whitepaper

CUTTING CARBON IN THE DATA CENTRE

1. OVERVIEW

Data centres are the backbone of modern society. 'Always on' digital connectivity, data storage and processing, and high-speed internet are integral to our modern way of life.

This seemingly unstoppable shift towards 'Smart' technologies and the 'Internet of Things' guarantees the global demand for data – and the vast amounts of energy required to safely store and process it – will continue to grow at a phenomenal rate.

For instance, even though it is already a large, mature market, the data centre sector in the UK is predicted to grow by more than 35% between 2021 and 2025.

While Ireland is expected to be the fastest growing market in Europe, with annual growth of nearly 6% forecast between 2022 and 2027.

There are two main ways a data centre consumes power. The energy used to run the IT equipment such as the servers or uninterruptible power supply (UPS) units, and the air conditioning required to keep all that machinery cool enough to function safely without risk of overheating.

Electricity is a data centre's single biggest operating cost, accounting for anything from 25-60% of its total overheads, according to TechUK, the body that represents the wider British technology industry.

Globally, data centres are said to consume at least 1% of the world's total electricity supply. Here in the UK, the approximately 600 commercial data centres are said to account for 2.5% of the country's power consumption.

Indeed, modelling by Britain's electricity network operator National Grid ESO suggest that colocation and hyperscale data centres could account for just under 6% of the country's total electricity by 2030.

While over in Ireland, where cloud service providers such as Google and Amazon host their European headquarters, average hyperscale power consumption is expected to grow by up to 200% between 2021 and 2030.

In an age where hyperscale facilities can typically consume 30 GWh of power a year, annual electricity bills running to several million pounds are becoming the norm rather than the exception. Even smaller-scale facilities are feeling the pinch from an increasingly volatile energy market.

Any shortcomings in efficiency will result in vast amounts of unnecessary wasted energy, with all the associated economic and environmental costs.

So whatever the size or set-up, whether onsite, colocation, or cloud, there isn't a data centre operator who can afford to ignore the drive to become more energy efficient, reduce their power consumption, and cut their carbon emissions.

In fact, many organisations are actually compelled by law – such as the UK Companies Act 2006 (Strategic and Directors' Reports) Regulations 2013 – to publicly demonstrate their progress in cutting greenhouse gas emissions in their annual directors' reports. They could even face fines if they fail to evidence the required level of improvement.

Collectively, the data centre industry is only too aware of its responsibilities. The Climate Neutral Data Centre Pact, a movement representing around 90% of Europe's cloud and data centre sector, has already introduced self-regulation aiming to make the sector carbon neutral by 2030 in an effort to head off any further regulatory restrictions.

2. MEASURING DATA CENTRE EFFICIENCY

In the years following its introduction in 2006-07, an improvement in Power Usage Effectiveness (PUE) rating was one of the main ways a data centre operator could demonstrate their commitment to reducing their carbon footprint.

PUE is a metric that compares an estate's total energy consumption with the amount of power used by ICT equipment to carry out data-related tasks. The closer the rating to 1, the more efficient a data centre is seen to be.

Globally, PUE has been on a downward trend, from an average of approximately 2.5 when the metric was introduced to around 1.55 in recent years, although improvements appear to have levelled off over the last five years or so.

However, PUE has become less influential during recent years with critics highlighting several flaws in its rather simplistic methodology.

For example, it doesn't consider differences in climate or factor in criteria such as how much water a facility uses or whether it generates any renewable energy on-site.

While it was, and to some extend still remains, a useful benchmark to encourage ongoing incremental performance improvements, as a method of comparing different data centres it leaves a lot to be desired.

Indeed, a facility's PUE rating has also been hijacked as a marketing tool used by some data centres – colocation operators in particular – keen to stand out from the crowd in an increasingly competitive market.

Performance improvements can be exaggerated and the overall PUE rating manipulated to paint a data centre in the best possible light.

That's why several new contenders for PUE's crown have emerged in recent years:

- **Green Power Usage Effectiveness (GPUE):** an energy efficiency measure that considers the amount of sustainable energy used by a data centre, its carbon footprint per usable kilowatt hour (kWh), and the efficiency which the data centre uses energy, in particular, how much power is actually absorbed by computer equipment (in contrast to cooling and other overhead costs).
- **Data Centre Infrastructure Efficiency (DCIE):** a performance improvement metric used to calculate the energy efficiency of a data centre by dividing the power of the computer equipment by the total power of the structure.
- **Grid Usage Effectiveness (GUE):** a metric that evaluates the data centre's network dependency in relation to the IT load.
- **Carbon Usage Effectiveness (CUE):** a metric defined by the Green Grid to measure data centre sustainability in terms of carbon emissions. CUE is a combination of PUE and the CDEF (Carbon Dioxide Emission Factor) and is calculated by dividing the total CO2 emissions caused by the total energy consumption of the data centre's computer equipment. An alternative way to calculate CUE involves multiplying the annual PUE value by the carbon emission factor for the region as determined by the EPA.

As yet though, none of these challengers have managed to separate themselves from the crowd as a more effective and trusted alternative.

So while PUE isn't perfect by any means, for the time being it is likely to remain the principal metric data centres use to measure energy efficiency.

3. ENHANCING UPS EFFICIENCY

In recent years, data centres have made huge advances in cooling technologies, which is just as well considering air conditioning can account for as much as half of a facility's total power consumption.

Intelligent cooling techniques such as the configuring of separate hot and cold aisles, and the use of blanking plates and rear door heat exchangers, have helped to reduce cooling energy losses. So too have advances such as direct liquid cooling.

But these energy efficiency improvements alone aren't enough. As another indispensable part of a data centre's infrastructure, an uninterruptible power supply (UPS) provides the potential for significant additional savings.

Similar to cooling, UPS technology has come on in leaps and bounds thanks to component innovations such as thyristors being replaced by transistors in inverters (and, much later, rectifiers), which enabled the removal of transformers.

Going back a couple of decades, a typical large data centre UPS would incorporate an input transformer, 12-pulse thyristor rectifier, and 6-step thyristor inverter with output transformer and output filter network.

At full load and at maximum efficiency, such a UPS would only achieve an efficiency rating of up to 85-90%.

Now data centres can opt for transformerless models based on insulated-gate bipolar transistor (IGBT) technologies capable of efficiencies upwards of 96% in double conversion mode.

The latest generation of UPS, manufactured with state-of-the-art silicon carbide (SiC) components, can deliver even better performance and achieve ultra-high efficiency of >98% in double conversion mode.

Transformerless UPS also have a flatter efficiency curve than the old transformer-based systems, meaning that many models can still achieve high efficiency (i.e. >95%) even at load levels as low as 20- 25%.

4. THE RISE OF MODULAR SOLUTIONS

The development of modular UPS is another area that is helping data centres improve efficiency.

Historically, data centre UPS comprised large monolithic units that tended to be oversized during initial installation to build in redundancy and allow for power expansion over time.

However, recent years have seen a boom in popularity of modular UPS, solutions comprising several smaller stackable modules housed within a cabinet that can be paralleled together to achieve the required power and redundancy.

This modular approach ensures capacity is 'right-sized' more closely to the data centre's specific load requirements, resulting in less risk of oversizing or unnecessary capacity – less waste leading to improved efficiency and reduced power consumption.

Modularity provides 'pay as you grow' flexibility, as extra power can be added as and when the need arises, either vertically by placing extra modules into a cabinet, or horizontally by installing additional cabinets in parallel.

As an example, take a data centre operator needing a system providing 100 kW power with N+1 redundancy. Prior to the introduction of modular UPS, this would have required two standalone 100 kW units to deliver the appropriate critical power.

But with a modular solution, they could achieve the same result with a system made up of five 25 kW power modules. If any module fails, you've still got enough power in the other four to support your load until you replace the faulty module.

In such a case, achieving N+1 redundancy only needs a 20% increase in capacity compared to the full load. With monolithic UPS you'd need a 100% capacity increase, which would also use up significantly more floorspace in the IT room.

5. ECO MODE, MONITORING & SMART GRIDS

In addition to ongoing technological advances, there are a few other factors that can impact on a data centre UPS's operating efficiency.

Economy & Energy Saving Modes

Running at partial load is a common feature in most data centre operations, with the notable exceptions of the largest social media and search engine data centres.

Many new build enterprise facilities come into operation carrying loads as low as 15%, take several years to reach 65%, and often never exceed 80%.

While the moves to transformerless and modular UPS have undoubtedly helped to improve efficiency at such load levels, there are other options available to operators.

Modern UPSs all incorporate so-called 'economy' or 'ECO' operating modes capable of boosting efficiency as high as 99%. In practical terms, ECO mode sees the UPS's inverter turned off while the bypass line (i.e. raw mains electricity) powers the load, potentially exposing it to voltage and frequency variations.

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

Even though some studies suggest a data centre could save as much as 2.3% of its energy by running in ECO mode, the risk of exposing the critical load means it is very rarely used.

Some UPS offer an 'Advanced ECO' operating mode, sometimes referred to as Active ECO. This is similar to standard ECO mode in that the mains supply powers the load, but the inverter remains on at all times and runs in parallel with the input without actually carrying the load current.

Because the inverter is always on in Active ECO, it can take over the critical load in the event of a mains failure far quicker. Active ECO mode efficiency is roughly 0.5-1% lower than standard ECO mode.

Many modular UPS also offer a smart 'Efficiency Control Mode' that helps ensure the highest possible efficiency depending on real-time load conditions.

This sees the UPS's microprocessors automatically activate only the required number of power modules according to the load and redundancy required, putting any surplus modules into standby.

Power modules can stay in this energy-saving state for several hours, before swapping with one of the active modules to ensure components age at a similar speed.

If there's any disruption to the mains supply, all the inactive modules immediately restart to provide maximum protection. The same happens if there's a fault with any of the modules or there's a sudden increase in your data centre's load.

UPS & Battery Monitoring

Another area where modern UPS can help lead to efficiency savings is its compatibility with the Energy Management Systems (EMS) and Data Centre Infrastructure Management (DCIM) software commonly used to encourage automation throughout the industry.

In essence, the unit becomes a 'smart' UPS that continuously collates, processes, and exchanges performance information such as operating temperatures, mains power supply voltage, UPS output, and remaining battery time.

This information can be used in real time to optimise overall system performance and identify areas for future improvement, ensuring the pursuit of carbon savings becomes an ongoing process.

For large-scale data centres with power protection systems scattered across several locations, often unmanned or in different cities or even countries, this connectivity and ability to remotely monitor several UPS units is an invaluable tool that helps to optimise load management and reduce waste.

Sophisticated Battery Monitoring Systems can also help with efficiency savings. Such systems improve the charging of the battery blocks compared to the more rudimentary charging of the overall string with a set float voltage.

Doing this can extend battery service life by as much as 30% and reduce the need for battery replacement. Even though this wouldn't factor into a data centre's PUE calculation, there are obviously wider sustainability benefits.

Smart Grids & Battery Storage

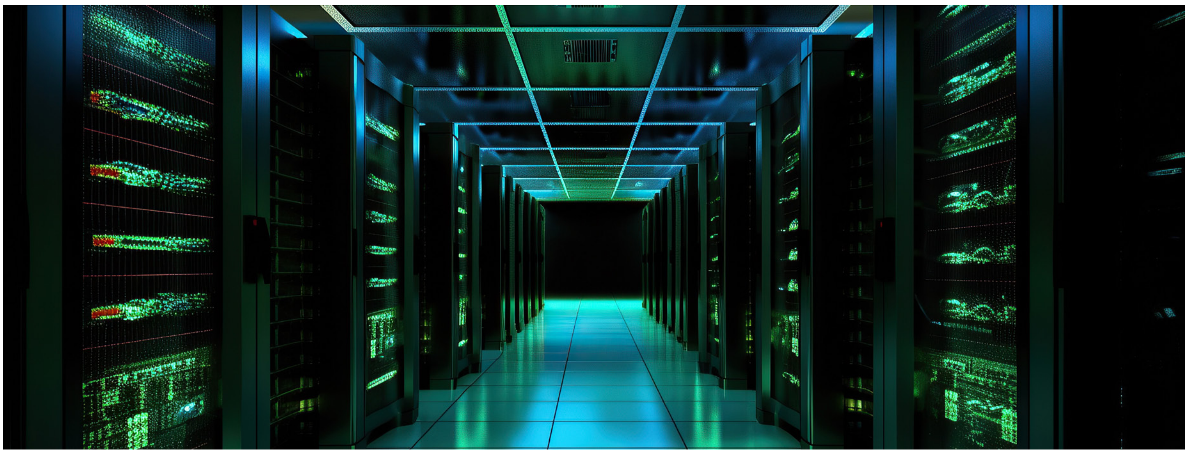
A data centre UPS, or perhaps more accurately its batteries, also has untapped potential as a generator of renewable energy as the UK moves more towards a demand side response (DSR) model.

Many UPS's now have the option to use Lithium Ion (Li-Ion) batteries which offer much greater power density even though they only take up approximately half the space of a more traditional valve regulated lead acid (VRLA) model.

In effect, Li-Ion UPS batteries can be used to store a surplus of energy generated during off-peak periods when the grid price is lower.

This stored power can then be used during more expensive peak times instead, or in the event of an outage. Surpluses could even be sold back into the grid on demand, generating valuable additional revenue for the data centre operators.

There's already more than 4 GW of power stored in UPS units across the UK, a figure that could rise considerably if the data centre sector shakes off its traditionally risk-averse shackles and embraces the possibilities that an increasingly volatile energy market offer.



6. PRACTICAL PROOF OF EFFICIENCY SAVINGS

Replacing legacy UPS systems approaching their end of life with new modular solutions can have a huge impact on cutting a data centre's carbon emissions, as the following recent project demonstrates.

A major colocation data centre that partners with several leading financial services, telecoms, and media companies needed to replace four UPS approaching their end of life that were protecting an average combined load of 330 kW.

At the average load, the existing UPS system was only capable of up to 89% efficiency with an input power factor of 0.8.

The old UPSs were replaced with a 1,250 kW scalable M2S version of Riello UPS's **Multi Power2**, the latest evolution of our modular UPS.

Thanks to its Smart Modular Architecture (SMA), the system adapts to the load demands to avoid any oversizing and provide the best performance in every working condition.

Multi Power2 is based on new 67 kW high density power modules, in this case ones manufactured using silicon carbide (SiC) components that enabled the new UPS to operate at 98.1% ultra-high efficiency even in true online double conversion mode.

Thanks to this significant improvement in efficiency, the data centre's annual cost for powering its UPS system fell by more than £180,000, while cooling reduced by £72,000 too. The data centre also saw its Climate Change Levy (CCL) – an environmental tax on energy use – fall by £13,000 a year.

All in all, upgrading to the M2S saved the data centre almost £290,000 a year compared to its previous UPS system, while its annual carbon emissions were cut by 345.89 tonnes too.

Over the 15 year lifespan of the new UPS, it is anticipated that total emissions could be reduced by more than 4,000 tonnes.

In addition to the energy saving and carbon cutting benefits, upgrading to the Multi Power2 also offered several other advantages.

Because it is manufactured using long-life components, it won't need any capacitor replacement over its 15 year lifespan, which will help to significantly reduce the overall total cost of ownership.

And as the UPS has a high mean time between failure (MTBF) and a very low mean time to repair (MTTR), the overall maintenance and service engineer costs will be reduced too.

7. CONCLUSION

Data centres in the UK already consume 3 TWh of electricity a year, and as demands for their services continue to grow, so too will this power requirement.

It'll be a similar case across Europe, where data centres already use 250 TWh of power.

As power generation shifts away from fossil fuels to renewable and zero carbon alternatives, we're heading into an era where data centre administrators and managers will be tasked with providing expanded capacity without any equivalent increase in electricity.

Being able to do 'more with less' isn't now just desirable it's becoming non-negotiable.

Taking proactive steps to reduce energy consumption and cut carbon emissions in the data centre makes sense not just from an environmental perspective, but from an economic one too.

The hard-headed business benefits of upgrading to more efficient, less wasteful modern, smart modular UPS are clear, for data centres of all shapes and sizes.

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