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WHITE PAPER

Mind the Gap: Energy Availability and the Challenge for European Data Centers

SECOND EDITION

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Executive summary

This white paper is an update to the original Mind the Gap report issued in late 2015. Many of the trends highlighted four years ago continue to apply, while others have accelerated. In just the past four years, we have seen increased migration to - and dependence on - the cloud for all forms of compute, even high-performance computing (HPC). We've also seen a growing movement towards edge computing, as well as increased applications of artificial intelligence (AI). These dynamics are changing the computing landscape. CIOs must therefore develop and adapt IT and data center strategies while continuously seeking to manage costs and minimise risks.

Electricity supply is a critical ingredient in this equation. As the virtual world grows in scale and complexity, data centers rely on a steady supply of very physical and very real electrons. In the past, CIOs could generally assume the required electricity supply would be readily available. They did not have to care much about where their electricity was coming from, or the reliability of the associated infrastructure. Today, that is no longer the case. CIOs looking to outsource to a third-party data center or cloud provider must consider access to affordable, reliable, and clean electricity as a prerequisite in the decision-making process.

In this respect, the answer to the challenge of data center reliability and low-cost clean energy has not changed over the past three years. In fact, it has probably become clearer: only a small number of markets and geographies can satisfy this combination of requirements. This paper will address these issues, with a particular focus on the challenges affecting European data centers and their options in solving the energy supply puzzle.

Risks related to reliable electricity supply

The data center lies at the heart of most enterprises, and the flow of power is its lifeblood. If the grid goes down, data centers are vulnerable, even when they have back-up uninterruptible power supply systems (UPS) and generators. Back-up systems fail quite frequently, often with costly results. In fact, failed switch-overs to the UPS are still the leading cause of data center outages, causing 25% of all disruptions.[1]

A recent striking example of this vulnerability was the 2017 blackout in Amsterdam, caused by a "component failure" at a high-tension power station that crippled part of the city and led to an outage at a major colocation company. The switch-over to back-up power supply failed, despite the fact that the faulty equipment had been tested only one month prior.[2]

[1] https://www.vertivco.com/globalassets/documents/reports/2016-cost-of-data-center-outags-11-11_51190_1.pdf

[2] https://data-economy.com/deadly-amsterdam-power-outage-knocks-data-centres/

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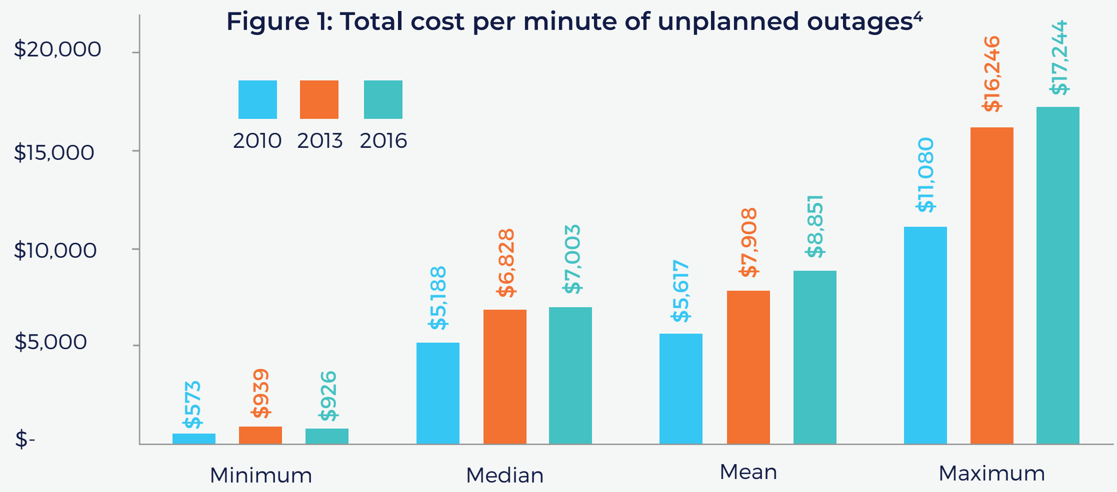
Such outages can be expensive. The most recent 2016 survey information of 63 companies[3] indicated that average outages lasted 95 minutes, with an average cost of $740,000. The rising cost per minute of unplanned outages has climbed from a median of approximately $6,800 to $7,000 over three years. Maximum costs per minute have also increased, from $16,250 to close to $17,250. Depending on the type of business, the financial impacts can occur immediately. The key, then, is to try and minimise the likelihood of system power outages. Locating data centers on reliable grids is the first critical step in reducing that potential liability.



The cost of outages can be crippling, so electricity grid performance and power reliability matter. Grid reliability should be one of the factors considered as part of the standard data center site selection process.

Source: Vertivco, 2016

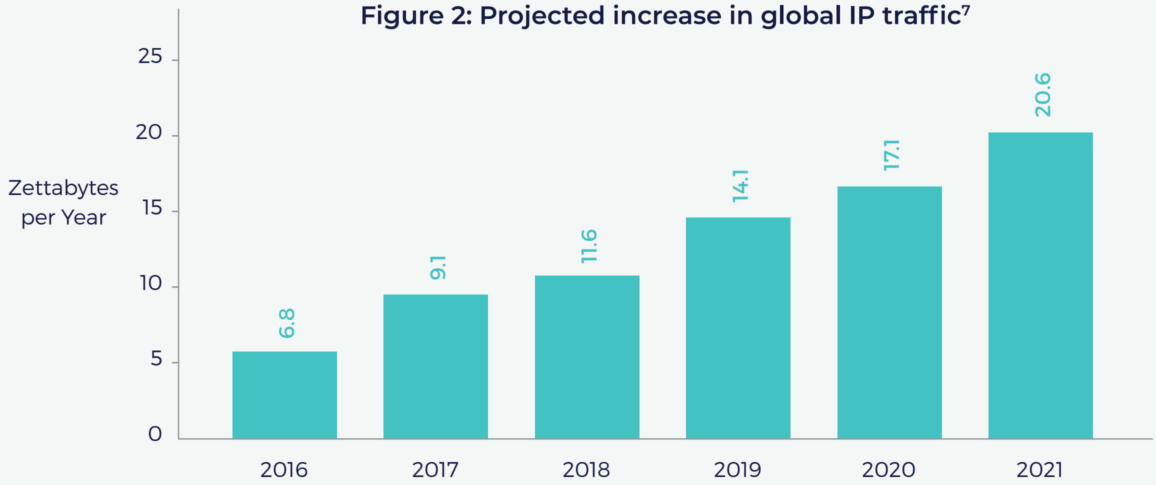
[3] https://www.vertivco.com/globalassets/documents/reports/2016-cost-of-data-center-outages-11-11_51190_1.pdf *(There are no recent comparable studies in Europe).*

[4] https://www.vertivco.com/globalassets/documents/reports/2016-cost-of-data-center-outages-11-11_51190_1.pdf

The explosion of data: generation, storage, real-time processing and AI

Since Mind the Gap was published in 2015, the continued growth of data has set an astonishing pace. In its 2018 Cloud Index Report[5] Cisco projects that annual global data center IP traffic will jump from an annual figure of 6.8 zetabytes (ZB) in 2016 to 20.6 ZB in 2021, increasing at a compound annual growth rate of 25%. (To provide some scale to that - if you consider a normal image taken with an iPhone is between 250-750 bytes, 1ZB is a staggering 1,000,000,000,000,000,000,000 bytes). Meanwhile, by 2021 the number of devices connected to IP networks will be triple the global human population. To take just one example of how much data is flowing globally, every second a million minutes of video content crosses the network.[6]

Figure 2: Projected increase in global IP traffic[7]



25% CAGR 2016 - 2021

Source: Cisco Global Cloud Index, 2016-2021

At the same time, many enterprises will continue to move data and related processes to the cloud and the cloud will also grow rapidly. In fact, Cisco forecasts a 22% compound annual growth rate as enterprises migrate workloads in that direction. In contrast, the use of traditional on-site data centers will see a steady decline.

[5] https://www.cisco.com/c/en/us/solutions/collateral/service-provider/global-cloud-index-gci/white-paper-c11-738085.pdf

[6] Cisco projects that global IP video traffic will represent 82 percent of all IP traffic (both business and consumer) by 2021, up from 73 percent in 2016.

[7] https://www.cisco.com/c/en/us/solutions/collateral/service-provider/global-cloud-index-gci/white-paper-c11-738085.pdf

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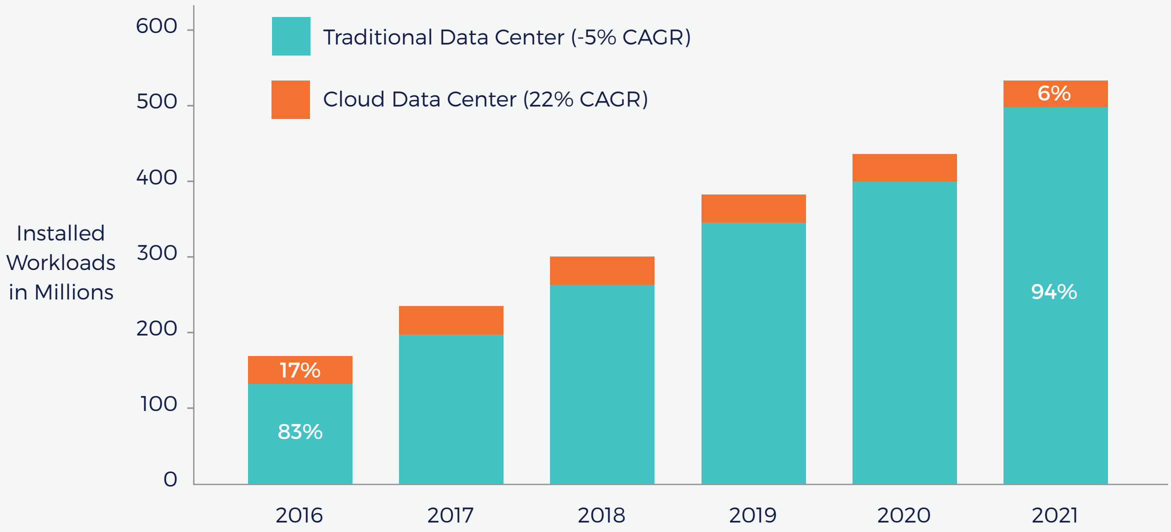
Figure 3: The cloud continues to see steady growth[8]



19% CAGR 2016 - 2021

Source: Cisco Global Cloud Index, 2016-2021

Research firm Gartner predicts that, "By 2025, 80% of enterprises will have shut down their traditional on-premise data center, versus 10% today."[9] Numerous factors drive this dynamic, including economies of scale, the growth of as-a-service or on-demand consumption models allowing buyers to use only what they need, access to state-of the art security, and a declining desire to own and manage one's own hardware or train the specialist staff to look after it. Edge computing – where activity must occur closer to the user – such as video streaming, autonomous vehicles, and other applications, will also accelerate that dynamic. Other specific types of computing will move to specialised data centers as well, especially where high-performance or very specific capabilities (such as crypto currency mining) are required.

As a consequence, Gartner projects that the traditional on-premise data center will be "relegated to that of a legacy holding area, dedicated to very specific services that cannot be supported elsewhere, or supporting those systems that are most economically efficient on-premise." Cisco echoes that view, forecasting that "by 2021, 94% of workloads and compute instances will be processed by cloud data centers."[10]

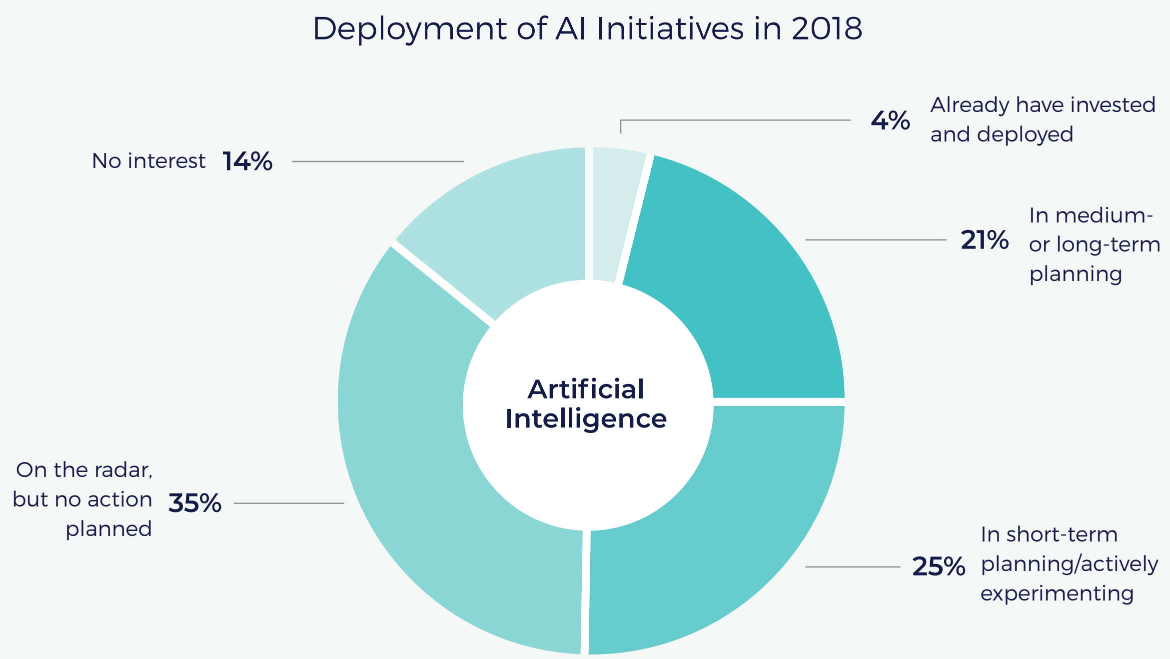
[8] https://www.cisco.com/c/en/us/solutions/collateral/service-provider/global-cloud-index-gci/white-paper-c11-738085.pdf
[9] https://www.gartner.com/doc/reprints?id=1-4WDVFD0&ct=180417&st=sb
[10] https://www.cisco.com/c/en/us/solutions/collateral/service-provider/global-cloud-index-gci/white-paper-c11-738085.pdf

Much of the global IP growth will come from the continued growth in connected devices, led by an increase in the Internet of things (IoT), with machine-to-machine applications responsible for autonomously generating enormous and constant streams of data. Much of this data will be accessed, analysed, and acted upon in near real-time.

The rapid growth in intensive forms of compute such as HPC and AI will act as accelerants in this dynamic, dramatically increasing the level of information processed almost instantaneously.

While still in its relative infancy, AI is expected to expand rapidly. A recent survey by Gartner highlights the vast potential for growth. While only 4% of CIOs have already invested in or deployed AI for their enterprises, 25% are either currently experimenting with AI or have it in their short-term planning horizon. Another 21% are contemplating AI in medium or long-term strategies.[11]

Figure 4: Future growth in AI[12]



Source: Gartner, 2018

[11] https://www.gartner.com/smarterwithgartner/2018-will-mark-the-beginning-of-ai-democratization/
[12] https://www.gartner.com/smarterwithgartner/2018-will-mark-the-beginning-of-ai-democratization/

The issue then becomes less about whether to maintain an on-site data center, and more about where to outsource specific applications and workloads, and why. It is important to determine which compute belongs where, with business partners to be determined according to criteria such as their vision, specialisations, capabilities, networks and ecosystem. It's also important to consider what is required to support the cloud's underling infrastructure and what physical locations are best suited to power the cloud. An increasingly critical element of this discussion becomes access to a clean, affordable, and reliable supply of electricity, and the grid infrastructure necessary to facilitate delivery.

Volumes of data are growing rapidly, with a continued migration to the cloud and a growing role for AI in many applications. In this fluid environment, CIOs must determine how to optimise their portfolio of options for accessing, storing, and processing data. Cost and reliability of electricity supply will factor into this decision-making process.

> "**By 2021, 94% of workloads and compute instances will be processed by cloud data centers.**"
>
> **Cisco**

Growing challenges in supplying electricity to data center hubs

In recent years, electricity use in the data and communications sector – including everything from our connected devices to the data centers – has grown significantly, and is expected to accelerate. One estimate has 20% of global power consumption dedicated to this sector by 2025.[13]

Utilities can respond by building new generating resources, but the issue of delivering power to where it is needed – providing sufficient transmission and local distribution infrastructure – is also growing in importance. Grids must not only generate enough electricity, but also deliver power exactly where it is needed when it is needed in order to support real-time data processing requirements. As data centers increasingly cluster in certain locations near robust fiber connections, the challenge of growing the infrastructure to meet burgeoning demands is already becoming a critical impediment in a number of traditional European data center hubs such as Dublin, Amsterdam, Frankfurt and London.

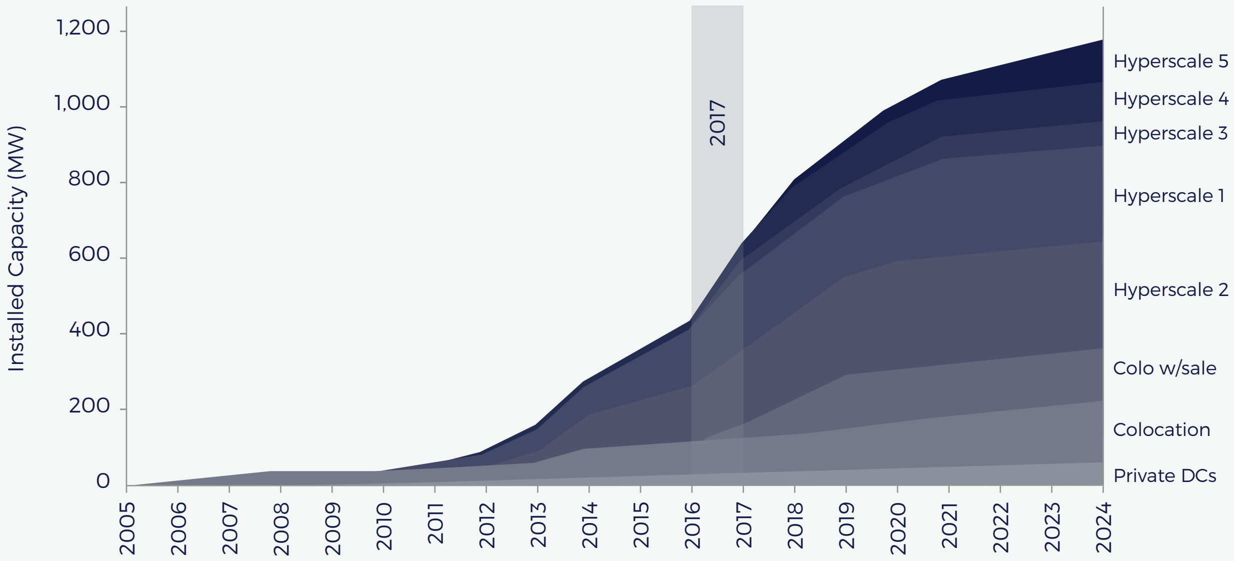
[13] http://www.climatechangenews.com/2017/12/11/tsunami-data-consume-one-fifth-global-electricity-2025/

Let's look briefly at each of those in turn:

Dublin

Dublin has seen the rapid growth of the data center industry. In 2017 420 MW of data centers were currently in operation, with another 150 MW of facilities under construction, and an additional 180 MW with construction permits in hand.[14] By 2024, an additional 1,000 MW of capacity is expected to be required. The sector is already a large energy user, consuming 1.4 terawatt-hours (1,400 megawatt-hours) in 2016, nearly 5% of Ireland's total energy consumption.

Figure 5: Ireland's rapid data center growth[15]



Source: www.seal.ie, 2018

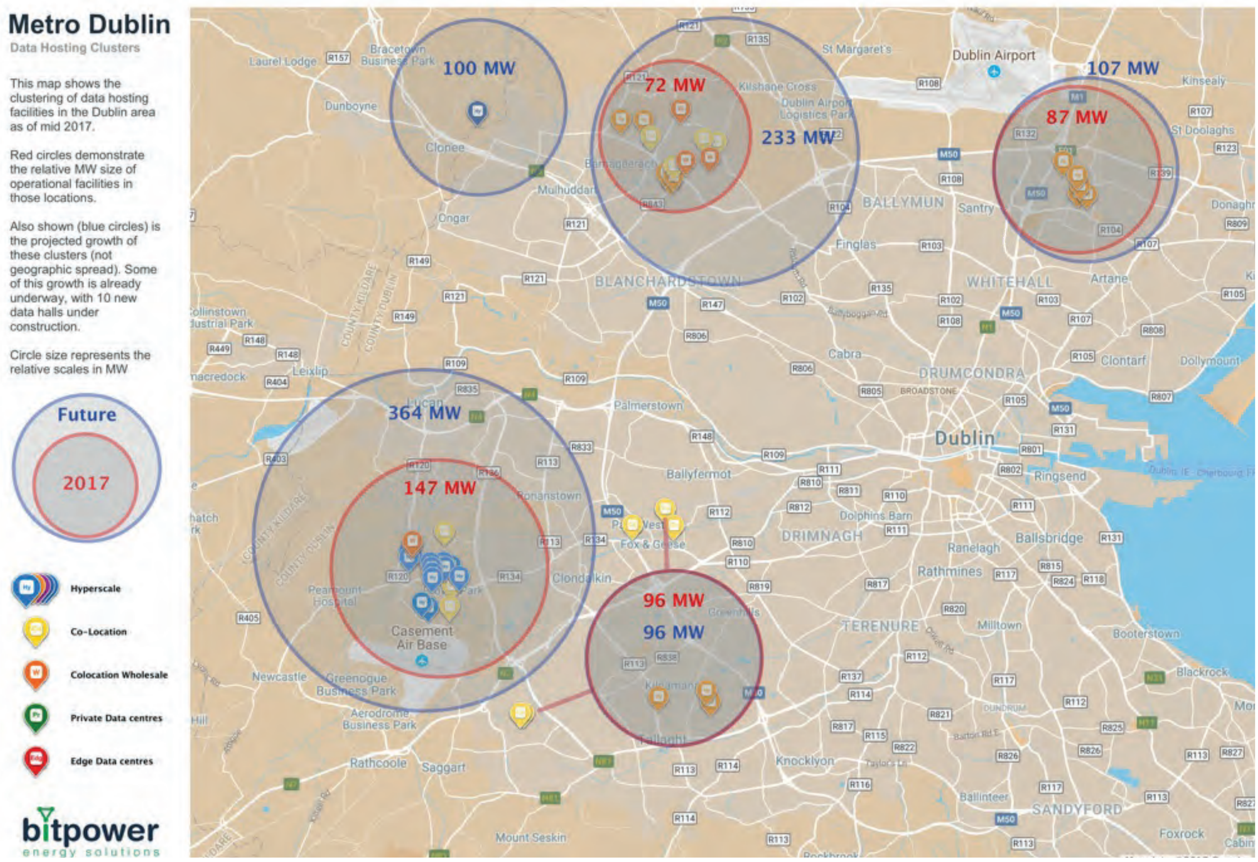
Investment analyst group Moody's indicates that this rapid growth (it forecasts 1,200 MW of data center capacity by 2022) is expected to have two unwelcome implications for Ireland: it is likely to drive overall electricity prices higher, and it may diminish the country's ability to achieve its 2020 carbon emissions reduction goals.[16]

[14] http://hostinireland.com/_assets/2017/12/HII-Ireland's-Data-Hosting-Industry-2017-Outlook.pdf (a Q1 update of this report updated that number to 480 MW, highlighting the rapid growth).

[15] https://www.seai.ie/resources/Irelands-Data-Hosting-Industry-2017.pdf

[16] https://www.irishtimes.com/business/energy-and-resources/data-centre-demand-to-lead-to-higher-energy-prices-1.3581998

Figure 6: Growing data center capacity in Dublin[17]



Source: www.seal.ie, 2018

The rapid growth of Dublin's data centers also crowds out the growth potential of other businesses. Local utility ESB Networks indicates it is facing "unprecedented" demand, with difficulty building out the transmission and distribution system to meet the needs of other enterprises. The addition of required infrastructure may take until 2020.[18]

[17] https://www.seai.ie/resources/Irelands-Data-Hosting-Industry-2017.pdf
[18] https://www.thetimes.co.uk/article/dublins-big-data-centres-devour-all-the-power-tbq3xdfh2

Amsterdam
Amsterdam, currently Europe's busiest data hub, is facing a similar situation.[19] The Dutch data center industry is crucial to the economy of the Netherlands, with roughly 1,200 megawatts and 283,000 square meters of data floors in Amsterdam. However, its pace of double-digit growth over the past decade may be similarly limited owing to electricity supply constraints. In a recent letter to the Netherlands Minister of Economic Affairs and Climate, the Dutch Data Center Association (DDA) warned about limitations to the Dutch energy infrastructure in critical locations in the city that may severely hamper the future growth of the domestic industry.[20]

Similar to Dublin, the issue here is not limited by the generating capacity of power plants, but rather constrained by local utility infrastructure that simply cannot keep up with rapidly burgeoning demand. Building new distribution infrastructure in congested cities is an expensive and time-consuming process, so these issues are not likely to be remedied in the short-term.

Frankfurt
German data center power consumption is also demonstrating strong year-on-year growth.[21] Frankfurt enjoys a leading position in the German market, in part because it sits astride two fiber optic cables connecting it to the rest of the continent. Growth is also driven by stringent domestic legal requirements related to security and protection of data. According to one source, it is a "must" for approximately three-quarters of German companies to host their cloud services in data centers located in Germany.[22]

Energy costs are high - approximately twice those of neighboring Amsterdam - a concern for companies that do not specifically need to be in Germany (or Europe, for that matter). Despite this fact, demand for new data centers is growing steadily, with some analysts expecting data volumes to increase as much as five times over a five-year period.[23]

Potential future constraints on Frankfurt's growth relate to both real estate requirements and power delivery infrastructure. In addition to requiring a large (and increasingly hard to find) footprint of approximately 50,000 square meters and fast fiber-optic ties, data centers are also finding that in some instances the local utilities cannot provide sufficient capacity to support new developments.[24]

[19] https://www.thehaguesecuritydelta.com/media/com_hsd/report/156/document/Digital-Gateway-to-Europe-State-of-the-Dutch-Data-Hub.pdf
[20] https://thestack.com/data-centre/2018/05/03/netherlands-power-shortage-disrupting-data-center-industry-growth/
[21] https://www.dotmagazine.online/issues/powering-and-greening-IT/Sustainable-Energy-Transformation/energy-requirements-of-data-centers
[22] https://www.dotmagazine.online/issues/powering-and-greening-IT/Sustainable-Energy-Transformation/energy-requirements-of-data-centers
[23] https://www.dlapiper.com/en/uk/insights/publications/2017/07/real-estate-gazette-28-change-on-investment/recent-developments-german-data-center-market/
[24] https://www.dlapiper.com/en/uk/insights/publications/2017/07/real-estate-gazette-28-change-on-investment/recent-developments-german-data-center-market/

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London
Although other British cities host numerous facilities, London currently leads the pack with over 160 data centers.[25] The UK is also a major focal point for interconnection between Europe and North America, with over 50 undersea cables tying it to other locations. Despite the uncertainty of Brexit, and the questions related to future interactions with continental markets, thus far the British data center industry has continued its steady march.[26]

However, concerns with electricity supply have also emerged in London. Since the original 2015 Mind the Gap report, electricity supplies have been tight, with the winter of 2016/2017 characterised by very limited supply margins and excess generating capacity.[27] Last year, the UK power supply situation stabilised at least temporarily, with excess generating capacity at 10% over demand – a relatively comfortable situation for the moment (resulting chiefly from a decline in overall societal demand and increased generating capability).[28]

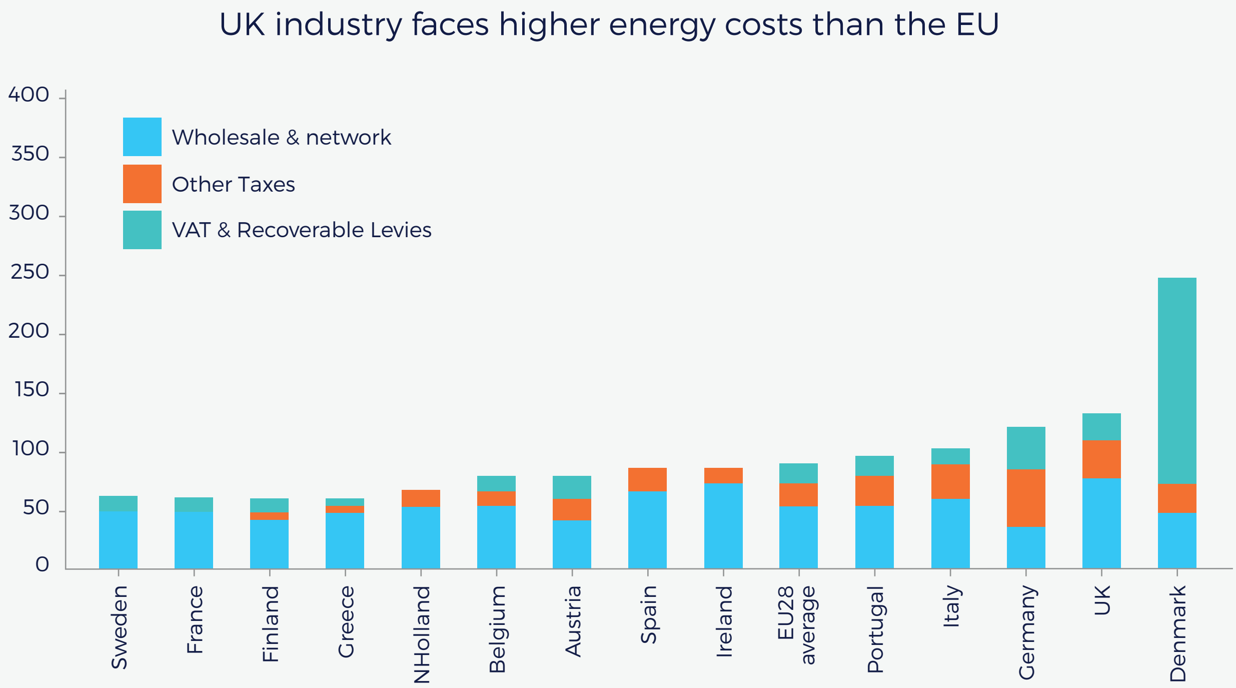
However, the future is more uncertain, with the pending closure of numerous aging and dirty coal-fired plants. The Institution of Mechanical Engineers recently warned that there is little time to remedy this situation, stating “the conclusion is that we have neither the time, resources, nor the sufficient number of skilled people to build enough CCGTs (combined cycle gas turbines) to plug this gap.”[29] Longer-term, the controversial 3,200 MW Hinkley Point C nuclear power plant may help mitigate supply concerns, but it has been beset by both delays and cost increases. It is expected to raise overall market prices, with a guaranteed price of £92.50 per MWh for the initial 35 years of operation,[30] substantially above historic day-ahead market prices of recent years.

Costs are already a real issue, with electricity tariffs to large energy users among the highest in Europe – second only to Denmark.

> “**The conclusion is that we have neither the time, resources, nor the sufficient number of skilled people to build enough CCGTs (combined cycle gas turbines) to plug this gap.**”
>
> **The Institution of Mechanical Engineers**

[25] https://cloudscene.com/market/data-centers-in-united-kingdom/all
[26] https://cloudscene.com/market/data-centers-in-united-kingdom/all
[27] https://www.telegraph.co.uk/news/earth/energy/12175367/UK-energy-supply-forecasts-into-the-red-for-first-time-next-winter.html
[28] https://www.nationalgrid.com/uk/publications/winter-outlook
[29] https://www.imeche.org/docs/default-source/position-statements-energy/imeche-ps-electricity-gap.pdf?sfvrsn=0
[30] https://www.world-nuclear-news.org/NN-Cost-of-Hinkley-Point-C-rises-by-8-percent-EDF-says-0307175.html

Figure 7: UK industrial tariffs are second-highest in Europe[31]



Annual electricity costs for large consuming industries (annual consumption of 70-150 GWh).
Policy costs are included but, depending on country, are categorised in differing segments of the bill.

Source: EDF Energy

As with other European cities, local growth in electric demand is also creating constraints on the local London electric distribution networks. Local utility UK Power Networks announced plans in June of 2018 to install a fleet of 40 distributed batteries to address local constraints.[32] UK Power Networks is also building four new substations[33] over the next four years to accommodate rapid growth in electricity demand.

Key data center locations in Europe are facing limitations on the ability to continue building out new data centers. The critical issue is a constraint on the utilities' abilities to continue expanding local transmission and distribution infrastructure to meet the rapidly growing demands of the data industry. Price is increasingly becoming a factor in some locations as well.

[31] https://www.telegraph.co.uk/business/2017/10/29/british-industry-faces-cost-energy-crisis-set-grow/
[32] https://utilityweek.co.uk/virtual-power-station-to-relieve-pressure-on-london-network/
[33] https://www.ukpowernetworks.co.uk/internet/asset/17f5dccb-ddcf-4f45-a446-3b2cd88f73fl/Central+London+Plan+Update+2017.pdf

The application-first approach: not all data needs to be treated the same

As data increasingly moves to the cloud, businesses have an opportunity to create cost-effective strategies for processing and storing that data. The costs of operating the cloud vary significantly based upon a variety of factors including real estate prices and operating costs. Operating costs are largely dependent upon the electricity bill, and the two major variables here are the energy devoted to cooling and the local electricity rates.

In managing costs, it's therefore critical to understand what applications require local siting - which may come at a cost - and what applications can be located in more cost-effective locations. The following table from EMC indicates the types of activity and latencies required.

Figure 8: Types of data and time intervals[34]

Application use case for events	Date time interval
Ultra low latency messaging	< 1 microsecond
Extreme transaction processing	< 1 millisecond
Streaming data analysis; no intermediate persistence	< 50 milliseconds
Real time event characterisation	< 500 milliseconds
Complex event processing; near real-time dashboards	< 15 seconds
Operational dashboard	< 2 minutes
Intraday analysis	< 30 minutes
Daily rollup	≤ 24 hours
Recent historical analysis	≤ 8 days
Medium-term historical analysis	≤ 13 months
Long-term historical analysis	≤ 5 years or more

Source: DellEMC, 2015

A large number of applications do not have to be located near the end user – either for latency, accessibility, security or other reasons – and are capable of being moved to other locations for cost-efficiency, reliability and sustainability reasons (amongst others).

[34] https://infocus.dellemc.com/wp-content/uploads/2015/10/joe2.png

Relocation of certain flexible and price-responsive applications can result in lower operating costs and less exposure to the risk of power supply disruption while taking stress off local power grids. While some data center activities clearly must be located close to customers and support applications, many applications are not location-dependent. For example, research undertaken by consulting firm The Broad Group indicates that even in the financial sector only 10-15% of applications actually required proximity to the London Stock Exchange. That research suggests that 50 to 60% of data centers could relocate outside London (and indeed the UK), saving operators vast sums of money without any negative business or regulatory impact (for example, government-mandated requirements for storing sensitive data).[35]

> **“Workload placement will become the key driver of the digital infrastructure delivery.”**
>
> **Gartner**

Many big data analytical operations are particularly flexible and can be relocated, and some companies are doing just that. For example, German automakers BMW and VW have identified a number of energy-intensive applications that are not subject to either privacy concerns or other geographic requirements. To cut costs, they have migrated activities such as computer-aided design, crash test simulations, and aerodynamic calculations from Germany to lower-cost environments in Iceland and Sweden.[36] Companies must therefore evaluate their various applications and determine which approaches help them balance costs versus other considerations, such as on-premise compute requirements.

In discussing the impact of the cloud, the research firm Gartner, observes that, “workload placement will become the key driver of the digital infrastructure delivery.” As the following diagram indicates, the key is to determine which data belongs where, based on the business rules of a particular department or organisation.

[35] Commissioned Research, September 2015: Steve Wallage, Managing Director, The Broad Group

[36] https://verneglobal.com/news/verne-global-helps-bmw-to-cut-carbon-emissions-by-3-570-metric-tons

Figure 9: Where to locate the applications and workloads[37]

Impact appraisal for emerging digital infrastructure

Impacts		Top recommendations
Workload placement will become the key driver of the digital infrastructure delivery.	>	• Rationalise which workloads belong where, based on business rules and benefits, to ensure successful cloud migrations. • Replace older workloads with "as a service" offerings where appropriate.
An ecosystem of partners will be required to enable scalable, agile infrastructures.	>	• Pick partners based on their vision, capabilities and their ecosystem. • Focus on geodiversity and interconnection services.

Source: Gartner, 2018

Today, a growing number of CIOs are increasingly comfortable with migrating to the cloud, with the knowledge that their data can literally be stored and processed anywhere via virtualised servers, and transported rapidly (for example, Verizon indicates it can move data round-trip from the U.S. to Europe in 90 milliseconds).[38] As a consequence there is little true economic justification for keeping many data applications close to home or on-premise. In a globally connected market, cost and reliability may matter far more than proximity for the majority of data centers in Europe or elsewhere.

Offshoring HPC applications

Depending on specific use cases, HPC and some applications of AI may be extremely non-latency sensitive (such as deep neural network training workloads), while other applications (such as autonomous vehicles) are highly latency-sensitive. In many instances, powerful computers are used to solve problems that do not require immediate communication of results or interaction with the broader network.

An example of this would be German software translation company DeepL, a company developing neural network translation services that sound more human. DeepL's 5.1 petaflop service can translate a million words in less than a second. The company had difficulty finding a data center at home that could handle the enormous power requirements of its AI neural network translation application. As a result, DeepL opted to relocate those activities to Iceland, cutting costs by 70% in the process.

[37] Adapted from https://www.gartner.com/doc/reprints?id=1-4WDVFD0&ct=180417&st=sb
[38] http://www.verizonenterprise.com/about/network/latency/

Data applications are extremely varied. Some must remain within specific geographic locations for latency or legal considerations. However, the majority of data that is processed is not location-dependent and could be relocated, with the potential to minimise electric supply risk while lowering costs. CIOs should be evaluating the flexibility of their workloads and potential cost and risk-mitigation strategies associated with moving applications to other locations.

Power supplies: where to find reliable and affordable electricity for data centers

In the search for low-cost and reliable power supplies to support data processing needs, the CIO often faces a search at the global level. As indicated previously, many power grids may not meet stringent requirements for reliability. Growth in demand for electricity in many developed countries has outstripped the infrastructure necessary to keep up, with implications for reliable delivery, and some local grids face uncertainty in their future abilities to supply power to specific locations.

In this context, Iceland ranks well above European competitors, with one of the most reliable power grids in the world. Power outages are rare and generally limited to short durations, with the average length of unplanned grid transmission interruptions per customer for 2016 at 5.1 outage minutes, well below transmission operator Landsnet's goal of 50 minutes.[39] To put this into context, 2016 average outage durations per customer for Germany were 23.55 minutes, while the U.K. was around 50 minutes, Sweden averaged 94 minutes, and Norway stood at 129 minutes.[40]

As shown in the chart on page 18, several of the Nordic economies (Iceland, Norway, and Sweden) offer some of the lowest cost electricity globally available, largely owing to an abundance of hydro-electric power (with Sweden supplemented by substantial amounts of nuclear power). Unlike systems primarily based on expensive hydrocarbons that are also highly volatile in price, hydro-based grids are not only more cost-effective, but generally more stable from year to year.

[39] https://www.landsnet.is/library/Skrar/Landsnet/Skyrslur/Frammistoduskyrsla/Performance_Report%202016.pdf

[40] https://www.ceer.eu/documents/104400/-/-/963153e6-2f42-78eb-22a4-06f1552dd34c Table 9: "Planned and Unplanned SAIDI Events." *(There may be some apples-to-oranges comparisons between Iceland and the other European economies, depending on how the numbers are captured. Some countries do not include low-voltage numbers in their reported SAIDI (system average interruption duration index) numbers. Inclusive of low-voltage distribution systems, Iceland stands at approximately 25 minutes).*

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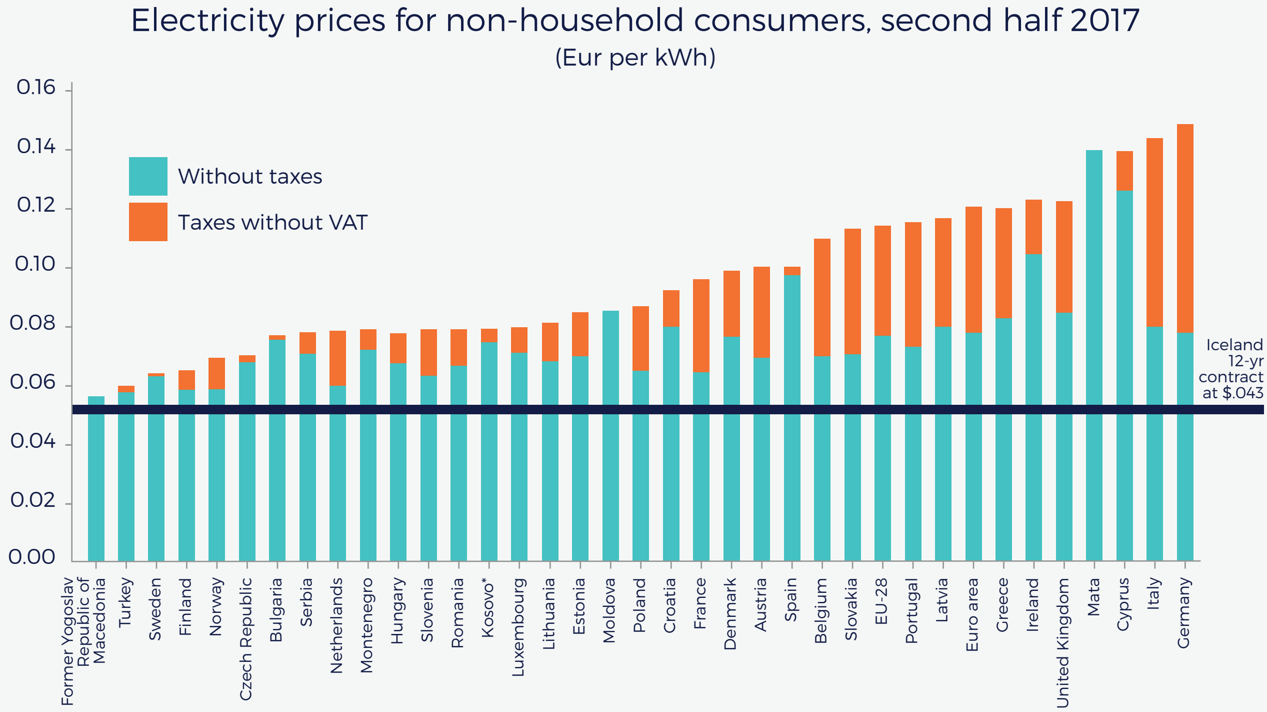
Figure 10: A comparison of power prices[41]



Source: Eurostat Statistics, 2017

In addition to existing generation, Iceland, Norway and Sweden possess both existing surpluses and potential new resources for future development – an important issue when taking future growth into account. All three nations are relatively cost competitive, and each has developed specific tariffs or policies to woo future data centers. Norway has recently launched a national data center strategy with multiple data center sites identified for development,[42] while Sweden has dozens of potential greenfield sites that have been identified as part of its Data Center Initiative.[43] For its part, Iceland's local utility – Landsvirkjun - can offer a fixed price contract to data centers at 4.3 cents per kWh for periods up to 12 years.[44]

In addition to low power prices, these northern economies also offer cool temperatures, a boon to data centers where up to half the energy consumed is used to cool servers.[45] Taken together, power costs and ambient temperatures have the greatest long-term impact on total costs.

The performance, reliability, and cost of electric grids varies widely. Whether considering an investment in siting a data center, or committing to a cloud-computing contract, reliability and cost issues cannot be ignored.

[41] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Electricity_prices_for_non-household_consumers,_second_half_2017_(EUR_per_kWh).png

[42] https://www.regjeringen.no/globalassets/departementene/nfd/dokumenter/strategier/strategi-nfd-eng-nett-uu.pdf

[43] http://www.business-sweden.se/en/Invest/Industries/ICT/The-Data-Center-Initiative/Available-Data-Center-sites/Greenfield-10-ha/

[44] https://www.landsvirkjun.com/productsservices/energyproducts/data-centers/competitive-energy

[45] Some data centers, such as Facebook's massive facility in Lulea, Sweden, have been located close to the Arctic Circle mainly for this reason.

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Summary and recommendations

The data center industry is in the midst of significant global transformation, with enormous growth in the amount of data being produced, stored and processed, and numerous new applications being developed. Migration to the cloud is in full swing, while AI is increasingly beginning to make its presence felt.

At the same time, this growth is causing significant challenges related to accessing reliable and cost-effective power supplies. This is particularly the case in some data hubs in mainland Europe, where electric supply infrastructure limitations are beginning to pose significant constraints. Meanwhile, power prices in many of these areas are also quite high and represent a large portion of overall costs.

At this time of transition and flux, CIOs should evaluate the potential for moving a portion of their data storage and processing requirements to countries that offer low prices, reliable and clean power, and the possibility of unfettered growth. Specific questions that should be evaluated in this process include:

1) Is it necessary to store and/or process information in existing locations, and if so, why? For example, are there specific legal issues or latency concerns that affect this decision?
2) Are there specific workloads and applications that could be moved if it were advantageous to do so?
3) How reliable is the local electricity distribution infrastructure and how often does the facility experience power outages?
4) Does the local utility face challenges related to growth that may threaten future power supplies or the ability to expand operations?
5) What percentage of overall operating costs is related to both the price of electricity as well as data center cooling?
6) Does it make sense from the perspective of economics, types of workloads, and relative latencies to move some or all of data-related operations to other countries?

The answers to these questions will help determine the best strategies for navigating this changing world. Many CIOs may find that partnering with data centers in northern climes – characterised by cheap and clean hydro-electric power, solid grid infrastructures, and the requisite connectivity – represents the most cost-effective and worry-free path to securing their data futures.

It should be anticipated that these northern locations will continue to host a growing number of high performance data centers that increasingly connect our world and add enormous value to the global economy.

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The Author

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Peter Kelly-Detwiler has 30 years of experience in the area of electric energy, retail power, energy efficiency, and distributed energy assets. Mr. Kelly-Detwiler offers expertise in the areas of new technologies and the integration and interaction of on-site distributed assets with electricity markets. He is professionally active on a national level with energy companies, demand response providers, software developers, datacenter owners, and various energy start-ups.

Mr. Kelly-Detwiler has written comprehensive research papers for clients on diverse topics relating to power markets. He is a frequent moderator and speaker at industry events concerning the interaction of power markets and emerging technologies, and runs professional workshops on the topic ranging from 3-12 hours. He also contributes regularly to Forbes.com and other publications focusing on topics related to disruptive innovation and the impact on the electricity infrastructure.

Mr. Kelly-Detwiler has spent the majority of his career in various aspects of U.S. competitive power markets and has a deep understanding of how they function. He has spent recent years helping energy companies optimize the interaction between distributed assets and electricity markets, and has advised multiple customers in various aspects of this field. As Senior Vice President at Constellation, he oversaw creation of VirtuWatt – a market leading platform to facilitate real-time awareness of electricity pricing and consumption and bidding of assets into various competitive markets.

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