WHITE PAPER

Sustainability – making your data center carbon neutral

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Five critical steps to achieving data center sustainability

Accelerate your journey towards a net zero future

TAKING ACTION FOR A GREENER DATA CENTER ECOSYSTEM

The data center market is no stranger to energy efficiency strategies and in recent years has led by example in the mission critical arena for its commitment to carbon neutrality and achieving a net zero data center ecosystem by 2030. Even in the face of rapid digital acceleration, where the demand for data is driving unprecedented growth, the data center market is working towards delivering its commitments to purchase 100% carbon-free energy, reuse and repair services, prioritize water conversation, recycle heat and prove energy efficiency by meeting measurable targets.

A recent study confirmed that while data centers' computing output jumped six-fold from 2010 to 2018, energy consumption rose by only six percent during the same period.[1] These are impressive achievements that have laid the foundations for further development towards total sustainability.

THE DATA CENTER MARKET MUST REMAIN ON TRACK TO DELIVER THE 'GREEN EVOLUTION' MASTERPLAN

The global demand for data is set to follow a steep trajectory in the coming years, reaching an estimated 181 zettabytes in 2025[2]. There are a number of macro drivers responsible for this growth:

A sharp increase in connected devices and the proliferation of technology which is projected to rise from 13.8 billion in 2021 to 30.9 billion units by 2025[3]

The sudden onset of working from home that generated an immediate 40 percent increase in traffic[4]

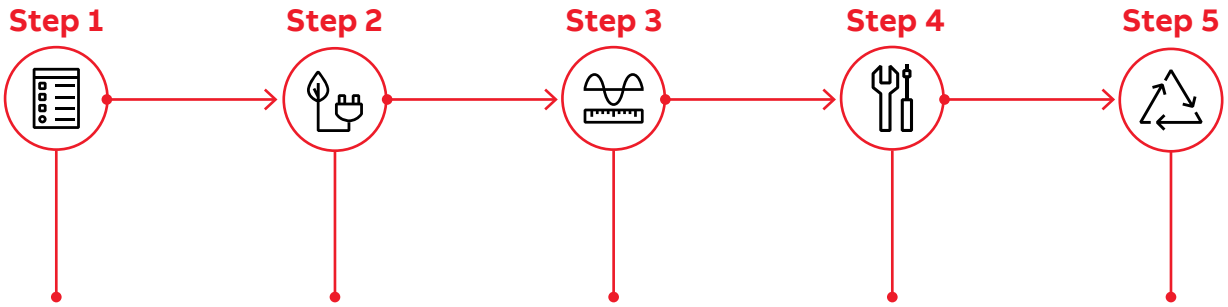
The rise of a data-driven economy in which 95 percent of businesses cite the need to manage unstructured data as a problem for their business and impacts how they navigate the market, make future predications and adjust to market trends[5]

Data centers have embraced sustainability both in design and in operation, making them a force for positive change - but there remains much work to be done. Now, more than ever before, customers are seeking out data center providers with a proven record of green credentials, and governments all over the world are moving at pace towards carbon reduction goals and net zero targets.

To maintain its position as a front runner in the sustainability evolution, the data center market must continue to embrace the advances that are happening in the areas of Artificial Intelligence (AI), remote management, state-of-the-art data center design and energy management systems. Sustainability was once the concern of hyperscalers only, but now, colocation data centers of all sizes, in all geographical regions, are planning and executing sustainability pathways that will promote an altogether more carbon efficient ecosystem.

There is a growing requirement among colocation users to store data in a conscious, net zero or sustainable way, which means selecting a data center provider that offers fully documented sustainability credentials. For colocation providers looking to monopolize on this growing demand, accelerating your sustainability pathway is critical to becoming a front runner in a market that will soon see sustainability as a prerequisite, not an added benefit.

In support of these efforts, the data center experts at ABB have created this whitepaper, that explores five key steps to achieving data center sustainability, with each step containing a wealth of advice and suggestions, including the latest technologies on the market:



Evaluation
You cannot manage what you cannot measure

Energy
Working with your local authority to purchase or integrate sustainable energy sources

Design
Minimizing energy usage and operating at peak efficiency

Maintenance
Upholding your newly implemented efficiency

Recycling
Recycling – end-of-life considerations and asset disposal

FOCUS: Specific drivers fueling the growth of data

The Internet of Things (IoT)
The convenience and efficiencies achieved by connecting digitized devices has created a groundswell of automation that penetrates how we live, travel and work. It is estimated that by 2025, this network of connected devices will generate 79.4 zettabytes of data, enough to fill around 80,000 data centers.6

Industry 4.0
The term industry 4.0 describes how manufacturing is evolving to leverage modern and future advances in computer power and connectivity. To make this a success, computer systems will interpret the physical world and communicate with each other through data.
It is no surprise therefore that Industry 4.0 will have an insatiable appetite for data that will need to be collected and stored effectively, creating a driving force for increased data center facilities throughout the world.

Autonomous vehicles
As driverless cars and autonomous vehicles become mainstream, the e-mobility sector must create an ecosystem in which these new-age vehicles can communicate with each other, as well as surrounding infrastructure and even pedestrians. It is estimated that each autonomous vehicle alone will create 4000 GB of data per day, based on one hour of driving in a 24-hour period.10 Multiply this substantial data requirements by the number of cars in major cities, and then add the data required by the connected street infrastructure and it is easy to see why creating an autonomous transportation system will be a specific driver for data center growth.

Evaluation – You cannot manage, what you cannot measure

STEP
01

"You cannot improve energy efficiency, unless you understand how much energy you are consuming, how it is distributed and where there is waste. Doing so enables informed decision making and targeted improvements, both now and as you progress along your sustainability pathway."

Brian Johnson, Global Data Center Leader, ABB

MEASURING PUE

The first and most critical step to developing a pathway towards data center sustainability, is to measure energy usage and the standard most commonly used within the industry is Power Usage Effectiveness (PUE). Put simply, PUE calculates the difference between total input power and the total IT load as a ratio, with the lowest theoretical value being 1, which for many data centers remains unachievable.

The lower the PUE, the more power is being used for IT, with most modern data centers calculating a PUE of between 1.5 and 1.7, and state-of-the-art facilities reaching ratios of 1.1. It is important to remember that data centers will perform differently according to a range of variables, including environmental factors such as humidity. PUE should therefore be considered as an individual benchmark for performance – a starting point from which to begin, and a marker for measuring success.

Theoretically, calculating PUE should just require two measurements – power in and IT power, but as data centers have become more complex and technology rich, measuring PUE has become more complex.

One effective method derived by The Green Grid, a collaborative nonprofit industry consortium dedicated to improving the resource efficiency of data centers, recommends monitoring PUE over a period of one year, taking ongoing measurements to compensate for peak and nominal loading changes that occur within the data center. If this is not possible, The Green Grid suggests an alternative method of measuring PUE over a period of time not less than one month and ensuring that the loading within that period is typical for that particular environment.

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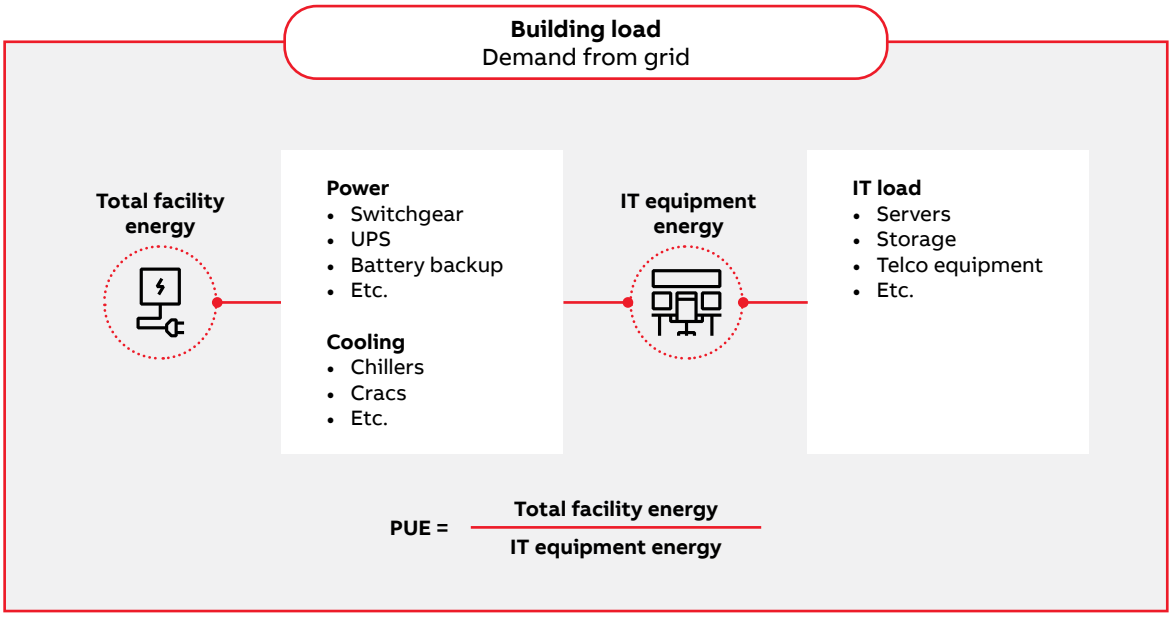
Illustration of how PUE would be calculated in a data center



Here are some of the key variables to consider when measuring PUE:

Input power distribution
Unless your facility is a dedicated data center, identifying the correct input power measurement can be difficult, and simply reading the load at the utility mains connection will not suffice.
The majority of data centers form part of a multi-use building and share the utility mains connection with a range of other loads, making the identification of the data center's input power challenging.

UPS connections may not reflect IT load
It cannot be assumed that all equipment connected to the data center's Uninterrupted Power Supply (UPS) are a direct contributor to the IT load. Examples include HVAC loads such as fans that are often connected to the UPS for "ride through" reasons.

Likewise, some IT loads that should be measured as part of your PUE calculation may not be connected to the UPS because they can tolerate interruption better than other systems. A good example of this is "cold storage" for data used infrequently or stored for compliance purposes.

Separate instrumentation for accurate results
Given these complexities, achieving an accurate PUE requires all data center loads to be instrumented separately from other non-data center loads within the building, and their input power summed individually. Furthermore, to obtain the total IT load, all IT devices need to be separately instrumented, and their input power also summed. In a typical 1 MW data center, this process is likely to require thousands of simultaneous power measurements, which is a technical and practical challenge.

A solution to measuring PUE with an aggregate IT load
Given the real-world complexities of measuring PUE, many data center operators now opt for using a small number of consolidated measurement points combined with mathematical models of the PUE system to demonstrate efficiency measurements of sufficient accuracy.
Measuring the aggregate IT load is one example of this more practical approach, as demonstrated in Figure 1, which shows a typical example of a large number of IT loads being supplied by Power Distribution Units (PDU), connected to a UPS.

ONGOING MONITORING

The ongoing monitoring of power distribution and consumption is just as important as measuring PUE. It will demonstrate changes in power usage, trends and spikes that will enable informed decisions to be made when the times comes to upgrade equipment or make infrastructure changes that will improve the sustainability of your data center.

By understanding where the most power is being consumed, data center operators can better understand how to drive efficiencies. As data center facilities grow and evolve, this constant monitoring will provide a real-time or near-real-time analysis of power performance.
There are a number of ways to monitor how power is used throughout a data center. Here are just a few highly successful aftermarket solutions to consider:

EKip Up
Ekip Up from ABB is a low-voltage digital monitoring unit that monitors, protects and controls power distribution from an “all-in-one” platform. Using this simple to install solution, you can:

- Update basic switchboards with new monitoring, protection and power control
- Operate up to 35 individual protection functions for power distribution and generation
- Utilize more than 1,000 measurements and power quality data
- Manage peak shaving and load shifting with four power thresholds everyday

CMS-700
ABB’s CMS-700 is a circuit monitoring system with up to 96 sensors for multi-channel measurement in either AC or DC. This versatile and easy to install solution can be integrated into already wired panels and provides easy access to data collection, analysis and downloads to optimize energy consumption, efficiency and energy management.

ABB Ability™ Energy and Asset Manager
ABB Ability™ Energy and Asset Manager is a state-of-the-art cloud solution that integrates energy and asset management in a single intuitive dashboard. Providing full remote visibility of asset and electrical-system behavior, ABB Ability™ Energy and Asset Manager provides insights that help you minimize both cost and risk and maximize performance and safety across your operations.

Collaborate – Work with your local utility provider to maximize sustainable energy sources

STEP
02

"Connecting to the smart grid not only allows data centers to purchase renewable energy from local independent sources via their mains utility provider, but also enables data centers to feed their own renewable energy back into the grid when IT loads are low, if they have power generation systems installed on site.

"Strategies like this make a considerable difference in offsetting your carbon footprint and place you a step closer to reaching your end goal of either net zero emissions or carbon neutrality."

Danel Turk, Solution Portfolio Manager, Data Centers, ABB

Being connected to mains power gives data centers an ally in the battle for sustainability. Your local utility provider will prove a profound source of knowledge and consultative expertise and can assist you in making key decisions about the power you purchase, distribute and consume.

Explore Purchase Power Agreements
A Purchase Power Agreement (PPA), also known as an electric power agreement, is a long-term contractual agreement between your business and the utility provider that enables you to purchase renewable energy in high volumes from an independent power producer (IPP).

PPA s are good way to mitigate risks on energy price changes and allows you to make long term plan for business plan.

Older data centers architectures are built in a way that they are energy consumers. Newer technologies and architectures are allowing data centers to become prosumers, and they are able to participate in grid support services.

PPA s will allow also agreements between utility and data center to agree what additional service can be provided to support the grid when needed. For such service usually is needed onsite generation eg Solar power, fuel cell or gas turbines and Battery energy storage or Medium voltage UPS combination

Consider an ESCO partner
When agreeing your next build location, consider working with an Energy Service Company (ESCO) to dramatically reduce the energy costs of your building.

Historically, an ESCO provides a broad range of energy solutions including design expertise, retrofitting, energy conservation, outsourcing energy infrastructure, risk management and much more.

In recent years, ESCO partners have also developed innovative financing methods, including off-balance sheet mechanisms that make onsite energy saving infrastructure an affordable and often appealing option for many data center providers looking to generate renewable energy for the first time. Working with an ESCO partner is often a safe way to take these initial tentative steps towards power generation because if the energy savings do not cover the capital investment during the agreed time frame, responsibility often lies with the ESCO to pay the difference.

A typical pathway for working with an ESCO partner would include:

- A comprehensive analysis of the property or build plans
- The designing of an energy saving solution
- Agreement of a payback period during which the energy savings are used to pay back the capital investment of the project over an agreed term, typically between five- and 20-years
- Installation of the required infrastructure and processes
- Ongoing maintenance of the system to ensure energy savings during the payback period

Design – minimizing energy usage and operating at peak efficiencies

STEP
03

"As an industry, we have eliminated 80 percent of energy losses by evolving how we design our data centers, but we are now hitting the point of diminishing returns. It is time to invest in technologies that improve energy efficiency and lower carbon footprint, like SF6-free switchgear and variable frequency drives to optimize cooling via segregation of cooling paths.

"Changes like this would reduce overall IT and infrastructure energy consumption by 15 percent and allow us to continue our progression towards carbon neutrality."

Harry Handlin, Data Center Solutions Architect, ABB

DESIGNING YOUR DATA CENTER FOR SUSTAINABILITY

Switching from LV to MV UPS
One important design consideration for any modern data center is whether a transition from Low Voltage (LV) to Medium Voltage (MV) level UPS protection and a more energy efficient configuration is viable. Recent technological advancements in the design of MV UPS allows to build more efficient energy buffer to avoid black outs and delay rotary systems start up. These systems can deliver significant energy savings compared to rotary systems.

Modern data centers are getting bigger, and this can make the transition from conventional LV UPS to MV level UPS protection more achievable. At MV, the lower currents require smaller cables and losses are lower, saving operators energy and carbon emissions. If there are less redundancies in the design of your data center and you are running as much load as possible through your MV UPS, your efficiencies will increase.

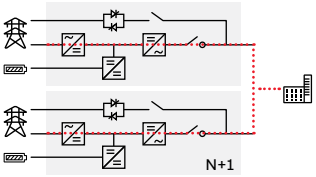
That said, both LV and MV technology is advancing at pace, and some market leading MV UPS systems can now offer 98 percent efficiency.

If switching to MV level UPS protection is not an option, it is still important to consider improvements in the design of your data center at LV. The following illustration demonstrates an example of current efficiency across several operating modes of a UPS design for LV:

Efficiency options

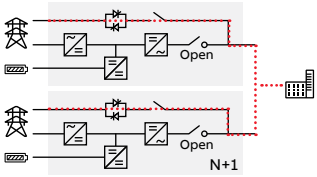
UPS's has multiple operating modes

VFI- double conversion
The default operating mode – **efficiency up to 97.4%** (recommended for all critical applications)



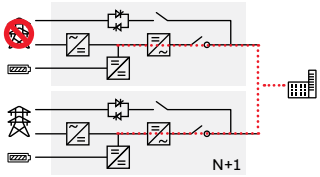
VFI: 97.4%

VFI- double conversion
Alternate operating mode – **efficiency up to 99%** (for ultimate efficiency savings – double conversion on demand)



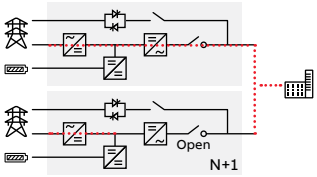
ECO: 99%

Battery mode
Load supplied from energy storage solution



BATTERY: 97%

Low load optimization
Double conversion mode with **enhanced efficiency when load is low** compared to total capacity



XTRA-VFI: > 97%

BLOCK REDUNDANT CATCHER SYSTEM

In recent years, the machinery and systems we use within our data centers has become more reliable and so has how we connect our facilities to a power supply. These advancements have led to new thinking around topology and efficiency, resulting in more utilization of the UPS.

Now, more than ever, data center operators are moving away from the conventional system-plus-system topology, in favor of using block redundant topology instead.

System-plus-system topology
System-plus-system topology uses two totally independent systems to feed the critical load and has long been the chosen method of design for more conventional data centers. These topologies have a strong record of reliability but can be prohibitively high to operate with a maximum asset utilization of 50 percent.

Block redundant (catcher) topology
For data centers with single corded loads, newer block redundant (also known as catcher) topology can achieve an asset utilization of 80 percent, by using a Static Transfer Switch (STS) to transfer the critical load from the primary system to the reserve or catcher system.

With such a difference in performance, it is clear to see why many future-focused data center providers are choosing block redundant design methods. This is a trend not only driven by the increasing scale of data centers but also improvements in networking.

Improve PDU arrangements to decrease transitions and increase voltage to the server
In addition to the specification of your UPS equipment, it is also important to consider how power is distributed around your data center. Making sure all connections are correct can help improve efficiencies and lower power consumption.

Remember, almost all IT equipment is designed to work with input power voltages ranging from 100- to 240- V AC in accordance with global standards. The higher the voltage, the more efficient the unit is. Operating UPS at 240/415 V three-phase, four-wire output power, a server can be fed directly and an incremental 2 percent reduction in facility energy can be achieved by eliminating transformers in PDUs.

IMPROVE ENERGY MANAGEMENT THROUGH DIGITALIZATION

There are many benefits to investing in digitalization. It can reduce wiring, minimize installation and commissioning time and promote scalability. There are clear trends, such as using IEC 61850 and other open protocols to add intelligence to electrical equipment, and the increased use of energy management software to promote informed specification decisions.

IEC 61850

The standardized framework of IEC 61850 specifies a range of parameters for digitalizing substation integration, such as communication requirements, the structure of data in devices, functional characteristics and naming conventions for data. It is being increasingly used across smart grid applications, renewable installations and process industry applications as well as the data center market.

When exploited correctly, this open protocol allows engineers to create features such as advanced logic selectivity based on device-to-device communication, real-time diagnostics and integrated engineering. These advancements benefit equipment such as protection relays, circuit breakers, communication gateways, programmable logic controllers (PLCs) and supervisory control and data acquisition (SCADA) architectures.
Together, these devices make it possible to design and operate a fully integrated protection and supervision system that spans all required voltage ranges.

Digitalization, using open protocols like IEC 61850 can reduce wiring in subsystems like switchgears by up to 90 percent and reduce the time it takes to assemble, test, install and commission the equipment. One of the reasons digitalizing switchgear and other components is so popular is because it enables fast, effective scalability by reducing the need for hardware upgrades and allowing changes to system configuration to be done remotely.

SOLUTIONS FOR DESIGNING DIGITAL

ABB Ability™ Operations Data Management-Zenon
Designed to deliver better quality assurance, energy management and online reporting, Zenon from ABB is a secure operations data management platform that easily connects machines, infrastructure and electrical assets, both on site and remotely, enabling them to share information and develop insights for optimized operation.

Turning data into information, Zenon provides insight into production processes via more than 300 communication protocols and drivers, enterprise resource planning and cloud interfaces.

ABB Ability™ Energy and Asset Manager
The Energy and Asset Manager from ABB Ability™ is a state-of-the-art cloud solution that integrates energy and asset management into a single intuitive dashboard. It can be paired with ABB Zenon to incorporate and monitor energy usage from remote sources.

This solution provides insights that help you minimize cost and risk, to maximize performance and safety across your data center operations.

ABB Cylon® Building Energy Management Solution
Cylon® from ABB provides scalable automation and energy control for any size commercial or industrial building. This building energy management solution uses open protocols, common and secure internet standards and emerging technologies to meet the needs of even the most digitalized data center.

ABB Ability™ Data Center Automation
ABB Ability™ Data Center Automation is ABB's industrial solution for on-premise and hybrid cloud environments. At a base level, it is an integration and automation platform to enable transparency and interoperability for continuous optimization and high availability.

It allows data exchange and automation among systems, equipment, components and applications so you can integrate data center tool sets faster, visualize and manage physical assets within a 'single pane' view of the entire data center, and automate cooling and electrical systems for continuous optimization and improved uptime.

DIGITALIZE COOLING

As one of the most critical aspects for the correct and reliable operation of a data center, cooling infrastructure accounts for the consumption of around 40 percent of a typical data centers total energy usage.7 It makes sense therefore that the compressors, pumps and fans installed to cool the IT equipment should be a serious contender when looking to drive efficiency gains.

Variable frequency drives
Variable frequency drives (VFD) enable the speed of electric motors used in cooling applications to be controlled with greater accuracy. In doing so, they can deliver energy savings of between 20 and 30 percent9 by ensuring that the flow produced matches the facility's fluctuating requirements, rather than relying on throttling and damping to control the output of a motor running at full speed all the time.

Correct specification of motors
Different motor technologies perform better in different load ranges, with an efficiency window of over 10 percent at certain loads.5 To optimize the efficiency of cooling motors, it is important to specify one that has been designed to work at the load it will operate at most of the time. In most cases, this will not be the nominal load, but well below it.

Take a whole-system approach to efficient cooling
Contrary to popular belief, it is simply not possible to calculate the efficiency of a cooling system by measuring the performance of each component – instead, you must take a whole-system approach, to ensure no losses go unaccounted for. For example, you may install highly efficient motors to run applications like pumps, fans or compressors with the minimum possible losses and use drives to match the motor speed, but if the design of a fan causes massive aerodynamic losses, the entire system efficiency or wire-to-air efficiency could suffer.

CONSIDER CHANGES TO BACK UP POWER ARRANGEMENTS

Power outages for the data center market cost in the region of $9,000 per minute8, making backup power an essential component of any mission critical facility, and in recent years, much investment has been made into advancing these technologies. With a notable increase in pilots using battery energy storage systems (BESS) and fuel cells, including unique solutions such as ammonia fuel cells, there are now more options than ever before for data centers to drive efficiencies through renewable back up power arrangements.

As with all market-leading technologies, the main draw with the latest back up power advancements is their connectivity, which is proving useful across many pilot locations for the integration and monitoring of renewable energy.

Choosing the right energy storage system offers the following benefits:

- Smoother grid integration of renewable energy by reducing variability
- Storing renewable generation peaks for use when demand is at its highest
- Flattening demand peaks, thereby reducing stress on grid equipment
- Providing infrastructure support as loads increase
- Decreasing or eliminating the power fees related to short time peak loads
- Maintaining generation and demand balance
- Postpone backup generator startup need

BESS

BESS manage energy costs by leveraging peak shaving, load shifting and maximization of self-consumption. These systems provide critical backup power buffer preventing revenue losses due to outages and can be easily scaled to meet the demands of growing infrastructures.
For a data center leveraging the benefits of digitalization, BESS are often easily connected to power management software and provide ample opportunity to carefully monitor, and control consumption of renewable power based on digital insights via any chosen building management system.

Maintenance – upholding your newly implemented efficiency changes

STEP
04

"Every product or system used within a data center carries a 'product carbon footprint' which accumulates at every stage of its life, from cradle to grave. From the extraction of resources right at the start, through to manufacturing of components and production of the final product, transportation by land, air, or sea, and then the emissions created during the use phase due to the product's intrinsic power losses, and finally the associated carbon cost of end-of-life disposal.

"It makes sense therefore, that expanding the system's usable life, will reduce the need for the more carbon intensive aspects of a products life cycle such as the extraction of metals, manufacturing and end of life disposal."

Lee Todd, Executive Product Manager, Data Centers, ABB

Condition monitoring and predictive maintenance
Harnessing the power of connectivity to introduce condition monitoring can further extend asset life and reduce the impact of your data center on the environment. By monitoring the operational conditions of key systems, such as the temperature around critical components, using sensors and a digital predictive maintenance solution, facility managers will be made aware when operational conditions breach the ideal parameters. This allows engineers to make fast, informed decisions that can prevent outages and maintain uptime.

Replacing outdated components
When it comes to maintaining systems that contain multiple components, it is now possible to replace only the components that have become outdated, rather than the entire system. This not only drives notable cost efficiencies, but also promotes circularity.

One example of this is with switchgear. Thanks to advancements in technologies, data center owners are now able to replace outdated circuit breakers using specially designed retrofitting solutions, without scrapping the rest of their switchgear system. In doing so, it is possible to keep much of their equipment in service, including the parts most damaging to natural resources, such as the metal cabinet, steel plates and busbars.

Upgrading technologies without upgrading systems
As data centers continue along their path of digitalization, it is inevitable that systems will need to be upgraded with the latest advancements in digital and connected technologies.

Thanks to substantial R&D investment into component design, it is now possible to retrofit upgrades of a range of key components rather than undergo the complete decommissioning and replacement of entire systems. By using retrofit kits and brownfield solutions to prolong the service life of equipment, it is possible to only upgrade the parts that will improve functionality in line with the latest connectivity standards, keeping the rest of the system in service. This approach allows data centers to promote a more restorative economy, whilst still operating at the forefront of technology.

Recycling – end-of-life considerations and asset disposal

STEP
05

"End-of-life circularity begins upstream in the design phase, where it is the manufacturer's responsibility to design products and systems that are smaller, lighter and use less raw materials. To promote circular economies in your data center, work with manufacturing partners that begin their product's life, with recycling in mind."

Kent Chow, Data Center Segment Leader Asia, ABB

PEP ecopassports
In response to many data centers signing the European Climate Neutral Data Center Pact to achieve net zero by 2030, market-leading manufacturers are now investing in the proven credibility of their systems.

One example of this is the PEP ecopassports, a prestigious label awarded to specific products that can meet stringent performance criteria throughout its life cycle, including manufacturing, distribution, installation, use and end-of-life. Providing an international reference framework, the PEP programme ensures reliable, transparent, comparable and verified environmental performance indicators for electrical, electronical, heating and cooling equipment.

ABB is proud to offer the PEP ecopassport label with its MegaFlex DPA, a low voltage UPS, that provides a best-in-class efficiency of 97.4 percent and reduces carbon emissions by 641 tons during the lifetime of the product.

Change is happening for circular end-of-life disposal
There are many signs of positive change throughout the data center ecosystem that suggest circular end-of-life disposal will soon be a mainstream priority. From ITRenew, the world's largest IT asset lifecycle management solution, receiving additional investment from its new parent company Iron Mountain, to progress in the recycling of Lithium-ion batteries and the increased use of non-toxic chemicals in battery design.

It is important, despite the pace at which the data center is moving, that facility managers keep up to date with the latest end-of-life disposal techniques, working with carefully selected manufacturing partners who can provide ongoing best practice consultation can help.

ABB, supporting data center sustainability

ABB has stood alongside the data center market throughout its transition towards a connected, digitalized and sustainable ecosystem. Offering a wealth of systems and software solutions for all aspects of data center efficiency, ABB is best placed to offer consultative reassurance and technical support from the early design stages, right through to operation and maintenance, and end-of-life circularity.

Our commitment to sustainability
At ABB, we actively contribute to a more sustainable world, leading by example in our own operations and partnering with customers and suppliers to enable a low carbon society, reserve resources, and promote social progress.

Further reading
Would you like to learn more about ABB's data center solutions? Click here

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