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Off the Grid

A 4 pillar approach for green data centres

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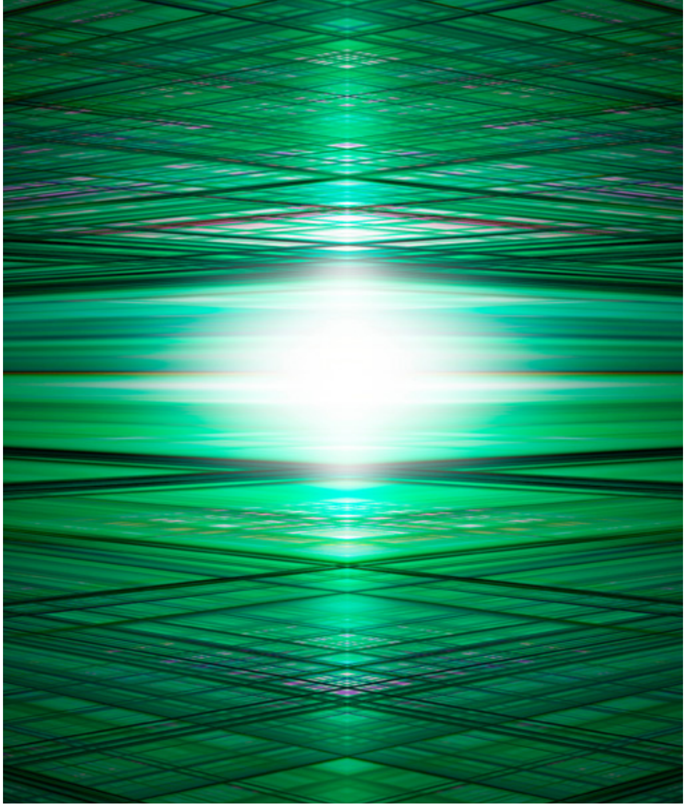


Climate action is now top of the corporate agenda. Regulatory and socio-economic pressures are forcing companies to act with greater urgency. In a world in which data use is growing exponentially, data centre (DC) providers increasingly face a pressing and existential challenge to demonstrate a commitment to sustainability.

Data Centres: Current Landscape

Everything that happens online is facilitated by a data centre.[1] These vast facilities form the foundation of our internet. As such, their importance to today's increasingly digital economies can hardly be overstated.

However, as the footprint of DCs worldwide has grown, so too have the concerns regarding their environmental impacts. Since 2015, internet usage has tripled.[2] DC capacity is set to increase ten-fold between 2018 and 2025.[3] There is a significant risk that the efficiency gains that have kept DCs energy use and environmental footprint in check thus far will be outpaced.[4]

Addressing Data Centre Sustainability

Regulatory landscape

It is within this context that the regulatory landscape has already started to shift. In Europe, the EU Climate Neutral Data Centre Pact is a major plank in Europe's bid to achieve climate neutrality by 2030. Elsewhere, the Science Based Targets Initiative (SBTi) is already helping organisations set targets and timelines for a transition towards a net zero economy.

The circular economy and why it's relevant to data centres

"A circular economy decouples economic activity from the consumption of finite resources. It is a resilient system that is good for business, people and the environment. It is a systems solution framework that tackles global challenges like climate change, biodiversity loss, waste, and pollution."[5]

Circular economy is based on 3 core principles:

1. Eliminating waste and pollution
2. Circulating products & materials and
3. Regenerating nature

This approach allows for a more complete view of emissions, going beyond Scope 1 (direct emissions) and 2 (indirect emissions), acknowledging the significant impact of upstream and downstream Scope 3 emissions (all other indirect emissions from the activities of an organisation, including from sources that they do not own or control).

As the pressure on DCs to place sustainability at the forefront of their operations increases, circular economy can provide a strategic roadmap. Applying the three core principles to operations will not only benefit the environment and lead to long-term competitive advantage but will also enable organisations to deal with ever increasing regulation.

The 4 Pillar Approach

Extensive research and discussion with experts repeatedly highlighted the same problem areas. These pain points can be segmented into 4 pillars which form a template for assessing sustainability maturity. This allows for a more targeted approach, highlighting distinct areas of focus while still ensuring all aspects of DC operations are covered.

The 4 pillars are: Renewable Energy, Energy Efficiency, Infrastructure Circularity and Water Usage.

Pillar 1: Renewable Energy

As companies consider making the transition towards powering their DCs with renewable energy (RE), they must weigh the risks of continuing with the use of fossil fuels in terms of reputation and regulations. When it comes to obtaining RE there are a variety of options, ranging from untraceable certificates to self-generation. Ideally, companies should aim to add RE capacity through self-generation and/or Purchase Power Agreements, as these options give real emissions reductions; the widespread use of Renewable Energy Certificates must ultimately be curbed.
In the longer term, vertically integrating renewable energy generation onsite offers the opportunity to move towards the circular economy. The lowering cost and increasing supply of renewables will help more organisations achieve this, though investment in next-generation computing, storage, and heat removal technologies will be required.[6]

Pillar 2: Energy Efficiency

Leading DCs are becoming more energy efficient largely by improving their IT equipment power usage. Such efficiency can be achieved in 5 steps – from optimising IT power, DC space, DC cooling, eliminating DC power inefficiencies and utilising Data Centre Infrastructure Management Software (DCIM).[7] Still, this will not be enough on its own. Potential remains for substantial efficiency gains but, again, investments in next-generation technology will be needed.

Parallel investments in renewable power sourcing will also be required. Governments can offer guidance, incentives and standards to encourage further energy efficiency, while regulations and price signals could help incentivise demand-side flexibility.[8]

Pillar 3: Infrastructure Circularity

To make a meaningful impact, infrastructure circularity must be tackled at the earliest stages of product and process design. Modularity, material selection and subcomponent life cycle tracking all offer pathways towards increased circularity. DCs should look to these processes if they wish to realise the positive environmental and financial effects highlighted by industry leaders.

Pillar 4: Water Usage

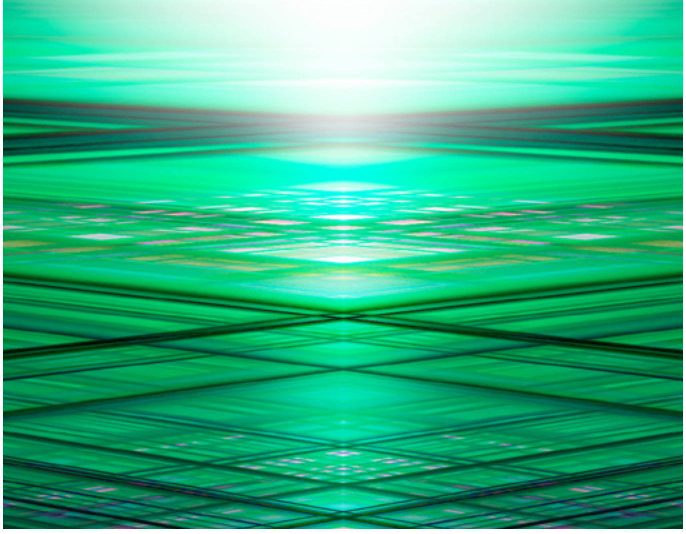
DC processes and operations are water intensive by nature. As an estimated 40% of total energy requirements are generated by cooling, water usage must be a key focus area for all organisations.[9] Incorporating sustainability metrics as KPIs and embedding those into governance structures is crucial for organisations as they transition towards greener business practices.

How can Deloitte help?

The pressure that data centres place on our electricity grids is ever increasing and is of importance not only DCs but to other residential, commercial, and industrial sectors as well. Action is urgently required if companies are to meet legislative requirements, particularly carbon neutrality by 2030.

Deloitte brings world-class capabilities and high-quality service to its clients, delivering the insights they need to address their most complex business challenges. Let us connect you to the professionals who can both transform your current practices and help to embed new ones, providing all the tools for addressing data centre sustainability – not only now, but well into the future.

Off the Grid



Introduction:

Climate action is now top of the corporate agenda. Regulatory and socio-economic pressures are forcing companies to act with greater urgency. In a world in which data use is growing exponentially, DC (data centre) providers increasingly face a pressing and existential challenge to demonstrate a commitment to sustainability.

What exactly is a DC?

Everything that happens online is facilitated by a DC.[1] They are the (often vast) facilities that house the servers and digital applications which form the foundation of our internet. As such, their importance to today's increasingly digital economies can hardly be overstated, with DCs playing a fundamental role in supporting the activities of governments, businesses and individuals.

Their design is based on a network of computing and storage resources which enable the delivery of applications and data. DCs are made up of several components, such as power subsystems, uninterruptible power supplies (UPS), ventilation, cooling systems, fire suppression, backup generators, and connections to external networks.[3]

The main purpose of DCs is to provide:

- **Network infrastructure:** Connecting servers, storage and external connectivity to end-user locations.
- **Storage infrastructure:** Used to hold the data itself.
- **Computing resources:** Servers which provide the processing, memory, local storage and network connectivity that drive applications.

In terms of how DCs operate, their fundamental function is to protect the performance and integrity of the core DC components. These are:

- **Network security applications:** Firewall and intrusion protection to safeguard the DC.
- **Application delivery assurance:** Maintains application performance and provides application resiliency.

These functioning components make it possible for society to benefit from online learning, keep connected with friends and family, log into work every morning and make crucial life decisions such as whether they want to swipe left or right.

DCs vary considerably in terms of size, ownership and technology used. They can, however, be classified into four distinct groups: Enterprise, Managed services, Colocation and Cloud.[4]

Enterprise DCs are built, owned, and operated by companies and are optimised for their own users. **Managed** service DCs are managed by third parties on behalf of a company. **Colocation** DCs are where a company rents space within a DC and it is located off premises. The DC hosts the infrastructure, and the company manages the components. Cloud DCs are off premises; data and applications are hosted by a cloud services provider.

Current Landscape

DCs are an essential part of our digital infrastructure and contribute significantly to the global economy. However, as the footprint of DCs worldwide has grown, so too have the concerns regarding their environmental impacts. Internet usage has tripled from 13 per cent in 2015, to 46 per cent in 2022.[5]

The latest evolution of enterprise DCs, known as 'hyperscale', are becoming increasingly popular for large organisations. Compared to standard enterprise DCs, these significantly larger facilities benefit from economies of scale and tailored, custom engineering. Google's hyperscale DCs, for example, push previous limits of energy efficiency, reporting Power Usage Effectiveness (PUE)* of 1.1 compared to the enterprise average of 1.67-1.8.[6]

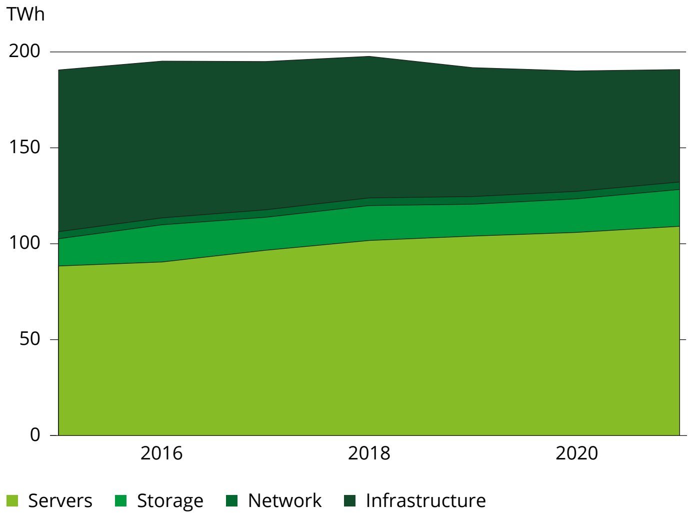
* Power usage effectiveness (PUE) is an important component in energy efficiency. It refers to the relation between the total energy entering a DC and the energy used by IT equipment inside the DC (cooling, heating, ventilation, power conversion and distribution, lighting, utility plugs).[8]

> Until today, the sector has relied on Moore's law, *"the principle that the speed and capability of computers can be expected to double every two years, as a result of increases in the number of transistors a microchip can contain."* *However, experts agree that this law cannot hold through indefinitely.*[9]

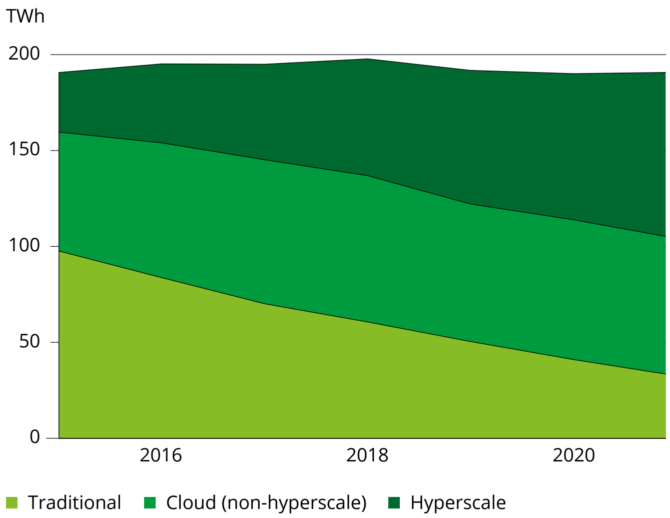
DC capacity is set to increase ten-fold between 2018 and 2025, and the global construction pipeline for DCs hit a new high in 2021.[10] This is largely due to the digitisation of industry and society. There is a significant risk that as demand for information services and computing applications increases, the efficiency gains that have kept DCs energy use and environmental footprint in check thus far will be outpaced.[11]

This risk is being exacerbated by the growth in popularity of cloud facilities. These have greater power usage requirements, largely due to the need for constant computing capacity. Increasing capacity demand has outpaced renewable energy grid expansion, creating a snowball effect of surplus energy requirements. This is problematic for the low carbon transition, which relies on growing availability of renewable energy.

Global data centre energy demand by end use



Global data centre energy demand by data centre type



Location matters

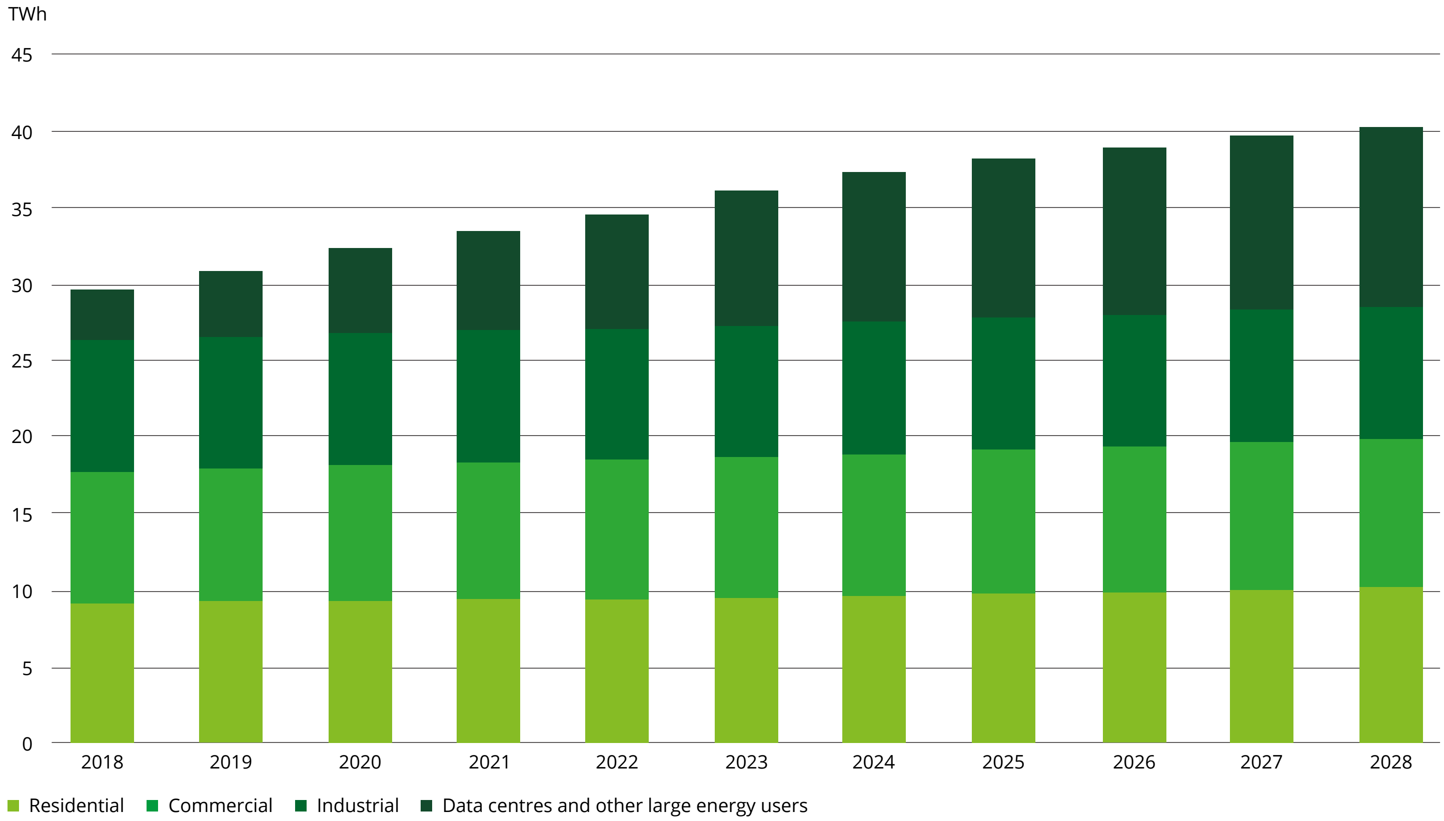
While DCs account for a sizeable percentage of energy usage worldwide, assessments of their climate impact at a global level are misleading. This is because DCs can have varying impacts depending on grid requirements and geography. Energy grids are decarbonising at varying rates depending on the investment in expansion of renewable generation. DCs are ultimately reliant on the availability of clean energy to power their operations.

In terms of geography, local energy operators in Denmark project total energy grid consumption from DCs to grow from 1-15% by 2030. In Ireland it is set to more than double, reaching 30% by 2028.[16] There are currently 70 DCs in operation in Ireland with a further 8 under construction.[18] This expansion has placed increasing strain on the energy grid. In 2021, DCs accounted for 14% of all electricity used in the Republic of Ireland, a 256% increase from 2015.[19]

As well as the challenges associated with the impact of DCs in accelerating climate change, there is also the question of climate change's impact on DCs. Local energy grids present concerns around resiliency, particularly with the increase in extreme weather events and the resulting availability disruptions. High temperatures and drought are causing alarm globally. In the US, regulatory bodies are warning of electricity shortages and blackouts. Not that such issues are limited to the summer: the energy grid in Texas faced similar shortages in February 2021, where freezing temperatures resulted in blackouts from natural gas and increased demand for heating.[22]

Climate impact is therefore key to DC location. The choice of site must factor in the likelihood of extreme weather events – such as increased flooding and droughts – which can put essential water supplies at risk.

Projected electricity demand in Ireland, by sector, 2018-2028



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Addressing Data Centre Sustainability

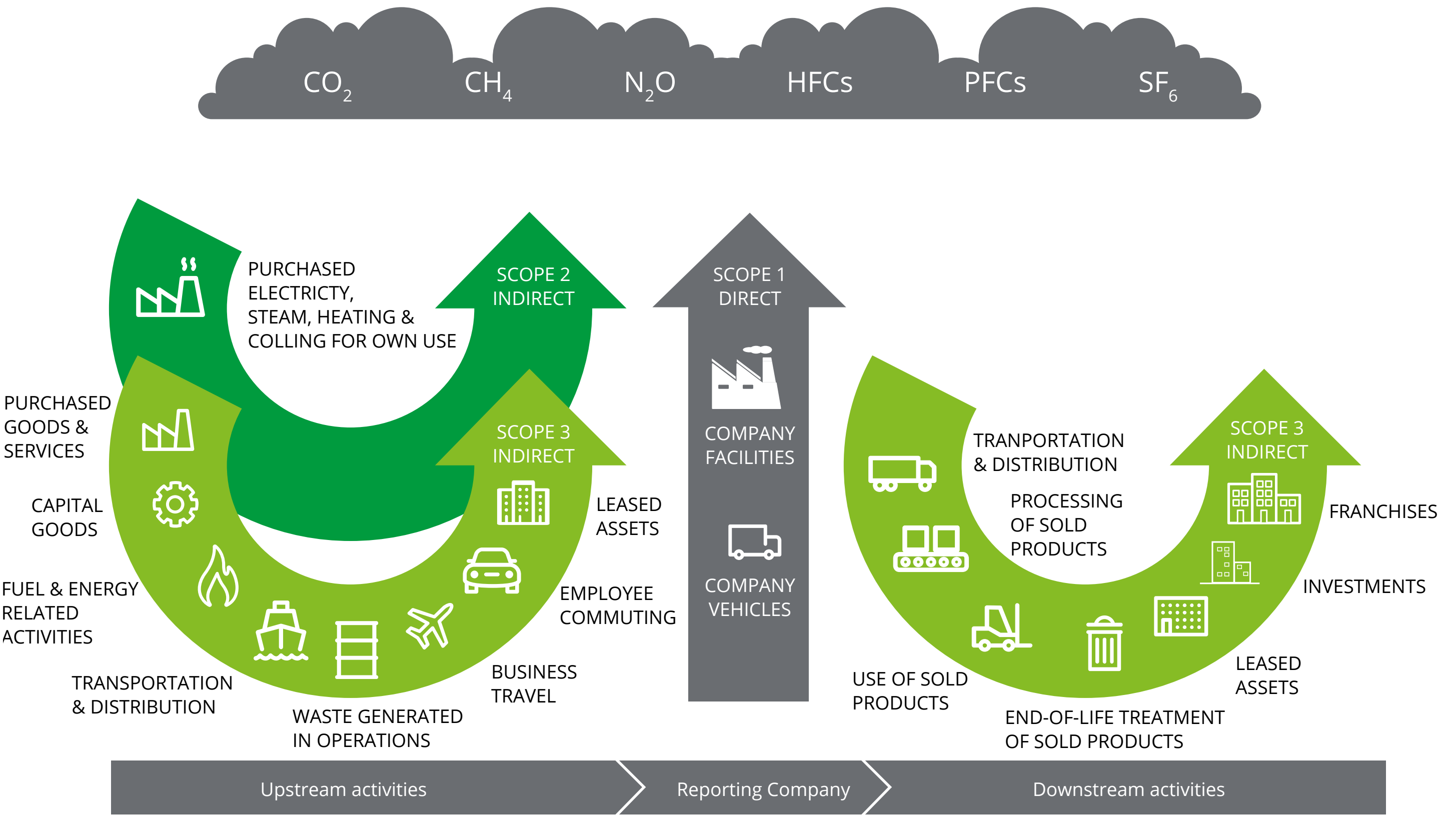
Companies urgently need to address environmental concerns to reassure society and safeguard their DC operations. The ever-changing regulatory landscape and transition towards circularity are critical success factors for achieving this.

However, before considering this in greater detail we must first establish what we're referring to when we talk about emissions.

Scope 1 emissions are all direct emissions from the activities of an organisation, including fuel combustion on site, such as gas boilers, fleet vehicles and air-conditioning leaks.

Scope 2 refers to indirect emissions from electricity purchased and used by the organisation. Emissions are created during the production of the energy that is subsequently used by the organisation. Reporting requirements, as well as companies' claims of carbon neutrality, often include only Scope 1 and Scope 2 emissions. However, for most firms, it is Scope 3 emissions that make up the majority and thus have the biggest adverse impact on the environment.

Scope 3 emissions refers to all other indirect emissions from the activities of an organisation, including from sources that they do not own or control. These usually amount to the greatest share of the carbon footprint, covering emissions associated with business travel, procurement, waste, and water. The omission of Scope 3 emissions from reporting and environmental claims is often misleading. Although they are difficult to measure, companies must take responsibility and ensure they are incorporated into sustainability reporting.[24]



Source: Greenhouse Gas Protocol

Regulatory Landscape

The construction of new DCs across Europe has seen increasing opposition from local government and environmental groups. For example, the senate in the Netherlands recently passed a motion to block the construction of a large Meta DC due to its energy requirements. These types of planning blocks are becoming more common as energy shortages worldwide come into sharper focus.

> *"The EU Commission noted that Data Centres and telecoms are responsible for a significant environmental footprint, and "can and should become climate neutral by 2030."*[26]

The EU Climate Neutral DC Pact stands to be a consequential piece of legislation, intended to help drive Europe's bid to achieve climate neutrality by 2030. The Pact is essentially a pledge by companies who own or operate DCs, and includes actions on energy efficiency, clean energy, water, circular economy, circular energy systems and governance.[27]

More and more organisations are now looking to established frameworks and environmental accreditors to assist in their transition towards more sustainable practices, for example through the Science Based Targets Initiative (SBTi).

Science Based Targets Initiative (SBTi)

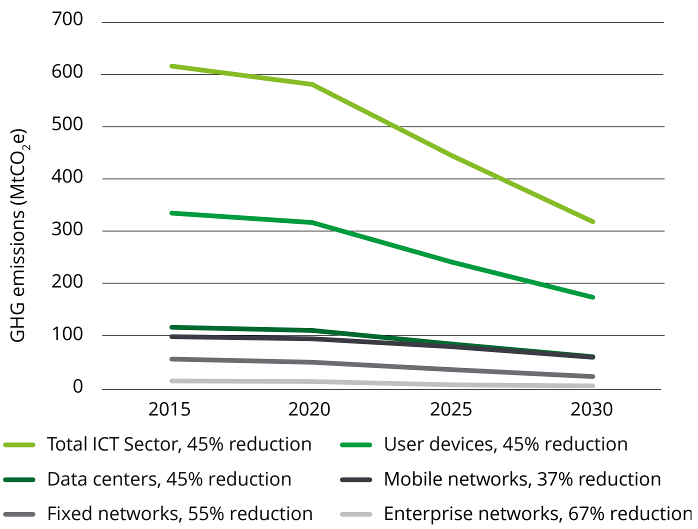
The SBTi is a partnership between CDP, the United Nations Global Compact, World Resources Institute (WRI) and the Worldwide Fund for Nature (WWF).[28]

The SBTi helps organisations to set targets and timelines for a transition towards a net zero economy. These inform how much – and how quickly – greenhouse gas (GHG) emissions need to be reduced in line with a 1.5º Celsius future. As of June 2022, 3249 companies have signed up with 1172 net zero commitments.

SBTi have guidance specific to the ICT sector which includes DC operators. This includes the use of electricity to run ICT operations (Scope 2) and the use of diesel to generate electricity used to run their ICT operations (Scope 1). SBTi have a set protocol that if a company has significant Scope 3 emissions, Scope 3 targets are also required. This is the reality for most DC owners and operators, further highlighting the importance of measuring value chain emissions.

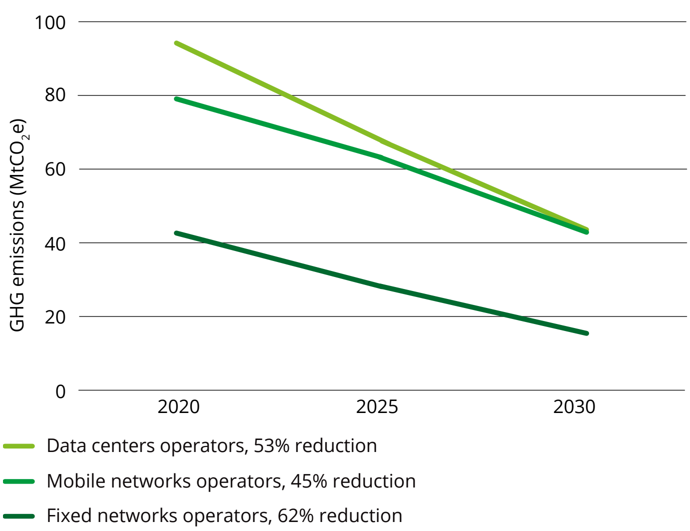
Summary of ICT sector and sub-sector trajectories including embodied emissions and operation

ICT Sector emissions trajectories 2015-2030 (with percent reductions from 2020 to 2030)



Trajectories for ICT operators for 2020-2030

Emissions trajectories for ICT operators 2020-2030 (with percent reductions from 2020 to 2030)



What is the circular economy and how does it impact climate change?

The concept of a circular economy seeks to transform the current linear approach used in the production of goods and services. The traditional take, make and waste approach is replaced with value adding and waste minimisation practices.

> *"A circular economy decouples economic activity from the consumption of finite resources. It is a resilient system that is good for business, people and the environment. It is a systems solution framework that tackles global challenges like climate change, biodiversity loss, waste, and pollution."*[32]

Circular economy is based on the 3 core principles of:
1. Eliminating waste and pollution
2. Circulating products & materials and
3. Regenerating nature

This incorporates a complete view of emissions, going beyond Scope 1 and 2, acknowledging the significant impact of upstream and downstream Scope 3 emissions – something which is particularly relevant for companies using third party DC providers.

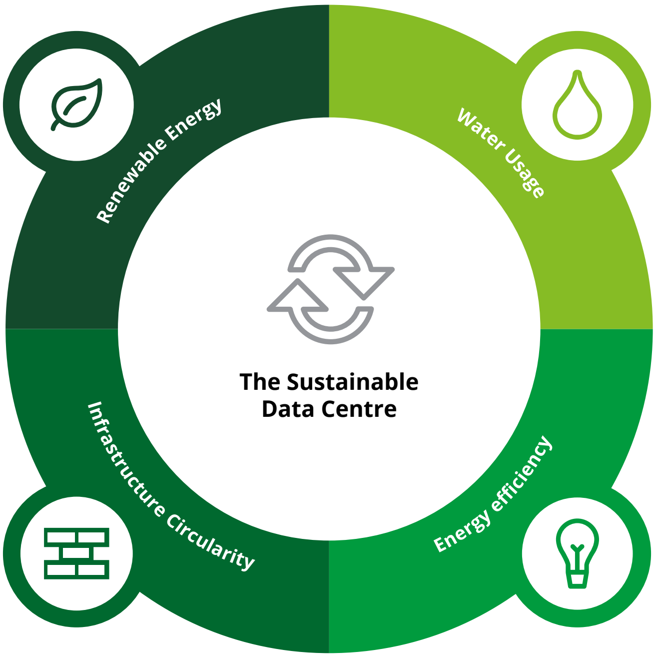
Why is circular economy relevant to DCs?
As discussed, DCs are assessed on the ability to provide computing power on demand. KPIs are focused on metrics such as capacity by resource, available rack space and power usage effectiveness (PUE). As such, they are constructed and maintained with output at their core. DCs therefore need to rethink how sustainability can be incorporated into strategy and operations.

Circular economy is a perfect template, providing a strategic roadmap based on process optimisation. Operating around the three core principles (Eliminating waste and pollution, Circulating products & materials and Regenerating nature) will not only benefit the environment and lead to long-term competitive advantage; a more circular approach will also enable organisations to deal with ever increasing regulation.

4 Pillar Approach

How can DCs begin their journey towards greater sustainability? Organisations that operate their own DCs need a framework to kickstart their sustainable transition, while those who use third-party providers require assessment criteria to inform vendor selection. Segmentation of DC functionality based on the 4 pillars below provides a template for assessing sustainability maturity, allowing for a more targeted approach.

These 4 pillars are Renewable Energy, Energy Efficiency, Infrastructure Circularity and Water Usage. This approach to segmentation highlights distinct areas of focus while still ensuring all aspects of DC operations are covered.



Why are these 4 pillars chosen?

Following extensive research and discussion with experts, the same problem areas were highlighted time and again. What also became clear was the commonality between certain issues, ultimately leading to the classification of pain points into four pillars, offering a clear segmentation of interconnected workstreams: improvements in any one workstream will have positive network effects for the others.

Extended server component life cycle, for example, will improve operating efficiency, in turn reducing the cooling required (WU) along with improving energy efficiency (EE). Likewise, harnessing heat produced by servers will improve renewable energy (RE) and EE. A deep dive into each pillar will provide greater understanding of the challenges and opportunities associated with sustainably transforming a DC.

Pillar 1: Renewable Energy

Introduction:

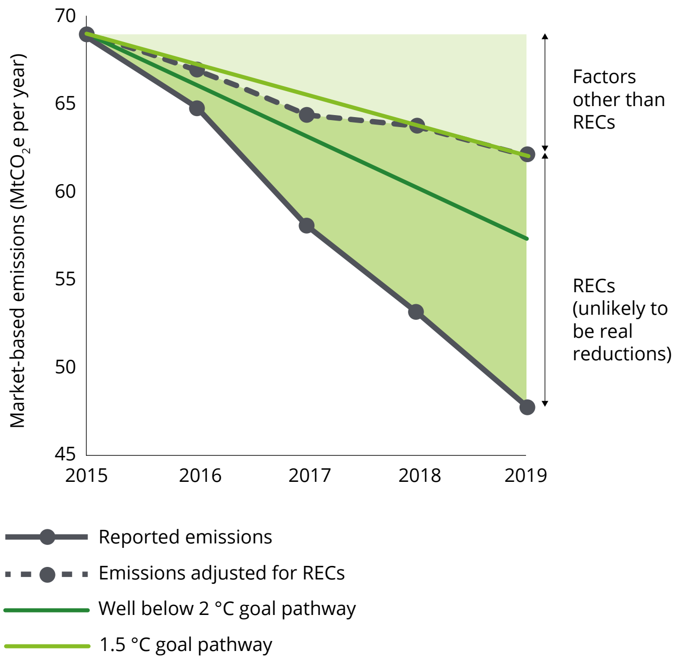
The US Energy Information Administration (EIA) defines renewable energy as "energy from sources that are naturally replenishing but flow-limited".[35] They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. There are different options when it comes to obtaining renewable electricity, varying from (untraceable) certificates to self-generation. All options can be used to account for reduction in GHG emissions, however the actual emissions impact and contribution to renewable capacity build-out varies.

Renewable Energy Certificates (RECs) provide proof of ownership of one Megawatt hour (MWh) of green energy. RECs are known as Guarantees of Origin (GoOs) in Europe. These certs act as a tracking mechanism for clean energy as they flow into the power grid. This is the simplest way to purchase renewable energy, and yet there seems to be a widespread lack of awareness around the limitations of RECs.[36]

SBTi's allow companies to use RECs to claim the use of renewably generated electricity, meaning they can then report zero emissions for each unit of electricity consumption covered by RECs. However, RECs do not reflect the physical electricity flow supplied to companies that buy them and there is evidence that they are unlikely to lead to additional renewable energy generation.[38]

In one study, firms were assessed on their use of RECs and the implications of this for their SBTi's and Paris alignment claims. The disclosures from these firms gave the impression that three quarters of the companies were in alignment with the Paris goals, but this dropped to half when removing contributions from RECs.[39]

	Certificates	PPA	Self-generation
Description	Company purchases certificates of renewable energy (unbundled from its electricity, GoO in Europe	Company enters into a contract with an independent producer, utility or financier to purchase a specific amount of renewable electricity at an agreed upon price for an agreed upon period of time	Company has its own renewable electricity systems on-site or off-site, primarily for self consumption. Development and construction risk can be mitigated through different ownership structures
Options	EU GoO i.e. purchased on the spotmarket	Virtual 3rd party owned, through grid	Off-site
	Local GoO i.e. offtaker of electricity of a local provider	Sleeved, 3rd party owned, direct cable	On-site
	Local GoO – traceable i.e. Traceable to specific renewable project		
	Local GoO – future build i.e. contribute to "to be build" wind farm, traceable		



Firms should be aware of the limitations of RECs and minimise their use. They should be a last resort and ideally make up a very small amount of an organisation's renewable energy procurement.

Purchase power agreements (PPAs) are where a firm enters a contract with a renewable energy provider to supply their DC with renewable energy capacity. PPAs can be physical, where the company entering the agreement takes title to the physical energy on the grid, or virtual (VPPAs) which are a financial contract for the underlying value of the energy.[40]

The last option is for companies to vertically integrate and generate renewable energy themselves. This is the optimal scenario from a sustainability perspective, however it requires significant investment. It can be offsite, where the energy is first delivered to the grid, or onsite, for example having solar panels on the roof of the DC. Self-generation reduces dependence on the grid and ensures energy efficiency and emission reductions. It can also deliver firms cost savings, as there are no grid transmission charges. However, a financial analysis must be done to truly determine if self-generation is a viable option. This ultimately comes down to the cost of building and owning a renewable energy project versus the cost of obtaining power from the grid.

Amidst concern over the strain on national energy grids, governments in some countries have begun to block proposed DC construction. If operators wish to locate to such countries in the future, self-generation may be the only option. It eliminates this concern while also offering resiliency in the event of an outage due to, say, extreme weather events (which with climate change are ever more frequent). Battery storage can provide firms with standby power for a short time in the event of an outage, however self-generation can provide long-term resiliency.

Further, with recent significant fuel price fluctuation, the use of renewable energy can offer stability of electricity costs thanks to fixed price model options.[41]

What does good look like?

The industry's minimum benchmark must be to ensure that DCs are, or have the capability to be, powered by 100% renewable energy. Some firms are already close to achieving this. For example, over the last decade Google have purchased over 73 million MWh of renewable energy through PPAs, via on-site generation and from local grids. This has resulted in a 65% reduction in their Scope 1 and Scope 2 emissions.[42]

Leaders in the renewable energy space limit the use of RECs in RE procurement. Apple, for example, focus on creating new renewables. They procure approximately 95% of electricity through PPAs, their own installations, and by investing in RE projects. RECs only account for 1% of their total load and are used as a last resort.

Current State:

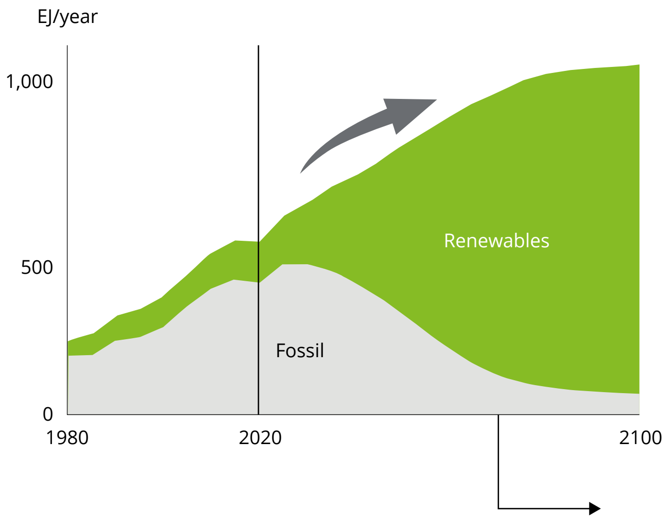
In coming years, the DC industry will face growing pressure to integrate renewable energy sources. The demand is being driven by legislation, such as the Climate Neutral DC Pact (backed by the European Commission) which states that DC electricity demand will be matched by 75% renewable energy or hourly carbon-free energy by December 31, 2025, and 100% by December 31, 2030.[43] There is also potential for US Federal legislation which will place a cap on DCs' carbon emissions.

Further, investors increasingly wish only to have ESG investments within their portfolio, while consumer preference for sustainable and socially responsible brands are also growing rapidly. Companies with carbon reduction pledges will need to assess the performance of their DC computing providers if they are to successfully reach their targets. Overall emissions, as well as how their energy is sourced, will need to be shared transparently.

The barriers to procuring clean energy have traditionally been cost and supply, however price changes to both have seen renewables become much more attainable. By the end of 2021, renewables accounted for 38 per cent of all global installed electricity generation.[44] The global energy mix is shifting away from fossil fuels, with renewable energy production and consumption on the rise.[45] In the UK, according to Greenpeace, 76.5% of the electricity purchased by commercial DC operators is 100% certified renewable and a further 10% is purchased according to customer requirement (which increasingly means renewable), taking that total up even further. [46]

However, the grid is not greening fast enough. If organisations become complacent and simply wait for the grid to switch to renewables, they will fail to meet 2030 targets. Although global renewable energy supply is heading in the right direction, companies must be proactive in RE procurement if they are to accomplish net zero goals.

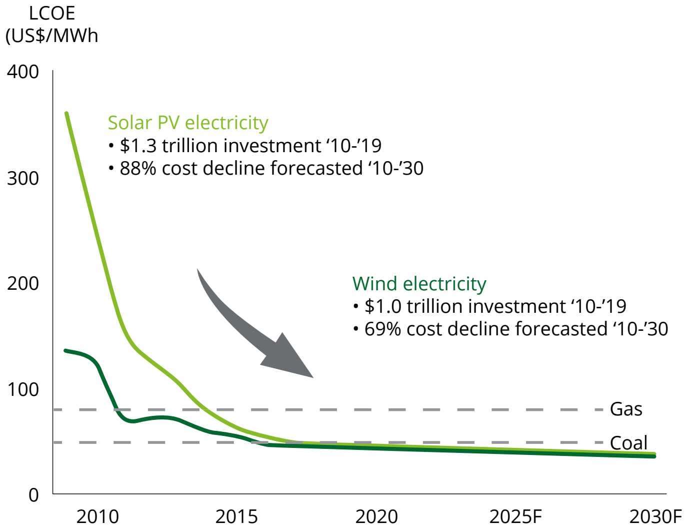
Global total primary energy by source



Notes: EJ = Exajoule = 1^18 joule
Source: Deloitte Future of Energy Scenarios; Shell sky scenario; IEA

Solar and wind are now cost-competitive. The rapid deployment of renewable power generation technologies globally, combined with high learning rates, has driven down costs. Indeed, more than half of the renewable capacity added in 2019 achieved lower electricity costs than new coal, with solar and wind projects now able to undercut the cheapest existing coal-fired plants.[47] As more regulations come into place and penalties for fossil fuels increase, companies must consider the cost of non-compliance.

Cost of solar PV and wind electricity



Industry Leading:

As mentioned above, the leaders in this space are companies where high-quality PPAs and self-generation make up a major share of their renewable electricity procurement.[48] Google aims to establish PPAs with new generation facilities on the local grid where its electricity is being consumed, and always procure the energy attribution certificates as part of those PPAs. As mentioned above, just 1% of Apple's RE procurement was through RECs.

In 2021, Google matched 100% of their operational electricity consumption with renewable energy purchases for the fifth consecutive year. However, matching 100% of annual demand with renewable energy purchases does not guarantee that DCs are actually powered by renewables 100% of the time. 24/7 green energy is emerging, and by combining wind, solar and battery storage, firms can power their operations by renewable energy around the clock. Google, for instance, have set a long-term goal to source carbon-free energy on a "truly 24x7 basis".[50]

Many industry leaders' claims of neutrality only cover Scope 1 and Scope 2 emissions but the major source of emissions for many firms are Scope 3. To address Scope 3 emissions, Apple initiated their Supplier Clean Energy Program, whereby they directly invest in suppliers RE projects. Apple's ambitious headline target for carbon neutrality by 2030 will address the remaining 98% of their emissions. The company now have measures in place to help reduce Scope 3 emissions, and have also pledged to address the remainder of emissions, thus bolstering their green credentials.

Spotlight: VIRTUS

In VIRTUS DCs in the UK, all energy consumed at their facilities is from 100% renewable sources. Since 2012, VIRTUS have been completely carbon zero on power consumption for their entire DC portfolio, 24/7. By doing this, VIRTUS saves around 45,000,000 tonnes of CO2 every year, helping the company move towards its goal of decarbonisation by 2025. As well as the environmental benefits, there is clearly a commercial advantage too: customers increasingly search out providers with green credentials.[51]

Conclusion

As companies look to make the transition towards powering their DCs with renewable energy, they must weigh the risks of continuing with the use of fossil fuels in terms of reputation and regulations. There are several renewable energy procurement options, with varying investment requirements. As mentioned, companies should aim to add RE capacity through self-generation and/or PPAs as these options give real emissions reductions. The widespread use of RECs must be curbed, as evidence suggests the environmental claims tied to their purchase are a façade.

Firms should begin with their clean energy goals, such as achieving 100% renewable energy sourcing by 2030. This will then guide the approach to meeting these targets. In the longer term, vertically integrating renewable energy generation onsite offers the opportunity to move towards the circular economy. Firms should also ensure the long-term costs of taxes and penalties are considered when looking at the switch; the push towards renewables will likely mean that not doing so will end up costing them more in the near future. The lowering cost and increasing supply of renewables will help more organisations achieve this. However, investment in next-generation computing, storage, and heat removal technologies will be required to avoid potentially steep growth in energy use later this decade. Parallel investments in renewable power sourcing will also be required to minimise the climate implications of unavoidable DC energy use.[52]

Pillar 2: Energy Efficiency

Introduction:

Most of the energy that is consumed within a DC needs to pass through various stages before it can be used by IT systems. This energy intensive stage of DC operations occurs when almost all electrical power supplied is converted into waste heat through a cooling system to keep components below critical temperatures. On average, servers and cooling systems account for the greatest share of direct electricity usage in DCs, followed by storage drives and network devices. With strong growth trends in computationally intensive IT usage and information services (such as AI), demand is set to accelerate further, strengthening the case for businesses to project DC energy usage and address the climate policy priority.

What does good look like?

Leading DCs today are becoming more energy efficient largely by improving their IT equipment power usage. According to Henrique Cecci, research director at Gartner, this power usage efficiency can be achieved in 5 steps – from optimising IT power, DC space, DC cooling, eliminating DC power inefficiencies and utilising DC Infrastructure Management Software (DCIM). (See diagram below.) Several hyperscale DCs are working towards improved energy efficiency through DCIM.[53] Fujitsu, who optimised their air flow and analysed environmental data collected by wireless sensors, were able to reduce their energy consumption by 48%.[54] This perfectly captures the benefits of DCIM, demonstrating the link between physical facilities (the cooling of the DC) and physical IT equipment (the wireless sensors). The changes not only led to improvements in how they used their energy, but also contributed to cost savings.

Strategy and Actions for Addressing Energy Efficiency

Key Focus Area	Optimising Data Center Cooling	Eliminating Data Center Power & Cooling Inefficiencies	Optimise IT Power	Optimise Data Center Space	Utilising DCIM tools
Key Activities	• **Install Economisers** – In cooler regions can improve the PUE. • **Contain Equipment and Heat** – Isolation structures can house the data center equipment generating the most heat to heat other parts of building • **Optimise Air Conditioning Systems** – Turn off periodically, use alternative colling source to continually vary the speed	• **Evaluating the current situation, future requirements and modern alternatives require** time and investments, but typically generate a good return in terms of PUE ratio improvement and savings	• **Clean up your workloads** and eliminate everything that is not necessary • **Consolidate virtual machines** • **Virtualise more workloads** • Continue to **eliminate those servers** that are powered but **doing nothing useful** • **Replace old servers** with newer ones	• **Considering a modular design** that breaks down the data center into individual modules that can be continually refreshed as part of a more flexible and organise data center design	• Provides the **necessary link** between the operational needs of the physical IT equipment and the physical facilities (building and environment controls).

Current State:

Due to the cooling process and energy costs scaling with ambient temperature levels, numerous companies have invested in DCs in Ireland over recent years. As a country where 80% of annual temperatures remain under 27°C, DCs located there can be cooled more efficiently.[56]

While cooler locations can aid the cooling process, it is by no means the only source of efficiency saving. Given that the world's largest DCs tend to be over three and a half times more efficient than smaller ones, the trend towards larger facilities will inevitably drive efficiency. It should be possible to accommodate a 60 per cent increase in demand for both traditional and hyperscale DC services over the next 12 months according to Silke Barlow of Fujitsu.[58]

The Climate Neutral DC Pact has set a high standard for DC energy efficiency through the use of aggressive PUE targets.[59] But reducing energy consumption is not without financial reward. The reduction in energy consumption in Fujitsu led to a saving of $230,000 on annual electricity usage across just two DCs in Australia.

Industry Leading:

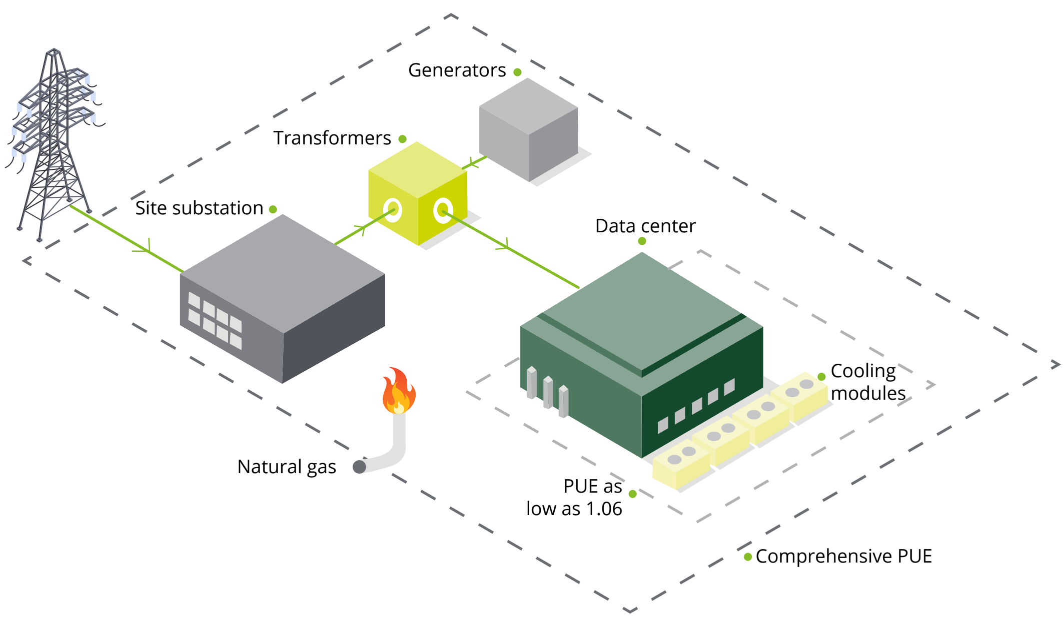
Opportunities for optimising energy consumption include virtualisation and the use of **ARM-based processors,[62] designed to perform a reduced number of computer instructions so that they can operate at a higher speed. This provides outstanding performance at a fraction of the power. The technological development of both these options is making them a viable solution, but they are still outside of the remit of most DC developers due to the high costs involved.

Good practical management of DC space is still a relatively simple, effective way of reducing energy consumption. Making use of aisle containment systems, installing blanking panels into unused rack slots, and providing brushed grommets into raised floor penetrations are all worthwhile energy saving methods that can be easily implemented.

Implementing aggressive power usage effectiveness (PUE) or NABERS Energy targets will also drive more energy saving initiatives and improvements within DCs. New facilities will find it easier to implement PUE targets, as high efficiency equipment can be selected to reduce parasitic load requirements.[63] Implementing low PUE targets, such as energy efficient lighting in existing facilities, is also achievable but takes more financial backing and careful planning to realise. When equipment needs to be replaced, more energy efficient options can be chosen.

Spotlight: Google

Google have handed over control of their DC server to artificial intelligence (AI), and by doing so were able to improve energy efficiency by 40%.[64] They achieve this by raising the temperature to 80°F, using outside air for cooling and building custom servers.[65] They also share detailed performance data in an effort to help move the entire industry forward, having succeeded in reducing their own overhead to just 11%.[66]



Conclusion

In order to establish an "energy-efficient" DC, companies need to view their online data as finite. Dr Patrick Bresnihan of Maynooth University insists that "personal responsibility" is needed when it comes to data storage.

> *"Do we accept unquestionably that data demand and usage is going to expand exponentially and ineluctably for ever? Do we accept that point or do we think about it like single-use plastic or oil or emissions?"*

This will not be enough on its own. Potential still remains for substantial efficiency gains but investments in next-generation computing, storage, and heat removal technologies will be needed. Parallel investments in renewable power sourcing will be required in order to minimise the climate implications of unavoidable DC energy use. Government policies will be essential to support further efficiency improvements on a national and global scale. Improving data collection and sharing on ICTs and their energy-use characteristics can help inform energy analysis and policymaking.[69] Governments can offer guidance, incentives and standards to encourage further energy efficiency, while regulations and price signals could help incentivise demand-side flexibility.[70]

Pillar 3: Infrastructure Circularity

Introduction:

The physical infrastructure that makes up a DC contains a vast array of raw materials. These range from the inputs used during their construction, such as cement, lighting, and electricity cabling, to the network infrastructure and components required for functionality.

While DCs vary in terms of size and design, most facilities share a common infrastructure set, enabling operations.[23]

1. Servers & internal component parts
2. Network cabling
3. Racks & cabinets
4. HVAC System
5. Backup generators

To re-emphasise, circular economy is based on the 3 core principles of:

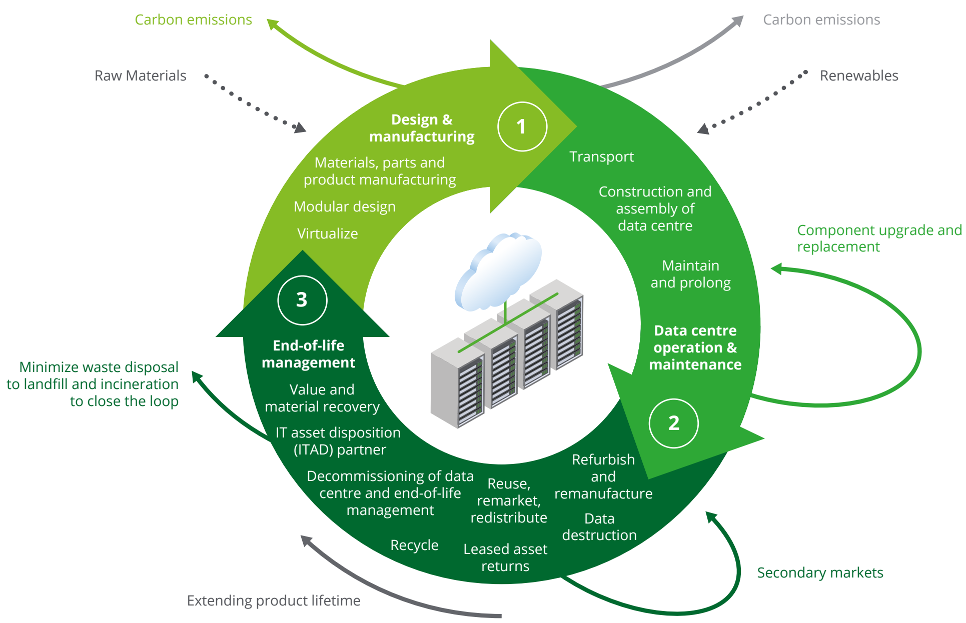
- Eliminating waste and pollution
- Circulating products & materials and
- Regenerating nature

These principles are key to achieving true infrastructure circularity for DCs. They offer opportunities to simultaneously decrease emissions and cost through continuous improvement and waste minimisation.

While sustainable considerations at the pre-construction phase (such as green cement and financing) offer some opportunities, our focus for this section will be directed at the servers and internal components in fully functioning DCs.

What does good look like?

At present, circular economy practices are largely reverse engineered to fit with existing processes and infrastructure. DCs of the future must be designed with circular principles at the centre of strategy, as the Global E-Waste Statistics Partnership have conceptualised below.



Design & Manufacturing

As stated above, this Phase (1) of infrastructure life cycle offers the greatest opportunity to achieve circularity. Infrastructure which has been designed and optimised with circularity at its core removes barriers in Phase 2 and 3. Modular design and sustainable procurement practices offer large impact potential.

Sustainable procurement is another important area. As discussed previously, Scope 3 emissions account for a significant proportion of an organisation's overall emissions, and sustainable procurement can be the key driver in effecting these upstream emissions. It requires companies to prioritise on recycled materials and components, as well as rethinking traditional KPIs, placing greater value on emission reduction decisions.

Operation & Maintenance

Phase 2 provides waste minimisation opportunities through the effective management of DC infrastructure, where lifespan can be extended by ensuring conditions are optimal. This can take the form of optimising rack assembly, temperature control and capacity output. It is, however, worth noting that the extent to which operation and maintenance can reduce waste is limited by the steps taken in Phase 1.

EOL Management

End of life management offers the potential to reuse components rather than sending them to landfill. Concerns around data security can be mitigated through effective EOL management systems, wiping hard drives for reuse elsewhere.

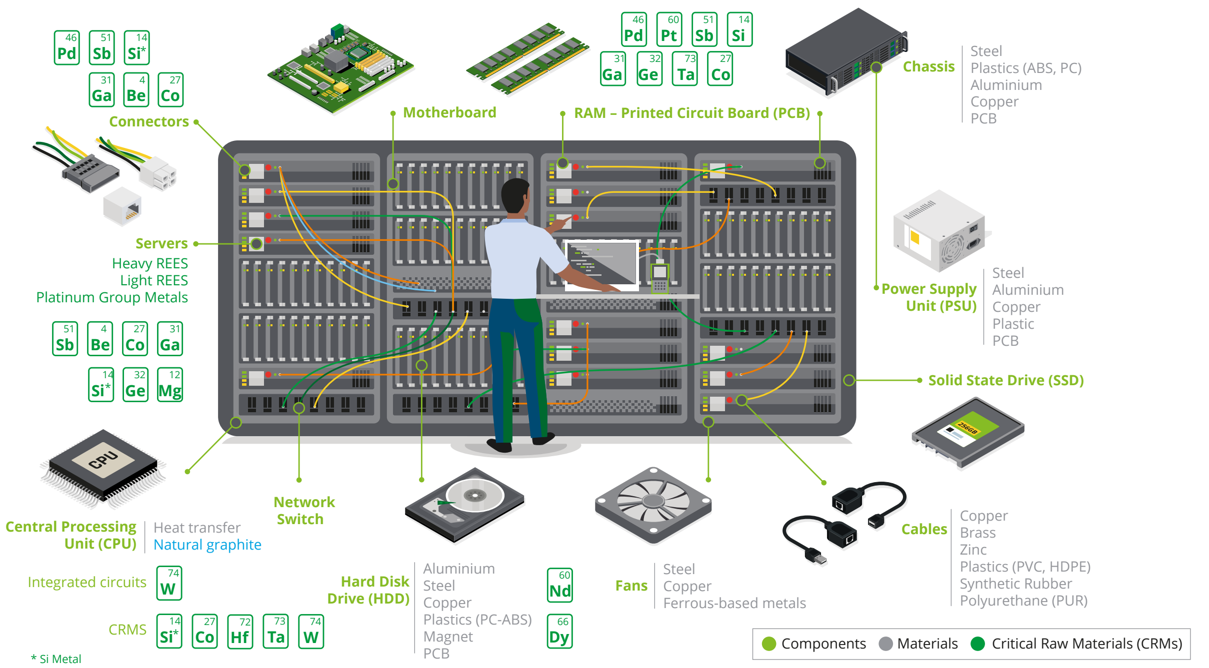
Modular design, discussed in relation to Phase 1, can also benefit Phase 3 through individual component tracking. This means that DC operators can be notified when replacements need to be made and provide clear directions for reuse/recycle pathways.

Current State:

At present, DC servers and internal components have a typical lifespan of approximately three years. As this equipment reaches its end of life, the common practice is to transfer for secure recycling, dispose via landfill, or burn for data security purposes.[71] It is estimated that almost 50 million tonnes of e-waste, with a value of $62 billion, is generated globally each year. This is expected to more than double by 2050 if no changes are made.[72]

The waste also contains finite precious metals, crucial to our transition towards a greener future powered by electricity.[73] DC server infrastructure can contain as many as 50 different elements and materials, outlined in the infographic below. Many of these materials and rare earth metals have been classed as critical raw materials by the European Commission.[74]

One of the major issues at present is the non-modular nature of these components, making them extremely difficult to reuse or recycle. Lack of visibility down to the subcomponent level then prevents effective life cycle planning. Many of these materials also have a finite supply and are crucial elements of battery design. Securing supply and minimising waste connected to these materials is critical to the transition towards greater sustainability.



Source: Based on data from Peiró & Ardente, at https://publications.jrc.ec.europa.eu/repository/bitstream/JRC96944/lb-na-27467-en-n%20.pdf

List of 30 critical raw materials identified by the European Commission *(new additions in 2020 compared to 2017 in italics*; blue materials identified in enterprise servers)		
Antimony	Hafnium	Phosphorous
Baryte	**Heavy rare earth elements**	Scandium
Beryllium	**Light rare earth elements**	**Silicon metal**
Bismuth	**Indium**	Tantalum
Borate	**Magnesium**	Tungsten
Cobalt	**Natural graphite**	Vanadium
Coking coal	Natural rubber	*Bauxite*
Fluorspar	Niobium	**Lithium**
Gallium	**Platinum group metals**	*Titanium*
Germanium	Phosphate rocl	*Strontium*

Industry Leading:

Leading tech companies are now beginning to make steps towards greater circularity, providing a roadmap for others to learn from and follow.

Google, for example, have become increasingly involved in reuse and recycling initiatives, with the company actively promoting drive reuse. In 2019, they resold more than 9.9 million units to the secondary market, and 90% of their waste is now diverted away from landfill.[75]

In line with their sustainability efforts, Google have also worked closely with the Ellen MacArthur Foundation to analyse ongoing circular economy practices in Google DCs through the lens of four strategies: Maintain, Refurbish, Reuse and Recycle.[76]

In addition to practices in their DCs, Google have a long list of other current and future circular economy initiatives – including utilising technology in Google cafés to avoid food waste, continuing as the world's largest corporate purchaser of renewable energy, and ensuring that, going forward, all hardware is made principally of recycled materials.[77]

> *"Our goal is to embed circular economic principles into the fabric of Google's infrastructure, operations, and culture,"* Kate Brandt, Google's Lead for Sustainability.

Original Equipment Manufacturers (OEMs) are also leading the way. Take Hewlett Packard Enterprise's (HPE) label for DC efficiency, and their commitment to refurbishing or recycling returned enterprise hardware. The company refurbished 73% of returned storage media and recycled the remainder in the 12 months through November 2018.[78] This is not only relevant to infrastructure circularity; it also seeks to improve overall energy efficiency.

The Cisco Takeback and Reuse Program is another excellent example of an industry leading initiative. Cisco equipment owners can return EOL hardware at no cost, including return, pickup and transport. This even extends equipment branded by companies which have been acquired by Cisco.[79]

Spotlight: Microsoft Circular Centres

Microsoft have stated that their ambition is to become carbon negative across their operations by 2030. Through an initial assessment, they pinpointed inefficiencies relating to the use of third-party asset disposition companies. To combat e-waste inefficiencies, they decided to retain ownership of this process and close the loop in a move towards greater circularity. From this came the concept of Microsoft Circular Centres (MCCs), which are designed with the goal of facilitating the reuse and recycling of DC servers and hardware.[80]

Microsoft have reported that the MCC pilot has achieved 83% reuse over the past year and 17% recycling of critical parts. This in turn has contributed to a reduction in carbon emissions by 145,000 metric tons CO2 equivalent. The current plan is for Microsoft to roll out the MCC concept globally, a move projected to lead to approximately $100M in savings.[83]

Conclusion

Infrastructure circularity must be tackled at the earliest stages of product and process design to make a meaningful impact. Modularity in design, material selection and subcomponent life cycle tracking all offer pathways towards increased circularity. DCs should look to incorporate these elements into their processes if they wish to realise the positive environmental and financial effects highlighted by Microsoft MCCs.

Pillar 4: Water Usage

Introduction:

For the general population, water requirements for DC operations are not commonly understood, with focus usually directed towards the strain on the energy grid. DC processes and operations are, however, water intensive by nature, largely as a result of cooling systems. As an estimated 40% of total energy requirements are generated by cooling, water usage must be a key focus area for all organisations.[84]

> *"According to details provided by Facebook, its Irish DC used 395 million litres of water in 2019 – roughly the same amount used by Kildare town's 8,600 inhabitants in any given year."* [85]

What does good look like?

Effective DC water usage starts with visibility. Understanding how a DC is performing in terms of water usage requires accurate reporting; only then can DCs pinpoint the main areas of waste and isolate improvement opportunities. These could take the form of equipment upgrades, infrastructure layouts or temperature thresholds.

Optimised water usage in DCs is an area undergoing rapid change, with improved technologies and non-water-based alternatives. While innovation will be the key driver in reducing overall consumption, it is essential that companies also focus on transparent reporting and incorporation of water usage into their KPIs.

Current State:

Today, DC temperatures are typically controlled via a combination of free cooling and infrastructure organisation.

Free cooling consists of the physical systems installed to manage temperatures, utilising water or air to do so. Chilled water is a targeted free cooling approach that is transmitted to the specific areas requiring attention. Air evaporative systems are an alternative method where air from outside is pulled inside to cool servers. This approach relies on specific geo location for optimal external temperatures.[86]

The second tool used for temperature control is organisation of infrastructure. This can take the form of hot/cold aisle arrangement, containment, and rack placement. Aisle arrangement optimises temperature control by separating hot and cold aisles to avoid air mixing. Containment builds upon aisle organisation, further segmenting based on temperature. Rack placement is specific to the positioning of heavier equipment on lower racks, ensuring that equipment with higher air circulation is not dispersed at the top of the racks.[87] Cooling is an essential aspect of DC functionality, and when optimised can help ensure equipment lifespan is maximised.

All these processes can also be tracked. Water Usage Effectiveness (WUE), developed by The Green Grid in 2011, is a similar metric to PUE. WUE is defined as the annual water usage divided by the IT equipment energy, with units of litres/kilowatt hour (L/kWh). Unsurprisingly, water usage is becoming more scrutinised as water shortages and droughts become increasingly common.

The UN recently reported that water usage globally has increased 6x in the last 100 years and continues to increase every year by 1%.[88] The sustainable development goal, SDG6 – to ensure availability and sustainable management of water and sanitation for all – is directly impacted by DC water usage. As such, increased regulation is inevitable.

Industry Leading:

New cooling technology can play a vital role in reducing the water required to run a DC. Indeed, organisations are already experimenting with innovative solutions, and Intel and Nvidia are two such companies making a significant investment.

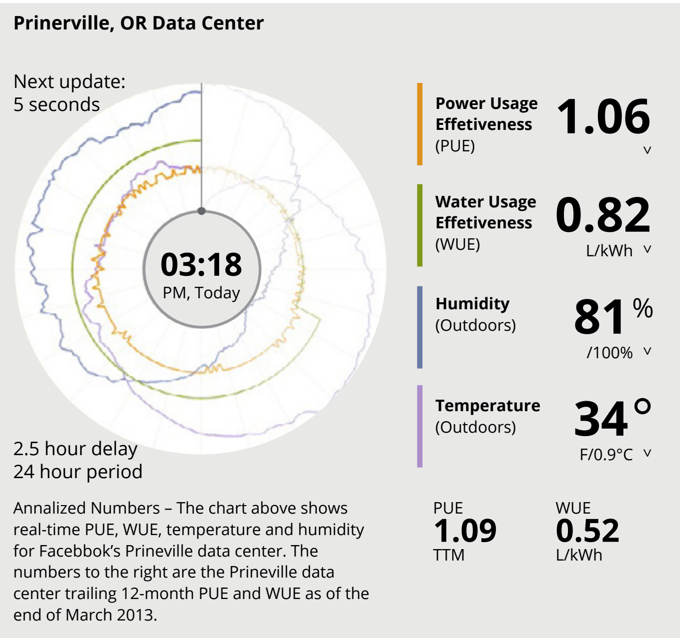
Intel have recently begun construction of a $700M research lab in Oregon, placing specific focus on immersion cooling. The research lab will be tasked with exploring circular methodologies such as heat recapture and reuse, immersion cooling technology and water usage effectiveness. Construction is expected to finish in late 2023 and signals the importance Intel places on water usage and cooling.[89]

Nvidia just announced a move towards liquid cooling in their Graphics Processing Units (GPUs) for DC customers. These new GPUs are expected to deliver 20x better energy efficiency on AI inference and high-performance computing jobs while eliminating air chillers which evaporate millions of litres of water every year. Liquid cooling uses less water and recycles within closed systems permitting overall reduction in space requirement – twice as much computing can be packed into the same space.[90]

Spotlight: Meta Water Usage Effectiveness (WUE) Reporting

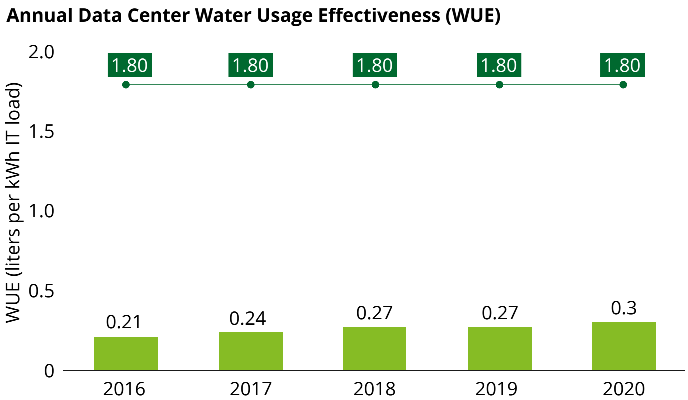
One of the critical success factors in any change process is the initial maturity assessment. This relies on detailed reporting/data infrastructure to provide an accurate snapshot of the situation. As discussed earlier, WUE is a key metric for tracking the effectiveness of water used.

Meta (formerly Facebook) have placed significant focus on their water usage, pledging to become water positive by 2030. They were one of the first companies to deploy WUE as a reporting metric, even incorporating it into one of their public dashboards, a signal of how seriously they take the matter. Meta have also incorporated WUE into their yearly reporting, measuring the KPI vs industry standards.



Conclusion

Incorporating sustainability metrics as KPIs and embedding those into governance structures is crucial for organisations as they transition towards greener business practices. This holds true for DC operators, where Meta are leading the way in prioritisation of water use reduction.



How can Deloitte Help?

Approach

The pressure that DCs place on our electricity grids is ever increasing and is of importance not only to DCs but to other residential, commercial, and industrial sectors as well. Action is urgently required if companies are to be well positioned to meet legislative requirements, particularly carbon neutrality by 2030.

Deloitte brings world-class capabilities and high-quality service to its clients, delivering the insights they need to address their most complex business challenges. Let us connect you to the professionals who can both transform your current practices and help to embed new ones, providing all the tools for addressing DC sustainability – not only now, but well into the future.

Step 1: Setting strategic vision and targets

Not all companies have the same ambitions when it comes to sustainability. Some will aspire to make DCs green enough to ensure regulations are adhered to. Others will have more ambitious targets, such as becoming 100% circular or 100% powered by renewable energy. The most committed providers are focusing on delivering a "cradle to grave" green strategy, where environmental ambitions are built into every step of DC construction and maintenance. However, these ambitions require significant investment and will be easier to achieve for large organisations, Therefore, the first step will be to discuss an organisations' overall goal when it comes to sustainability. The solutions provided by Deloitte will then be aligned to this.

Step 2: Calculate emissions breakdown beyond Scope 1 & 2

To achieve their goals and adhere to regulations, organisations must look at emissions across their entire value chain. Upstream and downstream emissions are often the largest contributors. Therefore, all emissions (Scope 1, 2 and 3) must be assessed when addressing a DC's sustainability. Calculating these will reveal the largest opportunity areas.

Step 3: Map out life cycle/ processes within the DC

The next stage would be an investigation into the process life cycle of the firm's DC (from procurement to waste). Deloitte can provide the industry pain points that DCs typically have within processes. Although these will be specific to each company, giving examples of common problem areas will help bring the framework to life.

Step 4: Conduct maturity assessment for each of the pillars

Deloitte will conduct a maturity assessment for a DC's approach to Renewable Energy, Energy Efficiency, Infrastructure Circularity & Water Usage. This will provide a starting point, allowing optimisation and improvement efforts to be tailored to the organisation. This will be carried out through questionnaires/interviews with senior leadership and technical SMEs.

Step 5: Identify 'problem areas' within each pillar

Based on the maturity assessment, the project team will identify the elements within each pillar which are yielding suboptimal results for the environment. These could be due to operational inefficiencies or technological issues.

Step 6: Highlight the key pain points that will make the most impact if addressed

Some areas will naturally have a larger impact on the environment. After identifying the key problem areas, Deloitte will investigate which ones would stand to have the biggest impact on emissions if addressed. In other words, there could be 30 problems overall, but the vast majority of gains might be made just by tackling the top 5.

Step 7: Recommendation of key actions

Based on the client's overall goal and the assessment results, Deloitte will recommend the key actions that the company should take and then outline how Deloitte can help them do so. Included in this recommendation will be the cost of the actions, as well as the risks and benefits they will bring. This recommendation will be proposed by subject matter experts (SMEs).

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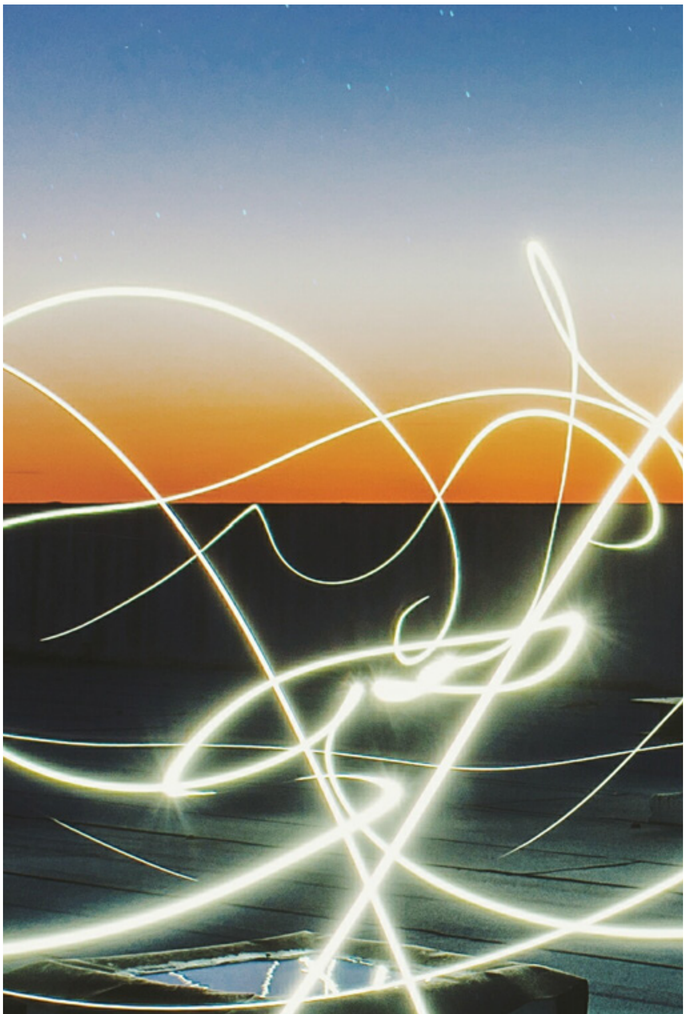

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