DEEP DIVE: DATA CENTRES

December 2021

Montanaro Investment Team

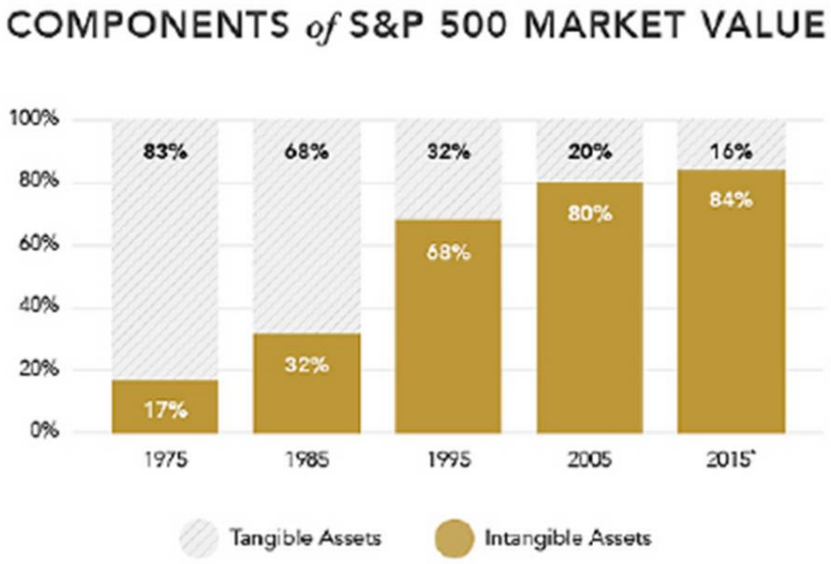
MONTANARO

ASSET MANAGEMENT

INTRODUCTION

Many of our investors will have heard us speak about the growing importance of intangibles when valuing companies. When we model the finances of companies, our Analysts make economic adjustments to the traditional balance sheet to reflect intangibles that we wish to consider as *assets* rather than *costs*, for example, the capital invested into research & development and brand value.

Understanding the value of such intangibles is ever more important in a world that is increasingly built and led by ground-breaking developments in the fields of science and technology. The rise in intangible asset values across the constituents of the S&P 500 over the last 50 years is no surprise given that in 1975, the largest company in the index was Exxon Mobil, a company valued largely on its tangible oil reserves. Today, the index is dominated by Big Tech – Apple, Microsoft, Amazon, Alphabet – companies that have huge intangible asset values. A similar picture exists across our Approved List of companies, especially for those businesses in the Montanaro Global Innovation Fund.



When meeting with our companies, we spend a lot of time trying to understand these intangible values. From an ESG perspective this got us thinking: what other footprints do we need to consider for companies that might not be as visible or obvious as those of more traditional bricks and mortar businesses?

As we engaged with our investee companies on climate change (see Montanaro's *Project: Net Zero Carbon* reports), we were struck by the number of technology companies lagging on environmental reporting. A consistent reason was given for this: *"We have a small operational footprint with just a few offices and employees whose work is computer-based. Therefore, there is little to report on, other than our own internal energy usage"*. This stance is shared by many service businesses: those whose tasks are mainly done via computers, such as asset managers.

The environmental footprint of intangible businesses is arguably more complicated than the picture painted in company sustainability reports, however. It seems that businesses with

high intangible asset values are forgetting about the less obvious elements of their environmental footprints.

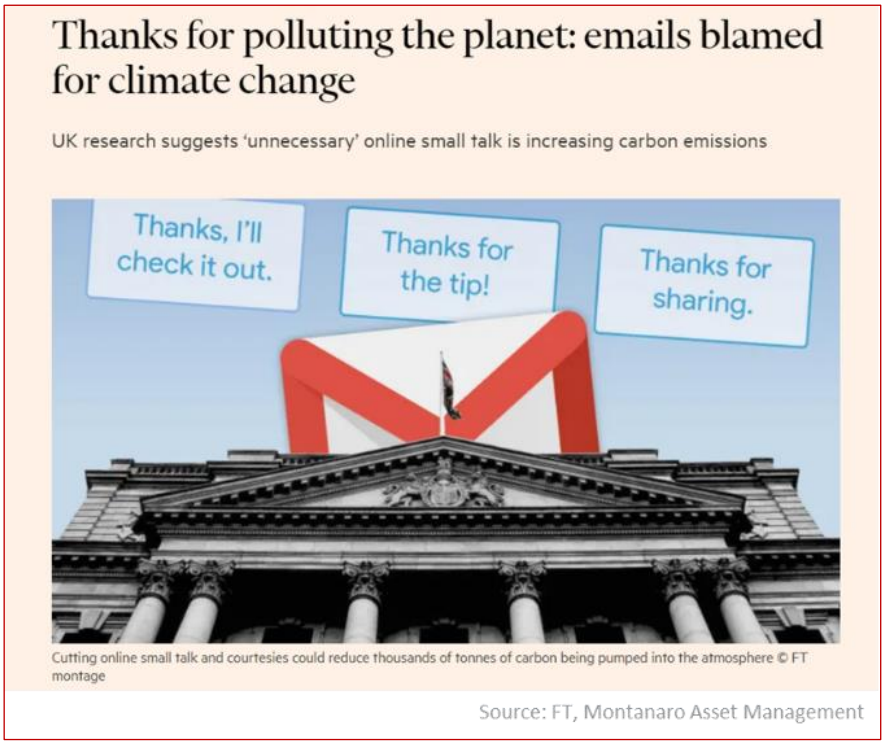
As we spoke to management teams about environmental reporting, we homed in on one issue: the growth and consumption of data. We struggled to see where data, which is increasingly stored in the cloud, was being accounted for by companies in environmental reporting.

This is a subject that we ourselves have been grappling with. In 2021, we moved our IT assets to the cloud and an external data centre. As a certified B Corporation with a net zero carbon target for 2030, we have been trying to understand how our use of external data centres will impact on our carbon footprint. This is not an easy task, for the reasons covered in this report.

We were unsure as to how serious an issue the explosion in data usage is to the energy equation and climate change. Should we believe headlines such as those in *The Financial Times*, *Thanks for polluting the planet: emails blamed for climate change* and *The Independent*, *Global Warming: Data centres to consume three times as much energy in next decade, experts warn*?

This got us thinking: if our companies are contributing to the data explosion, are their environmental footprints much greater than we think? Where are they storing this data and how are these data centres considering sustainability in their own operations? Does a tangible data-based energy problem exist within the carbon footprint of companies whose activities are largely cloud-based?

We didn't have answers to these questions, so we set off to find out.



Source: FT, Montanaro Asset Management

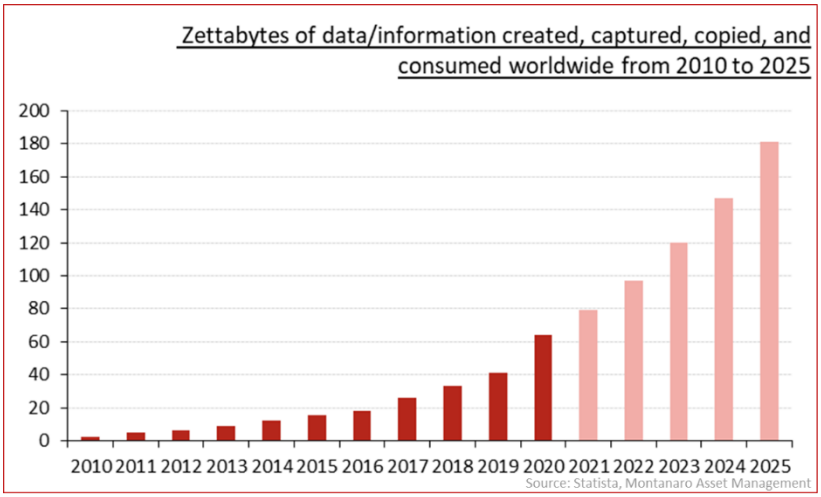
THE ZETTABYTE ERA

Data has always been important to life on Earth. From our distant ancestors standing in the entrance of their caves, scanning the plains for signs of threats, to intrepid Fund Managers working in the jungle of the City of London, forecasting share prices. With an introduction like that, can you tell that Montanaro Asset Management was founded by an anthropologist?

In today's technological world, the amount of data created is so enormous that a new age has dawned: The Zettabyte Era. This began in the early 2010's, when the amount of digital data in the world first exceeded a zettabyte, a unit of measurement that is equivalent to 1,000,000,000,000,000,000,000 bytes (a "sextillion")[1]. If that does not make much sense, consider that one zettabyte accounts for 30 billion 4K movies, or 60 billion video games, or 7.5 trillion MP3 songs, according to Seagate, a mass data storage solutions company.

It is not only the volume of data that is so extraordinary, but the rate of growth too. Despite exponential increases in computing power from 1970s onwards, it took over 40 years for the amount of data to reach 1 zettabyte. The current rate of data growth is exponential. As former Google CEO Eric Schmidt put it, *"there was 5 exabytes of information created between the dawn of civilization through 2003…but that much information is now created every two days, and the pace is increasing"*[2].

By 2020, more than 70 zettabytes of data were in existence, meaning that there are many times more bytes zooming around cyber-space than there are stars in the observable universe. The rate of growth from here is forecast to be fast and vast.

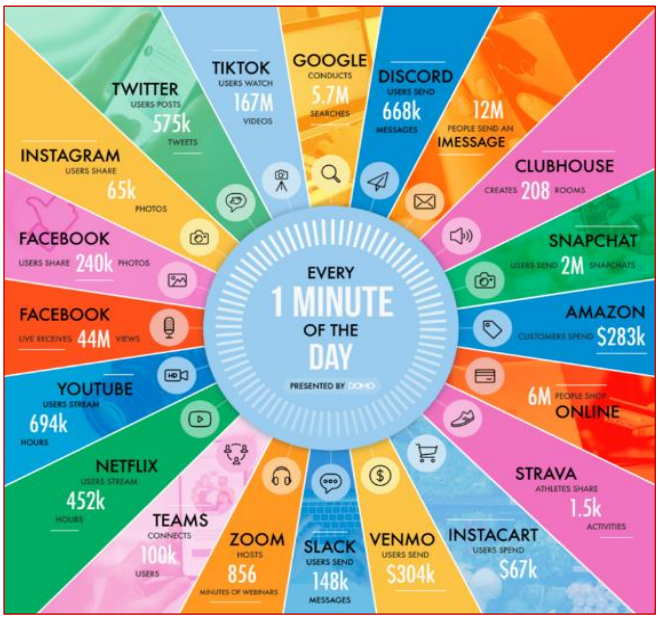


As the volume of data has increased, so has the demand for data centres. A driver of this is the expansion of digital infrastructure and new connections to businesses and communities in under-served markets (those who until recently had limited access to the internet).

Technologies such as artificial intelligence, smart energy systems, robotics and autonomous vehicles are further increasing demand for data centres. Self-driving cars, for example, are forecast to produce 32 terabytes of data *per day* (one terabyte is equal to the memory needed to store 250,000 photos). Exponential growth in cloud-based services resulting from data-intensive applications is also increasing the demand for ever-higher bandwidth networks and storage requirements.

[1] According to research by Cisco, global Internet traffic reached an annual run rate of one Zettabyte in 2016
[2] https://www.datamation.com/applications/big-data-analytics-overview/

The Covid-19 pandemic has further catalysed advancement in digital services and led to even more digital activity. The global internet population grew from 3.4 billion in 2016 to 5.2 billion in 2021. The *"internet of things"* and the *"connected world"* is here.



We are all so active online. The adjacent graphic, *"Data Never Sleeps 9.0"*, published by Visual Capitalist, shows the activity that occurs every minute across some of the main internet providers, collectively producing unimaginable quantities of user activity and associated data[3].

What does this mean for the purposes of this report?

There are clearly many ramifications from the data explosion, not least privacy concerns and cyber-security. Our Investment Team covered these areas of risk in a previous Deep Dive report (*Supply Chain Investigation, 2018*), which is why we have chosen to focus on the energy intensity of stored data here.

The energy efficiency of data centres has become a pressing issue as the world becomes more technological and confronts the challenge of climate change. As a report in the *Financial Times* noted, technology companies are big consumers of electricity because of their data centres, which need large amounts of power to keep the servers cool. The combined power usage of Amazon, Google, Microsoft, Facebook and Apple is more than 45 terawatt-hours a year, about as much as New Zealand.

Given the growth in data, what has happened to the energy consumption of data centres over the last decades? How big a problem are data centres in the context of climate change?

We conducted engagements during 2021 with technology companies as we attempted to answer these questions and understand how businesses can better assess their digital carbon footprints. We thought it prudent to focus on technology businesses given they likely had the most direct experience of data centres of all the companies on our approved list. Clearly, the questions we are seeking to answer are relevant to all companies storing information digitally. We also spoke with experts and academics to understand the role of data centres in the energy mix. These conversations have helped to inform us of climate change related risks and opportunities for businesses with intangible and cloud-based assets.

[3] *From Amazon to Zoom: What Happens in an Internet Minute In 2021?*, Visual Capitalist, November 10, 2021

CLOUDS, SCOPES & POWER PLAYS

Shifting to "The Cloud"

A clear trend exists among our investee companies. Many had, or are in the process of, upgrading IT systems by moving to cloud-based data storage providers. Demand, it seems, is only going one way. The technological drivers of this are clear: *"cloud computing makes it possible to collect, analyse, and store huge quantities of data, reduce the total cost of ownership of IT, and increase business agility",* according to report commissioned by Microsoft[4]

What is the cloud? *The cloud enables users to access the same files and applications from almost any device, because the computing and storage takes place on servers in a data centre, instead of locally on the user device.*

The reasons given by our companies for the shift away from on-premises servers to large, third-party data centres were largely consistent: improved functionality; better cybersecurity; and a reduction in on-site electricity use. Such benefits are offered by a large number of data centre operators, although the market is dominated by those whose operations benefit from economies of scale, such as Amazon Web Services (AWS), Microsoft Azure and Google.

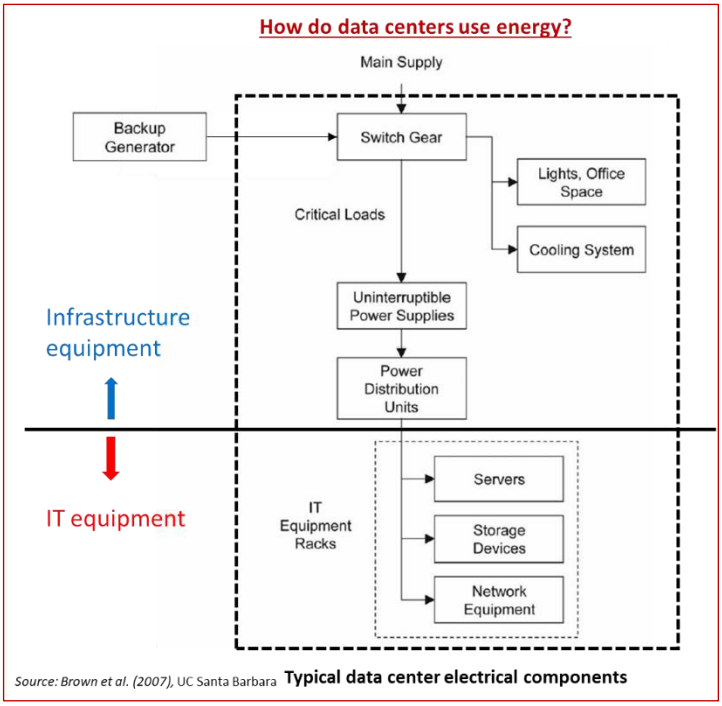
A hierarchy of importance also emerged when decisions to move IT assets to data centres were being made. Overwhelmingly, our investee companies cited technological considerations as the most significant factor when selecting which data centre to move assets to. Where providers cited sustainability factors, such as renewable energy procurement, this was seen as a secondary benefit. Certain companies had included sustainability requirements in the selection process, but these were typically viewed as "nice to have" rather necessities.

Technology One is a provider of Software as a Service (SaaS) based Enterprise Resource Planning (ERP) software to governments, higher education, and some corporate clients. Its ERP software represents an integrated suite of applications that an organisation can use to manage its businesses processes more efficiently.

The company is certified as carbon neutral by Climate Active, a certification backed by the Australian government. It has spent a lot of time and effort verifying and calculating the carbon intensity of its business in order to achieve this certification. We asked how sustainability factors are incorporated into the selection process for data centre providers and were told that technological considerations are primary. The company currently uses AWS and although environmental considerations do play a role, they are secondary to functionality and security. While Technology One is clearly working hard to mitigate its climate impacts and has sought verification from reputable independent sources for its efforts, it was thought-provoking to hear how carbon considerations do not feature prominently in data centre selection criteria.

[4] *The carbon benefits of cloud computing, A study on the Microsoft Cloud in partnership with WSP*, 2018 (updated 2020)

We spoke to Jay Dietrich, Research Director of Sustainability at the **Uptime Institute** (a technology research firm[5]) who noted that the conclusions from our company engagements corresponded with his experience. He said that environmental considerations often take a backseat in the selection of data centre providers. Jay felt that the reticence to prioritise sustainability amongst IT teams is due to an aversion to risk. There is a perception that environmental efficiencies come at the cost of technological performance. As an example, he noted the reluctance to make use of Power Management Functions. Such systems help to manage fluctuations in demand from users, for example if there is less demand for data, then the centre could be run at a reduced rate, saving energy. Yet in most service contracts, customers are promised 24-hour access to their data. This sounds sensible, but it means that centres often run at full throttle even when it is unnecessary. The risk for data companies is that response times to requests for data increase if the facility implements a power management strategy.



Source: Brown et al. (2007), UC Santa Barbara **Typical data center electrical components**

IT companies are typically hesitant to implement this feature and Jay estimated that around 80% of teams he has spoken to won't use Power Management Functions because of the risk of delay. The fines that could be handed out for a breach in the service level agreement because of delays are far greater than the cost saving of improved energy efficiency. Functionality and risk management is prioritised over sustainability.

This supports the findings of an **IEA** research note, which noted that as demand for data storage grows, *"the build-out of infrastructure to accommodate greater anticipated peak capacity could raise overall network energy use in the long run"* as *"data transmission networks generally have high fixed energy costs (even at low utilisation)",* for the reasons outlined above.

This poses challenges for companies shifting assets to the cloud and data centres. Energy usage could increase just as companies come under even greater pressure from a range of stakeholders to take action to reduce their environmental footprints. A finding of our engagements is that we must emphasise that sustainability should be seen as an important factor when our investee companies are considering IT assets.

[5] Uptime Institute is the IT industry's most trusted and adopted global standard for the proper design, build and operation of data centres as well as serving as an authority on digital infrastructure risk and resiliency as enterprises shift workloads between on-premises, colocation, cloud and edge providers.

One way to achieve this is to facilitate communication between those in charge of sustainability and those in charge of IT operations. In many companies that we spoke to, these departments have little overlap.

Scope issues

Another issue we identified when speaking to our companies was the impact the shift to data centres is having on environmental reporting. It is another complication to navigate when a company is attempting to measure its greenhouse gas (GHG) emissions. The energy use of on-premises servers is more easily measured as this can be monitored through the direct electricity purchased by the company to run them. This falls under Scope 2 emissions. However, when data centres are used, the related energy consumed falls under Scope 3 emissions (indirect emissions across an organisation's value chain). The variety of elements that can be included in the definition of Scope 3 emissions often means that this is the hardest Scope to accurately calculate and report on. In addition, the indirect nature of these emissions means that there is a reliance on third parties to publish the correct information.

Ansys provides engineering simulation software to engineers, designers, researchers, and students. Simulation enables engineers to test new products virtually rather than physically. Ansys has recently introduced a cloud offering in partnership with Microsoft Azure, due to the resource intensity of simulations software, as it is a more cost effective and scalable solution.

We asked the company if the carbon data that the company monitors has been affected by the new partnership. The company explained that the comparison was proving difficult as the current on-premises facilities fall under Scope 1 and 2 emissions, whereas the migration to cloud-based services sits under Scope 3 emissions, which are proving difficult to measure. It was noted that Microsoft Azure has more sustainability opportunities due to their use of renewable energy as well as the increasing efficiencies of their facilities.

We also asked how sustainability factors had influenced the selection of Microsoft Azure over and above other cloud providers. We were told that, whilst they had been pleased to hear of the sustainability credentials of Microsoft Azure data centres, functionality had been the most prescient issue.

Calculating the environmental footprint of IT assets is made doubly hard by the fact that large IT companies are guarded about the energy use of their data centres. We spoke to **Eric Masanet**, Professor and Mellichamp Chair in Sustainability Science for Emerging Technologies at the University of California Santa Barbara, who informed us that the lack of publicly available data is a barrier to assessing the energy efficiency of data centres. No statistics on data centres are given in national energy accounts; only a fraction of data centre operators report energy use; data centre operators rarely report explicit site-by-site energy consumption; most data small data centres provide little or no reporting.

Eric emphasised that while large tech companies offer limited disclosure, they do at least publish some information (usually as part of an annual sustainability report). Data centres

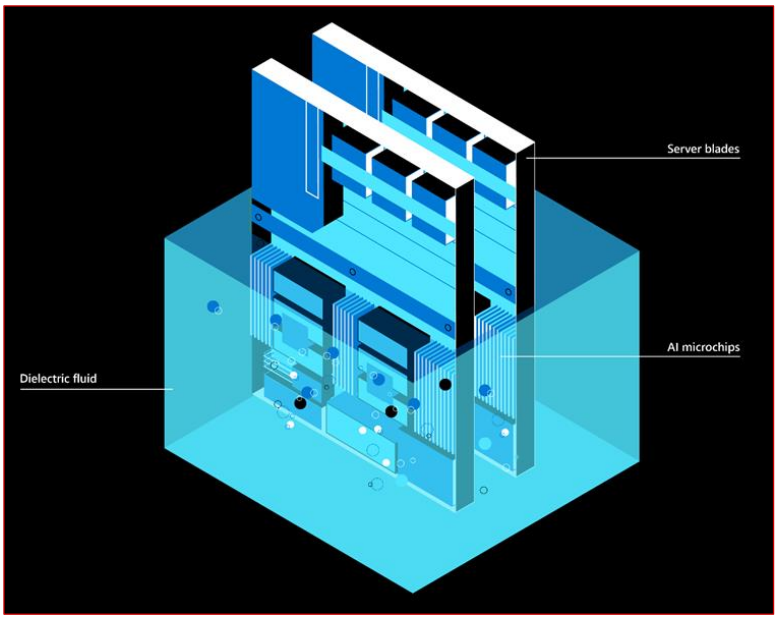
that exist outside of the big tech players are almost impossible to analyse from an energy perspective due to poor levels of disclosure and transparency.

Are small players powerless?

Feedback from our investee businesses indicates how smaller companies that are moving IT assets to the cloud are reliant on the sustainability strategies of large providers, but feel they have a limited ability to assess, compare and influence the sustainability performance of these providers.

There has, however, been some positive progress on the sustainability front for data centres. Large data centre clients increasingly have their own sustainability targets to meet and pressure is filtering down supply chains to data centre operators. One example is Microsoft. It has pledged to become carbon negative by 2030 and has acknowledged that its Azure data centres pose a major challenge to this ambition. This is leading to change, as Microsoft has noted: *"a big part of going carbon negative means completely changing the way data centres operate. Data centres have adopted some sustainable methods around cooling, including open-air and adiabatic cooling. These methods have helped to drastically reduce the water and energy consumption of data centres, but they're not enough.* ***Currently, data centres and the backup that powers them in peak load times depend on fossil fuels like diesel. Microsoft is working to change that[6]".***

One potential innovation is the use of liquid immersion cooling technology, which Microsoft predicts will not only help to eliminate water consumption, but to lower energy consumption by a minimum of 5% to 15%.



Innovation is helping make data centres more sustainable. Microsoft's cloud carbon study[7] found that the Microsoft Cloud is between 22% and 93% more energy efficient than traditional enterprise data centres, although this clearly depends on the specific comparison being made (it is worth noting that some on-site IT assets are old and highly inefficient). According to the study, savings are attributable to four key features: IT operational efficiency; IT equipment efficiency; data centre infrastructure efficiency; and renewable electricity.

[6] https://azure.microsoft.com/en-us/blog/aiming-for-more-than-just-net-zero/
[7] *The carbon benefits of cloud computing, A study on the Microsoft Cloud in partnership with WSP*, 2018 (updated 2020)

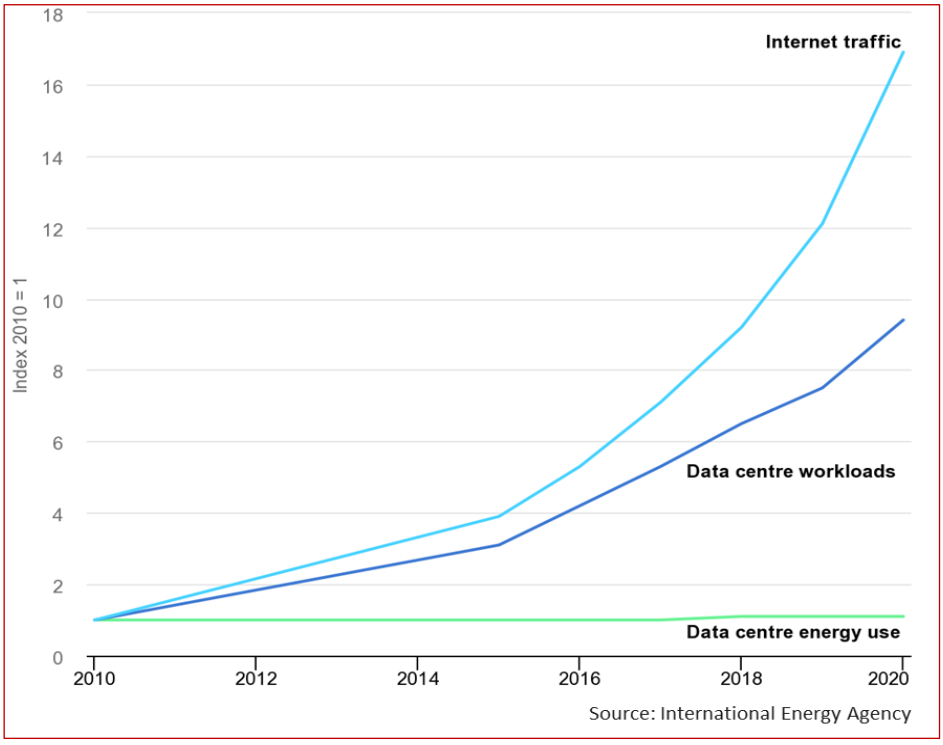
These advancements are influencing other actors. A recent survey from **451 Research** (a global research and advisory firm) found that 97% of participating multi-tenant data centre providers now have at least some customers looking for contractual commitments on sustainable practices[8]. This shows how businesses can positively influence the efficiency and sustainability of their providers.

The curious energy flatline

As well as posing a challenge to companies when it comes to gathering information on Scope 3 emissions associated with their data usage, the information asymmetry between large IT companies and the wider public makes it difficult to assess broader trends between data traffic and energy use. Academics find it difficult to predict how the energy usage trend will develop as data centre workloads increase. Eric contributed to the IEA report that we referenced earlier in the report, which shows that energy usage has hardly increased, despite the rise in internet traffic and data centre workloads.

In fact, energy growth has been remarkably flat since 2010, even during the Covid pandemic when global internet traffic surged by more than 40%.

Much of this is due to improvements in energy efficiency within data systems. As the IEA report noted, *"strong growth in demand for data centre services continues to be mostly offset by ongoing efficiency improvements for servers, storage devices, network switches and data centre infrastructure, as well as the high and growing share of services met by highly efficient cloud and hyperscale data centres"*[9].



[8] https://markets.businessinsider.com/news/stocks/new-451-research-report-captures-the-impact-of-efficiency-and-sustainability-on-cloud-service-provider-market-1029661814

[9] https://www.iea.org/reports/data-centres-and-data-transmission-networks

The report cited some interesting case studies: *"Data from several large network operators demonstrate how energy efficiency improvements have helped decouple data traffic from energy use. For instance, Sprint reduced its network energy intensity more than 80% between 2014 and 2019 to keep total network energy consumption flat, and data traffic through Telefónica's networks increased fivefold between 2015 and 2020 while electricity consumption fell 2%"*[10].

Despite only a minimal rise in the energy use of data centres cited in the IEA report, data centres still account for a not insignificant 1% of global electricity use[11]. The question is whether this line will remain flat in the coming years as the technological revolution gathers yet more pace.

This trajectory from here is a much-debated point in academic and expert circles and focuses on a metric known as the "Power Usage Effectiveness" (PUE) rate. In simple terms, this tells you how efficiently a computer data centre is using energy by measuring the ratio of the energy used by the IT equipment to the energy used by the entire data centre:

$$\text{Power usage effectiveness (PUE)} = \frac{\text{Total facility power}}{\text{IT equipment power}}$$

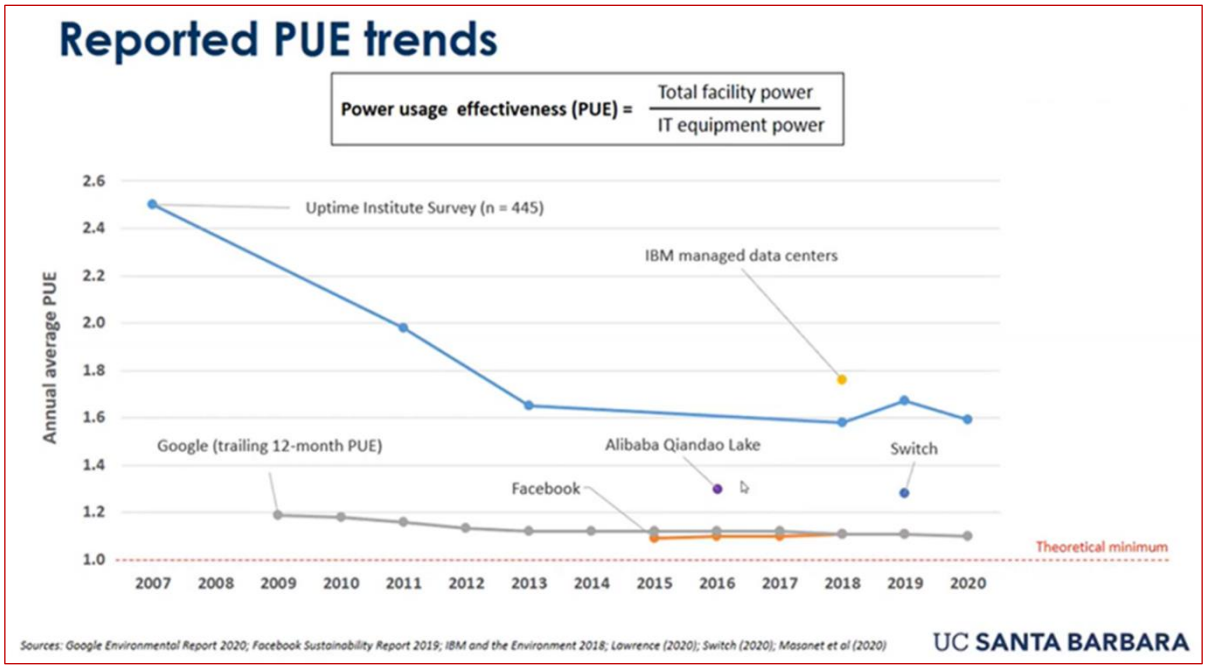
Since 2007, PUE rates have declined sharply as data centres have become more efficient. Large scale data centres – of the kind that many companies are shifting IT assets to - are one reason for this. Such large-scale centres typically have low PUE rates: *"the most efficient hyperscale data centres can have PUE values of ~1.1 (meaning 0.1 kWh is used for cooling/power provision for every 1 kWh used for IT equipment)."*[12]

Yet there are signs efficiency improvements are stalling. There has been a flattening of the PUE rate since 2013. Research by the Uptime Institute found: *"the average power usage effectiveness (PUE) ratio for a data centre in 2020 is 1.58, only marginally better than 7 years ago"*[13]. Indeed, this research found that *"big improvements in energy efficiency were made from 2007 to 2013, mostly using inexpensive or easy methods such as simple air containment, after which improvements became more difficult or expensive"*[14]. If the PUE rate were to increase, then so too would the data centre energy line.

This future trajectory of PUE rates has become even more important given pressure from regulators and governments on the IT sector to increase climate action. In its Digital Strategy report, released in February 2020, the European Commission included a key action for the IT sector to achieve climate neutrality by 2030, while improving data collection and transparency: *"Initiatives to achieve climate-neutral, highly energy-efficient and sustainable data centres by no later than 2030 and transparency measures for telecoms operators on their*

[10] https://www.iea.org/reports/data-centres-and-data-transmission-networks
[11] Note that this estimate excludes cryptocurrency data use
[12] https://www.iea.org/reports/data-centres-and-data-transmission-networks
[13] https://journal.uptimeinstitute.com/data-center-pues-flat-since-2013/
[14] Ibid

environmental footprint". If the regulatory curve continues in this fashion, there will be even greater incentivises to keep the PUE rate moving downwards.



However, when speaking with Eric, he cautioned that much of the existing research is retrospective and based on extrapolating historical trends into the future, something that is as challenging to do with technological developments as it is financial markets *("How many times have we heard people say 'Moore's Law' is dead?")*.

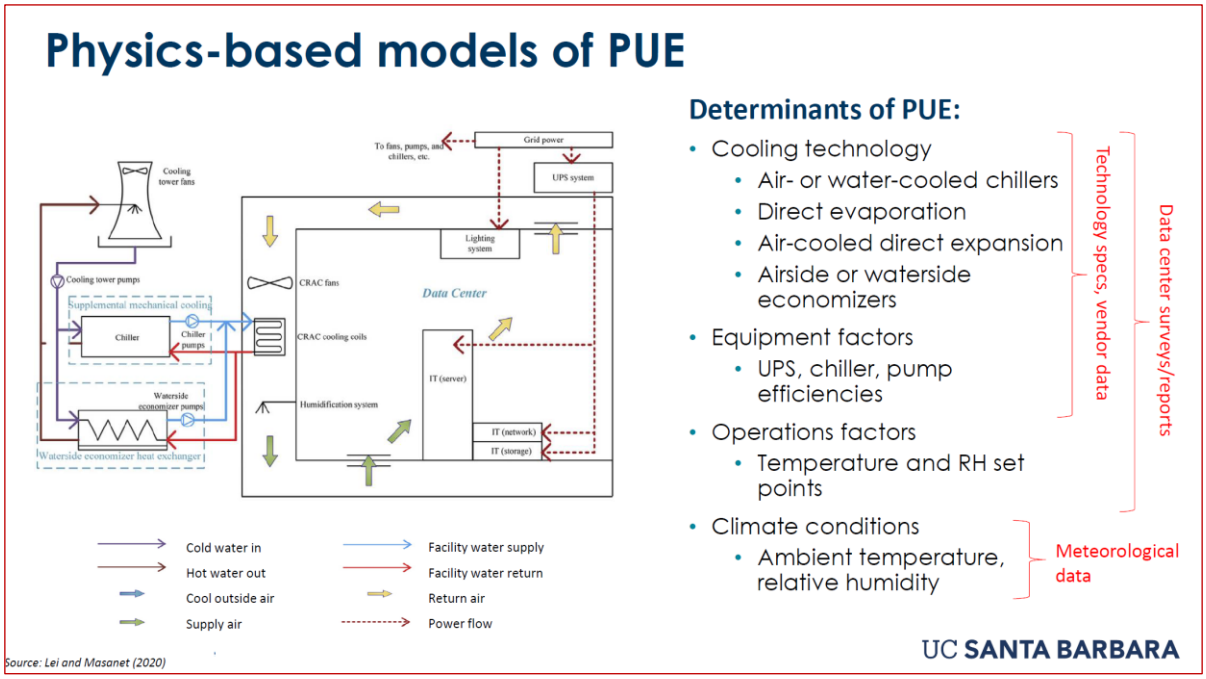
A further point is caution comes from work conducted by the Uptime Institute. As ever, conclusions are based on the data that you are looking at. The data in the chart above is based on the average PUE per site, regardless of size or age. As the Institute notes, *"newer data centres, usually built by hyperscale or colocation companies, tend to be much more efficient, and larger. A growing amount of work is therefore done in larger, more efficient data centres"*[15].

Indeed, *"operators who cannot improve their site PUE can still do a lot to reduce energy and/or decarbonize operations. First, they can improve the utilization of their IT and refresh their servers to ensure IT energy optimization. Second, they can re-use the heat generated by the data centre; and third, they can buy renewable energy or invest in renewable energy generation"*[16].

It is difficult to assess if the relationship (i.e., that energy consumption has remained flat despite the growth in data) will continue. Eric suggested that the energy usage associated with advancing technologies, such as AI, would increase the energy requirements of data centres, but not necessarily to the extent that some of the worst *"doom and gloom"* predictions have outlined. Nevertheless, complex algorithms that sit at the heart of advancing technology rely on large data volumes ("big data") and it will be a challenge to

[15] https://journal.uptimeinstitute.com/data-center-pues-flat-since-2013/
[16] Ibid

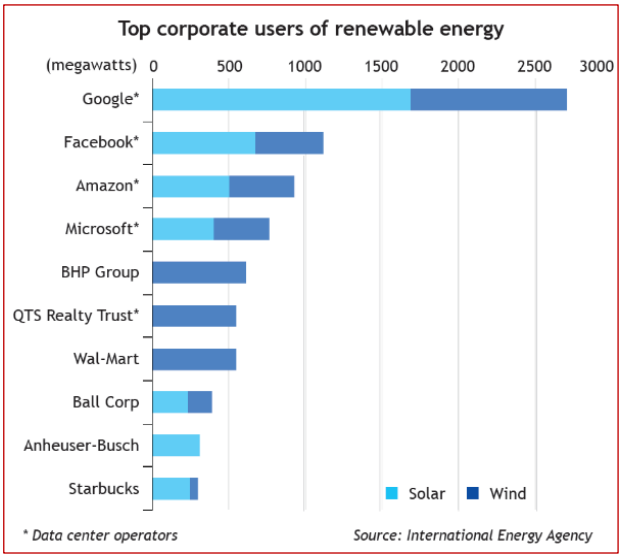
ensure that the historic improvements in hardware energy efficiency are matched in the future.



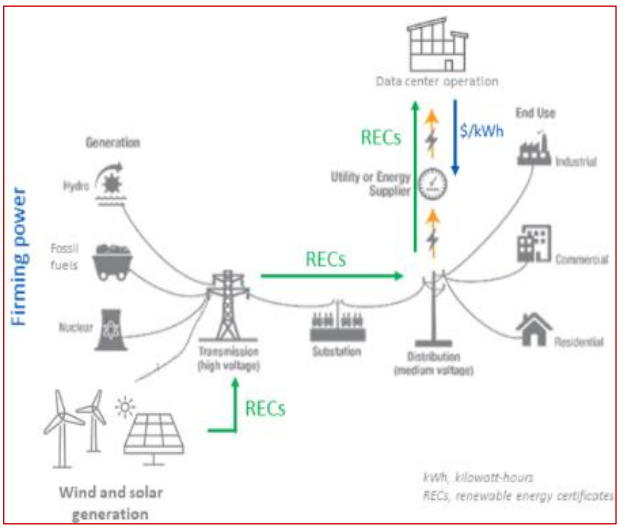
It is clear that the lack of disclosure surrounding energy consumption from the operators of this increasingly vital digital infrastructure poses two key challenges. The first is a barrier for service users to overcome when measuring their own GHG emissions. The second is a problem for researchers who are trying to accurately calculate energy consumption and forecast how the swelling of the global internet population will affect energy supplies.

Renewable Energy

One source of hope is that data centre operators have been some of the first organisations to pivot to renewable energy consumption on a large scale. These investments allow companies to protect themselves from volatile power prices, reduce their environmental impact and bolster their ESG credentials. IT companies have accounted for close to half of global corporate renewables procurement in the last five years, while the top four corporate users of renewables in 2019 were all IT companies with their own data centre operations, led by Google[17].



[17] https://datacenterfrontier.com/wp-content/uploads/2021/01/DCF-Special-Report-Green-Data-Centers-2.pdf



However, while this is a positive trend, Jay Dietrich suggested caution during our conversation with him and pointed us towards some of his recent research (*"Renewable energy and data centres: Buyer, be aware"* [18] and *"Green tariff renewable energy purchases"* [19].) which detail how companies are sourcing energy and the wider impact of their procurement decisions. The important consideration is how many electrons generated from renewable sources are actually reaching data centres. Jay used the example of Renewable Energy Certificates (RECs). These are a tradeable, market-based instruments that represents the legal property rights to a megawatt hour (MWh) of electricity generated and delivered to the grid from a renewable energy resource. These certificates can be used to verify the origin of the electricity purchased by a company.

However, he questioned the validity of a renewable energy usage claim when the MWh has been generated in a completely different region to where the electricity is being consumed. It is for this reason that he remains sceptical about the actual renewable energy usage of some providers. We have heard concerns such as these be voiced before about carbon offsetting markets.

Jay's research indicates that large IT companies are effectively becoming energy traders due to their purchase of instruments such as RECs to support their energy needs. This trading activity influences the market and means that smaller businesses are less able to procure these instruments due to the inflated cost. In his view, the use of retail purchases was the best way forward. He gave the example of Google's partnership with AES Corporation as good way in which data centre providers could verify their renewable energy usage.

We raised Jay's concerns about the sourcing of renewable energy to Eric during our call. He was rather more sanguine about the use of market instruments in determining the validity of renewable energy purchases. He thought that this approach to climate action still indicates a demand for clean energy and encourages the decarbonisation of energy grids.

For many data centres it is simply impossible to have their own direct source of renewable energy due to the space needed to have an adjacent wind or solar farm, while some countries are further behind when it comes to creating renewably powered grids. Hence the current reliance on other methods to source and validate renewable energy. We hope that the use of RECs will be an interim measure and will place pressure on utility providers to increase the proportion of electricity generated from clean sources for all.

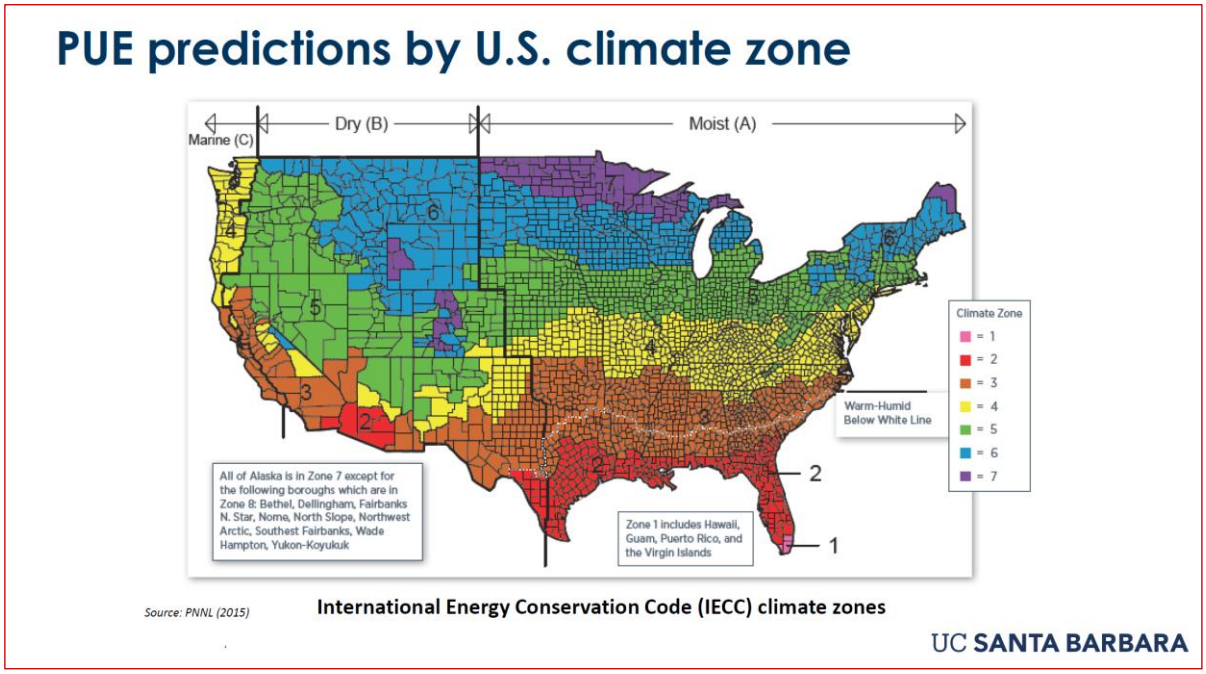
[18] https://journal.uptimeinstitute.com/renewable-energy-and-data-centers-buyer-be-aware/
[19] https://journal.uptimeinstitute.com/green-tariff-renewable-energy-purchases/

Atea is the market leader in IT infrastructure and related services for businesses and public sector organisations in the Nordic and Baltic regions. We had the opportunity to meet the Director of Corporate Responsibility, Andreas Antonson, to discuss carbon emissions.

Atea operates its own data centres. We wanted to know if this poses a particular challenge when it comes to keeping carbon emissions low due to the large energy requirements. Andreas assured us that this is not a significant challenge for Atea. The renewable energy used across the energy grid in Sweden and Norway, where they are based, means that they are powered by green sources of electricity; they also use a verification scheme to show the source of the energy used. He also discussed the reduced need for cooling associated with data centres situated in Northern Scandinavia, given the climate is cool for long periods of the year. These regional advantages mean that the carbon emissions associated with Atea's data centres are a minimal part of their overall footprint.

Such advantages are clearly not possible for all companies and Atea is able to benefit from the clean energy infrastructure in its regions of operation. In the future, we hope that an increasing proportion of global electricity grids will be powered by renewable energy, in line with Sustainable Development Goal 7: Ensure access to affordable, reliable, sustainable, and modern energy for all.

Atea is a good example of how dependent data centres are on their location when it comes to energy efficiency. This is something Eric's research has touched on in the US, a country that has numerous climate zones. Not only do data centres benefit from being close to renewable sources of power, but given the cooling requirements, a centre based in Alaska is likely to require less cooling than one based in arid Arizona.



There is increasing scrutiny on data centres as they compete for finite resources. This is not just for renewable energy assets – for example, the capacity of a wind turbine project in the

Netherlands that was initially pitched as a clean source of power for 370,000 homes has largely been bought up by Microsoft[20] – but also land. The largest data centres can be millions of square feet in size. The impact on biodiversity, due to building on agricultural land, and marine life (Microsoft has experimented with data centres in the sea to keep them cool[21]) are poorly understood. Data centres also compete for land that could be suitable for largescale housing projects. Housebuilders and data centre operators like the same conditions: access to stable electricity supply (preferably renewable); favourable climate conditions with low risk of natural disasters (flooding, earthquakes, etc.); and good local infrastructure[22].

These factors are likely to increase the debate about the role of data centres as they continue to expand, fuelled by our desire for an increasingly technological world. As Marietje Schaake, international policy director at Stanford University's Cyber Policy Centre, wrote in the *Financial Times* recently, *"thus far, the so-called techlash has spared data centres, but that could soon change unless companies and governments change their behaviour".*

[20] https://www.ft.com/content/fe968bbb-c15d-455f-964c-9aeeef9db5f1
[21] https://news.microsoft.com/innovation-stories/project-natick-underwater-datacenter/
[22] https://www.iea.org/commentaries/data-centres-and-energy-from-global-headlines-to-local-headaches

Conclusions

As society's use of the internet grows, so does demand for data centres. Our *"connected world"* has brought innumerable benefits, as so many people have experienced during the pandemic. With this, however, comes the requirement to acknowledge the influence digitalisation is having on our energy systems.

Greater information, transparency and subject interest are needed to understand the environmental footprint of businesses that increasingly exist in the realm of intangibles. As shareholders, we must encourage companies to grasp the environmental footprint of their technology assets – and increase the prominence of sustainability factors when they are selecting providers for services such as data management and storage.

Standards of reporting for companies with large IT assets need to improve. Better reporting from the technology sector would be a start. The sector is the clear laggard when it comes to environmental reporting. As we noted in the 2021 update to *Project: Net Zero Carbon*, "*the Technology sector is the clear laggard, with not one company [in the FTSE 250] providing a clear link to climate change-related factors in its discussion of its business model"*[23].

Efforts must be made to assess the environmental quantum of data consumption and storage, so that cloud usage can be accurately incorporated into Scope 3 emissions. Current secrecy surrounding the energy consumption of data centres means that understanding the relationship between digital innovation and climate change is challenging.

Improved reporting will have numerous benefits, such as lifecycle analyses that offers comparisons between everyday choices, allowing businesses and consumers to understand the net effect of energy consumption decisions and the systems level implications of increased digitalisation. For example, despite our Zoom call with Eric creating and relying on data, we saved a huge amount of carbon emissions by not flying to meet him in person in California. This is a developing field of systems modelling and is hampered by a lack of accurate information. Eric noted the following caveats to current research:

- It relies on retrospective analysis (2010-2018);
- Workloads, virtualisation levels, and installed storage capacities are based on Cisco internal estimates;
- Exclusion of GPU (graphics processing unit) processors may miss early artificial intelligence energy use;
- Cryptocurrency mining is also excluded from analysis;
- It is not possible to further distinguish closets, rooms, edge data centres, etc (the small data centres).

[23] https://www.clientearth.org/latest/documents/accountability-emergency-a-review-of-uk-listed-companies-climate-change-related-reporting-2019-20/

While efforts have been made to mitigate environmental risks through the sourcing of renewable energy and the use of energy certificates, these need to be monitored. Some renewable certificates and offsetting mechanisms are better than others.

Looking ahead, several trends will shape the future of data networks and electricity use. Global internet traffic, which more than doubled between 2017 and 2020 is forecast to double again by 2023, based on current trends. The nature of data transmission is also changing rapidly, with mobile device data traffic growing at a rate of over 50%, while Wi-Fi only devices such as laptops and desktop computers are more in demand than ever before. The continued shift to mobile networks and the advent of 5G may also have implications for data networks: mobile networks have considerably higher electricity intensities than fixed-line networks.

A risk is that technological progress – *"The Fourth Industrial Revolution"* – will produce a volume of data that simply overwhelms the energy efficiency improvements possible at large-scale data centres. Advancements in science, technology, agriculture and many other fields, that are required to help tackle the world's most serious problems will require ever larger data sets. This revolution must be compatible with – and not fight against – the sustainability revolution that must happen at the same time too.

There is so much to consider, but what is clear is that even businesses comprised of predominantly intangible assets, still have real world environmental footprints. It is our intention to improve this element of reporting by our companies in the months ahead.

Reasons exist for optimism. Given the rate of historical technological advances, it would be no surprise if data centres find a way of continuing to achieve greater energy efficiencies in the years ahead, even as the data explosion continues. For now, efficiencies are keeping the energy usage curve remarkably flat. Sending an email – or saving this report to the cloud – is not destroying the planet quite yet.

We would like to thank all of our companies for engaging so willingly with us during the writing of this report. We would especially like to extend our thanks to ***Eric Masanet****, Professor and Mellichamp Chair in Sustainability Science for Emerging Technologies at the University of California Santa Barbara, and* ***Jay Dietrich****, Research Director of Sustainability at the Uptime Institute, for their invaluable help.*

Ed Heaven, Head of Sustainable Investment

Kate Hewitt, ESG & Impact Specialist

About Montanaro

Montanaro Asset Management ("MAM") was founded in 1991 by Charles Montanaro. We are an independent investment boutique focused exclusively on quoted Global Small & MidCap equities. We view our clients as our partners and seek to grow their investments sustainably over the long-term.

In June 2021, MAM launched the **Montanaro Global Innovation Fund ("GIF")** to invest in quoted Global Small and MidCap companies that are leaders in technological innovation. Through its focus on Smaller Companies, the Fund offers investors access to a vast investable universe of over 4,000 companies and complements Technology Funds in the market that predominantly focus on the largest companies in the world, such as the FAANGs. We believe that GIF is different.

GIF is managed by Guido Dacie-Lombardo, who is supported by Yannis Gidopoulos and Hal Miller. They lean on our in-house team of 14 analysts and the wider MAM team of 36, one of the largest specialist Small and MidCap teams in Europe.

The Fund is supported by a highly experienced **Advisory Committee** of experts in the fields of technology, innovation and healthcare. The Committee is chaired by **David Gann, CBE,** Chairman of the UK Atomic Energy Authority and a member of the UK Government's Innovation Expert Group. David is joined by Anne Glover, Benedict Evans and Dr Axel Heitmueller.

[END]