Baringa

Green Data:

A vision for sustainable data centres in Ireland

in association with

bitpower energy solutions

commissioned by

Cloud Infrastructure Ireland Ibec

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Formed in July 2021, Cloud Infrastructure Ireland (CII) is a trade association within Ibec focused on the infrastructure policy issues that affect cloud providers.

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Executive Summary

In this study, Baringa and BitPower examine the role of data centres in modern society, the value Ireland's cloud infrastructure sector creates in social, economic and sustainability terms, and the steps that should be taken by the sector, Government, and other stakeholders to ensure a sustainable future for the industry in Ireland.

Key findings

- **Data centres are essential for modern society**, powering the digital services we use, enhancing cyber security and enabling the digital transformation of all sectors. They were officially recognised as essential services during the COVID-19 pandemic.
- **Data centres were key to enabling people to feel connected, socialise and work from home**, including communicating with colleagues and friends over video calls and to access remotely delivered public services during the pandemic. They continue to enable remote working and more efficient, accessible and personalised public services.
- **Data centres are critical enablers of decarbonisation:**
  - They significantly reduce the emissions from computing - they typically use 80% less energy than traditional on-premises servers to do the same amount of work[1].
  - They reduce the need for travel and physical goods, lowering emissions from transport and manufacturing.
  - They support digital technology being deployed across the economy to deliver emission reductions and efficiency gains - a study in Germany[2] estimated that rapid digitalisation could deliver half of Germany's target emissions reductions to 2030.
  - Hyperscale[3] cloud companies, which are the leaders in the data centre industry, are also the leading buyers of renewable energy in Europe and the world.
- Data centres attract **over €1bn of direct investment into Ireland annually**. They are a key part of Ireland's **computer services industry**, which generated **€134bn of exports in 2020, representing 33% of all Irish exports**.
- **Data centres can help accelerate the energy transition in Ireland by:**
  - directly supporting new renewables projects
  - financing improvements in energy security and networks
  - offering grid support services to facilitate renewables integration
  - supporting innovative solutions to achieving a zero-carbon power system in Ireland, and
  - providing zero-carbon heat to neighbouring buildings.

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[1] 451 Research 2021

[2] Bitkom March 2021

[3] "Hyperscale" refers to cloud infrastructure and companies (dubbed "hyperscalers") that are of massive scale, effectively limitless from the individual user perspective: the leading hyperscale cloud providers are Amazon, Google and Microsoft. Data centres operated by hyperscalers may be termed "hyperscale data centres".

- **But this will require engagement between Government, the data centre industry and other stakeholders** to deliver changes in practice, policy, and regulations.

The value of Ireland's data centres

We use cloud data centres every day without realising it: when we send messages, when we search and shop online and when we join a video call, we depend on data centres. We access better and cheaper products and services thanks to the **advantages cloud services bring to businesses**, and we benefit from **better and more efficient public services**. Recognising its benefits, **the Irish Government has pursued digitalisation as a policy goal**, most recently in "Harnessing Digital – The Digital Ireland Framework" (Ireland's new national digital strategy). Irish businesses are ahead of the EU average in adoption of cloud services.

Digitalisation is best achieved through the cloud, which centralises IT resources in data centres, **leading to massive efficiencies**. The cloud is much more powerful than the individual devices used to access it, so even a low-powered mobile phone can be used to access powerful services that rely on hyperscale computing. **Reliability, scalability, and security are all better through cloud data centres.**

Businesses, public services and researchers using the cloud also benefit from:

- **Reductions in costs** and potentially **80% reductions in the carbon footprint of their IT use.**
- **Collaborative working** enabling global teams to work as one.
- **Access to powerful tools** such as big data, AI and high-performance computing

Cloud services are delivered by data centres. The data centre industry is also a major contributor to Ireland's economy, attracting **an estimated €10bn of investment** over the past 10 years, and **averaging over 25% growth per year**. There are over 90,000 jobs in computing, almost universally relying on data centre services. Jobs in the computer services sector have grown faster than jobs in other sectors over the past decade (Figure 1). In the wider economy, Ireland now boasts over one million jobs in digitally-intensive industries.

Ireland's tech industry has taken off as data centre capacity has grown, and 15% of the gross value added (GVA) in the Irish economy now comes from Information & Communications. This is a particularly export-focused sector, with **computer services now accounting for 33% of total Irish exports**. The growth in these exports closely follows the increase in investments in data centres (Figure 2). The data centre industry has also contributed to impressive growth in construction services exports as Irish companies have become world leaders in developing data centres.

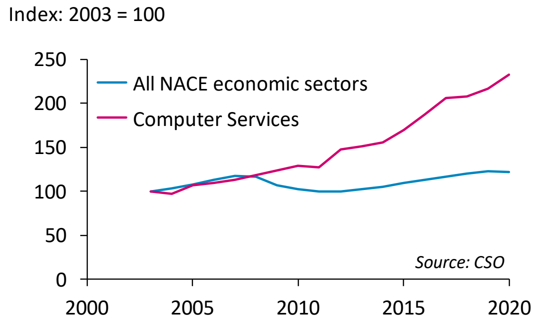


Figure 1: Evolution of jobs numbers in computer services versus all jobs in Ireland (2003-2020, index)

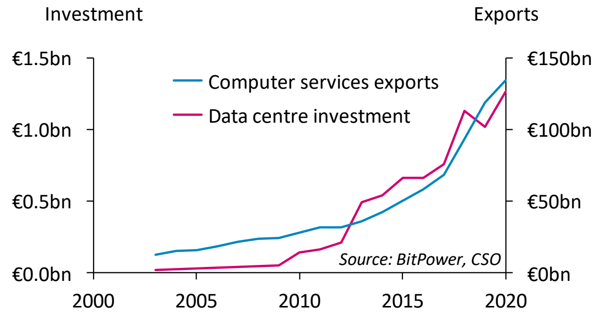


Figure 2: Investment in data centres (left axis) & computer services exports (right axis) 2003-2020 (€bn, nominal)

Looking ahead, Ireland has massive potential renewable energy resources which exceed Irish demand by over 300%. As these are developed, the electricity they produce can either be **exported "raw" to overseas markets** via interconnectors, or it can be **"refined" domestically, including in data centres**, and exported as computer services. **This latter option creates much more value in the Irish economy.**

Cloud services support wider sustainability

Data centres and digitalisation help drive emissions reductions across the economy in multiple ways.

Digitalisation can deliver significant emissions reductions by replacing physical goods and services with virtual ones. For example:

- The shift to **working, meeting and studying online** during Covid-19 restrictions was linked to a reduction in transport emissions in Ireland of almost 2m tonnes CO_2e[4], more than offsetting the 0.6m tonnes CO_2e increase in residential emissions.
- **Online shopping** can reduce emissions by up to 59%[5] compared with in person shopping.

Many decarbonisation solutions depend on data centre capabilities, including platforms to **manage energy use and software to make agriculture more efficient** – in fact **data and analytics are being deployed across almost every sector of the economy to support energy efficiency gains and increase productivity.** A cross-sector study in Germany found that potentially half of Germany's planned reductions in emissions by 2030 could be delivered by rapid digitalisation.

Cloud data centres can be 80% more energy efficient than traditional onsite servers, reducing the carbon footprint of computing workloads (Figure 3). Procurement of renewable energy to power them could reduce this further, and tech companies are leading on this in Europe and globally.

[4] Environmental Protection Agency October 2021

[5] Oliver Wyman 2021

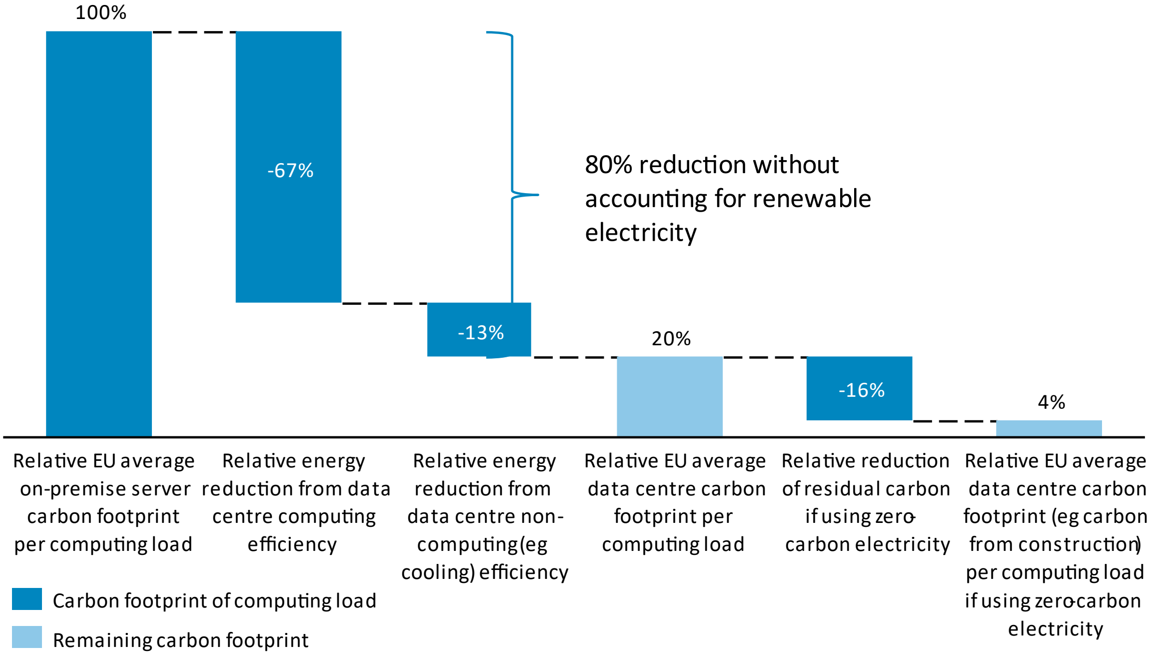


Figure 3: Calculated reduction in carbon footprint of computing loads shifted to cloud data centres from on-premise servers (%)[6]

The future of data centres in Ireland

Ireland's strong existing data centre and computing sector, together with its large potential renewable energy resources, people, climate and connectivity, puts it in prime position to capture expected future growth in the data centre industry.

Future data centres can lead the way on decarbonisation. Below, we set out the key ways they could do this, building on today's best-in-class examples.

Supporting new, unsubsidised renewables on the Irish grid, continuing to lead the way on sustainable corporate power procurement.

Decarbonising electricity use, by aiming to match electricity demand to carbon-free supply and investing in or enabling technologies such as batteries and green hydrogen to decarbonise peak generation.

Providing grid stabilisation services, that will replace services from retiring thermal generation and help integrate a higher proportion of renewable generation.

Providing low carbon heat for other applications, saving emissions that would otherwise have come from sources such as gas boilers.

[6] 451 Research 2021. Remaining relative data centre carbon footprint would include embodied emissions - some other emissions (such as occasional use of backup generators) not accounted for.

We conclude the report with a **set of principles** (Table 1) that we believe the data centre industry should work with the Government and other stakeholders to achieve.

Each principle tackles a different challenge and can be achieved by implementing different solutions. **We further recommend a set of concrete actions that should support these solutions.** Although these recommendations focus on data centres, many are also applicable to other large energy users, and **we would encourage** stakeholders to take **a sector-neutral, principles-based approach** as far as possible, to **maximise the scale of the impacts and to ensure consistency** across different parts of the economy.

Table 1: Principles & recommendations to enable sustainable digital infrastructure in Ireland

Principles	Challenges	Solutions
Decarbonise data centre electricity use	Power sector emissions must decline as electricity demand grows	**More granular carbon reporting**
		Carbon-efficient computing
		Cutting edge energy efficiency
		Low-carbon energy procurement
Enable secure and sustainable growth in electricity supply	Security of supply must be maintained and network capacity upgraded as the economy electrifies	**Collaboration on generation capacity**
		Enabling provision of electricity grid services
		Tackling network constraints
		Unlocking private wire renewables
Contribute to sustainability in other sectors	All sectors must become more sustainable	**Zero-carbon construction**
		Sustainable water use
		Sustainable sourcing and waste minimisation
		Making use of waste heat

All the solutions will require collaboration, and so we recommend:

Dialogue and engagement

It is crucial that central Government, industry (power, data centres and other large energy users) and regulators work more closely together to achieve a sustainable future for data centres in Ireland.

1 Data centres are essential for modern society and have a positive impact in Ireland

Data centres are a fundamental infrastructure which enables the digitalised services that we now use every day. Ireland has become home to a thriving data centre industry that is an important part of its wider tech sector. This section will discuss:

- how our modern society relies on digitalisation powered by the cloud
- how digitalisation relies on cloud data centres, and
- the economic impact of data centres in Ireland.

1.1 Our modern society relies on digitalisation powered by the cloud

Data centres underpin the functioning of almost all modern economies. They are the home of cloud computing, which is fundamental to how the internet works and to most of the services we use on our phones and computers. Data centres were recognised as an essential service under Ireland's public health guidelines during COVID-19[i].

Almost everything you do on a computer, mobile phone or tablet is backed by cloud services: booking a flight, ordering a take-away, attending a video call, applying for a passport, accessing your medical records, paying a bill, or finding your way home. Businesses and Government agencies offering these services through apps and websites build their platforms in the cloud, hosted in data centres, and increasingly organisations use cloud services to deliver the computing power needed, and to store their documents and data, rather than relying on local servers.

"Digital infrastructure underpins the delivery of Ireland's digital economic and social ambitions"
"Harnessing Digital – The Digital Ireland Framework" (Ireland's new national digital strategy)

What is the cloud?

Cloud computing is the on-demand delivery of IT resources over the Internet. Instead of buying, owning, and maintaining their own physical data centres and servers, users can access technology services, such as computing power, storage, and databases, on an as-needed basis from a cloud provider.

What is a data centre?

A data centre is a physical building or set of buildings housing a set of computers called servers that are connected to the internet to provide cloud services. These services are provided to users who are not on the same site and who connect through the internet. Alongside the servers, data centres include networking infrastructure and equipment to provide the power, cooling, and protection necessary to ensure they can provide highly dependable and resilient cloud services.

1.1.1 Digitalisation is transforming our everyday lives

Modern life is increasingly digitised – more and more of what we do is aided by or mediated through data centres via the connected devices we use. This enables us to communicate and to find or to save information through digital devices, and it means that even where we don't notice the computer, we benefit from better and more efficient goods and services that are delivered to us with the help of digitalisation. The consumer-facing applications of digitalisation include:

- communications and social media
- navigation *(eg, Google Maps)*
- online shopping and banking, and
- entertainment & gaming.

Our lives are transformed by being able to communicate and to share instantly with friends and family wherever they are in the world, and to participate in new communities of interest established online. We can easily navigate ourselves, with instant access to directions, including using low-carbon public transport options. We have increasingly convenient access to more products at better prices and can sort out finances or insurance from the comfort of our own homes. We have access to more entertainment options than ever before. Beyond these applications, digitalisation can also transform:

- education
- work, and
- healthcare & government services.

We can learn at any hour of the day, anywhere, and offline learning could shift online when it had to during the COVID-19 pandemic. Many jobs also had to shift online during COVID-19 and being able to do this preserved much more of the economy than would have been possible without digitalisation. As we transition to a new normal, the ability to work from anywhere has lasting benefits for where and how people can choose to live. As will be discussed later, healthcare and government services can also be more personalised, responsive and efficient when delivered with the help of digitalisation.

Digitalisation enables better products and services to be delivered to more people, and it enables us to connect to more people and more information from wherever we are.

1.1.2 Digitalisation is driving business

Business demand for cloud services has increased dramatically over the past 10 years (Figure 4[ii]). Irish companies are rapidly migrating business IT functions, with over two-thirds of enterprises using cloud-based email, file storage, and office software[iii] and some also using advanced services such as machine-learning. This is in line with the global trend for increased adoption of the cloud.

Cloud services enable businesses to retire less efficient, legacy on-premises systems, which were hosted, administered and upgraded locally. They are replaced with cloud systems that are centralised and that benefit from enormous economies of scale. The change is analogous to moving from a system of using local wells to one of having a water network: quality and reliability is higher whilst effort and costs are lower.

The value of digitalisation is recognised in the Ireland's "Harnessing Digital – The Digital Ireland Framework"[iv], the first dimension of which is the *"Digital Transformation of Business"*. Research has shown that moving to the cloud can enhance business growth[v] and productivity, with 78% of users in a business survey in Australia reporting improvements in productivity since they started using cloud services[vi].

Two-thirds or ~180,000 of the 270,000+ businesses in Ireland are judged to have at least a basic level of 'digital intensity'[vii]. The ambition for 2030 is to get this to 90%. Even for businesses that are already digitalised to some extent, there is likely to be plenty of scope left for growth in digitalisation with respect to the applications discussed in Table 2, many of which also apply to the public sector.

All these applications can be enhanced by cloud services, and indeed the "Harnessing Digital – The Digital Ireland Framework" sets out a target for 75% of business to use cloud computing by 2030. It is a testament to Ireland's technology leadership that 41% of Irish businesses use the cloud, well ahead of the EU average of 26%[viii]. As it notes, data centres are: *"more than ever, a core infrastructure enabler of a technology-rich, innovative economy, which makes Ireland a location of choice for a broad range of sectors and value-added activities"*.

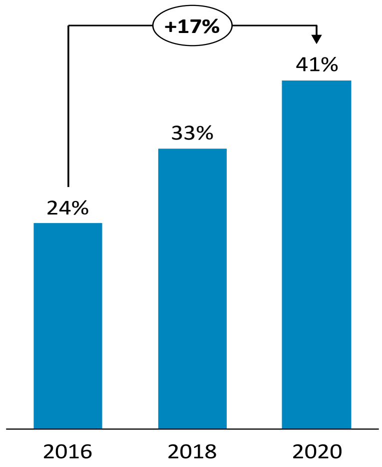


Figure 4: Percent of Irish enterprises buying cloud services

41%

of Irish businesses used cloud services in 2020

75%

target for businesses using cloud services in 2030

Table 2: Private and public sector applications of cloud computing *(not exhaustive)*

Applications	Details	Private sector	Public sector
Ecommerce	**Selling online.** This increases the potential number of markets and customers a business can access. It is most efficiently done through the cloud, ie through data centres, eliminating the need for heavy technology investment by individual business. Companies like Shopify (which runs in hyperscale datacentres) allow even very small businesses to create professional ecommerce platforms quickly and easily.	✔	
Collaborative working	**People in different locations working on the same projects, materials and documents - critical to hybrid and home working.** Shared items are kept in data centres.	✔	✔
Edge computing	**Cloud services that require data centres very close to the user because they need low latency.** Latency is a measure of how long signals take to get from one computer to another and back and is roughly proportional to physical distance. To provide necessary redundancy, several data centres must locate together to provide low-latency services. 5G will support billion of IoT devices, and for it to be effectives, data has to be computed and stored near the end user (i.e. via edge computing). Edge architecture aims to allow the compute and content delivery process to occur within 10 milliseconds or less to the end user. Edge computing reduces the volume of data that must be moved, reducing transmission costs, shrinking latency, and improving overall quality.	✔	
High-performance computing	**Cloud computing gives businesses access to enormous processing power**, that previously would have been reserved for those who could afford super-computers. This is particularly useful in research fields with complex models, eg climate models.	✔	✔
Use of AI	**Advanced computing mimicking human problem-solving abilities.** AI is already used for: voice-recognition, image recognition, content moderation, complex modelling, cyber security, medical research (including Covid vaccine development); and a myriad of other uses. Data centres make it accessible to a wide range of businesses, rather than only the largest who can afford their own super-computers.	✔	✔
Use of big data	**Analysing very large amounts of data, which can only be handled with significant computing resources.** These resources are unavailable to most businesses or public institutions except through data centres. Local data centres are preferable because of the costs of transmitting large amounts of data.	✔	✔
CAD & CAM	**Computer-aided design (CAD) & computer-aided manufacturing (CAM) enable better and more efficient products to be produced more quickly and efficiently.** When products have been designed through CAD, the data this generates can typically be transmitted straight through to the manufacturing side, and even turned into a set of machine instructions for CAM.	✔	
Digital twins	**Digital twins are virtual representations of physical objects and processes.** A digital twin is a model that is kept constantly up to date with changes to the physical original it represents. Digital twins enable projected impacts of real or proposed changes to be modelled. Examples include digital twins of machines, which can predict performance characteristics and when maintenance is required, or digital twins of cities used for urban and traffic planning.	✔	✔
Internet of Things (IoT)	**Physical objects becoming connected to the internet, so they can send and receive data, enabling a range of innovations.** Connected objects reduce the need for physical inspection and enable data flows that can lead to efficiencies. Objects can change behaviour according to signals, eg responding to prices or weather patterns, or coordinating routes to avoid traffic. IoT can support decarbonisation, eg sensors detecting leaks, or smart appliances concentrating energy use when low-carbon energy is more abundant.	✔	✔

1.1.3 Digitalisation is making public services more responsive, accessible and efficient

The Government's "Harnessing Digital – The Digital Ireland Framework" **laid out a vision for more government services to be delivered digitally** (Figure 5). Digitalisation can enhance the responsiveness, efficiency and accessibility of public services. Digital services are best delivered through the cloud, ie, by data centres, and indeed some government services are already being delivered this way, including tax payments, agricultural certifications, and a whole host of other services accessible from Gov.ie. Increasing numbers of critical services across Europe run in the cloud, including healthcare, power infrastructure monitoring, and transport systems, making reliable data centre services critical for public safety.

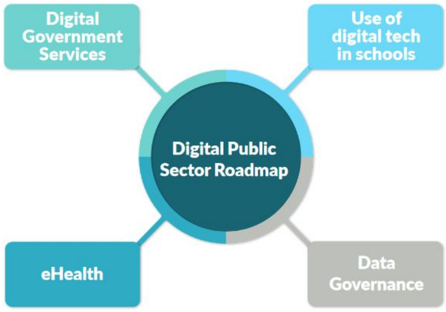


Figure 5: The Government's Digital Public Sector Roadmap

Public services can be more efficient and responsive in the cloud, as cloud deployment can move faster and cheaper than traditional services. In the Covid pandemic, the Irish Health Service Executive (HSE) was able to build a prototype Covid Tracker application in just 2 days. The app was downloaded 1m times in its first 36 hours of public release, and with a total cost of <€1.4m including maintenance, was one of the cheapest public health interventions of the pandemic. This was possible because of the efficiency and elasticity of cloud computing provided by data centres[ix].

Examples of innovative digital public service applications of cloud computing include:

- **Use of digital tech in schools: Digital technology enhances learning in physical classrooms**, using tools such as digital whiteboards (often cloud-based, eg Microsoft Whiteboard), educational videos (hosted on platforms like YouTube), and classroom use of computers and tablets, usually connecting to cloud services. When schooling needs to be done virtually, it relies totally on cloud services, such as Google Meet, Teams (Microsoft) or Zoom (hosted on AWS).
- **eHealth: Online health services can deliver new and innovative applications in care that are cheaper and more convenient for patients** such as enabling access to a doctor without leaving the home; giving greater access to records and information; and allowing for at-home health monitoring and patient empowerment[x].

- **Data governance: For private data, cloud services can make data governance much more effective and efficient**, making data more secure and giving people control over their own data. When data is kept in data centres, its preservation, modification and deletion can all be more assured.

  For public data, Cloud services enable openness and democratisation of data, allowing more data to be made available more flexibly and more cheaply to the public. This improves public trust and can make government data more accessible and easier to use for applications in business and education.

1.2 Digitalisation relies on cloud data centres

The internet and cloud services are built on a global network of fibre connections and data centres.

The cloud does not fully remove the need for computing local to the user – your phone or laptop still needs to be able to process and store some information. However, the cloud means that local devices do not have to do all the computing themselves and can access resources far beyond their own. As local devices become a means to access cloud services, it is easier to work across devices because the services and data themselves are stored in the cloud rather than the device itself. As a result, we can access our emails, shopping, or photos on any device, without worrying about storage. (Figure 6)

Enhanced efficiency, enhanced capabilities and enhanced security are driving the rapid shift from local to cloud computing. Much greater computing power and storage is available through the cloud at lower cost. Voice recognition services can take advantage of the processing power of servers in data centres to provide results faster and more accurately than would otherwise be possible. Navigation apps use cloud data and processing power to plot hugely complex routes with great accuracy in a matter of seconds, which would be much harder for a local device. Businesses and researchers store and analyse enormous amounts of data and complex models. The cloud does all this whilst offering high levels of cyber-security that most organisations could not achieve on their own.

Ireland has many cloud-native businesses, which can scale rapidly and serve large and dispersed client bases with high-quality services backed up by the cloud[xi], without having to build the physical computing infrastructure themselves. The various benefits of cloud computing for digitalisation are laid out in Table 3.

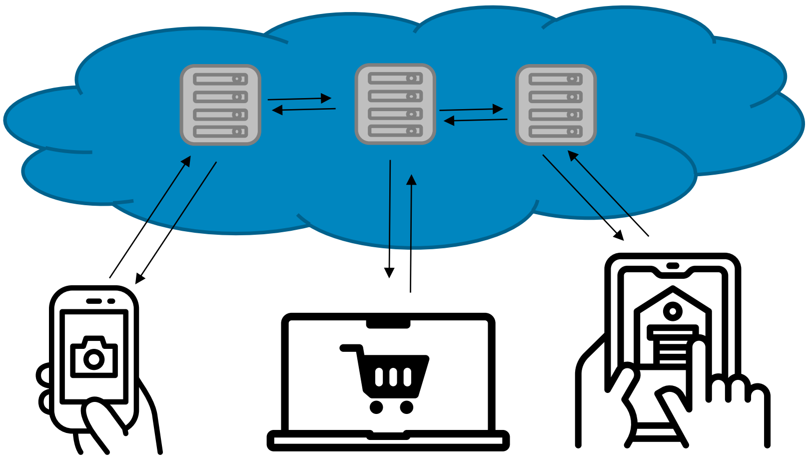


Figure 6: Cloud data centres serving users through internet-connected devices

Table 3: Benefits of cloud computing driven by data centres

Features	Benefits	Details
Elastic computing	• **Flexibility** • **Lower costs** • **Improved capabilities**	Instead of having to buy a computer with a certain amount of processing power and storage, cloud computing allows **customers to easily scale the computing power to their needs**, and to pay only for what they use. This gives businesses and researchers easy access to high-performance computing without high up-front costs.
Software as a Service (SaaS)	• **Lower costs** • **Enhanced security** • **Always up to date** • **Available anywhere**	**Software that runs in the cloud, with access provided to the user on subscription.** SaaS reduces business IT capital costs and complexity. Software is constantly updated by the provider, enhancing security. As the software is accessed in the cloud, it is typically available from anywhere with an internet connection. Software vendors get more stable and often higher revenues from SaaS (in return for a higher-value product).
Redundancy	• **Data protection** • **Resilience**	**Multiple redundancy means having multiple back-up resources**, whether that is back-up copies of data, or back-up servers in case one is unavailable. In case one element of the system fails, other backup elements can take its place. Data is less likely to be lost, and services can continue without disruption.
Cybersecurity	• **Dedicated tools** • **Expertise** • **Redundancy and elasticity**	**Dedicated security tools** are available on cloud platforms, with cloud providers being able to bring high levels of expertise and resources to bear across their digital estate. They have specific protections against the different kinds of attack, such as ransomware, botnets, and DDoS attacks. Because cloud computing is elastic, it can scale for a **sudden increase in resources needed to deal with a cyber-attack**, and redundancy means **alternate resources or backups are available if needed**.
Reliability	• **Five-nines reliability**	**Cloud services often come with up to 99.999% (or five nines) guaranteed uptime,** meaning they will be available 24/7 year-round, with a maximum of ~5 minutes unavailability per year. This reliability exceeds the reliability that can be offered by traditional on-site computing. Customers can sometimes access lower prices by choosing lower reliability levels if five-nines are unnecessary.
Outsourced IT and economies of scale	• **Lower costs** • **Reduced complexity**	**Moving computing to the cloud reduces complexity and costs for customers**, who no longer have to manage or to procure as much IT, with much of their needs consolidated and served offsite in the cloud. As cloud companies access economies of scale by serving the needs of thousands of clients in each data centre, computing can be offered more cheaply.
Energy savings	• **Lower costs** • **Reduced carbon footprint**	**Replacing in-house servers with cloud services saves energy**, reducing power bills and lowering carbon-footprint. Although the cloud services still use energy in the data centre, this is typically much less than the in-house servers being replaced (see 2.3).

1.3 The growth of Ireland’s data centre industry is an economic success story

The growth of data centres in Ireland has attracted billions of euros of inward investment directly and stimulates wider investment in the technology industry in Ireland, contributing to significant economic growth. It has been estimated that Ireland has a 25% share of the European data centre market[xii].

Digital Realty / InterXion, Keppel DC, and Equinix pioneered colocation data centres in Ireland, offering shared rented space for companies to place their servers. They have continued to grow, along with others such as EdgeConneX and CyrusOne. These companies offer either retail colocation, where they offer space by the server rack, or wholesale, where each client’s space is entirely separated, and one large client may even lease an entire data centre.

Microsoft has been in Ireland since 1985 and was joined by Google and Amazon in 2003 and 2004 respectively. These companies started adding data centres to their operations and by 2012 all three had built data centres in Ireland. With massive demand for their services, these companies, dubbed ‘hyperscalers’, have become the global leaders of the cloud services market. They have successfully grown their businesses in Ireland, both serving local demand, and as a base serving Europe. As well as building their own data centres, they are key customers for the wholesale data centre providers.

With this growth, Ireland has become a leader in Europe in terms of cloud infrastructure. Today, there are 75 data centres in Ireland of varying sizes. Data centres have become crucial to how computer services are delivered. BitPower’s figures show that the Irish data centre industry has grown by >20% compound annual growth rate (CAGR) in Ireland since 2010.

75

number of data centres in Ireland

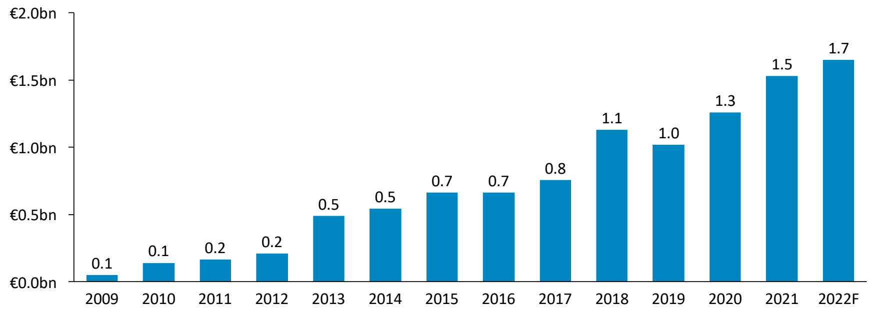
1.3.1 Data centres increase Ireland’s productive capacity

Investment in data centres in Ireland is the digital equivalent of investment in steam engines during the first industrial revolution – it increases the productive capacity of the Irish economy, supporting GDP and job growth. Unlike the engines powering the first industrial revolution, however, data centres are electrified and inherently low-carbon facilities, with very few direct emissions. Emissions from data centre electricity use amount to ~2% of Ireland’s emissions (see Chapter 2). Figures from BitPower show that data centre investment in Ireland has surpassed €1.5bn annually, with total investment since 2009 of over €10bn (Figure 7).

What is productive capacity?
The productive capacity of the Irish economy is a measure of how much it can produce in economic terms. Productive capacity is enhanced by capital formation (including human capital, ie workers’ skills).

Data centres in Ireland are also a source of investment in human capital, in workers’ skills and experience. They bring training opportunities that enhance the Irish workforce, and they support digitally-enabled businesses.

A recent analysis by the CSO estimated the Gross Value Added (GVA) of the ICT sector in Ireland at €51.5bn[xiii] in 2019, over 15% of total Irish GVA. GVA per employee was €567,089.



15%

of gross value added in the Irish economy comes from Information & Communications technology

Figure 7: Estimated investment in data centres in Ireland (construction spend only) 2009-2022F (€bn) [xiv]

As Ireland's renewable energy resources are developed, the electricity they produce can either be exported 'raw' to overseas markets via interconnectors, or it can be 'refined' domestically, including in data centres, and exported as information services. This latter option creates much more value in the Irish economy and supports highly skilled jobs in the process. The export is low-carbon too, involving fibre-optic cables to move the virtual output rather than ships and trucks to move physical products.

1.3.2 Data centres support jobs

The construction and operation of data centres involves 230 separate job roles and supports over 2 million jobs across the world (>600,000 across EMEA), according to the Uptime Institute[xv].

In Ireland, BitPower estimates that in 2022 there will be €1.7 billion of inward investment in data centre construction.

The computer services industry in Ireland (which includes data centres) supported more than 90,000 jobs in 2020, with these jobs growing at more than twice the rate of overall jobs growth[xvi] (Figure 8).

The OECD estimated that 312,000 people were employed in 'ICT task-intensive' jobs in Ireland in 2017[xvii] and in 2018 that 20% of Irish jobs were in highly digitally intensive industries. There is also an additional 28% of people in medium-high digital intensity industries, for a total of over one million jobs.[xviii]

Many of the tasks that are undertaken by these workers and in their companies will be cloud-enabled. This means that workers will be doing their jobs using cloud services, which reside in data centres. Even if they never step inside a data centre, they use data centres to do their jobs.

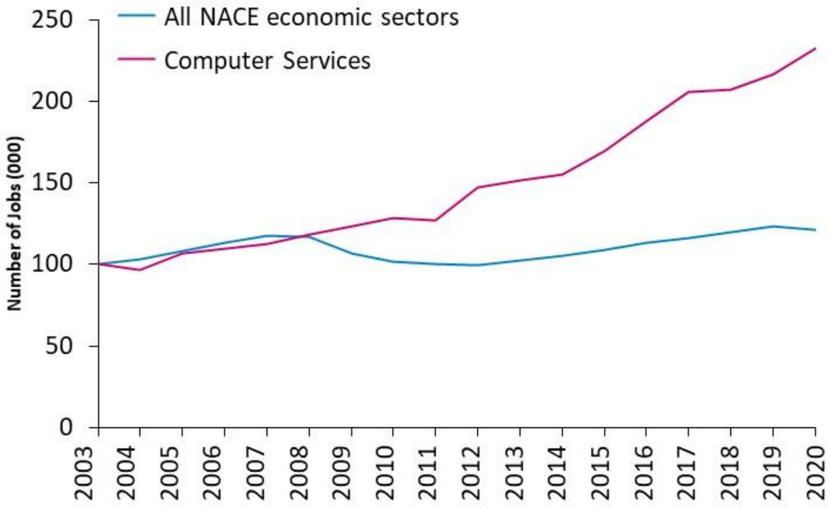


Figure 8: Evolution of jobs numbers in computer services[xix] versus all jobs in Ireland

Digital jobs are among the highest-paying in Ireland

Computer services ('Computer programming, consultancy and related activities' and 'Information service activities') jobs had the 4th-highest earnings of all 55 subsectors in the Irish economy in 2020, having experienced the 5th highest wage growth 2010-20 according to the CSO (Figure 9). Top on both measures was 'Publishing Activities', which includes online publishing and software publishing (but also offline publishing). The wider Information and Communication sector had the highest and fastest growing earnings per employee of any macro sector in Ireland.

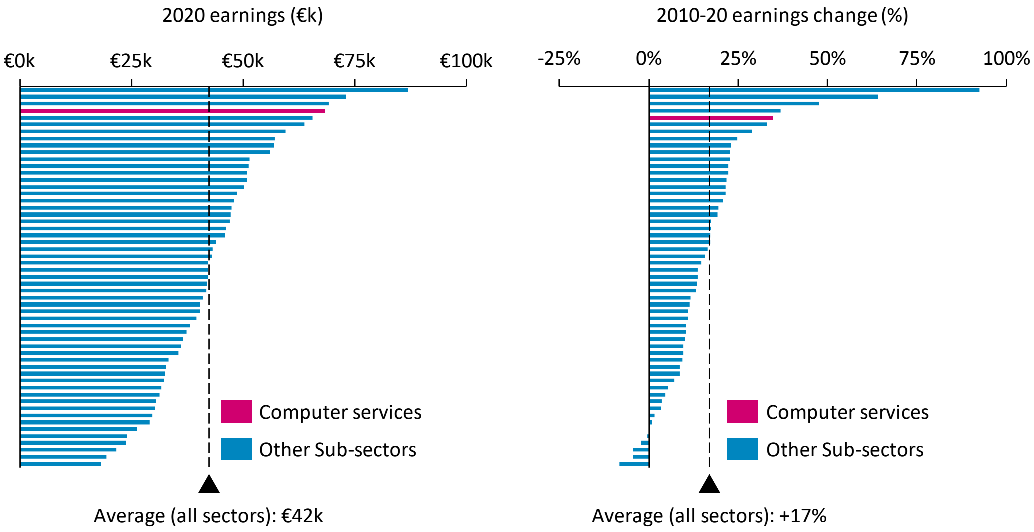


Figure 9: Average total earnings in 2020 per sub-sector in Ireland (and % change in average total earnings 2010-20)[xx]

Digital skills can transform lives

Digital skills development helps individuals to access the benefits of digitalisation and can also help them access jobs. Data centre companies in Ireland invest in this skills development.

Case Study 1[xxi]: Google and IT Sligo collaborate to develop a new degree programme in data centre facilities engineering. The Bachelor's Degree, BEng. in Data Centre Facilities Engineering was one of the first of its kind in Europe. The programme was developed following 18 months of consultation and planning with data centre industry partners, including Google, who provided expert input and validation of the programme's technical subject matter. The programme has been structured to serve the entire pan-European Data Centre services community.

Case Study 2[xxii]: The Data Centre Technician Programme at TU Dublin Tallaght, supported by Amazon, enabled a former mechanic and a former refugee to find new careers in the data centre industry. The programme teaches hands-on practical skills and includes opportunities for paid work placements with Amazon. This process of upskilling enhances individual lives and also supports growth in the Irish economy.

Case Study 3: The StepIn2Tech programme, a partnership between Microsoft and Fastrack into Information Technology (FIT), which aims to equip 10,000 people with digital skills to support their employment. According to Microsoft, *"StepIn2Tech is designed to support anyone who is interested in growing their digital skills. It's particularly focused on supporting those who have lost their jobs as a result of the pandemic and are now looking to reset their plans by pursuing new career opportunities in the digital economy. It will also support people who have either recently left school or college or are mid-career in an industry that is digitally transforming."*[xxiii]

1.3.3 Data centres are a crucial part of Ireland's biggest export sector

Data centres are now a crucial part of Ireland's wider computer services sector, which is the biggest contributor to the large, positive trade surplus Ireland has run for many years. Computer services grew approximately 63% between 2015 and 2020 and is responsible for services overtaking goods as the largest export sector, accounting for around a third of Ireland's total exports in 2020 (Figure 10). Whilst data centres are only a part of Ireland's computer services industry, they are a crucial and significant anchor: the infrastructure that enables the delivery of the services. As computing moves to the cloud, data centres are the engines that power these computing services, which are both used within Ireland and exported.

33%

of Irish exports in 2020 were Computer Services

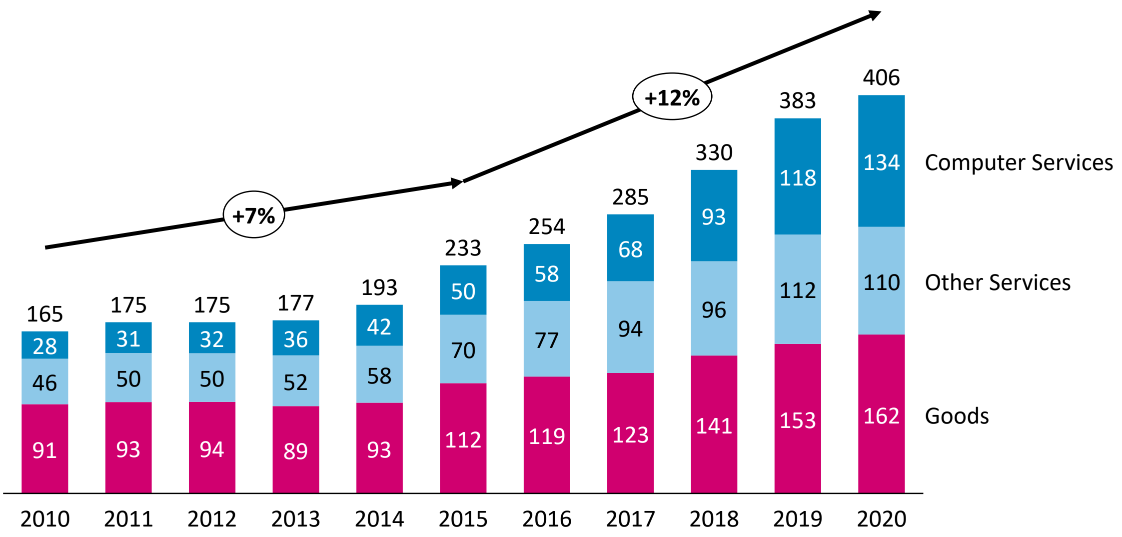


Figure 10: Irish exports by sector 2010-20 (€bn)

Ireland has also developed an export industry in data centre construction. Because Ireland has been a pioneer in the sector, Irish companies' data centre construction skills have been in great demand internationally as data centres roll out in other countries. According to Host in Ireland, in 2008 before the boom in data centre construction in Ireland, total Irish construction services exports were €200-300m annually, but by 2021 data centre construction services exports reached €3.2-3.5bn, 10× the level of total construction services exports in 2008[xxiv].

2 Cloud services unlock sustainability across the economy

As we face the climate crisis together, carbon emissions are a key focus area for every sector. This section will discuss:

- how digitalisation is driving decarbonisation across the economy today
- how data centres power cloud-enabled decarbonisation solutions
- how data centres can decarbonise digitalisation, and
- the carbon emissions of data centres.

2.1 Digitalisation is driving decarbonisation

The digital transformation of modern society described in Chapter 1 is also contributing to reducing carbon emissions and material consumption.

A 2021 Bitkom study in Germany, which examined various sectors, including energy, agriculture, health and industrial manufacturing, showed that digitalisation could contribute half of the emissions reductions needed for Germany to meet its 2030 targets[xxv]. The study examined carbon savings from digitalisation and the carbon footprint of digitalisation itself, including emissions from data centres and digital devices (both in production and use). It concluded that the potential for emissions savings from digitalisation was 6 times higher than the carbon footprint of the digital technologies. Digitalisation saves carbon by removing the need for physical objects or activities in some sectors and enabling greater efficiency in others. Some examples are explored below.

2.1.1 Digitalisation of presence can reduce transport emissions

Even prior to the COVID-19 Pandemic, digitalisation was enabling an increase in working from home, and a reduction in the need to travel to access services such as retail, banking, and Government. The pace of this transformation in daily lives was dramatically accelerated when in 2020, much of the world entered an unprecedented period of lockdowns related to Covid-19. This involved restrictions on travel and forced much of life online, with a huge increase in working from home and video-conferencing, replacing commuting to offices and travelling to business meetings.

This resulted in a 2.7 million tonne reduction in CO_2e[7] emissions from the transport and energy sectors in Ireland between 2019 and 2020, more than offsetting the increase in household emissions due to increased home heating (Figure 11). Globally, there was a one-third reduction in aviation emissions[xxvi].

Notably, despite the increased use of data centres, energy sector emissions continued to fall, as the decarbonisation of power generation more than offset the impact of higher data centre demand.

Some of the shift to working from home has endured post-pandemic, with an increase particularly in hybrid working, where people work at home some days and in the office on other days. In a November 2021 CSO survey, 65% of people said they worked from home (Figure 12)[xxvii].

[7] CO_2e or carbon dioxide equivalent; describes emissions from various greenhouse gasses in a common unit

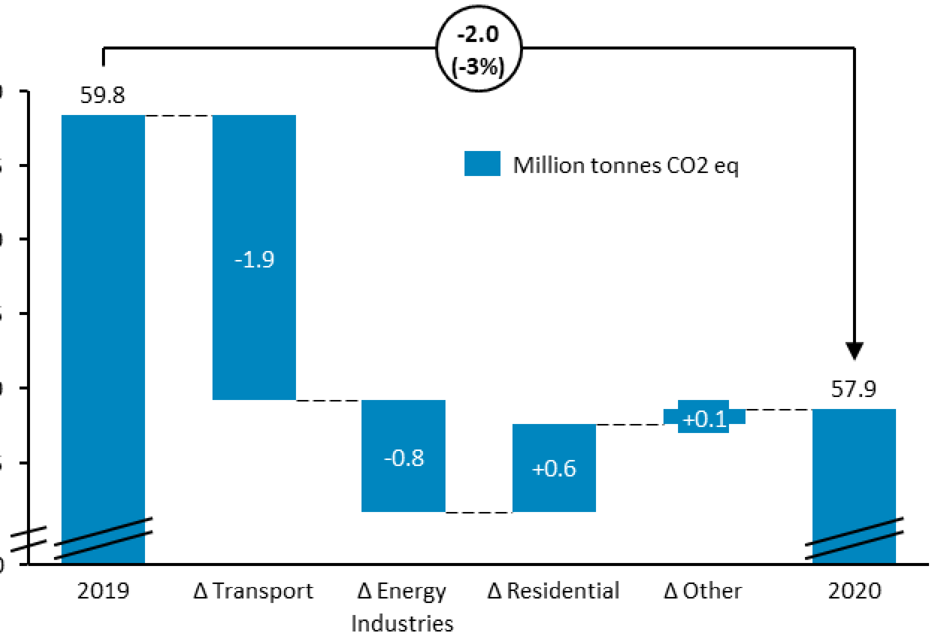


Figure 11: Change in Irish CO_2 equivalent emissions 2019-20 by sector[xxviii]

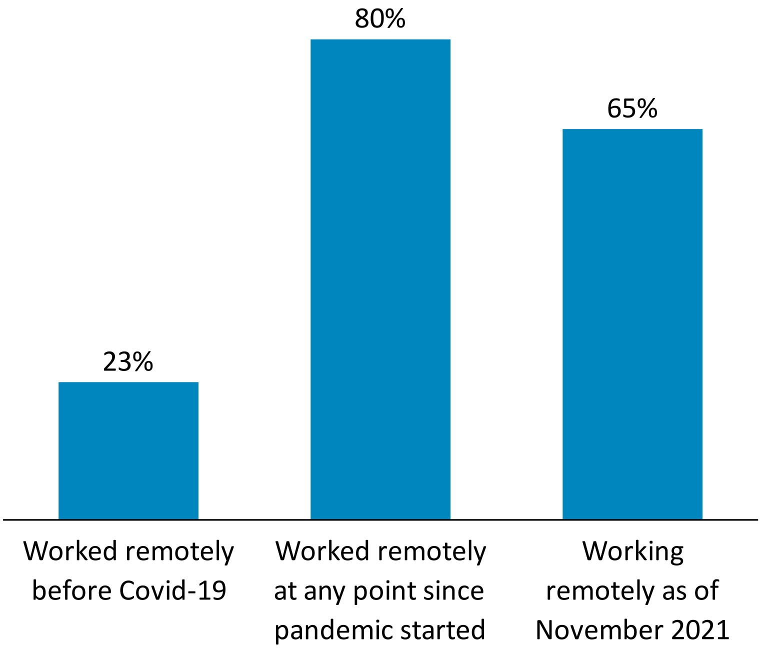


Figure 12: % of Irish people in employment who work from home

2.1.2 Physical media is largely being replaced by digital

The media landscape has been transformed by digitalisation in recent years. Physical media such as CDs and DVDs have been replaced with digital streaming services, with industry leader Technicolor's DVD volumes halving by 2021 from 2011 levels (Figure 13)[xxix]. E-books and news websites are increasingly taking over from physical books and newspapers, with worldwide demand for paper for printing (graphic paper) down ~30% 2010-19, led by developed economies, where consumption roughly halved[xxx]. Consumption in developing economies started to fall from 2017, as digitalisation began to outweigh the effects of economic growth.

Studies have shown that this can often lead to significant savings in greenhouse gas emissions, depending on the carbon intensity of the electricity mix, behaviours such as driving to buy physical media, object re-use rates and equipment efficiency[xxxi,xxxii,xxxiii], although in some cases emissions can increase, eg, shifting to streaming from terrestrial broadcast TV[xxxiv], or where consumption increases outweigh savings per hour of viewing. A larger factor than the technology of content delivery can be the electricity consumption of viewing devices, with the increased share of low-power devices such as mobile phones saving emissions, whilst large TVs increase them. Emissions savings will become greater as electricity is fully decarbonised and the efficiency of data centres continues to improve.

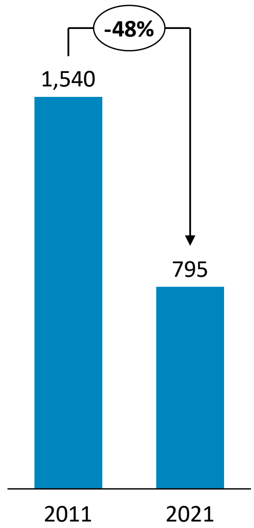


Figure 13: Technicolor DVD volumes (millions)

2.1.3 Online retail saves emissions

Digitalisation of retail can also save emissions, although again this would be countervailed by any increases in consumption driven by the increased convenience and choice etc of online retail.

Moving online typically reduces store emissions, as customer distribution centres are lower carbon than stores, mostly due to using less energy for heating and cooling, whilst fulfilment from retail stores may increase utilisation of those stores without equivalent increases in their emissions. Transport emissions are lowered when individual consumers' car journeys are replaced by delivery drivers making multiple deliveries per trip (where consumers walk or visit multiple shops per journey, the picture is less clear). A recent study found a 59% average reduction in retail emissions for non-food products from online versus offline, despite increased packaging emissions[xxxv]. Decarbonisation of delivery fleets, eg, through use of electric vehicles, will reduce transport emissions further, with drone delivery potentially offering further savings in the future[xxxvi].

2.2 Data centres power cloud-enabled decarbonisation solutions

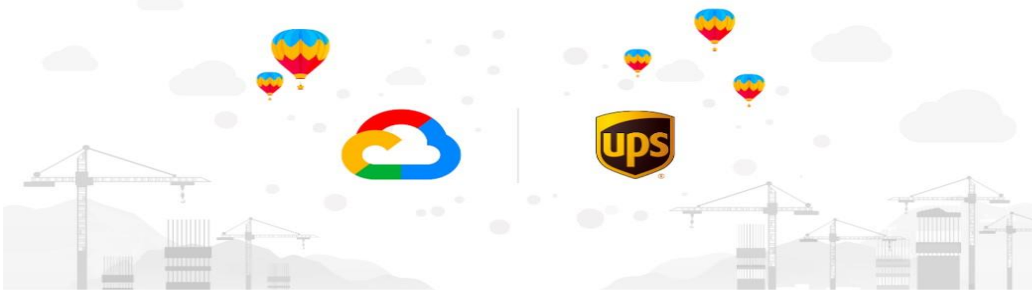
The power and accessibility of data centre services also unlocks a range of new sustainability applications, which leverage the power of the cloud to drive decarbonisation. Many of these applications involve energy efficiency, whilst others may involve efficiency of other resources, eg, water or raw materials, and yet others involve applications of sustainable alternatives, such as renewable energy. The modelling, software platforms, and communications that underpin these applications often rely on the cloud. Several case studies of such initiatives are described in the boxes below.

Case Study 4: Toward Zero Carbon's energy management platform, Priority Metrix, runs in Microsoft Azure. The system enables users to effectively manage their resource consumption by collecting and analysing live operational data from thousands of sensors in commercial buildings across Ireland. In one example, the software identified a previously unknown hot water leak of approximately 1,000 litres per day. Priority Metrix allowed TZC to dive into the data, correlate production times to consumption times and identify a continuous load regardless of the production. This then allowed the client's engineers to investigate the source and prevent further waste of energy and water. Microsoft Azure facilitates the secure and efficient transmission, analysis and visualisation of data that makes this possible.

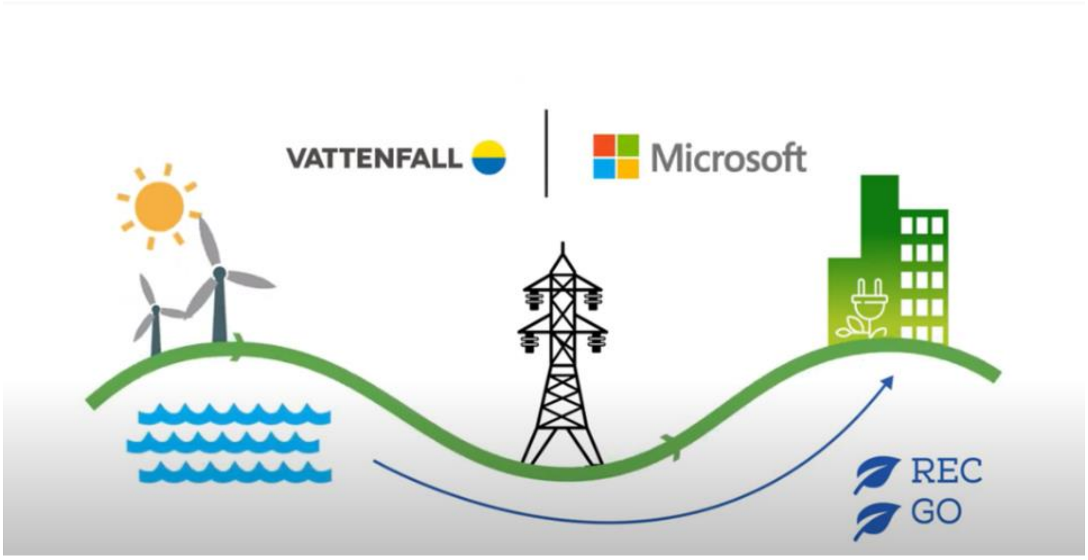
Case Study 5: CropX's soil analysis platform runs in AWS. Most agricultural companies rely on above-ground data such as satellite imagery and do not receive live data from within the soil. In-soil data can lead to much better awareness of crucial soil conditions such as moisture, salinity and temperature. CropX provides this data via in-soil sensors and integrates it with several layers of above-ground data, such as imaging, weather and topography. Combining this data with AI-based algorithms and the power of cloud computing, the CropX system can provide insights and crop-specific recommendations on irrigation and crop nutrition, leading to efficient use of water and fertiliser. During irrigation experiments, CropX has demonstrated >40% water savings across different crop types, with a 10% yield increase.

Case Study 6: Octopus Energy's cloud-based renewable energy platform is built entirely in AWS. The software, Kraken, uses the elasticity of cloud computing and the power of machine learning to estimate and to predict half-hourly consumption across millions of electricity meters. This supports the procurement and supply of carbon-free energy to customers, supporting individuals and businesses in decarbonisation, and supporting the development of renewable energy. Octopus has grown rapidly, with this growth enabled through the scalability of cloud computing. Octopus's Kraken energy platform is now licensed for 17m energy accounts across the world.

Case Study 7: E.ON's Optimum is a digital asset management solution providing insights on energy usage to support decarbonisation and reduce costs, which runs in Google Cloud. The software, originally an in-house E.ON tool, needed to be more reliable and more scalable to be released as a public product. E.ON migrated it to Google Cloud and now it provides energy insights to 10,000 businesses worldwide. This kind of product can reach many more users more quickly through the power of the cloud, as scaling no longer means committing expensive capital investment to buy inefficient on-premise servers. Companies simply pay for what they use, when they use it, so such products can grow without limits, backed up by >99.9% reliability and easy global availability. E.ON relies on efficient cloud data centres for the computing, and so can focus its efforts on its ambition *"to use the Optimum product family to create digital enablers that can contribute to a more sustainable world."* [xxxvii]



Case Study 8: UPS developed routing software for their delivery drivers with Google Cloud. Between the roughly 10 drop-offs and pick-ups each driver does each day, the number of permutations of potential routes they could take is extremely large. Cloud computing solves the optimisation problem, enabling drivers to identify the routes to support them to be as time and fuel efficient as possible. The software tells drivers exactly where to go, reducing fuel consumption by 10m gallons per year (~45m litres) and saving UPS up to $400m per year.[xxxviii]



Case Study 9: Microsoft and Vattenfall partnered to deliver 100% renewable energy at every hour to Microsoft's Swedish data centres from 2021. This involved building a new technological solution to match consumption and production on an hourly basis, using Azure and IoT. Matching means that the data centres can be operated on renewable energy at every hour of the day, with enough renewable energy being procured on an hourly basis through a mixture of wind and hydro power to power the data centres. This is a significant step on Microsoft's journey to 100% renewable energy 100% of the time, but the solution has also become a product that Vattenfall can offer to other customers, so the effect can be much wider than simply the carbon footprint of Microsoft's own data centres. To achieve full decarbonisation of our electricity supply will require using 100% renewable energy all the time across the grid, and this proof of concept is a significant step on that journey.

The solution has also become a product that Vattenfall can offer to other customers, so the effect can be much wider than simply the carbon footprint of Microsoft's own data centres.

2.3 Data centres can decarbonise computing

According to 451 Research[xxxix], data centre customers who shift their computing loads to hyperscale data centres can achieve reductions in carbon-intensity of up to 80% depending on what the customer was using previously[8]. The lower carbon-intensity of hyperscale data centres relative to traditional on-premise servers is driven by two key factors that mean less energy is used:

- computing in data centres is more efficient, and
- data centres use less energy on non-computing tasks.

80%

Potential reduction in carbon-intensity from moving computing loads to CII data centres

If the energy used were fully decarbonised, it is estimated that the potential reduction in carbon-intensity could reach 96%. Increases in computing demand will act in the opposite direction (see 2.4).

2.3.1 Computing in data centres is more efficient

More efficient and higher-utilised servers that can do more computing with less energy are the largest factor in reducing energy use for computing tasks. This is akin to the energy savings from 400 people travelling in a modern train instead of in 200 private cars. On-premise servers need the capacity for the maximum load required by the enterprise, but will rarely operate at full capacity, like a 7-seater family car driven around usually with 1-2 people in it. Instead, hyperscale data centres typically operate at near-full capacity, bringing together workloads from thousands of customers, and with an ability to shift workloads to different data centres to maximise efficiency. 451 Research calculated the efficiency gain of this factor for typical businesses in Europe to be roughly 3x, meaning that a computing load will use ~67% less energy on computing in a data centre than if the business runs its own on-premise servers. Customers also save money by not having to procure and to run expensive servers on their own premises.

What is PUE?
Power Usage Effectiveness (PUE) is the ratio of overall energy use to the proportion of that energy that powers servers. It shows how much power is spent on non-computing systems relative to how much goes to the servers that do the computing. Lower PUE means higher energy efficiency, but PUE cannot go below 1.0 (which would mean no energy spent on lighting or cooling etc). PUE is lower in cooler countries, due to lower cooling needs, so a data centre in Ireland can be more efficient than one in eg, Spain. PUE has tended to improve over time, so newer data centres tend to have better PUE.

2.3.2 Data centres use less energy on non-computing tasks

Data centres use power for computing tasks, and non-computing tasks (cooling, lighting, and power transformation). Data centres have lower PUE and so use much less power for non-computing tasks than traditional on-premise servers, with hyperscale data centres even more efficient.

In the 451 study, this is estimated to remove a further 16% of the overall starting carbon footprint, based on shifting from enterprise on-premise servers to average hyperscale data centres. Hyperscale leaders' data centres save even more carbon, as they are ~20% more efficient in terms of PUE than the EU average (Table 4).

[8] Total emissions savings across the economy depend on the degree to which the lower cost and accessibility of data centre services increases overall demand for computing, and the activities which that displaces.

Table 4: PUE figures per data centre type

Data Centre	PUE
Hyperscale leaders	1.1-1.2[xli]
EU average hyperscale	<1.4[xlii]
EU average enterprise on-premise server	2.01[xliii]

2.4 Data centres account for ~2% of Ireland's carbon emissions

Whilst there are some emissions associated with data centre construction, the key factor in data centre emissions is the emissions from generating the electricity they use. Electricity is the easiest energy source to decarbonise, giving data centres a head start over other sectors such as transport, which use fossil fuels and may have to electrify in order to decarbonise.

The carbon emissions intensity of electricity in Ireland has declined by over 60% in the period 1990-2020 (from 769g CO_2e[xliv]/kWh to 296[xlv]), driven by a dramatic reduction in use of coal, peat and oil for electricity generation and an increase in generation from renewables. The Irish Government's *Climate Action Plan 2021* has set a goal of 80% of electricity being generated from renewable sources by 2030[xlvi], which could reduce emissions intensity to under 50g CO_2e/kWh.

Whilst there are some emissions associated with data centre construction and IT equipment, the key factor in data centre emissions is electricity use and emissions from generating that electricity (Figure 14). The latest data indicates that data centre electricity-related emissions equated to 2.3%[xlvii] of Ireland's emissions in 2021. This increased from 2020 (1.8%[xlviii]) due to a combination of increased demand from data centres and lower than expected renewable generation on the grid. These estimates do not account for data centre companies buying renewable energy through corporate power purchase agreements (CPPAs) and instead allocate all renewable generation credit evenly across all electricity users. Data centre companies have pioneered renewable CPPAs in Ireland[xlix] and across the world[l], and accounting for the decarbonising effect of data centre companies' investments in renewable generation might lead to a lower estimate of their emissions.

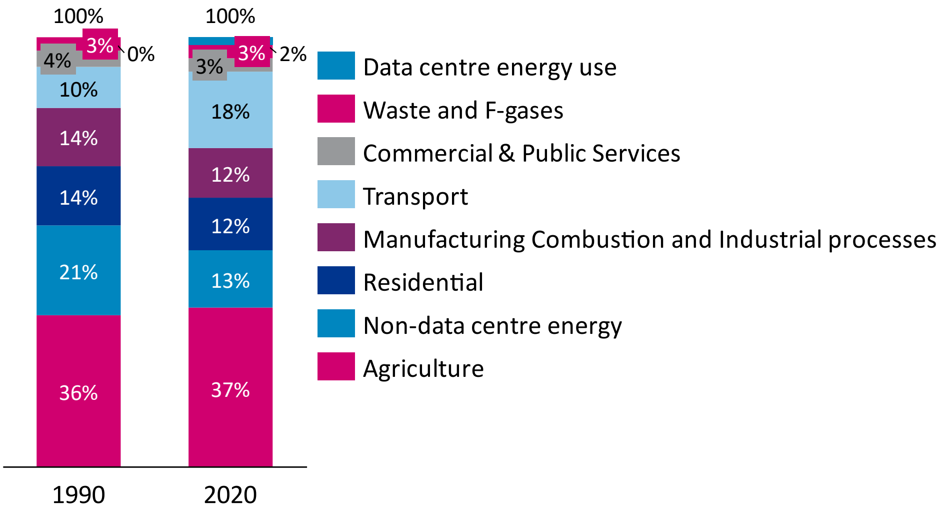


Figure 14: Greenhouse gas emissions share by sector 2020[li]

Although demand has greatly increased, computing has become much more efficient due to cloud data centres. Although there is significant uncertainty over exact figures, it has been estimated that globally a 550% increase in server compute instances was achieved 2010-18, with only a 6% increase in energy use[lii]. This was attributed mainly to the shift to hyperscale cloud data centres (from smaller installations, including on-premises servers), reductions in non-computing energy use, more efficient servers and increased virtualisation. Some of this effect could be obscured in the figures by emissions shifting to the data centre sector as cloud data centres replace other sectors' less efficient on-premises servers, and by shifts in the location of computing between countries.

3 A positive outlook for data centres in Ireland

Chapters 1 and 2 have outlined the role of data centres in modern society and Ireland's economy, and how cloud services can support sustainability today. This chapter looks to the future, and will discuss:

- how demand for data centre services is likely to continue to grow
- why Ireland remains an attractive location for data centres, and
- how future data centres in Ireland can lead the way on decarbonisation and sustainability.

3.1 Growing demand for digital services from data centres will drive data centre growth

The trends that we described in Chapters 1 and 2 are expected to continue over the coming decade, driving increased demand for data centre services and a need for new or expanded data centre capacity in Europe and globally.

3.1.1 There is a lot of digitalisation left to do

Data centre services are likely to become ever more important in the economy as digitalisation and the shift to the cloud continues. This will be from a combination of deeper digitalisation in already digitalised sectors and businesses, such as increased use of big data, artificial intelligence (AI) or virtual reality (VR), and from increased expansion of digital services into currently less digitalised areas, eg, agriculture, health, and construction.

3.1.2 This will drive continued growth in data volumes

Digitalisation has driven an exponential increase in the volume of data created, captured, copied and consumed worldwide over the past decade, and this is expected to continue, with data volume expected to almost double between 2022 and 2025 (Figure 15). Growth continues across governments, consumers and businesses, both organically and as a result of digitalisation initiatives and targets.

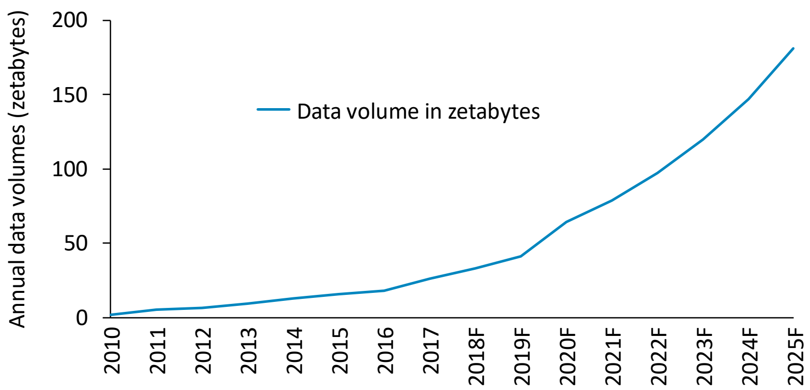


Figure 15: Volume of data created, captured, copied, and consumed worldwide 2010 to 2025[liii]

3.1.3 Computing efficiency is likely to continue to improve

We expect to see continued improvements in computing efficiency, driven both by continued increases in proportion of data processing carried out in hyperscale data centres rather than on premises services, and continued improvements in data centre performance. The sustained, exponential improvements in computing performance and efficiency of the top 100 supercomputers seen over the past two decades (Figure 16) demonstrates the scope for continued progress in data centres.

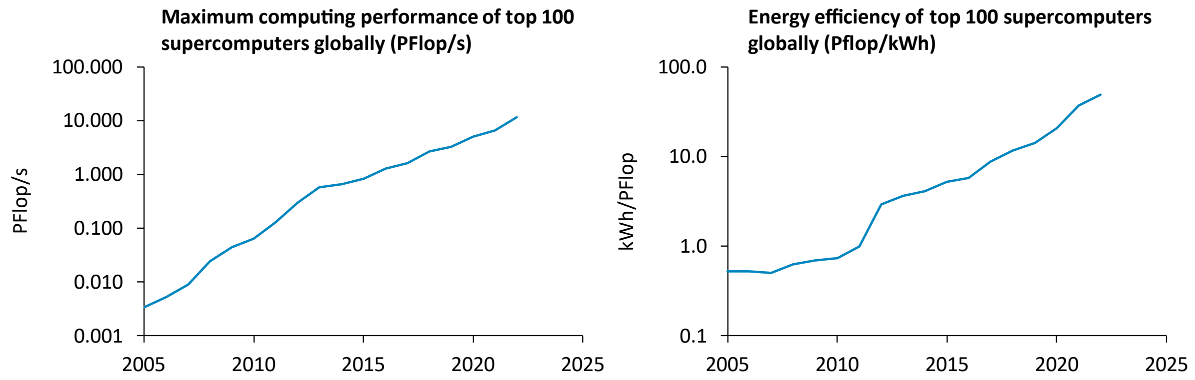


Figure 16: Trends in computing performance of top 100 supercomputers 2005-2022 (logarithmic scales)[liv]

3.1.4 This will drive growth in demand for data centres in Europe

Despite expectations for continued increases in data centre efficiency, the exponential nature of the growth in data volumes and the increasing share of cloud data centres will inevitably lead to a need for new and expanded data centres in Europe and globally (Figure 17). The question is where this growth will be.

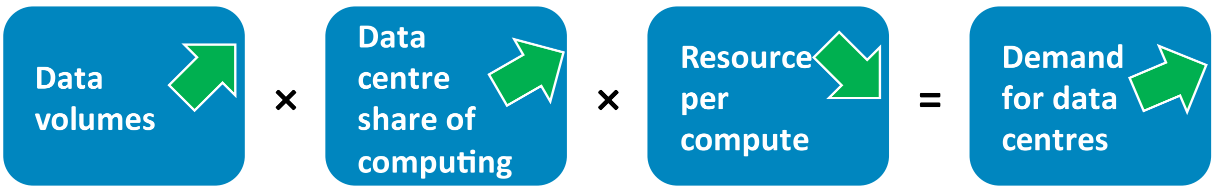


Figure 17: Key drivers of demand for data centres

3.2 Ireland remains a favoured location for this valuable data centre growth

Ireland, as a gateway to Europe and committed EU member, has enjoyed a head-start versus its European counterparts in attracting digital technology investment, including data centres.

Dublin remains in a prime position for data centre growth, accounting for 18% of all data centres under construction in major European cities listed in JLL's Data Centre Outlook H2 2021, behind only Madrid and Frankfurt (Figure 18). This is due to the continued relevance of the factors that have driven Irish data centre growth historically (Table 5) and also due to Ireland's renewable energy resources potential.

As described in Chapter 1, data centres and the computer services industry have contributed greatly to Ireland's economic success in recent years. Sustainable data centre growth could be a key part of continuing this in years to come.

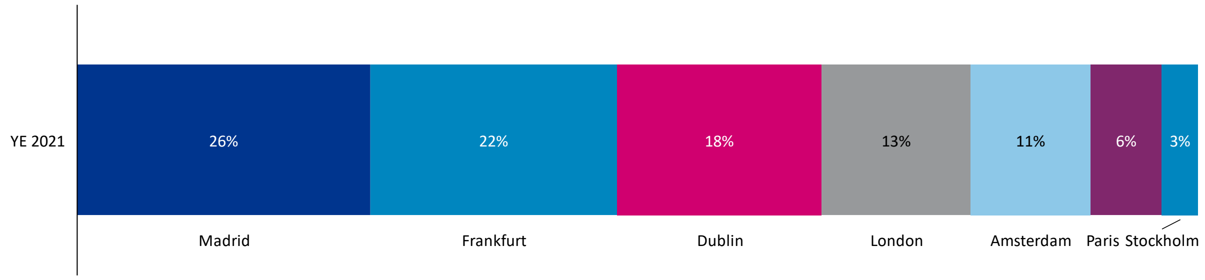


Figure 18: Data centre capacity under construction in selected European cities[lv]

Table 5: Factors favouring Ireland as a location for data centres

	Driver	Details
History	**History of working with US tech companies**	IBM began electronic data processing in Ireland in the 1950s. Microsoft have had operations in Ireland since the 1980s and Google and Amazon since the 2000s. This historic presence has been and remains a key catalyst for data centre development.
Climate	**Mild climate**	Ireland's relatively cool climate, with mean average annual temperatures 9- 10°C, means lower data centre cooling demands relative to hotter locations[lvi], lowering power consumption.
Infrastructure	**Off-island fibre connectivity**	Ireland has excellent fibre connectivity to the US and Europe with ample capacity for continued growth in traffic, making it well situated as a gateway to the EU for US companies.
	Existing data centres	Much of data centre traffic is between data centres, eg to keep multiple backup copies to ensure data is safe, so locating near existing data centres saves energy and increases performance. Also, some data centre investment is to upgrade existing data centres, adding new capabilities requested by clients.
	Renewable power potential	Ireland's renewable resource potential greatly exceeds domestic demand, meaning there is ample opportunity to develop low-carbon, low-cost power sources to supply new data centres.
Policy	**Political Stability**	Ireland has a stable political environment, including EU membership.
	GDPR	Technology companies can choose one EU country in which to base all their GDPR compliance activities, and this is Ireland for major tech companies including Apple, Google and Microsoft.
	Business-friendly environment	Ireland has been called *"One of the best countries for business"* by Forbes Magazine[lvii], and has remained in the top 25 countries for doing business for the last 10 years[lviii]. Ireland has favourable tax rates compared to alternatives in Europe. It has worked to attract foreign investment across sectors with support from the IDA (Industrial Development Agency), a key driver of this investment and active since 1949.
People	**Skills**	Ireland has a highly-skilled workforce, now including many people skilled in building and operating data centres.
	Language	English language makes transatlantic working easier.
	Demography	Ireland has a relatively young population, with a median age of 38[lix] and a working age population that is projected to keep growing[lx].

3.3 Future data centres in Ireland can lead the way on decarbonisation

Going forward, there are opportunities for future data centres to help drive decarbonisation of the Irish energy system, moving faster than the wider economy, to support stability of the electricity system and integration of renewables, and to help decarbonise other sectors of the economy.

This is enabled by Ireland's abundant renewable resources, particularly offshore wind. Baringa's 2021 *Endgame* report[lxi] illustrates a credible pathway for meeting or exceeding Ireland's target for 80% renewable energy by 2030, even under EirGrid's 'high demand' scenario which assumes a very significant demand increase from new data centres. Ireland's long-term renewable potential exceeds maximum 2030 demand by a factor of 4 (Figure 19).

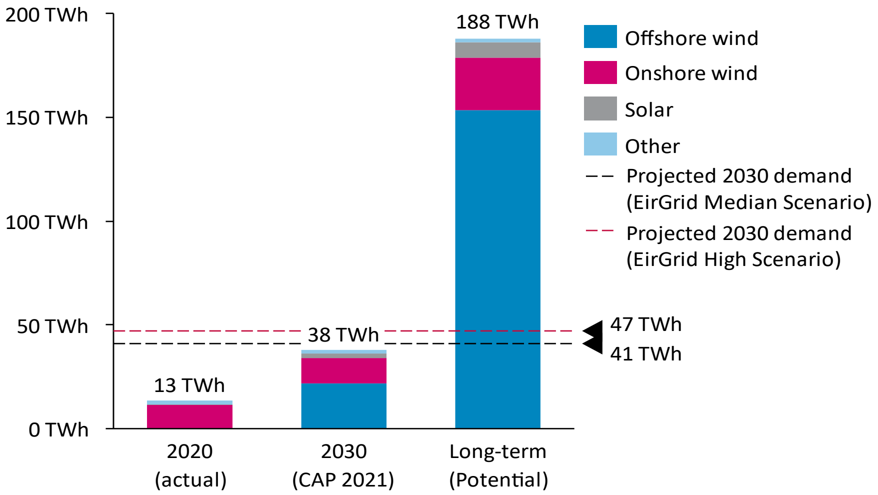


Figure 19: Renewable electricity generation potential[lxii] versus 2030 projected maximum demand[lxiii]

Seizing these opportunities will require collaboration between the data centre industry, the Government, and other stakeholders, but if enough is done, it could accelerate sustainability in Ireland, whilst reducing the costs of the energy transition for Irish consumers.

We have set out below (Table 6) how future data centres could achieve this, based on best-in-class examples operating today:

- supporting new, unsubsidised renewables
- decarbonising electricity use
- providing grid support services, and
- providing low carbon heat for other applications.

Table 6: Opportunities for decarbonisation driven by data centres

Opportunities	Details
Supporting new, unsubsidised renewables	Data centre companies can support new, unsubsidised renewables in Ireland through corporate clean energy procurement (eg via corporate power purchase agreements (CPPAs)) or direct investment, rather than using green certificates. They have the scale of demand, balance sheets, and technical sophistication to continue to lead the way in CPPAs[lxiv], growing a market in which other companies can also participate. Tech companies procured 2.8GW of CPPAs in Europe in 2021 according to RE-Source, more than any other sector[lxv].
Providing low carbon heat for other applications	80% of the average Irish household's energy consumption is for heating[lxvi], usually from carbon-emitting sources, such as gas, oil or peat[lxvii]. Data centres generate 'waste' heat from cooling processes, which can – in the right circumstances – be supplied to households and businesses, saving emissions from the fuels they otherwise would use for heating (see Case Study 10). Note that the feasibility of using offtake heat will differ between data centres and requires development of necessary third-party infrastructure.
Decarbonising electricity use	For a fully decarbonised electricity system, it is not sufficient to simply grow the total capacity of renewables on the system: carbon-free supply needs to match demand every hour of every day[lxviii]. This will require an increasing focus on the temporal profile and location of renewables and demand, grid enhancements, more interconnection and technologies and tools such as short and long-term electricity storage, biofuels, hydrogen, and demand-side response. Data centre companies can lead, and already are leading, the way in supporting these developments, trialling new technologies and procurement strategies such as 24/7 Carbon-Free-Energy (see Case Study 11) and 100/100/0[lxix].
Providing grid support services	As the proportion of traditional thermal generating capacity reduces, there will be an increasing need for new ways of providing flexibility and ancillary services such as frequency response. Future data centres have the potential to offer some of these services, either through their on-site electricity infrastructure such as backup power or storage (see Case Study 12, describing Google's Belgium battery project) or flexing other systems such as cooling.

Case Study 10[lxx]**: Amazon is partnering with South Dublin City Council, Codema, Fortum and Heatworks** on the first project in Ireland reusing heat from a data centre to provide district heating – **the Tallaght District Heating Scheme.** District heating is where heat is provided to homes and businesses across an area from a single source, instead of relying solely on individual boilers in each home. It can be a key decarbonisation technology where the heat source is a low-carbon one, which particularly applies in the case of waste heat. This is heat which would otherwise not been used, and so there is an emissions reduction, because the waste heat displaces carbon-emitting heat generation that would have been necessary otherwise, eg heating using a domestic gas boiler.

The Tallaght District Heating Scheme will heat 47,000 m^2 of public sector buildings, equivalent to 3x the pitch at Croke Park, as well as 3,000m^2 of commercial space and 135 affordable rented apartments. The scheme is projected to save 1,500 tonnes of carbon emissions per annum during the first phase. Amazon is providing the heat for free, and it will be further supplemented by the offer of low-carbon heat pumps, with both provided to end users by a new not-for-profit company, Heatworks.

Case Study 11[lxxi]: Microsoft is partnering with Caterpillar Inc. and Ballard Power Systems on a pioneering hydrogen project in Quincy, Washington, USA. The project is aiming to test decarbonisation of data centre backup power through hydrogen fuel cells.

Backup power is a particularly hard-to-abate source of emissions globally, as high reliability is required and intermittent renewables are not suitable. The market is currently dominated by diesel, which produces carbon emissions as well as localised air pollution, although run-times for backup generation are typically low in Europe, reducing emissions impacts. The project in Quincy aims to demonstrate a 1.5MW hydrogen fuel cell system that would meet or exceed the current performance levels of diesel generators. As fuel cell costs fall, and as the hydrogen economy is built out, this sort of project could become more feasible for data centres in Ireland.

In another Microsoft pilot project, hydrogen fuel cells ran a data centre for 48 hours. Hydrogen could play a key role in the transition to 100% zero-carbon energy all the time as it can be produced when renewable energy is abundant, and then converted back to electricity in times of need without producing emissions. Microsoft have expressed a vision for a data centre *"outfitted with fuel cells, a hydrogen storage tank and an electrolyzer that converts water molecules into hydrogen and oxygen"*[lxxii] that could also provide services to the electricity grid, and potentially supply fuel to hydrogen-powered trucks.

Case Study 12[lxxiii]: Google is pioneering the use of batteries for replacing generators at a hyperscale data centre, partnering with Fluence and Centrica in Belgium, and looking to provide services to the grid.

Batteries are a non-emitting replacement for diesel generation in data centre backup systems. They are able to provide immediate response during interruptions to grid supply. Google has chosen 2.75MW of LFP (lithium ion phosphate) batteries for the project, which last longer than other chemistries and are safer.

Google pointed out the wider benefits and ease-of-deployment of the solution, *"Battery-based energy storage is a quickly deployed, cost-effective, and low-emission solution that not only increases the resilience of commercial and industrial facilities but also supports system-wide decarbonization and energy security goals across Europe and worldwide."*[lxxiv]

Because of the extremely fast response times of batteries, they are able to provide frequency response services to the electricity grid, and half of the energy capacity of the batteries will be made available to the grid for this purpose, operating as a non-emitting virtual power plant through Centrica's FlexPond solution. Google's senior lead of data centre energy and infrastructure stated, *"Our battery will help the Belgian electricity grid maintain its target frequency and stay in balance."* The Director of Centrica Business Solutions International highlighted the benefit of this in supporting full decarbonisation, *"Managed correctly, we can not only support data centres to operate more sustainably, but also deliver grid-scale flexibility - balancing the volatility of renewable energy, in support of a 100 percent zero-carbon energy network of tomorrow."*

4 Principles & recommendations to enable sustainable digital infrastructure in Ireland

Chapters 1-3 set out the important role data centres play in modern society, their contribution to Ireland's economy, and how they can help to decarbonise the energy sector and wider society.

However, rapid growth in data centres can also bring challenges. Data centre development has been increasingly scrutinised in Ireland, with questions raised around whether their growth remains consistent with efforts to reduce economy-wide carbon-emissions and whether the electricity system can cope with growth in demand.

Wider concerns about lack of sufficient generation capacity to ensure the grid's security of supply have led EirGrid to announce strict conditions, and more recently what has been called *"a de facto moratorium"*[lxxv], on connections for new data centres in the greater Dublin area.

We believe that these concerns can be addressed through close engagement between the data centre sector and Government, public authorities, utilities and regulators to develop appropriate policies, regulations, and best practice guidance for data centre development and operation.

In this chapter we set out three principles for development of the data centre sector in Ireland, with associated recommendations for actions. These could unlock additional investment in Ireland's digital infrastructure and contribute towards development of a robust and sustainable power system in Ireland, boosting the economy, Ireland's digital leadership, and the energy transition. If enough is done to implement them, the principles and associated recommendations should help ensure that the data centre industry contributes positively to Ireland's climate goals and sustainability agenda, whilst helping to reduce the costs of the energy transition for Irish consumers.

Although these recommendations focus on data centres, many are also relevant to other large energy users across other sectors. We would encourage stakeholders to take a sector-neutral, principles-based approach as far as possible, to maximise the scale of the impacts and ensure consistency across different parts of the economy.

The data centre industry should work together with the Government and other stakeholders to:	
	Decarbonise data centre electricity use
	Enable secure and sustainable growth in electricity supply
	Contribute to sustainability in other sectors
	To realise these principles, there must be: ***Dialogue and engagement***

4.1 Decarbonise data centre electricity use

Large energy users, including data centres, have a special role to play in achieving Ireland's power sector emissions reduction targets, particularly where they will be contributing to increasing electricity demand in coming years. The tech industry has a strong track record in deploying clean energy technologies internationally and can bring that experience to bear to accelerate the decarbonisation of electricity in Ireland.

This decarbonisation will require:

- **Accelerating the roll-out of renewables**
  - Ireland's goal is for 80% of generation to be from renewables by 2030, up from 42% in 2020[lxxvi].
  - This is likely to require ~9GW of new renewable capacity to be delivered over the next 8 years, tripling Ireland's current renewable capacity.
- **Improving the correlation between renewables generation and demand**
  - The carbon-intensity of electricity generation in Ireland varies between and within hours, being <200gCO_2e/kWh ~25% of the time, and >400gCO_2e/kWh ~30% of the time[lxxvii], driven largely by variation in demand and the output from renewables. The net result is that ~50% of the emissions are produced in ~30% of the hours.
  - There is therefore potential for significant reduction in carbon emissions if the timing of high demand can more often be matched by high generation from renewables.
  - This can be achieved both by shifting demand where possible to periods of low carbon-intensity, and by increasing the geographic and technological diversity of the renewable generating portfolio in Ireland.
- **Scaling up the next generation of energy technologies**
  - Even with better correlation between demand and renewables generation, there will remain a need for dispatchable low and zero-carbon electricity supply to meet any shortfalls in renewable generation.
  - For the long-term, zero-carbon solutions will be needed, such as long-term storage (eg, batteries, pumped hydro, and other technologies), green hydrogen, and other technologies. Tackling these challenges will require action by Government and many players in the wider energy value chain, but data centre companies can play a key part as highly sophisticated, high-value and forward-thinking pioneer customers to help in developing and scaling up these technologies.

The principles and solutions we have outlined below aim to incentivise the most efficient carbon-reducing behaviour by data centre operators and other Large Energy Users.

Principles	Challenge(s) addressed	Solutions
Decarbonise data centre electricity use	Power sector emissions must decline as electricity demand grows	**More granular carbon reporting**
		Carbon-efficient computing
		Cutting edge energy efficiency
		Low-carbon energy procurement

4.1.1 More granular carbon reporting

Companies sometimes claim reductions in their greenhouse gas emissions from electricity consumption based on the amount of renewable electricity (or renewable certificates) purchased, regardless of when or where this was generated, or whether it was 'additional' or from an existing generating station. For example, a company that used 1GWh of electricity over the year might report zero greenhouse gas emissions from electricity consumption if they purchased 1GWh of electricity from renewable sources over that year, regardless of where or when the electricity was generated in relation to the facility's demand.

There are a number of issues with this approach:

- New versus existing renewable projects If the renewable electricity (or certificates) is purchased from an operating asset or one that received public subsidy, it is unlikely to actually be supporting any new investment in renewables – it simply reflects an accounting transfer of renewable credits with limited real-world impact in terms of supporting the financing of renewable projects.

- **Timing of generation and demand**
    - As described at 4.1 and elsewhere[lxxviii], if the profile of demand over time differs from the profile of generation from the renewable asset(s), emissions calculations that match demand at one time with generation at another will not be accurate.
- **Location of generation and demand**
    - If the renewable generation and demand are located on separate electricity grids, or if there are transmission constraints between the generation and demand, it is likely that the carbon intensity of the networks each is connected to will differ. This means that it is not necessarily valid to assume that additional renewable generation in one region can offset the carbon emissions from additional demand in another.

Emissions reporting is not merely of academic interest – it drives companies' sustainability strategies and investment in low-carbon technology. More accurate emissions reporting is therefore a key enabler of more effective decarbonisation actions and will become increasingly important as the penetration of renewables on the grid increases.

What needs to happen

The data centre industry (and potentially other large energy users) should:

- Be early adopters of more granular carbon reporting standards taking into account
    - carbon-intensity of energy use on an hourly (or sub-hourly) basis, using local grid carbon-intensity (where data is available).
    - the contribution of data centre operators' own renewable power purchase agreements in Ireland in decarbonising their electricity supply, enabling new projects, hourly generation profile and local grid constraints.
    - other quantifiable, eligible (eg additional) carbon-reductions, such as those related to offtake heat use, carbon-absorbing building materials.

The Government should:

- Work with industry on effective implementation of reporting standards
    - Give early guidance to the industry on forthcoming standards.
    - Take into account industry views and needs in developing regulations and policy.
- Follow the principles in the 2022 CPPA roadmap[lxxix] to develop a market that supports accurate reporting
    - Make sure that any future regulations relating to carbon-reporting are focused on carbon emissions, and drive industry towards energy strategies that support faster grid decarbonisation, considering temporal and spatial issues and additionality.
    - Enable certification of hourly clean energy reporting by enabling time-stamping of Guarantees of Origin.
- Collect and report relevant data
    - Establish processes to collect data on development of renewables and other low-carbon generating assets outside of the RESS, eg supported by corporate PPAs, to inform policy development.

EirGrid should:

- Improve collection and provision of carbon emissions data
    - Enhance the CO_2-intensity data provision that already exists[lxxx], by making more historic data easily available, and making data available via an API.
    - Investigate the possibility of estimating and publishing forecasts of CO_2-intensity, with temporal and spatial granularity if possible, and making this available in machine-readable format to facilitate automated carbon-reporting and carbon-reducing behaviour. This approach has been pioneered in GB by National Grid ESO working with a range of partners[lxxxi].

4.1.2 Carbon-efficient computing

As section 2.3 shows, cloud computing is typically more efficient than traditional on-premises computing and can drive significant emissions savings. Additional savings can be brought about by:

- **Distributing computing loads to where they can be done with the required performance (reliability, latency, speed etc) at the lowest carbon-cost**
  - Carbon-intensity varies between data centres over time, according to efficiency, energy-sourcing, and variations in the carbon-intensity of local grids over time.
  - Where computing loads can be moved to lower-carbon data centres (note this is not possible for all types of computing tasks), this can reduce their associated emissions (and potentially reduce curtailment of renewables).
- **Efficient use of computing power**
  - Reducing the amount of computing to be done will reduce the associated power consumption. This can be achieved by eg eliminating any redundant application instances, coding efficiently, and choosing appropriate quality levels (eg resolution).

  Efficient design should also take into account the user side, reducing compute load on user devices, and the need to upgrade hardware.

What needs to happen

The data centre industry should:

- Continue to develop tools to enable distributing computing loads according to carbon-intensity
    - Provide information on carbon-intensity to enable customers to factor this into their choices of cloud locations (some already do this[lxxxii]).
    - Investigate any future possibilities to enable customers who chose this to allow their loads to be movable (within defined limits accounting for GDPR) so movable loads could be processed at times and places with a predicted low carbon-intensity energy.
- Work with others on a carbon-labelling scheme for cloud computing[10]
    - Seek to develop an industry-wide scheme (meeting the standards discussed above at 4.1.1*)* that enables the expected carbon-impact of cloud services to be quoted to customers during procurement in a comparable format that allows them to factor this into their choice of provider / package and, where relevant, to compare the carbon-impact to assessments of any existing on-premise servers they intend to replace.
    - Such schemes should, where possible, be harmonised with proposed EU rules on data centre transparency.
    - This should reward low-carbon choices on the behalf of data centre providers and enable customers to choose lower-carbon computing.
- Use its expertise to help customers to be efficient with their computing needs:
    - Give guidance to customers on how to reduce overuse of computing that can occur due to badly written code, lack of virtualisation, running of redundant applications, over-burdening of user devices etc (some already do this[lxxxiii]).

The Government should:

- Support the use of carbon-labelling through public sector procurement
    - Consider carbon-efficiency of computing (between providers and relative to existing solutions such as any on-premise servers) in public sector procurement when comparable carbon-labelling of cloud services becomes available.

[10] Work done in the GHG Protocol Product Life Cycle Accounting and Reporting Standard for cloud computing (2017) may be relevant: GHG Protocol

4.1.3 Cutting edge energy efficiency

Continuing to improve energy efficiency can further reduce the carbon-impact of data centres.

What needs to happen

The data centre industry should:

- Sign up to industry-leading energy standards, such as the EU Code of Conduct for Energy Efficiency in Data Centres[lxxxiv] or ISO 50001[lxxxv]
    - Use best practise energy efficiency guidance[lxxxvi] when constructing new data centres, and to retrofit existing data centres where feasible to improve their performance.
- Meet or beat Climate Neutral Data Centre Pact (CNDCP)[lxxxvii] energy efficiency targets for data centres and seek continuous improvement
    - In Ireland, the current CNDCP targets are Power Usage Effectiveness (PUE)[11] $\leq$1.3 for new data centres from 2025 and $\leq$1.3 for existing data centres by 2030, although better PUEs are already possible and progress beyond 1.3 should continue.
    - The industry should continue to invest in new technologies and innovate in how they operate facilities to ensure that the long-run trend of improving data centre energy efficiency continues.
    - When targeting better PUE, there should also be consideration of other factors, such as the trade-offs between PUE and water use, and of local conditions, eg priorities may be different in water-constrained areas.
    - The industry should continue to work with organisations such as the CNDCP on better efficiency metrics that may supersede PUE, and to adopt targets based on them.

The Government should:

- Require data on energy efficiency when procuring data centre services
    - Scoring criteria for public tenders for cloud services should take into account PUE or future improved metrics that replace it (including potential carbon-labelling).

4.1.4 Low-carbon energy procurement

Large energy users, including data centres, are well placed to procure zero-carbon or low-carbon energy directly from producers, supporting their development. Indeed, tech companies are the largest corporate buyers of renewable energy in the world[lxxxviii]. As per the discussion at 4.1.1, to make the best contribution to decarbonisation and to Ireland's renewable energy targets, such procurement should aim to support the development of new renewables and other low carbon technologies in the appropriate locations, and increasingly focus on reducing overall carbon emissions from electricity use rather than just matching annual renewables generation with demand.

[11] PUE is the ratio of overall energy use to the proportion of that energy that powers servers, eg a PUE of 2.0 means that 50% of energy is used to power servers and 50% for other uses.

What needs to happen

The data centre industry (and potentially other large energy users) should:

- Directly support new unsubsidised renewables development in Ireland, eg through CPPAs
    - Corporate energy procurement should take into account location and grid constraints. For example, demand in Dublin may be well-placed to support development of offshore wind in the Irish Sea.
- Set ambitious targets for reducing carbon emissions from electricity use when measured on a more granular basis (as set out in 4.1.1), including a target date for achieving fully zero-carbon electricity use
    - Targets should be clear and measurable, with interim milestones to check progress.
    - It should be recognised that such plans may depend also on factors that industry can influence but not control, such as development of networks, long-duration storage and other low carbon technologies.
- Support and invest in innovative solutions for enabling zero-carbon operation
    - In the short-term this means investing in pilot projects to test new approaches and technologies, such as battery storage and hydrogen.
    - Long-term, when this becomes more possible, it means investment at scale in low-carbon technologies to match the role of data centres and other large energy users in the energy system.

EirGrid should:

- Investigate and seek to remove any bottlenecks in the planning and grid connection processes that slow development of renewables and other sources of generation
    - Investments in the capacity to process applications should be considered, given current issues with the speed of this process[lxxxix], which might be funded by eg appropriate increases in application fees.
    - Projects that will contribute to Ireland's renewable energy targets should be prioritised, particularly in response to the new REPowerEU Plan[xc], which underlines the urgency of developing renewables and suggests measures such as designating 'go-to' areas for renewables development.

The Government should:

- Support further development of the CPPA market
    - Consider options recommended in the SEAI/Baringa *Corporate PPA Policy in Ireland* report[xci], including addressing interactions between RESS and CPPA support.
- Develop clear route-to-market opportunities for long-duration storage in Ireland
    - Provide support mechanisms that enable investment in long-duration storage. Eg Long-term contracts over multiple years for long-term storage based on the existing 'Fixed Contracts' framework used in 2019 for short-duration storage.
    - Consider the actions recommended by Energy Storage Ireland in response to the Baringa *Game Changer* report[xcii], including removing barriers to hybrid projects.
- Develop a hydrogen strategy for Ireland
    - Firm policies and routes-to-market need to be established to achieve the targets in CAP 2021[xciii] for delivering 1-3 TWh of zero emissions gas (including green hydrogen) by 2030.

- <u>Ensure that large energy users cover the costs of their impacts on the electricity system</u>
    - Pricing and charging arrangements, including levies, should reflect the net costs that large energy users have on the electricity system, including requirements for new low carbon or firm generation.
    - Charging arrangements should reflect the degree to which large energy users have supported development of renewable or other electricity infrastructure outside of public subsidy scheme RESS or capacity auctions, and hence reduced the costs to other Irish consumers.

4.2 Enable secure and sustainable growth in electricity supply

Over the last seven years there has been a 90% reduction in the derated capacity margin (the degree to which installed reliable capacity is expected to exceed peak demand) in Ireland, which was reported at 0 MW for winter 2021-22[xciv] and forecast for increasing tightness in winter 2022-23.

The security of supply issues in Ireland have been driven by the closure of older thermal generation (such as coal and peat-fired power stations), and an increase in electricity demand over the last nine years – reversing a longer-term trend of falling demand due to energy efficiency and offshoring of manufacturing, combined with a lack of new firm capacity coming online.

Security of supply challenges

The increasing demand has been mentioned in EirGrid Capacity and Generation Statement since 2015[xcv], and EirGrid has sought to procure additional capacity through Capacity Auctions to mitigate the risk. There have been 4 GWd (d=derated) of new-build contracts awarded, to meet the capacity targets that were calculated both to replace retiring plant and to meet growing demand. In the T-3 2024/25 auction, over 1.5 GWd of new-build contracts were awarded, the majority at the price cap of 147 €/kWd/year for 10-year contracts. However, several generation projects that had successfully secured capacity agreements in previous auctions at lower prices have not been delivered[xcvi], with >400 MW of new-build contracts for the 22/23 winter terminated.

To tackle the short-term challenges of security of supply in Ireland, there have been two additional tenders for a total of up to 300 MW of emergency capacity to be installed in the next 2 years. Longer term, the CRU has pledged to secure 2 GW of new dispatchable capacity by 2030.

Due to these issues and some unexpected outages of existing plants, there have been several days (especially when wind generation was low)[xcvii] when demand has come close to exceeding available supply, causing EirGrid to issue ‘amber alerts’.

Supply security and data centres

This situation has prompted EirGrid to implement a policy that grid connections will only be offered to new data centres if they construct on-site dispatchable generation facilities equivalent to 100% of their demand to provide support to the system at these times.

EirGrid has also stated that in the event of a supply shortfall in the coming winter, data centres may be required to reduce their demand on the grid by up to 50% of their maximum capacity. Although data centres have back-up generating facilities (necessary to deliver the ‘five-nines’ reliability their customers require), these are generally diesel-fuelled, and their running hours are limited by environmental regulation (they are also designed to run for a limited number of hours). Frequent or prolonged shortfalls in grid electricity supply could therefore risk outages at data centres, with potentially severe impacts on the critical services – such as healthcare, transport, and banking – that depend on them.

Grid services and network capacity

Apart from generating capacity, the Irish grid is also in need of investment to meet new demand and to enable integration of renewables, including a need for more grid services, such as inertia, frequency response, primary reserve, etc– services that help maintain frequency and voltage within required limits, and which are typically provided by thermal generators. As renewables become dominant, the grid operator will need to find new providers of these services, including from low-carbon generation and the demand side.

Investment is also needed in the network itself. Some new demand and some renewable generation projects have been held back by a lack of grid capacity, despite the potential of these projects to finance the necessary upgrades. In addressing these issues, it is important that the interests of consumers are protected, and investments necessitated by new demand are not financed by imposing their costs on other consumers.

This section makes several recommendations to help address these issues.

Principles	Challenge(s) addressed	Solutions
Enable secure and sustainable growth in electricity supply	Security of supply must be maintained and network capacity upgraded as the economy electrifies	**Collaboration on generation capacity**
		Electricity grid services
		Tackling network constraints
		Private wire

4.2.1 Collaboration on generation capacity

By working together on generation capacity issues, EirGrid and industry may be able to address them in an efficient way that improves Ireland's overall security of supply.

What needs to happen

EirGrid, the data centre industry (and potentially other large energy users) should:
• Work together closely on demand forecasting
  o In the past, there have been some issues with communication regarding how much demand will come from data centres in particular years, since data centres' grid connection capacity reflects the level of demand they anticipate in the future, rather than the level they have reached (data centres typically begin operations below full capacity and then build out) in response to growing demand for digital services.
  o Better communications between the industry and the EirGrid planning and forecasting teams are important, eg more regular meetings and discussion of current and future challenges and solutions.
 	
The Government and EirGrid should:
• Consider reforms to capacity auctions to ensure that future promised capacity is delivered
  o Reforms may include greater penalties for cancellation or greater progression of projects before they can receive a capacity market contract.
• Consider reforms to capacity charges that might enable more capacity to be procured. For example:
  o If the System Operator determines there is a need for new large energy users to contribute more to the cost of developing new capacity, they could consider differentiated capacity charges with a higher charge for new connections of large energy users (potentially as a temporary measure whilst capacity margin issues persist).
  o Alternatively, projects requesting new connections could be required to pay capacity charges before they are connected to secure funds for capacity procurement in advance of need.
  o Key to the success of any such revenue-generating proposals is that the revenue is used to procure new capacity (particularly in the regions where it is most needed).
  o Direct procurement by industry of firm capacity in grid-constrained regions could also be incentivised, with reduced capacity charges and increased access to connections if this occurred. Similar models whereby large energy users are incentivised to support new generating capacity have been used in other countries – for example, the 'Mankala' model in Finland.

4.2.2 Electricity grid services

Some data centres have the potential to offer services to the grid, such as fast frequency response. Such services are likely to be increasingly important as thermal plants (which typically provide them) retire and renewable penetration increases.

There are general technical constraints around the ability of data centres to offer these services without affecting the reliability they must guarantee to customers, many of whom provide critical services – they cannot halt operation. The precise ability of a particular data centre to offer grid services depends on:

- Its computing and non-computing load and whether either of these can be flexed.
- Its infrastructure, eg batteries or onsite generation, that might be leveraged to provide grid services.
- What services markets exist and whether the services the data centre could provide are eligible for and incentivised by those markets.

As more such services are needed, it will benefit Ireland's electricity system to maximise the contribution of all industries, including data centres, and our recommendations seek to enable this.

What needs to happen

The data centre industry and EirGrid should:

- Work collaboratively to explore options for data centres to offer grid services
    - Given the criticality of data centre services to many important industries, and the reliability they must guarantee, amounts of demand side-response may be limited, but what some data centres can do should be explored.
    - Pilot projects may be necessary in the short-term to determine what is feasible, useful and cost-effective.
    - Participation in grid services markets should always be voluntary, with rewards for participation that incentivise data centre developers and owners to invest in technologies that might allow more facilities to participate.
    - New designs or modifications to existing designs of grid services markets may be necessary to enable data centres to participate, but these should be considered where they can provide good value services that enhance the system at competitive cost.
    - This should increase efficiency and result in modest cost-savings for the system, which may be passed on to consumers.

EirGrid should:

- Consider whether new connections could be prioritised according to potential contributions to the grid
    - Where newly connected demand installations can offer services to the grid, such as dispatchable capacity or frequency response, connecting them could support the grid.
    - Prioritising such connections could result in greater availability of grid services and could incentivise further provision in future developments. DRAI have made proposals on this issue in more detail[xcviii].

4.2.3 Tackling network constraints

Ireland's electricity grid is constrained in certain areas, meaning that investment is needed if it is to transmit more energy in those areas. This places constraints on connection of new demand, and also constraints on supply, which can make it difficult to add renewables to the grid or lead to curtailment of existing renewables (where they are told not to generate as the system cannot carry the electricity). Our recommendations aim to unlock investment that could tackle these issues.

What needs to happen

EirGrid should:

- Consider whether new charging structures can facilitate removal of network constraints
  - Investigate whether investments in network upgrades in constrained areas can be financed by higher network charges for large energy consumers connecting in those areas.
  - Regionally differentiated network tariffs will only be effective though if the additional revenues are ring-fenced for provision of upgrades in those same regions.

The Government and EirGrid should:

- Investigate and seek to remove any bottlenecks in the planning process that hold up improvements in the grid
  - *See above recommendations on planning at 4.1.4.*
- Rapidly implement the solutions identified in Shaping Our Electricity Future[xcix] to enable network improvements
- Consider incentive-based policies to support locating generation and large energy users where grid capacity is or will be available

4.2.4 Private wire

'Private wire' electricity networks, where electricity generation and/or storage and commercial or industrial demand are connected via a private, non-regulated electricity network, are widely used in some other markets such as Great Britain.

They offer benefits to other electricity consumers because they ensure that the full costs of the network are borne by the network developer and their commercial customers.

They also offer benefits to the customers on the network. Networks and generation can be developed faster, there are fewer electricity losses, pricing can be adapted to the nature of the customers (rather than specified by a regulator), and synergies such as combined heat and power can be designed in from the outset. There may also be potential for private wire reform (along with more streamlined planning) to unlock development of smaller projects, including in rural areas, as the Irish Farmers Association has suggested[c].

Currently regulation requires all electricity distribution networks in Ireland to be fully licenced and regulated, which effectively prevents the development of private wire networks. Whilst private wire is not likely to be a solution for a majority of data centres or large energy users, it could be an important niche solution that will enable development of additional generating capacity, reducing demands on the grid and potentially leading to more small renewables projects in Ireland.

What needs to happen
The Government and EirGrid should: - Review policy on private wire in Ireland per Action 113 of the Climate Action Plan 2021[ci], and within this consider reforms to remove unnecessary barriers to private wire networks in Ireland   - EirGrid should look to introduce regulatory reforms to enable the development of private wire networks in Ireland, potentially building on the 'licence exempt networks' model in GB.   - Private wire is private provision, and may appropriately avoid some costs, but should not avoid those where they are still relying on the services provided (eg if importing electricity from the grid, they should pay the PSO that funds renewables).

4.3 Contribute to sustainability in other sectors

As with all commercial and industrial activities, the construction and operation of data centres has the potential to have negative impacts on the environment, eg, unsustainable water use practices, waste, and embedded emissions from construction and sourcing. However, these can be mitigated and with enough effort impacts can be positive.

Principle	Challenge(s) address	Solutions
Contribute to sustainability in other sectors	All sectors must become more sustainable	**Zero-carbon construction**
		Sustainable water use
		Sustainable sourcing and waste minimisation
		Making use of waste heat

4.3.1 Zero-carbon construction

Data centre buildings have embedded carbon eg, from concrete and the emissions of diesel vehicles used in construction, but new techniques and new materials can turn buildings from a source of carbon into sinks that store and -in some cases- absorb carbon from the air as they age[cii].

What needs to happen
The data centre industry (and potentially other large energy users) should: • <u>Collaborate with the construction industry on pioneering zero and negative carbon buildings</u> o Pilot projects have the potential both to deliver reduced or negative impacts, and to serve as experiments that contribute to wider knowledge of how to deliver zero-carbon construction. o As there are currently multiple low, zero and negative carbon materials being explored (eg recycled steel, green hydrogen steel, wood-frame, living materials, concrete alternatives such as hempcrete), pilot projects should seek to innovate and to contribute to wider knowledge of optimal techniques, including by dissemination of knowledge gained from these projects. o Zero-carbon construction also means using zero-carbon machines. This is also in its infancy, but examples already exist, with JCB planning to offer hydrogen construction vehicles for sale by the end of 2022.[ciii] • <u>Consider engaging with zero-carbon construction initiatives</u> o The Irish Green Building Council[civ] has published a draft roadmap to decarbonise buildings in Ireland.[cv]

4.3.2 Sustainable water use

According to Irish Water, data centres represent <0.2% of national water demand[cvi]. Water use per data centre varies, and can be reduced by water-conscious design, for example Amazon's new data centre in Drogheda will use the same amount of water annually as just eight households[cvii]. Water impacts can also be addressed by using non-potable water[cviii] and on-site water storage can enable time-shifting of demand so that data centres do not place large demands on the water network during hot weather.

Addressing use of water can go hand-in-hand with investments in water, such as reforestation and rainwater harvesting that aim to give back more water than data centres use. Google[cix] and Microsoft[cx] have both committed to replenishing more water globally than they extract by 2030.

As there are trade-offs between water use and power use (water cooling generally uses less power than air-cooling) water solutions should always be local, taking into account relative water abundance or scarcity in a particular region.

Renewable energy procurement can also conserve water, as wind and solar plants require far less water than the thermal plants they replace. Amazon calculated that in 2020, their global electricity generation from renewables helped avoid the withdrawal of 480 billion litres of water – enough to cover the water usage of all Irish households twice over[cxi].

What needs to happen

The data centre industry should:

- Align with the Climate Neutral Data Centre Pact on sustainable water use
  - Meet or exceed targets as these are developed.
  - Contribute to the development of additional sustainable water use metrics to modify and enhance Water Usage Effectiveness.
- Where freshwater is constrained, design new data centres to reduce strains on the water system and consider retrofitting existing data centres
  - Increase use of greywater / rainwater capture to reduce freshwater use and surface water run-off.
  - Increase use of water storage to reduce peak daily water usage during times of water stress.
  - Optimise air vs water-cooling according to local conditions, including relative levels of water stress/abundance.
- Improve transparency around water use
  - Eg publish data on performance on sustainable water use metrics, peak daily water usage, levels of storage.

4.3.3 Sustainable sourcing and waste minimisation

Data centres produce conventional waste and also WEEE (Waste Electrical and Electronic Equipment). Conventional waste management is as important for data centres as for other businesses and can be tackled in similar ways. WEEE is a bigger challenge for data centres, due to the volume of electrical and electronic equipment they use, and the need to replace this periodically. Data centre companies need to consider sustainability in their approach to this equipment, including repairing and upgrading where possible, using equipment that is designed for ease of repurpose/recycling, and making sure that waste that they pass on is dealt with according to sustainable closed economy principles.

What needs to happen

The data centre industry should:

- Implement sustainable sourcing
  - Prioritise procurement of servers and other items made from recycled materials.
  - Ensure suppliers' conflict materials policies are robust.
  - Avoid materials with high environmental impact, eg refrigerants with high global warming potential and 'substances of concern' not already covered by ROHS[cxii].
  - Consider using labelling schemes such as Blue Angel[cxiii] and EPEAT[cxiv] as a guide to sustainable procurement.
- Optimise refresh cycle of IT hardware
  - Balance potential energy efficiency improvements of new hardware against extending the life of existing hardware.
- Align with the Climate Neutral Data Centre Pact on waste and the circular economy
  - Assess for reuse, repair, or recycling 100% of their used server equipment.
  - Set stretching targets for the proportion of IT equipment repaired or reused.

4.3.4 Making use of waste heat

Use of waste heat from data centres (and other producers of waste heat, such as power stations and industry) presents a further decarbonisation opportunity. All data centres produce heat – although amounts will vary – and in many cases it can be used either on-site, for example to heat people's work and rest areas, or used offsite to heat neighbouring buildings (or for industrial applications), where it may displace carbon-emitting heat generation from gas or other fossil fuels. Because this heat is a waste product, it effectively incurs no additional emissions (indeed, it may be a by-product of use of zero-carbon electricity in the first place) and so it can have negative emissions since it reduces emissions that would otherwise have occurred. The scale of this opportunity could be considerable, but there are barriers such as a lack of heating networks and offtake projects to use the heat.

What needs to happen

The data centre industry should:

- Work with the Government, CRU and others to support policy measures that encourage use of waste heat
  - The Tallaght District Heating scheme involving Amazon (see 3.3) provides a good example that could be followed more widely[cxv].

The Government should:

- Encourage the development of district heating networks and an offtake heat ecosystem in Ireland
  - Consider the recommendations of the Climate Neutral Data Centre Pact regarding heat recovery, and whether these would help its development in Ireland[cxvi]. These include:
    - Recognising recovered heat as an energy source that reduces building emissions.
    - Enacting a policy framework that encourages heat recovery projects.
    - Ensuring that policies recognise other circular approaches, such as closed loop heat recovery, and do not limit opportunities for alternative heat recovery technologies.
  - Keep the protection of consumers at the heart of any policy framework for offtake heat.
  - Further progress Actions 186-192 in the Climate Action Plan 2021 relating to district heating, prioritising use of waste heat where feasible, in particular supporting district heat projects under the Climate Action Fund (action 186) and ensuring that planning frameworks facilitate district where appropriate (action 190)."

4.4 Dialogue and engagement

To implement these solutions, it is crucial that central Government, industry (power, data centres and other large energy users) and regulators work more closely together.

What needs to happen

All stakeholders should:
 	
• Meet regularly in a forum that enables open, candid communication to discuss:
    o sustainability issues (eg, emissions, water use)
    o network issues (eg, grid constraints, need for system services)
    o generation issues (eg, development of renewables, procurement of capacity)
    o community issues (eg, jobs and localised impacts)
    o any issues arising under the national digitalisation agenda (eg cybersecurity, skills)
    o planned developments (eg, network plans, potential new sources of demand)
    o pilot projects (eg, battery projects, grid services projects), and
    o development of new technologies (eg, hydrogen).

Endnotes

[i] List of essential service providers under new public health guidelines
[ii] Ireland in the Digital Economy and Society Index
[iii] Use of cloud computing services in enterprises 2021
[iv] Harnessing Digital - The Digital Ireland Framework
[v] Small Business, Big Technology, Deloitte 2014
[vi] The Economic Value of cloud services in Australia, Deloitte 2019
[vii] Eurostat 2021
[viii] Digital Economy and Society Index Ireland (DESI) 2021
[ix] Amazon Web Services Innovation Stories
[x] Extra.ie 2021
[xi] Thinkbusiness.ie 2020
[xii] RTE May 2022
[xiii] Central Statistics Office 2019
[xiv] BitPower proprietary data. Total investment including investment in digital equipment is likely to be several times higher.
[xv] Uptime Institute Global data center staffing forecast 2021-2025
[xvi] Central Statistics Office Jobs in Ireland in 'Computer programming, consultancy and related activities' and 'Information service activities' grew at 6.4% CAGR, versus 2.2% for total jobs (annual average of quarterly figures 2015-2020 Q3, latest figures available).
[xvii] OECD Measuring the Digital Transformation 2019
[xviii] OECD Going Digital Toolkit
[xix] Central Statistics Office: Computer Services jobs are jobs in 'Computer programming, consultancy and related activities' and 'Information service activities'
[xx] As above
[xxi] Irish Tech News June 2017
[xxii] Amazon: Former refugee and a mechanic became data technicians
[xxiii] Microsoft: Providing a StepIn2Tech for those impacted by COVID-19
[xxiv] Host in Ireland 2021
[xxv] Bitkom March 2021
[xxvi] IEA Aviation November 2021
[xxvii] Central Statistics Office November 2021
[xxviii] Environmental Protection Agency October 2021
[xxix]Technicolor 2011; Technicolor 2021
[xxx] McKinsey September 2020
[xxxi] Journal of Energy in Southern Africa May 2016
[xxxii] New Scientist February 2021
[xxxiii] IOP Science May 2014
[xxxiv] BBC June 2021
[xxxv] Oliver Wyman 2021
[xxxvi] Inmarsat 2021
[xxxvii] Google Cloud: E.ON Powering businesses on their sustainable journeys, supported by Google Cloud
[xxxviii] Google Cloud: UPS uses Google Cloud to build the global smart logistics network of the future
[xxxix] 451 Research 2021; 80% is an average across Europe. The study focused on AWS, but with results that generalise to other hyperscale cloud providers who offer similar efficiency. Estimated energy reduction from servers for Ireland was ~68%, and estimated energy reduction from non-computing efficiency for Ireland was 16%, giving a total 84% estimated energy reduction.
[xli] Arithmetic average from Amazon Web Services June 2020; Google Data Centers; Microsoft Azure April 2022
[xlii] 451 Research 2021
[xliii] As above

[xliv] European Environment Agency 202174
[xlv] Sustainable Energy Authority of Ireland 2021
[xlvi] Wind Energy Ireland June 2021
[xlvii] BitPower estimate, based on grid carbon-intensity and data centre energy use figures
[xlviii] Host in Ireland Bitpower 2020
[xlix] IDA Ireland April 2019
[l] RE-Source Renewable Energy Buyers Toolkit
[li] Environmental Protection Agency combined with BitPower estimates
[lii] Center of Expertise for Energy Efficiency in Data Centers February 2020
[liii] Statista
[liv] Top 500
[lv] JLL March 2022
[lvi] Climate Change Knowledge Portal
[lvii] IDA Ireland
[lviii] Trading Economics
[lix] Knoema 2020
[lx] The Pensions Commission July 2021
[lxi] Wind Energy Ireland June 2021
[lxii] 2020 data from: EirGrid Group System and Renewable Data Summary Report 2021; 2030 (CAP 2021) estimated from mid-points of capacity targets: Government of Ireland Climate Action Plan 2021 and annual electricity generation estimated using estimated load factors from Baringa modelling; estimated long-term capacities from multiple sources: Wind Energy Ireland April 2021; RTE 2020; Irish Times and annual electricity generation estimated using Baringa modelling; 'Other' renewable generation held constant at 2020 figure.
[lxiii] EirGrid Group All Island Generation Capacity Statement; demand assessment includes projected increase in demand from data centres.
[lxiv] IDA Ireland April 2019
[lxv] RE-Source Renewable Energy Buyers Toolkit
[lxvi] Sustainable Energy Authority of Ireland Residential Statistics
[lxvii] Central Statistics Office Regional SDGs Ireland 2017
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[lxix] Google 24/7 carbon-free energy; Microsoft's 100/100/0 vision
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[xci] Sustainable Energy Authority of Ireland December 2020
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[xciii] Government of Ireland Climate Action Plan 2021
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[xcv] Cloud Infrastructure Ireland Submission to CRU Consultation July 2021
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[xcvii] Eirgrid All Island Generation Capacity Statement 2021-2030
[xcviii] Demand Response Association of Ireland CRU Letter July 2021
[xcix] Eirgrid Shaping Our Electricity Future Roadmap 2021
[c] IFA response to CRU's ECP-2 Proposed Decision Consultation
[ci] Government of Ireland Climate Action Plan 2021
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[ciii] JCB
[civ] Irish Green Building Council
[cv] Irish Green Building Council Have Your Say Roadmap
[cvi] Irish Water
[cvii] Data Centre Moratorium Dáil Éireann Debate September 2021
[cviii] Amazon Web Services August 2020
[cix] Google Sustainability
[cx] Microsoft September 2020
[cxi] Amazon Web Services Water Stewardship
[cxii] European Commission July 2011
[cxiii] Blue Angel Server and Data Storage Products
[cxiv] EPEAT
[cxv] Codema Tallaght District Heating Scheme
[cxvi] Climate Neutral Data Centre Pact

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We extend a thanks to Bitpower for their analytical support and for sharing their expertise regarding the data centre industry in Ireland.

Bitpower is a specialist data centre consultancy with a specific focus on power and sustainability. Bitpower brings local knowledge and experience to help clients achieve their objectives. They work with data centre operators, developers, and investors. Bitpower provides industry-leading analysis of the data hosting market in Ireland and tracks the scale and growth of the data industry for industry and government bodies.

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