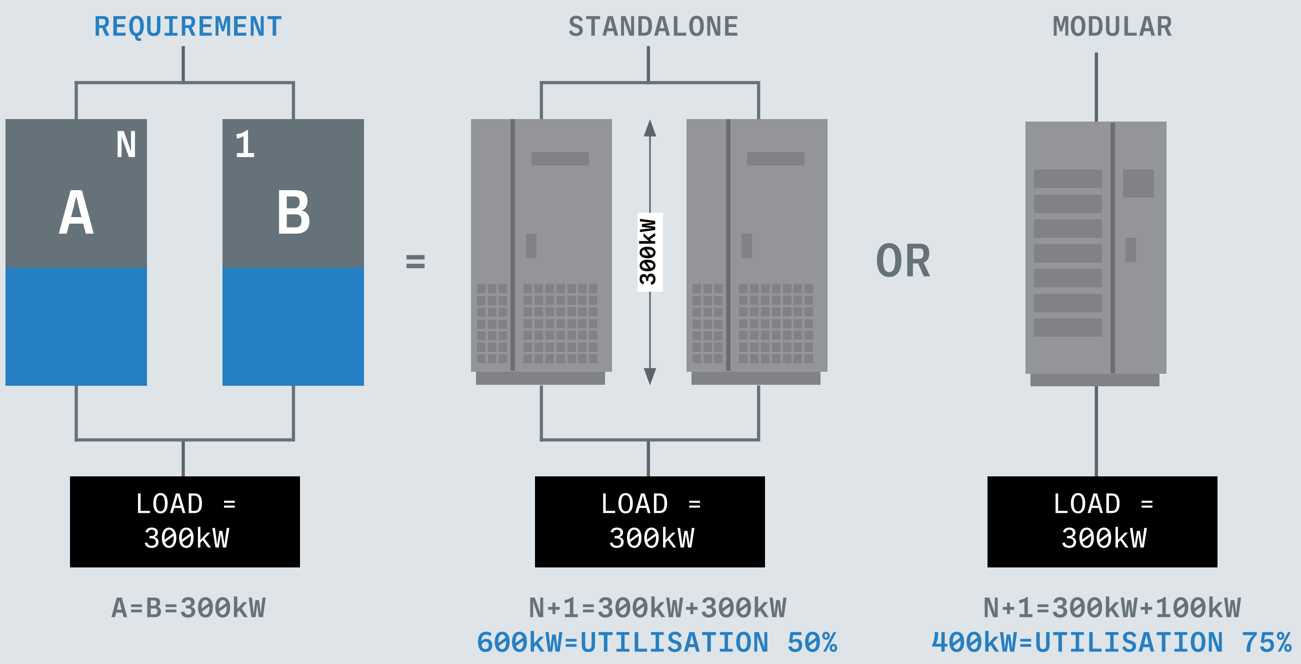
Managing the load

Modular UPS topology

For small and medium systems, the advent of modular systems (where rackable modules are contained within a single infrastructure cabinet) has made the 'right-sizing' of UPS to a given load easier than ever before. Expansion of capacity is a simple matter of adding a further module and contraction is a simple matter of turning off modules in turn. The initial installation must be sized for the ultimate load and frames can be added as required, providing the design is correct. The selection of the module rating should be influenced by the load steps anticipated and the ultimate load. Hence a 100kW ultimate load may be suitable for 10kW modules and a 1MW ultimate load suitable for 100kW modules. Above 1MW, it is usual to engineer a multi-module scalable solution (eg. of 250kW modules) and provision the switchgear infrastructure for the ultimate configuration, but not necessarily installing all UPS hot-swappable modules on 'day 1'.

The aim is simply to allow the UPS system to be loaded at the most efficient level – where the UPS will be able to provide its highest efficiency rating.

Sizing for redundancy



Managing the load

Perhaps with the exception of the largest search engines and social media network data centres, partial load is a common feature of data centre operations. Newly constructed 'enterprise' class facilities can start life carrying loads as low as 15% and take 4–6 years to reach higher than 65%, often never exceeding 80%.

For single-bus ICT systems with N+1 redundancy, this can be mitigated by scalable systems (where UPSs can be disabled to keep the load factor at the most efficient level). For example, replacing five monolithic 500kW UPS for a 2MW system load with modular systems utilising smaller size modules.

Dual-bus scalable and modular UPS architecture can help raise the efficiency of each bus, but the load is never likely to exceed 40% per bus, and very often will be less than 20%. Hence the UPS contribution to the PUE will be higher than an N+1 single bus system unless more radical measures are taken – such as using smart mode features in one or both buses. In the case of smart mode enablement, the usual penalty from highly partial load in dual-bus systems can be entirely overcome.

Typically, in a data centre UPS, the energy efficient centre point is around 50%. Above 75%, it lessens while below 25%, systems tend to be a lot less efficient. The most efficient region for the Kohler MF Series is 30-60% but when data centres are calculating their PUE, even small factors can make a big improvement to their carbon reduction target.

Kohler's Cost Calculator

Kohler has developed a cost calculator to help you see what system would benefit your operations and your energy efficiency. After a discussion with you and a visit to your site, we can calculate the best option for your future system, working on energy efficiency and the cost of the systems over several years.

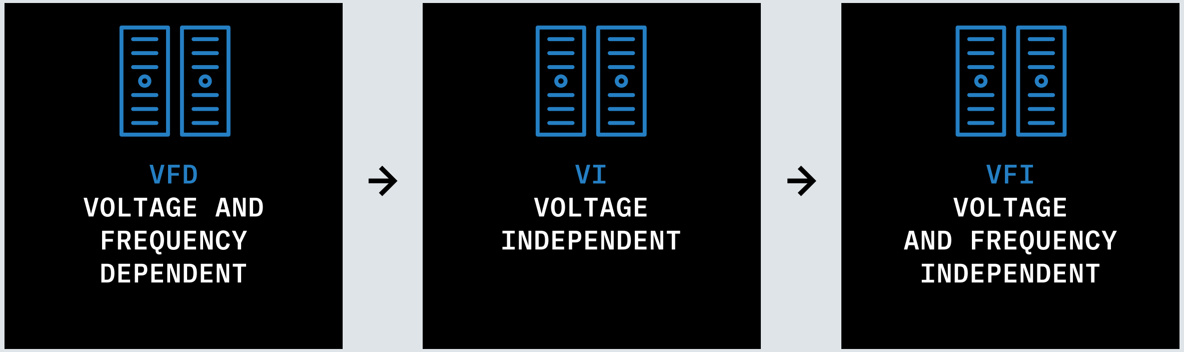
Energy Saving Smart Modes

Today, UPS systems are available with different levels of protection and these can be run in smarter, energy efficient modes. The challenge is working out which configuration really works to offer you the greener option.

First, let's look at protection. In data centres usually only 'VFI' UPS systems are acceptable as the load is protected from both frequency and voltage variances. While 'VFD' and 'VI' UPS are available at lower cost due to their lower complexity, as the diagram opposite indicates, these offer a lower level of protection.

Similarly, most modern VFI UPS can be operated in three modes. In standard on-line mode all modules will operate.

In contrast, so-called 'Eco-mode' will leave modules in standby mode to save power. However, this can expose the load to the voltage and frequency variations that a VFI UPS is intended to protect against, and may even produce a break in supply if power fails - something that is unacceptable in a data centre. For this reason, while high efficiency figures mean it is often talked about, 'Eco-mode' is rarely, if ever, used.



SIMPLEST DESIGN SUITABLE FOR EQUIPMENT FED BY STABLE MAINS SUPPLY.

SWITCHES TO BATTERY WHEN POWER FAILS.

LIMITED CONDITIONING OF SUPPLY TO LOAD – WILL KEEP CONSTANT VOLTAGE.

NOT SUITABLE FOR ADVANCED DATA PROCESSING EQUIPMENT.

CONTINUOUS POWER CONDITIONING AND PROTECTION AGAINST VARIANCES IN MAINS VOLTAGE AND FREQUENCY.

ONLY MODE GENERALLY ACCEPTED IN DATA CENTRES.

Another approach is to use smart modes such as Kohler's 'Xtra VFI' mode. These match the number of active modules to the load and redundancy required and put surplus modules into standby. The best smart modes also balance load so that modules are operating in their most efficient band and cycle between modules so that wear is spread, further reducing ownership costs.

Exceptionally resilient, flexible and scalable from 250 – 6000kW, Kohler's high power modular UPS MF Series offers the best-in-market energy efficiency (97.4% efficiency) in regular VFI mode. This energy efficiency redefines the lifetime cost for data centres and other high-density applications - reducing environmental impact, optimising PUE measures and delivering significant financial savings in energy and cooling costs, without compromising reliability of the power protection capabilities.

Advances in technology

For many years, UPS efficiency has been gradually improving but it has been the mechanical cooling systems that have attracted the most attention regarding energy-overhead reduction.

As the cooling systems have themselves improved, in some cases drastically, the focus has now returned to the power system.

The efficiency improvement of UPS has followed a combination of component innovation, such as thyristors being replaced by transistors in inverters (and, much later, rectifiers), which enabled the removal of passive filters and transformers. Topology has also changed, with double-conversion being enhanced with eco-mode and new designs enabling higher load power factors.

In the early 90s, a large UPS module would have an input transformer, 12-pulse thyristor rectifier, passive 11th harmonic input filter, DC capacitors, 6-step thyristor inverter with output transformer and output filter network, which all resulted in a maximum efficiency at full load of 87%. Compare that today with a transformer-less insulated-gate bipolar transistor (IGBT)/IGBT rectifier/boost-stage/inverter model which can offer >96% in double-conversion mode.

New UPSs do not have transformers in. One of the big efficiency-increasing steps has been to remove transformers due to the higher DC bus voltage created by the booster. Other ways that efficiency has been increased include internal layout, for example, busbars and airflow, different IGBT switching techniques of the inverter, and the use of high efficiency components and fans.

Sustainability in a wider sense should also include use and replacement of batteries - the use of battery management systems allows more effective balanced charging of the battery blocks rather than charging the overall string with a set float voltage. This can extend service life by 30% or more. While VRLA (lead acid) batteries are highly recyclable and there is an established cycle in most countries, this is still a process that involves energy and cost. As such, if it is possible to reduce the need for battery replacements that is highly beneficial from a sustainability point of view, even if it does not factor into the PUE calculation.

Questions to ask your supplier

Data centre managers need to be informed to ensure the choices they make are right for ensuring mission-critical data centre applications – for today and for the future with the demand continuing to grow.

This means collaborating with suppliers and consultants who understand current and future challenges and who can make this decision-making process much simpler. In-depth knowledge, extensive experience as well as a comprehensive choice of solutions that will fit the data centre's specific needs should be considered. And this level of expertise must be continued throughout the life of the protected power installation, to meet the challenges of providing timely UPS maintenance and adapting to evolving site requirements.

If you are looking to update your UPS system, here are some considerations to ask your supplier.

- What is the basis of your supplier's claims? Are they proven-in-field? Factory tested? Independently verified? Or extrapolated from technical research?
- What is the availability and historical on-time delivery performance?
- What are the running and maintenance costs of the solution?
- Assess the financial stability/longevity of the solution provider
- What is the supplier's service and spares capability? (e.g. How many engineers do they have? Are they subcontracted or direct employees? Where are spares held – in the UK, Europe or overseas?

Conclusion

ICT loads need an effective UPS system for continuous operation as much today as they ever have, and those UPS units must provide operational efficiencies of >96% (even at partial loads) to produce the level of infrastructure energy efficiency (PUE) expected by end-users and future carbon-reporting and possible legislation.

With energy costs continuing to sit high on the agenda of data centre operators, highly efficient UPS with smart operating modes delivered from modular formats will only grow in significance. In conjunction with the most advanced cooling systems and developments in technology such as direct liquid cooling and adiabatic indirect cooling with air:air heat exchangers, overall efficiency will also improve.

This level of performance in conjunction with the most advanced cooling systems and increases in technology such as adiabatic indirect cooling with air: air heat exchangers and LED motion-controlled lighting will help with optimising energy efficiency. But it pays to do some homework into suppliers and systems and ensure you are installing equipment that meets current and future critical power needs with in-built redundancy and energy efficient modes.

Training

Kohler offers a series of CIBSE accredited CPD options. Below are details of our UPS Academies and our options for Continuing Professional Development.

UPS Academy

Designed specifically for Graduate Engineers and Engineers who have recently qualified, this FREE one-day training course will cover basic and some technical information related to specifying UPS systems for mission-critical applications. Senior Electrical Engineers may also be interested in attending the afternoon session. This course is CIBSE CPD-approved.

Technical Seminars

Ideal for consultants and electrical engineers, Kohler Uninterruptible Power offers free technical seminars to keep you up to date with the latest power protection specification and selection requirements and the latest technology available. The content of the seminar has been independently certified as conforming to CPD guidelines, by the Chartered Institute of Building Services Engineers (CIBSE).

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Backed by Kohler Co.'s 100+ years of power protection experience and innovation, Kohler Uninterruptible Power is well resourced and well positioned to provide the necessary depth of advice and support. It provides expertise, remote support facilities and an extensive network of field service engineers offering fast 24/7 availability.

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