Ireland's Data Hosting Industry 2017

"Irish Data Centres, an Industry of Substance"

Host In Ireland

bitpower
energy solutions

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December 2017

This report has been part-funded by the Sustainable Energy Authority of Ireland under SEAI's Energy Research, Development, and Demonstration (RD&D) Fund 2017.

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Foreword

This research has been carried out by Bitpower[i] on behalf of Host in Ireland[ii] to examine the opportunities and risks associated with the digital asset hosting industry in Ireland. With $71 Billion of ICT Services exported in 2016[iii], Ireland clearly has a thriving digital economy. It boasts the biggest names in the tech industry. Dublin is now the envy of many of its European counterparts in terms of the reach of its data hosting ecosystem.

Over the course of the last six decades, the planet is moving at a pace not seen previously to the "always-on", digital world we know today. Ireland (Dublin) has evolved to be ranked as a Tier 1 hosting location due to the evolution of its status as the "Digital Gateway to Europe" for US companies. This started with the IBM mainframe computer in 1950's and now continues with cloud, colocation, and managed service providers.

This success is not without its challenges. How will sustainability and energy use be kept in check? What about planning? What benefits does the industry bring to Ireland? These questions appear in media reports daily and have stirred a lot of debate in 2017.

Today's data centres are designed and operated to be much more efficient than previous generations. Energy accounts for up to 50% of operating costs post-construction, so there is a constant drive to reduce energy consumption.

This report attempts to establish a baseline in terms of the sustainability of the data industry. We address the scale of energy use and its growth, and explore options for better integration with the energy system. We have mapped the location of the leading data centres in Ireland. We look at the different types of data hosting, and how their business models differ in terms of sustainability reporting. We address energy efficiency and best practice in data centre design and operations.

By providing the most timely and accurate update on data centre activity in the Irish market, we believe that this baseline will act as a useful reference for policymakers. This will be beneficial to Ireland as we look to continue our leadership in the creation, retention and exporting of digital products for the long term.

It is important to acknowledge that in Ireland today the supply challenges in the Data Hosting Industry are as a direct consequence of the pent-up demand for the Irish Hosting product. The recent proposal by the Irish Government to include data centres as part of the Strategic Infrastructure Act may provide clarity. If it can provide time-certainty on planning applications and state-driven clarity on energy supply it will be of great benefit to Ireland in retaining and attracting new data hosting opportunities.

This report has been part-funded by the Sustainable Energy Authority of Ireland[iv] under SEAI's Energy Research, Development, and Demonstration (RD&D) Fund 2017. I would like to thank SEAI for supporting this important research, and I look forward to engaging further with the energy policy system in Ireland.

Garry Connolly
President & Founder - Host in Ireland

Research and analysis performed by:
David McAuley - Bitpower

1. Scope & Methodology

In our analysis of the data hosting industry, we have focused on large, purpose-built data centres over 1MW in size. We make no attempt to quantify the smaller on-site IT facilities that exist in many businesses. There is a trend towards most IT capability moving to the cloud, co-located or managed services facilities. The data has a physical presence, in the form of large data hosting facilities. Such facilities offer economies of scale, flexible growth, and secure connectivity to the wider world.

Our survey, a copy of which can be found in Appendix I, included questions on location, scale, growth, motivation to locate in Ireland, parent company origin, jobs, energy use, efficiency, sustainability measures, renewable energy procurement, and data content.

We carried out extensive desktop research on publicly available information to augment the data gathered and to provide a complete picture of the sustainability of the industry. We developed a reckoner based on industry metrics. Using a combination of satellite imagery to measure the scale, and metrics to establish the power demand, we have calculated the power capacity of 60 data halls built or planned in Ireland. The numbers were then compared with information from planning applications, press releases, and utility data. The aggregation of these sources is the basis for the findings in this report.

2. Growth of Digital Information

We all interact with digital information in our daily activities. From email to social media, our demand has grown exponentially since the arrival of smartphones in 2007. Video streaming consumes the biggest portion of the total world data bandwidth. This trend is shown in Figure 1 below. We have grown used to information and services being available online. Many businesses have prioritised their online presence and describe themselves as digital-first companies. For example, online shopping has grown and is expected to double in Ireland by 2021[v]. According to the EU Commission, Data is new the driver for productivity, jobs, and innovation.[vi]

We all create data, probably without realising it. Each iteration of smartphone produces increasingly higher resolution photos and videos. The trend towards storing this information online instead of on our home computers is the basis of the "Cloud".

Not all data is the same. Financial exchanges require the most secure ultra-low latency connections. London and Frankfurt invested heavily in fibre connectivity to support their financial districts, leading to the growth of the data industry in these cities. Social media sites might store your most recent information locally for instant availability, but archive your older documents in more distant locations where energy costs, for instance, might be lower. Businesses require access to multiple providers to support their operations. This includes email and office applications, data management, marketing, social media, design, and so on. Software is now offered as a service.

The cloud is the collective name for where all this data is processed and stored. Despite the name, the cloud is a real, solid, and physical entity. It consists of data centres connected by fibre optic cables across the globe.

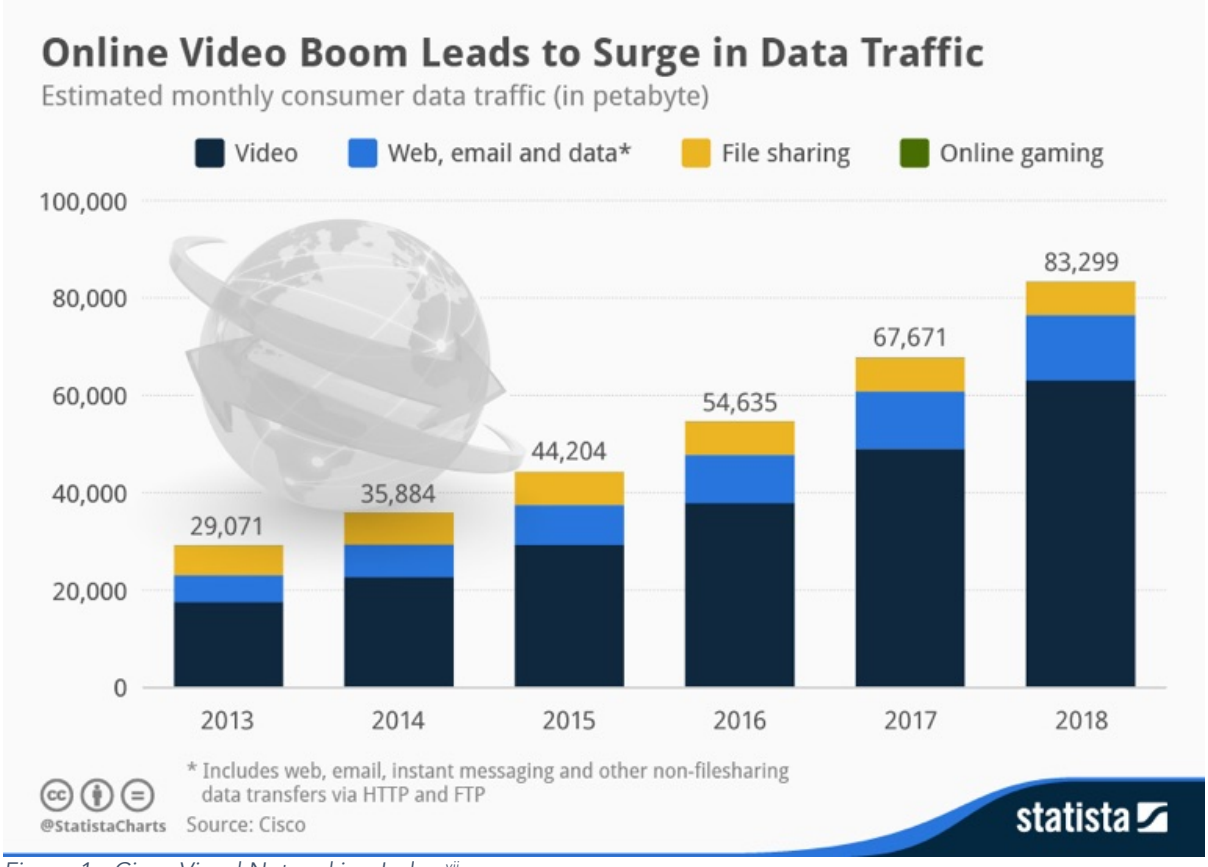

Figure 1 - Cisco Visual Networking Index.[vii]

3. Data Hosting Models

Data centres are custom-designed energy efficient facilities built to store and forward data securely. They need resilient power and fibre connectivity. Our study reveals that data centres of different types tend to cluster and evolve together.

Types of Data Hosting

The data industry is composed of different types of operators. Traditional data hosting was implemented on-site, where a business or government department would host its own data on servers located in the building. As demand for data grew and services became more diverse, these facilities began to be outsourced. Paired to that is the emergence of very large product, app, and data storage providers, who build their own, very large, centres. The distinctions between the different types of data centre are explained below.

Hyperscale Data Centres

The term Hyperscale is usually used to refer to large companies that manage the hosting of data for their clients. There may be as many as twenty such operators worldwide, depending on how they are defined. In Ireland, these include Microsoft, Amazon, Google, and Facebook. These are household name corporations that build and operate their own data facilities to their own specifications. For security and competitive reasons, their internal architecture and design are kept mostly private.

Hyperscale data operations in Ireland represent about 300 MW of connected power, increasing to 760 MW over the next seven years.

Colocation Wholesale Data Centres

Due to the phenomenal growth of the Hyperscale sector, there is a trend towards private investors and/or third party wholesale colocation companies to fund, build and lease facilities to hyperscales. In this model, the third party constructs the facility and the hyperscale leases the internal (white) space. This happens where the demand for space outpaces the speed at which the hyperscale can build its own facilities. Operating costs including energy costs are passed on to the client. There are several such facilities in operation and planned in various locations across Ireland. EdgeConnex is the largest example of the colocation wholesale model. Gemini and JCD are new entrants using this model.

Colocation Data Centres

Colocation data centres provide managed facilities for partial use by third parties. IT managers can lease "white space" in these facilities which include power and cooling. The facilities are highly secure and need to meet industry standards to attract clients.

It is worth noting that when companies such as Microsoft and Google first considered operating in Ireland, they began by leasing space in colocation facilities. The quality of hosting and the ease of doing business in Ireland was such that these companies gained confidence in Ireland's capabilities.

Major colocation providers with Irish operations include InterXion, Keppel Data Centres, Digital Realty, and Equinix. Five of the top nine big colocation providers operating in Europe have an Irish presence.

Leading US colocation providers Cyrus One and Serverfarm have also announced their intent to develop facilities in the short/medium term. Because of the diversity and nature of the colocation business, the collation facilities can accommodate up to 100 telecom providers who connect their facilities to the local Hyperscale providers or connect to their other global facilities. The combined colocation power in Ireland is 100 - 120MW across 12 buildings.

Private Data Centres

The smallest subgroup of Data Centres in Ireland is the purpose built / enterprise / private type. This is because they are often built for a specific type of operation. They include telecoms operators, financial transaction processing companies, and computer graphics specialists. Their scale is relatively small in comparison with the larger centres, and they do not have the same modular design. We have included 30MW to capture their scale. Private operators are mostly excluded from this study, but they remain an important part of the ecosystem.

Edge Data Centres

The Edge is where we access the data. It is where the "eyeballs" view the content. There is a growing need to have specialist data centres located near the edge to improve user experience. The term "Edge" can also describe distributed data infrastructure designed to facilitate the deployment of the Internet of Things (IoT). Edge Data centres are expected to appear in cities when 5G communications mature. In terms of energy demand, we expect edge data centres to be in the 500kW to 1MW range. We have not identified any existing Edge data centres in Ireland in this study, and we have not estimated their growth in our model, but we do expect them to begin appearing in the next 12-18 months. In the context of Ireland, they could be classified as micro or containerised data centres due to size and latency considerations.

In 2016, Hyperscales made up 75% of the total digital hosting capacity in Ireland. [see Figure 2].

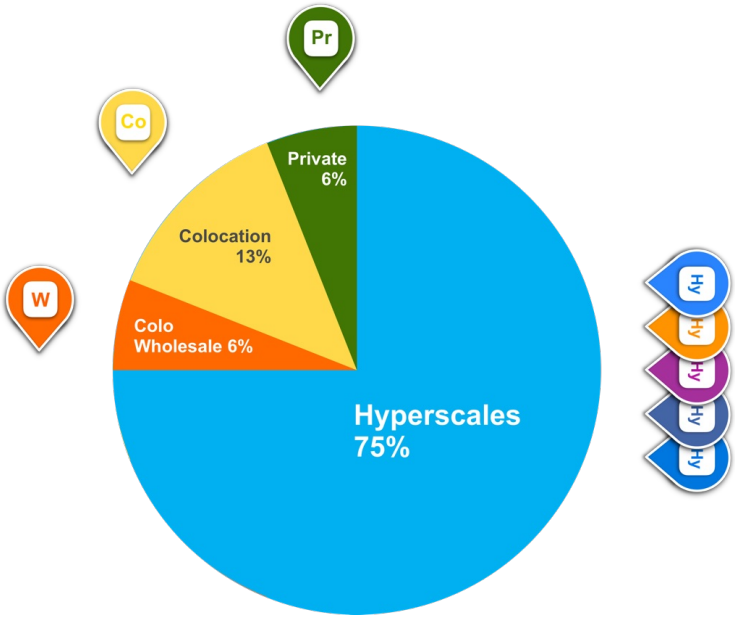

Figure 2 - Relative scale of digital hosting types in Ireland in 2016.

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4. Why Ireland? Why Dublin?

The commercial data hosting industry originated as a US Phenomenon. Ireland has strong relationships with American corporations and is physically the closest European country to the US.

Sixty years of innovation and working with the world's largest, particularly US, ICT companies have evolved into now making Ireland an EU Tier I location for data hosting. This, in turn, has created the need for data centres. For instance, Corporations like Microsoft and Apple have consistently designed, built and distributed their products from Ireland for over thirty-five years. The establishment of their hosting facilities here is a further endorsement for Ireland as a location that they continue to trust to assist them in building and growing their "Connected Planet" platforms.

We asked colocation providers why they chose to locate to Ireland. Some established a presence in Ireland in the late 1990s, and have steadily grown their business here since then. The main reasons cited for setting up in Ireland and Dublin, in particular, are:

- Off-island fibre connectivity & the T50 (diverse Dublin fibre ring) Figure 3.
- Clustering effect & critical mass
- Power availability & reliability (not price)
- Political stability
- Accessibility
- Open and Transparent Planning
- An educated and native English-speaking workforce.

Figure 3 - Dublin's Fibre network (T50 in blue)

Ireland's temperate climate is NOT the primary reason data centres set up in Ireland.

Ireland's climate is advantageous in an international context, but most data companies have a worldwide presence, operating facilities in many global regions. Ireland compares with other European countries with similar climate conditions, Nordic countries have cooler weather. Climate conditions (weather) rank further down the decision-making process than other factors.

This can be seen in Figure 4 below for cooling degree days in Europe (a standard measure of how much annual cooling is needed).

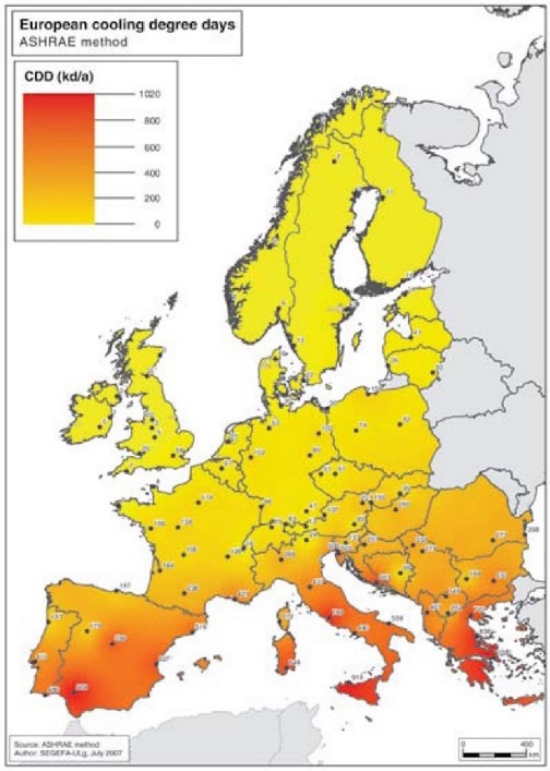


Figure 4 - Cooling Degree days in Europe - Ireland's climate is similar to most of northern Europe. Source[viii]

Fact – Ireland's temperate climate is NOT the primary reason data centres set up in Ireland

European Hosting Market

The European data hosting industry is categorised by the presence of large colocation facilities in several major cities. The Tier I locations are sometimes referred to as FLAPD - Frankfurt, London, Amsterdam, Paris, and Dublin. Dublin has joined the ranks of these cities. Ireland's combination of Colocation and Hyperscale data facilities is unique in Europe - no other city hosts such a comprehensive range of industry leaders.

The key advantage that Dublin has in this regard is the proximity of colocation providers to Google, Amazon, and Microsoft. It is not uncommon for multinational organisations to have multiple platforms running in-house, co-located and connected to the cloud. i.e., most businesses require connections to five or six different providers. They might use Microsoft's Azure Platform for content management, Outlook 365 for email, Dropbox for file storage, and AWS for website and retail hosting. Being able to quickly, seamlessly, and securely connect to these services is advantageous to online businesses.

CBRE recently demonstrated relative the scale of the FLAPD market against Dublin's hosting industry. Refer to Figure 5.

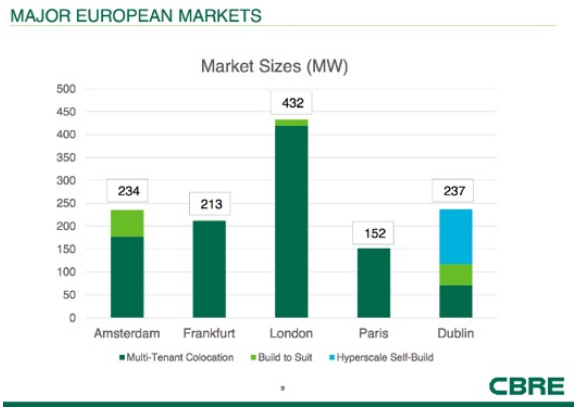


Figure 5 – CBRE analysis of the major European markets. "Build to Suit" refers to colocation wholesale.

The Five Ps of Location

Host in Ireland refers to the Five Ps when highlighting Ireland's digital success[ix]. The Ps include People, Policy, Pedigree, Power, and Pipes. The combination of these attributes makes Ireland an attractive location for data hosting.

Our open economy, pro-business approach, attractive corporation tax, common law legal system, and native English-speaking Data Protection Commissioner (GDPR[x]) make Ireland attractive to global operators. Our pedigree includes Ireland's track record with international pharmaceutical, biotech, and software companies. Our people are our biggest asset both at home and abroad. Power and pipes (fibre) are a pre-requisite for a data industry anywhere in the world. See Appendix III for a discussion on connectivity.

A sixth "P" is emerging – Proximity. The emergence of public, private and now hybrid data clouds in proximity to the leading colocation, managed services, and hyperscale players is leading to the industry dubbing Ireland "Home of the Hybrid Cloud".

Like all forms of foreign direct investment into Ireland, the data hosting industry has grown from Ireland's ability to adapt to the requirements of the global ICT industry, for Ireland the "Data" is the "Why?", the "Centre" is the "How?".

5. Mapping Ireland's Data Hosting Industry

Understanding the physical scale and evolution of the cloud in Ireland is important if we are to develop sustainable solutions. Mapping the industry reveals an acceleration of growth, and highlights a definite clustering effect. This type of clustering effect in the Dublin metro area is also seen in locations like Loudoun County Virginia, London, Frankfurt and Amsterdam.

Most data centres are located in the metropolitan Dublin area (including County Meath). Cork has one colocation facility, and there is a small number of private data facilities in the regions. Refer to Figure 6.

We mapped the known commercial data centres. We found forty-one operational sites, ten buildings under construction, and twelve sites with approved planning permission. These buildings are located mostly in the Dublin region. Within Dublin, there are two significant clusters - one near Blanchardstown and the other at Grange Castle.

Figure 6 – Data Centre Locations[xi]

For a sense of scale, the collated image on the opposite page [Figure 7] shows **half** of Dublin's data hosting facilities to scale. (Note this is a composite image and does not represent one site).

A map of the locations of data hosting facilities in Dublin is shown in Figure 9.

For the purposes of aggregation of the data in this report, we have classified the data hosting industry into several geographical areas:

- Dublin North East (Clonshaugh)
- Dublin North West (Ballycoolin)
- County Meath (Clonee)
- Dublin South West (including Grange Castle and Profile Park)
- Dublin City (including Tallaght, Parkwest, and CityWest)
- Other

Data centres operational in mid-2017:

17
Data Centres operated by **Hyperscales**

12
Data Centres owned by **Private** operators

12
Data Centres operated by **Colocation** providers

2.2 Million ft²
of White Space for 60,000 racks

We also mapped the locations of major energy utilities and electrical substations to explore the basis of grid connection challenges. The map may be useful in evaluating the opportunities for district heating, or other community-based schemes.

Figure 7 – [Previous page] Satellite imagery montage showing some of Ireland's data centre facilities. Images from Google maps.

Dublin Area

Data Centres

This map shows all data centres covered by our study.

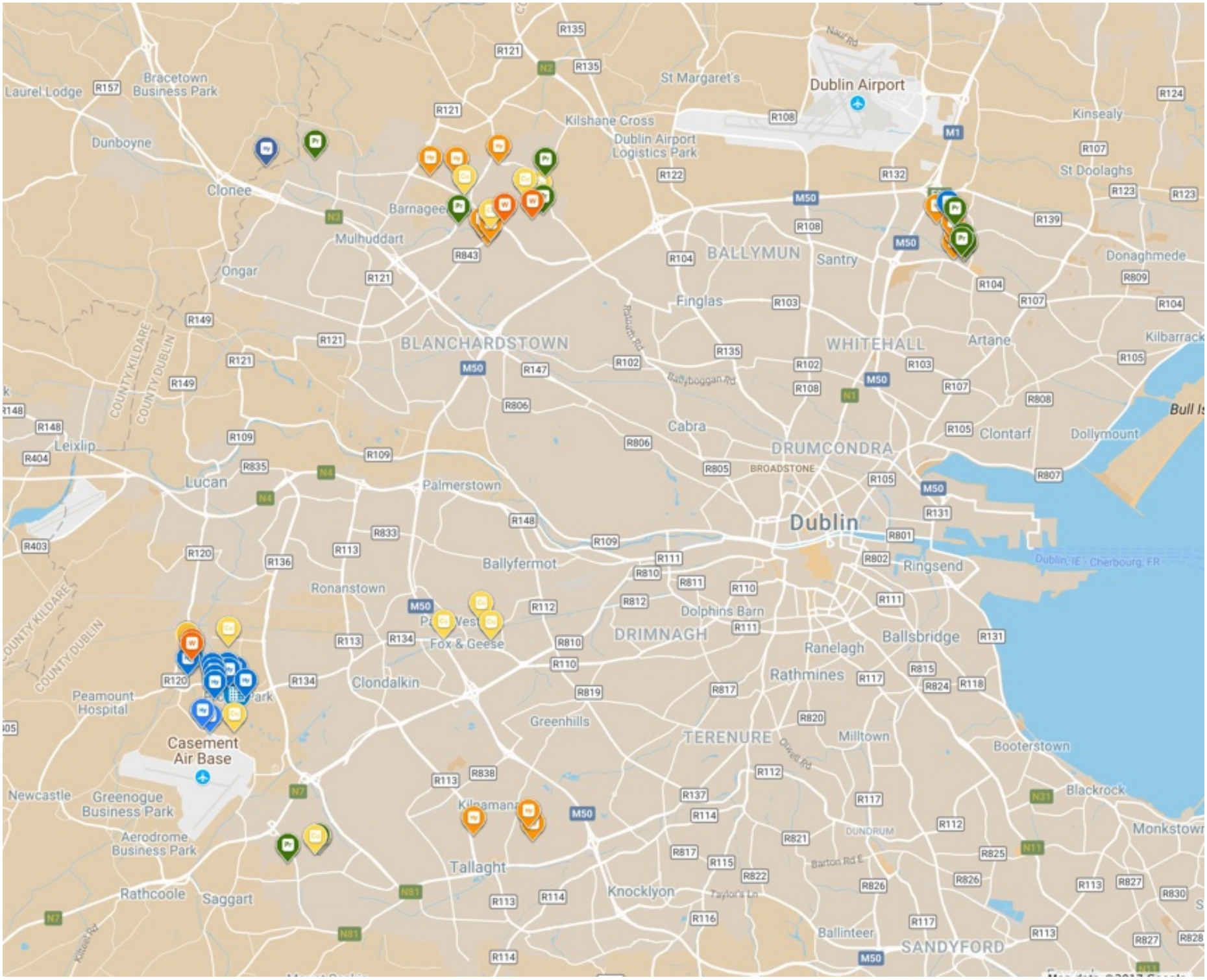
These include data centres which are:

- Operational
- In-construction
- With planning permission
- In the oplanning process
- In masterplans

The map shows the following types of data centre:

- Hyperscale
- Colocation
- Colocation Wholesale
- Private Data Centres

- No Edge data cantres yet



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6. Power Requirement for Data Centres

Power availability defines the size of any data centre operation. Without a guarantee of power availability, the data centre business model would not work. Facilities are built never to exceed the power available.

Our study identified forty-one operational data facilities of various types in Ireland. Ten new buildings are in construction in 2017, and a further twelve have approved planning permission. We have identified five data centres in the planning process, and up to twenty data halls indicated in masterplans submitted for planning.

To calculate the power capacity, we have aggregated data from several sources. We first calculated the total maximum power capacity across all facilities identified using a methodology described in Appendix II. Power capacity relates to the infrastructure required to deliver power through the national grid. Up to 40% of energy costs are based on the Maximum Import Capacity (MIC). Energy users cannot exceed their MIC without incurring high penalty charges. Data centres who sell space cannot sell more power capacity than they can guarantee to each client.

420 MW
Total connected data centre power capacity in 2017

150 MW
data centres in construction in 2017

180 MW
with full planning permission

70 MW
in the planning process

185 MW
Masterplans

~1,000 MW by 2024
Total requirement for power capacity

These numbers assume that all approved and proposed projects will proceed. In the Dublin area, the total demand growth would be as described in Figure 10. Circles represent the MW size in each region in 2017 and 2024.

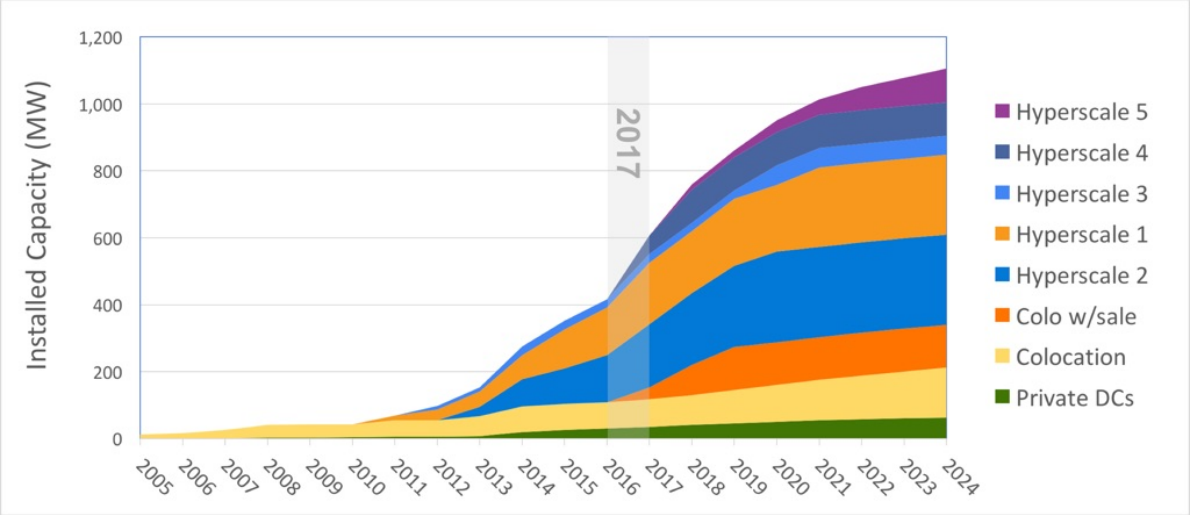

Figure 8 - Projected scale and Growth of Ireland's Data Centres

Figure 9 - [Previous page] Map of Dublin Metropolitan area data centres.
Figure 10 - [Next Page] Map of the projected growth in data centre capacity in Dublin.

Metro Dublin

Data Hosting Clusters

This map shows the clustering of data hosting facilities in the Dublin area as of mid 2017.

Red circles demonstrate the relative MW size of operational facilities in those locations.

Also shown (blue circles) is the projected growth of these clusters (not geographic spread). Some of this growth is already underway, with 10 new data halls under construction.

Circle size represents the relative scales in MW

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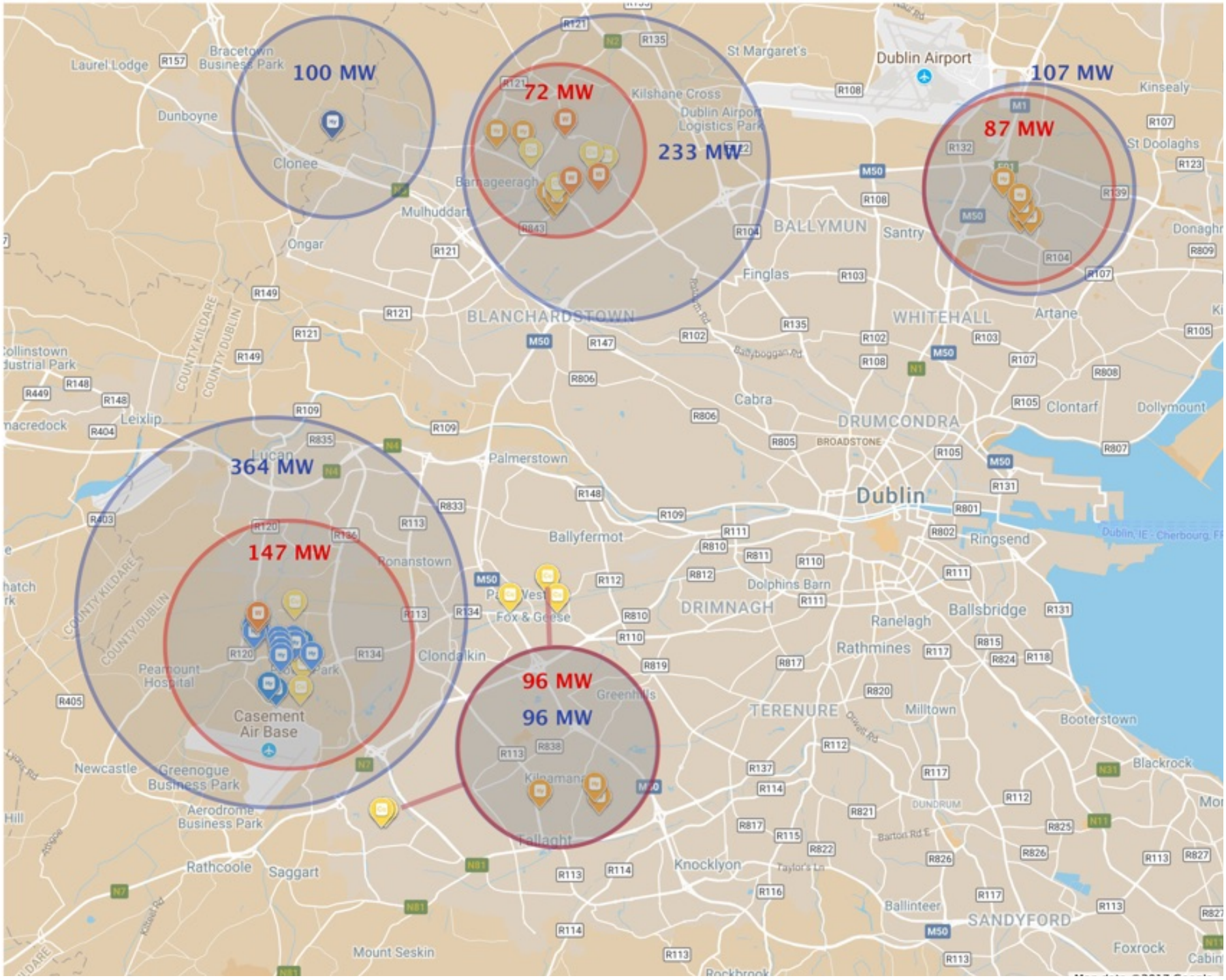


7. Energy use in Data Centres

The numbers calculated in the previous section indicate the scale and growth of the installed and planned power capacities of data centres in Ireland. It is important to note that these are maximum numbers. The actual energy demand is lower in practice. Many factors affect power utilisation: demand for data; client build-out rates; outside temperature, etc. While these factors are sometimes out of the control of the operator, demand profiles for data centres tend to be relatively flat on a day-by-day basis.

It is not unusual for power utilisation in data centres to be as low as 30% on an annualised basis. It can be assumed that hyperscale operators are better placed to optimise energy demand to avoid over-provisioning, and could potentially average a demand of 70% of their power capacity.

The diagram in Figure 11 below (available from "Advanced concepts for Renewable Energy Supply of Data Centres"[xii]) demonstrates the difference between power design capacity and operational capacity over the initial lifecycle of a data centre.

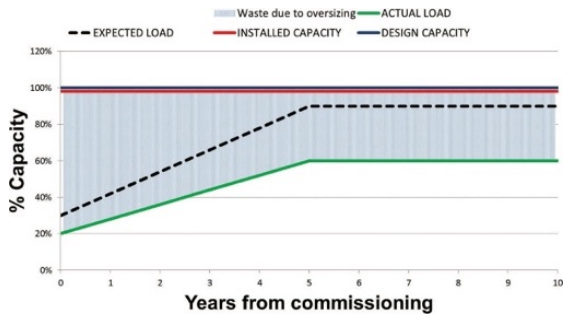


Figure 11 - Ramp-up of data centre power utilisation.

Operators work hard to utilise their power assets optimally. The Green Grid has proposed a new Open Standard for Data Centre Availability (OSDA), covering resilience, efficiency, and sustainability. Interxion has proposed new open design standards that better facilitate innovative power technologies[xiii].

We have applied a power utilisation factor of 45% across the industry to reach an estimate of the total energy use. This is justified for our study as many of the data centres we have examined have only recently been constructed, and will not necessarily have been fully fitted out. Our model can be adjusted in the future.

45%

Assumed annual power utilisation factor for data centres.

1.4 TWh

Estimate of annual energy use

The total energy use for all operational data centres in Ireland is estimated to be 1.40 TWh in 2016. Ireland's total electricity use in 2016 was 27.6 TWh. Data centres represent 4.8% of Ireland's electricity use - Figure 12.

The world's data centres used 416.2 TWh in 2016[xiv]. Ireland's data centre energy use represents 0.34% of the data industry total.

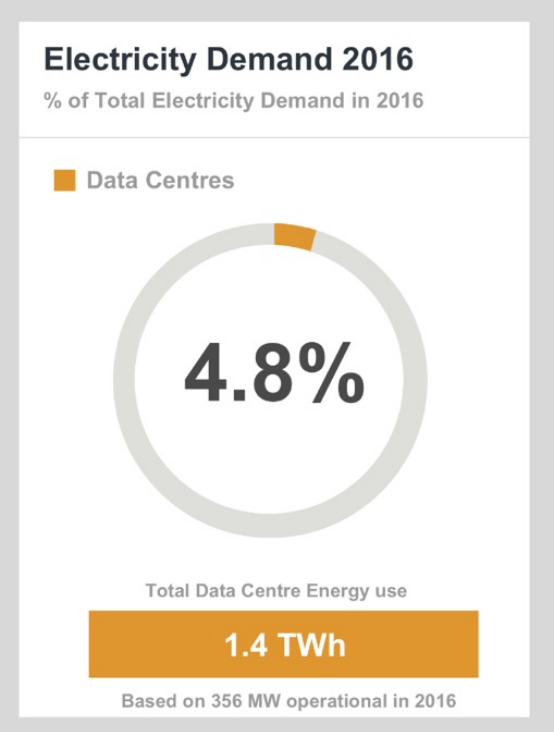


Figure 12 - Data Centre energy use as a percentage of Ireland's total electricity use in 2016.

8. Energy use in context

How does 1.4 TWh (1,400,000,000 kWh) compare with the overall energy system? It equates to 0.120 MTOE (Million Tonnes of Oil Equivalent). Ireland's total primary energy requirement in 2016 was 14.3 MTOE. Data centres, therefore, used 0.83% of all energy (including electricity, heating, and transport) used in Ireland in 2016 - Figure 13.

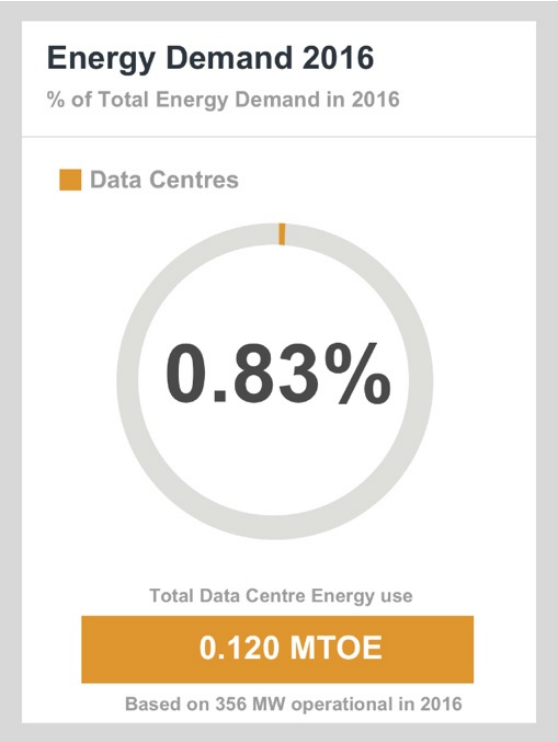


Figure 13 - Data Centre energy demand as a percentage of Ireland's total energy demand in 2016.

Ireland's total carbon emissions in 2016 were 63,000,000 Tonnes of CO2. We discuss renewable energy procurement in a later section, but if we were to assume that the data industry used only direct fossil fuelled power, then the data industry would represent 1% of total CO2 emissions. This is not a representative figure, as renewable energy procurement is standard for data centre operators.

Ireland's wind generation in 2016 was 6.5 TWh. If data centres only procured electricity generated by these wind farms, it would make up 22% of all wind energy generated.

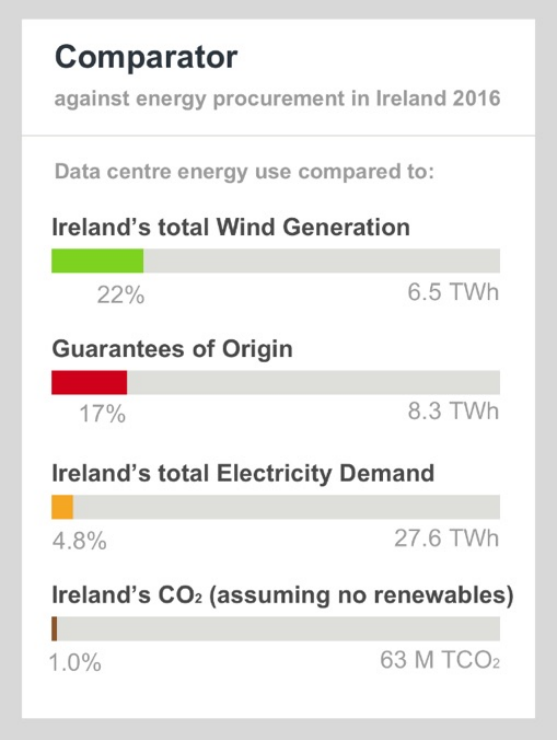


Figure 14 – Comparisons against energy sources.

In 2016, according to the Central Regulator of Utilities (CRU), electricity suppliers purchased 8.3 TWh of renewable generation from outside of Ireland in the form of certificates (Guarantees of Origin) for sale to their customers. If data centres procured all their energy from this pool, they would have consumed 17% of the total "virtual" imports. See Figure 14 for relative comparisons.

These renewable energy numbers are hypothetical for comparison only. See Figure 15. They demonstrate that the data industry has only a minimal impact on renewable energy capacity available to Ireland. Data centre operators pay a premium for 100% guaranteed renewable energy. This extra investment should help to drive the deployment of more renewable energy generation by providing certainty to investors in renewable systems.

Data centres are the most likely customers for renewable generators.

Figure 15 – [Next Page] Digital Hosting dashboard

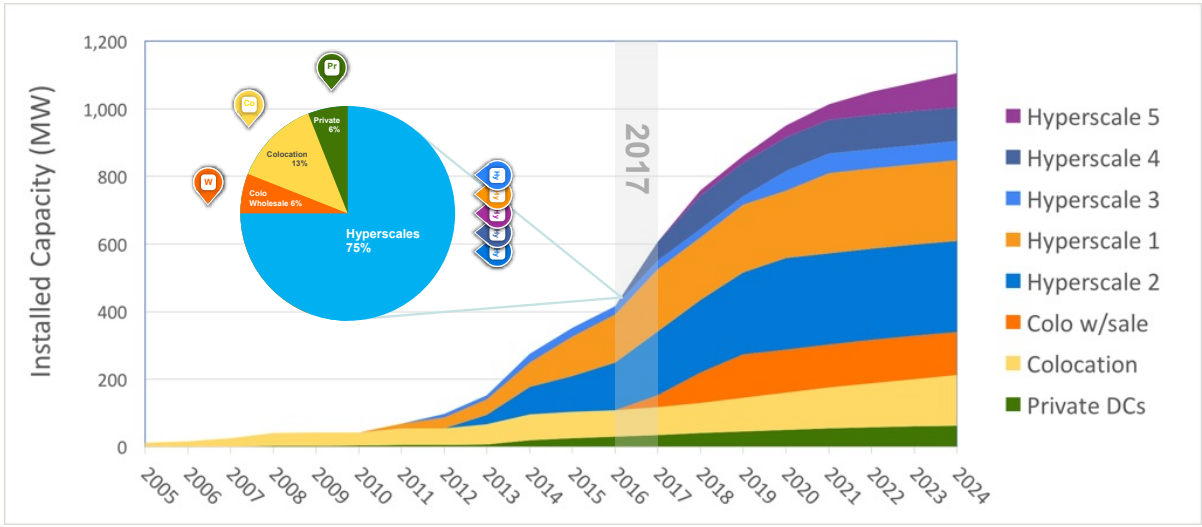
Data Centre Capacity
Operatonal in 2017
420 MW

Construction Activity
10 New Data Centres
150 MW

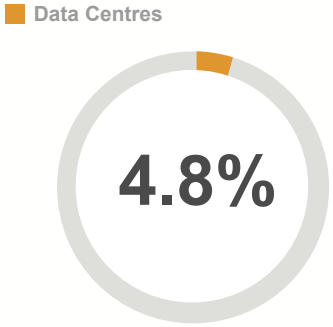
Planning Approved
Shovel-ready projects
180 MW

Digital Hosting

Growth Trend
Ireland's Data Industry



Electricity Demand 2016
% of Total Electricity Demand in 2016

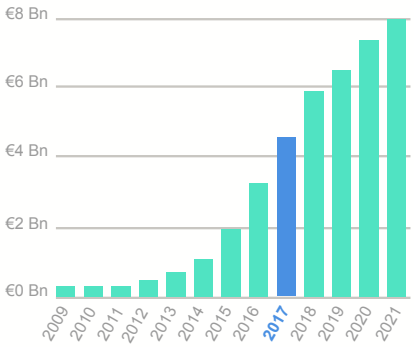


Total Data Centre Energy use

1.4 TWh

Based on 356 MW operational in 2016

Construction Investment
Cumulative 35% annual growth



€3 Billion by 2016, 4.8 Billion by 2017

Sustainability Metrics
Industry participation in CSR reporting

RE 100
FTSE4Good
SGX
LARGE INDUSTRY ENERGY NETWORK
Dow Jones Sustainability Indexes
Nasdaq
CDP DISCLOSURE INSIGHT ACTION
CODE OF CONDUCT DATA CENTRES

Comparator
against energy procurement in Ireland 2016

Data centre energy use compared to:

Ireland's total Wind Generation
22% — 6.5 TWh

Guarantees of Origin
17% — 8.3 TWh

Ireland's total Electricity Demand
4.8% — 27.6 TWh

Ireland's CO_2 (assuming no renewables)
1.0% — 63 M TCO_2

Measuring the Sustainability of Ireland's Data Hosting Industry
2017 Study by Host in Ireland and Bitpower part-funded by SEAI under the Research, Development, and Demonstration Fund 2017

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9. Energy efficiency in the data industry

IT Efficiencies

Measuring energy efficiency in the data hosting industry is a complex task. From an energy perspective, the input is electricity, and the output is digital information; hours of streamed video, emails sent, photos uploaded, numbers crunched, etc. Data is different to other industries in that the output is extremely diverse. The nature of digital information is that its content is often encrypted and protected. Data hosting providers typically do not have access to the content. Colocation operators often provide space in which the client places and controls their own servers and IT equipment.

Each generation of processors can do many more computations than older ones, and software optimisation methods are mature. But we cannot measure what is inside the data. IT equipment in data centres is replaced every three to five years and is on a different efficiency trajectory than support hardware.

We have excluded the IT energy load from our discussions on data hosting efficiency, as we have no reliable metric that that could be applied across the industry. IT efficiencies will most likely be consumed by doing more with the same input energy in the long term. In the context of the energy system, the overall energy demand is more important.

Operational Efficiencies

From a facilities perspective, the input to a data centre is electricity, and the output is heat from servers and equipment. Minimising the cooling load by widening the bands of acceptable temperature and humidity in which the IT equipment operates is now the norm. This approach was facilitated by ASHRAE when it updated operational temperature and humidity bands (TC 9.9), defining wider operating ranges for IT equipment. This encouraged equipment manufacturers to design for harsher conditions.

This standardisation approach has been very successful. IT managers can have confidence that their servers, storage, and communications equipment will remain in warrantee at higher inlet temperatures.

The facilities energy load of a data centre consists of power conditioning, uninterruptible power supplies, air movement and treatment, and office functions. The industry has availed of many of the opportunities available, particularly in relation to cooling. In Ireland, data centres no longer install mechanical chilling systems, for instance. The PuE of data centres has been reduced to 1.2 versus a PuE of 2.7 of a decade ago. More on PuE in Appendix V. Management of airflow in data centres has also undergone a shift, with hot/cold aisle separation equipment part of the standard design for most data centres.

Discussions have identified that the following factors are significant in affecting the efficiency of a data centre:

- Customer policies regarding space use and cooling (especially for colocation).
- Economy of scale
- Utilisation of IT and space
- Standardisation
- Modularity

Efficiency Support Schemes

Most of the survey participants already have or plan to avail of the efficiency support programmes administered by SEAI. These include:

- Accelerated Capital Allowance Programme
- Energy Supplier Obligation Scheme
- EXEED Energy efficient design
- Large Industry Energy Network
- Energy Agreements & ISO50001

These schemes are welcome and have scope for further application across the industry.

10. Investment in Data Centres

There has been an uptick in investment in data centres in Ireland in recent years. The scope of this study was not to quantify the full jobs and economic benefits, but our research does provide some useful insights. We have explored reports of investment featured in public announcements. Our model allows us to estimate the investment in data facilities based on their type and size. This information may prove useful for other studies.

To calculate the cost of each facility, we applied a metric of €m per MW of data centre capacity to our model. We varied the value depending on the type and age of the data centre. We compared the results to the investment numbers provided by survey respondents and to other reports of investment.

The aggregated results [see Figure 16] indicate that by 2016, €3 Billion had been invested in data centres. There are €1.1 Billion facilities under construction in 2017. A further €1.6 Billion have secured planning permission, and there are approximately €2 Billion indicated in various masterplans. We, therefore, expect to see investments averaging €1 Billion per annum for the next 3-4 years.

These numbers represent the investment in land, buildings and energy infrastructure only. The computer servers, storage, and racks contained in data centres are a separate investment. We do not indicate how much of the IT equipment is manufactured in Ireland.

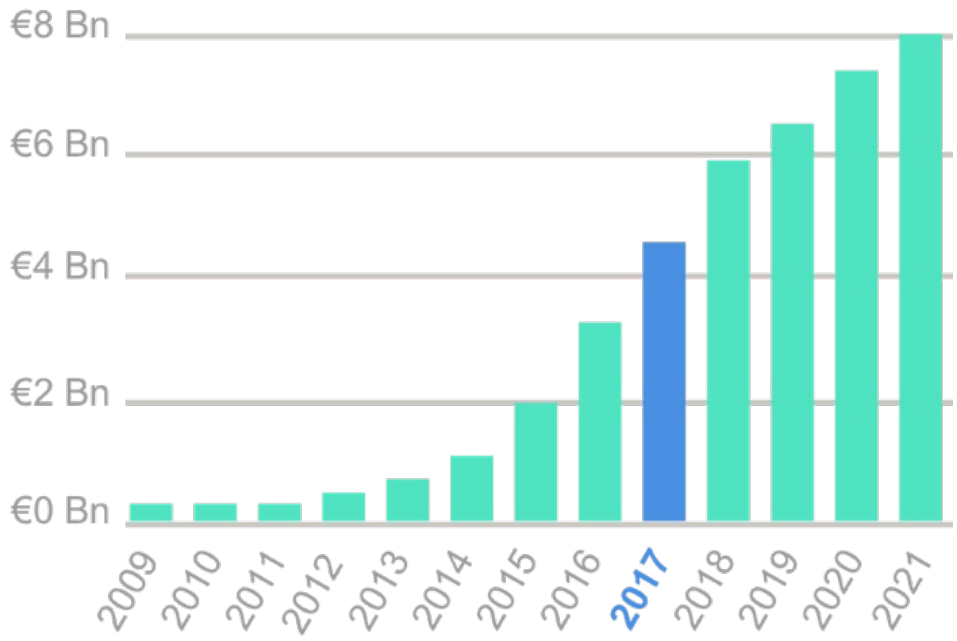

Figure 16 - Construction Investment in Data Centres 2009 – 2021 – Cumulative.

11. Renewable Energy Procurement

Operators of colocation data centres find that their clients, especially banking and corporate clients, regularly request proof of renewable generation attributable to their hosted data. The Hyperscale companies have their motivations, driven by their public image. Greenpeace's annual green energy reports also act as checks on data corporations.

Figure 17 - Wind farm in Ireland

For our survey, we defined four possible energy procurement setups applicable to data centres:

- Standard grid electricity (28% renewable assumed – which includes 22% wind).
- 100% Renewable Certificates from energy suppliers (Guarantees of Origin).
- Power Purchase Agreements with renewable generators in Ireland.
- Direct Renewable generation on site.

We reviewed public announcements from the hyperscale data centre operators to find that Amazon, Microsoft, Google, and Facebook all have a similar position in that they procure 100% renewable energy from their suppliers. Apple has also made announcements that they would run their data centres on 100% renewable energy.

Guarantees of Origin

The guarantees of origin (GO) system overseen by the Central Regulator of Utilities, CRU (formerly the CER) allows for this. It's 2016 statement[xv] accounts for each supplier's energy sales and reports on the quantities of renewable electricity GOs purchased. In 2016, energy suppliers purchased the equivalent of 8.3 TWh of electricity traceable back to renewable sources off-island.

Supplier	Coal	Gas	Peat	Renewable	Other
All Island Fuel Mix	13.76%	39.66%	5.35%	40.09%	1.14%
Bord Gais (Ireland)	0.00%	74.51%	0.00%	25.49%	0.00%
Electric Ireland (Ireland)	13.54%	51.10%	5.26%	28.98%	1.12%
Energia (Ireland)	0.00%	0.00%	0.00%	100.00%	0.00%
Flogas (Ireland)	0.00%	0.00%	0.00%	100.00%	0.00%
LCC Power Limited t/s Go Power (Ireland)	0.00%	0.00%	0.00%	100.00%	0.00%
Panda Power (Ireland)	0.00%	0.00%	0.00%	100.00%	0.00%
SSE Airtricity (Ireland)	0.00%	0.00%	0.00%	100.00%	0.00%
Vayu (Ireland)	0.00%	0.00%	0.00%	100.00%	0.00%
BRI Green Energy Supply	0.00%	0.00%	0.00%	100.00%	0.00%

Figure 18 - Electricity Supplier fuel mix 2016 - Source - CRU.

Accompanying this are 2,827 MW of wind installed in the Republic of Ireland which generated 6.5 TWh in 2016. On an all-island basis, renewables counted in this manner equated to 40.09% of all electricity purchased in 2016. The system details each energy supplier, listed in Figure 18 above (from CRU report).

With data centres drawing 1.40 TWh of electricity in Ireland annually, their total demand would represent approximately 22% of Ireland's current indigenous wind power resource, or 17% of the GO ("imported" renewables). See Figure 14.

Initiatives such as RE100 (see Figure 19 below) demonstrate the appetite of global organisations for investing in renewable energy.

Google is now the world's largest renewable power customer. Microsoft recently signed a Power Purchase Agreement in Ireland with a 37MW new wind farm in Kerry. Facebook has publicised their agreement with Brookfield Renewables to procure 100% of their electricity from Brookfield's 460MW Irish wind

portfolio. Amazon stated it would power its new data facilities with 100% renewable energy. Apple is also an advocate of renewable energy procurement.

The Public Service Obligation Levy (PSO) is billed on the basis of MIC. It supports the peat and renewable energy sectors. We have calculated the Industry's contribution to the PSO as €7.5 million per annum. The total PSO levy in 2016 was €350 million, meaning the data industry contributed about 2% of the total PSO levy. The PSO Levy increased in October 2017, meaning the same data centres will contribute €14 million to the PSO in the next 12 months.

With 2,600 MW of new wind farms in development and a similar amount of solar PV in the grid connection process, there is sure to be sufficient new renewable energy capacity to feed the growth of the data industry, if these industries grow together as expected.

RE 100

RE100 is a collaborative, global initiative uniting more than 100 influential businesses committed to 100% renewable electricity, working to increase demand for - and delivery of - renewable energy, extensively. RE100 is brought to you by The Climate Group in partnership with CDP. Both organizations are part of the We Mean Business coalition, working with leading businesses around the world.

Apple - Apple leads the world in innovation with the iPhone, iPad, Mac, Apple Watch and Apple TV. Apple's operations in 23 countries run on 100% renewable power. Worldwide, 96% of its electricity use comes from renewable sources, and Apple is committed to reaching 100%. Apple is also helping its manufacturing partners lower their carbon footprint, working with them to install more than 4 gigawatts of new clean energy worldwide by 2020.

eBay - eBay is a multinational e-trading company that connects millions of buyers and sellers around the world – aiming to create a more sustainable form of commerce. eBay has committed to 100% renewable energy in its electricity supply by 2025 at its data centres and offices.

Equinix - Equinix is a global interconnection and data centre provider, committed to using 100% power across its global operations. The company has set an interim goal of sourcing 50% renewable electricity (against a 2015 baseline) by 2017.

Facebook – Facebook was founded in 2004, and its mission is to give people the power to share and make the world more open and connected. The company is committed to powering connectivity with the smallest footprint possible and set a goal of reaching 50% clean and renewable energy in its electricity supply mix for its data centres in 2018. Eventually, Facebook aims to have 100% clean and renewable energy in its mix.

Google - Google is a global technology leader focused on improving the ways people connect with information. Google's innovations in web search and advertising have made its website a top Internet property and its brand one of the most recognized in the world. Google is committed to sourcing 100% renewable electricity and is on course to reach this goal in 2017.

Microsoft - Microsoft, based in the U.S., is the leading platform and productivity company for the mobile-first, cloud-first world, and its mission is to empower every person and organization on the planet to achieve more. The company has been 100 percent powered by renewable energy since 2014.

Figure 19 - RE100 Renewable Energy Commitments.

12. Sustainability measures and policies

Our study explored the ways in which data centre operators and their corporate owners define the sustainability of their operations.

For data centre efficiency, we examined memberships and participation in various government and industry reporting schemes, such as the EU Code of Conduct for Data Centres by the EU JRC, the SEAI energy Agreements and LIEN programmes and The Green Grid.

For corporate standards, we checked stock market sustainability metrics, like FTSE4Good and the Dow Jones Sustainability Index.

The list below [Figure 20] is not exhaustive and is intended as a guide to the scope of schemes which are relevant to different parts of the industry. Geographic differences exist, which is relevant as Ireland's digital hosting partners originate from the US, the EU, and Asia.

Figure 20 – Some examples of efficiency and CSR schemes that are relevant to data centre operators from various geographic regions. The list is not exhaustive and is for indicative purposes only. Not all schemes would be relevant to all listed companies.

Wider Digital Industry Sustainability

We included the data centre supply chain partners and wider industry where information was readily available. These include many large corporations with international influence. The list below details participation in sustainability reporting programmes. Again, this list below [Figure 21] is not intended as a comprehensive analysis, but as an indication of the reach of these schemes.

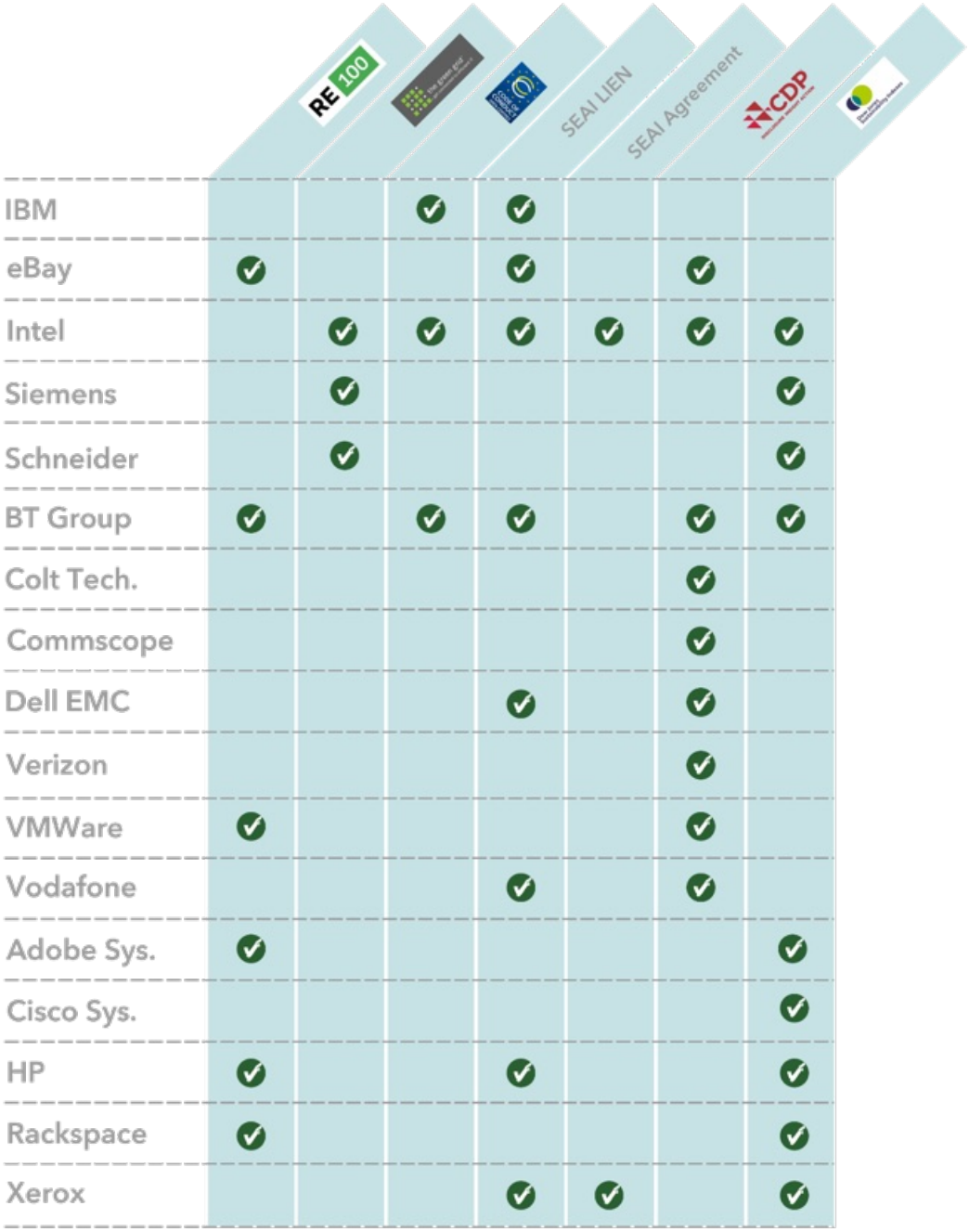

Figure 21 – Examples of digital tech industry participation in selected CSR schemes. The list is not exhaustive and is for indicative purposes only. Not all schemes would be relevant to all listed companies.

Efficiency Reporting

Data centres report their energy performance and share best practice at an engineering level. Refer to Figure 20 and Figure 21. The schemes below are of particular interest.

SEAI LIEN and Agreements Participation

The Large Industry Energy Network (LIEN) is a collaborative network of energy users run by SEAI. Annual reporting of performance metrics is a requirement of membership of this network. Energy use is indexed against the year of joining to track relative energy performance against a defined metric.

ISO 50001 is a standardised approach to energy management. It is built on similar principles to familiar ISO management standards, such as ISO9001: Quality Management Systems.

The SEAI Energy Agreements Programme requires it's members to commit to the implementation of the ISO 50001 standard for their Irish operations. The table shows the data operations that were members of the scheme in 2016.

EU Code of Conduct for Data Centres

The EU Code of Conduct for Data Centres provides best practice guidelines for data centres and collects performance data for verification that members meet minimum efficiency criteria. It is a voluntary scheme, and energy data on individual data centres is not published. It was established by the EU Joint Research Centre.

"All Participants have an obligation to continuously monitor energy consumption and adopt energy management in order to look for continuous improvement in energy efficiency. One of the key objectives of the Code of Conduct is that each participant benchmark their efficiency over time, using the Code of Conduct metric(s) (or more sophisticated metrics if and when available) in order to produce evidence of continuous improvement in efficiency."

The DCiE metric is applied. Currently, the EU Code of Conduct for Data Centres is developing new metrics around IT usage efficiency. Participation in the EU Code of Conduct includes over 100 companies.

Uptime Institute

The Uptime Institute is an international body that provides operability standards and evaluations of site infrastructure topologies for data centres.

"For over 20 years, Uptime Institute has been providing customers with the assurance that their digital infrastructure can perform at a level that is consistent with their business needs, across a wide array of operating conditions. With its data centre Tier Standard & Certifications, Management & Operations reviews, Efficient IT Stamp of Approval, and accredited educational curriculum for data centre professionals, Uptime Institute has become the defacto standard for data centre reliability, sustainability, and efficiency."

Although many Irish colocation operators design to Tier III specifications, only one Irish Data Centre (Digital Realty DUB13-S110) is listed on the Uptime Institute register for Certification of Design Documents and Certification of Constructed Facility. It also won the 2014 Uptime Institute World energy efficiency award.

Corporate Sustainability Reporting

Many data centre operators report their sustainability credentials at a corporate level. Refer to Figure 20 and
Figure 21. Our survey identified the following sustainability metrics that data companies are either participating in or make up part of their supply chain.

Carbon Disclosure Project (CDP):

The carbon disclosure project runs a global disclosure system that enables companies, cities, states, and regions to measure and manage their environmental impacts. Over 5,600 companies reported in 2016.

While data operators do not generally report to CDP, some data supply chain companies with operations in Ireland do report. Users of data facilities with operations in Ireland, for example - eBay Inc., are included in CDP reporting.
Source - CDP Ireland climate change report 2016

Dow Jones Sustainability Index (DJSI), New York:

US-listed companies participate in the DJSI.

The Dow Jones Sustainability Index is collated by RobecoSAM - "*an investment specialist which focus exclusively on Sustainability Investing*. "

In 2016, 867 companies participated in the Corporate Sustainability Assessment, providing data for the 2016 Sustainability Yearbook.

Singapore Stock Exchange Sustainability Index (SGX):

Companies listed on the Singapore stock exchange report to the SGX sustainability index.

In 2016, the SGX introduced sustainability reporting on a "comply or explain" basis, covering five primary components: material ESG factors; policies, practices, and performance; targets; sustainability reporting framework; and their Board statement. Reporting will be mandatory for listed companies after the end of 2017.
Source: SGX Sustainability Index - Full Constituent List 2016

FTSE (London):

Companies listed in the UK can participate in the FTSE4Good Index of sustainability.

The FTSE and Russell indexes provide market data for investors. Indexes include measures of environmental performance and green revenues. "The FTSE4Good Index Series is designed to measure the performance of companies demonstrating strong Environmental, Social, and Governance (ESG) practices. Transparent management and clearly-defined ESG criteria make FTSE4Good indexes suitable tools to be used by a wide variety of market participants when creating or assessing sustainable investment products."

The FTSE Green Revenues Index captures the percentage of green revenues of companies that are engaged in transitioning to a green economy. The 2017 Index lists Apple, Microsoft, Amazon, Facebook, and Alphabet (Google) in it's top 10 Constituents. These technology companies are helping to drive the green economy.
Source FTSE Fact Sheets

13. Views & Recommendations

Our discussions with the data industry revealed some interesting insights into the challenges and opportunities available. With digital hosting expected to more than double in the coming five years, now is the time to ensure that Ireland Inc. is ready to innovate. Some of the options are explored below.

Infrastructure

Dublin's success was built on the blend of four of the five P's - pipes (off-Island connectivity), power, people and pedigree with US ICT Companies for the past six decades which led to it being the choice for the colocation providers in the late 1990's (dotcom bubble). This is evident in the clusters containing a mix of hyperscale, colocation and telecoms providers, which is not easily replicable.

To have sustainable growth of the Data Hosting industry outside of the Greater Dublin Metropolitan area at a minimum these locations will need to be able to provide power and connectivity (Data Hosted in Ireland is for Export) redundant and resilient connectivity to the 18 off-island fibres to EU / US is a minimum. New affordable easy-to-access dark fibre to the regions would be a good first step. Fibre needs to be quickly accessible in the event of faults - the National Roads Authority standards for new roads include for 100mm ducting.

Sustainability

Procurement of renewable energy is standard, with most data operators paying a premium purchasing 100% renewable certified energy from their suppliers. There is a trend for direct PPAs with renewable energy projects both in Ireland and abroad. This demand for renewable energy will provide much-needed investment certainty to the renewable industry, and may reduce the need REFIT schemes for renewable energy.

The Energy System

The grid connection process is very different than in other EU Tier 1 locations (e.g., Frankfurt, London). More clarity is needed in Dublin in particular as to availability timelines for new connections to avoid uncertainties that could impact future investment.

Some countries calculate fixed energy costs for large energy users based on energy used, not the MIC. Energy users project their demand for the coming month.

Investment & Jobs

There is a dependency amid Ireland's reputation as a digital hub and its data hosting industry. Opportunities for digital innovation are built on access to data.

In terms of building the data centres - €3 billion had already been invested in constructing data hosting facilities over the decade to the end of 2016 [refer to Figure 16]. Another €3 billion will have been invested in the subsequent three years to 2019.

A detailed job and economic benefits study would help with understanding the value added for citizens.

Research and Development

SFI funded research centres such as IC4, ADAPT, and INSIGHT are delivering collaborative projects with major tech companies. Topics range from network optimisation to data analytics and digital content innovations.

There is an opportunity for a new strategic research cluster addressing the opportunities in energy supply and district heating for data centres. TCD's Department of Economics has commenced promising research in this area. The IERC model for industry engagement with research has proven successful. A coordinated

research effort could leverage Ireland's mature energy research capabilities in terms of policy, electricity grid, renewable energy integration, and smart cities. With access to industry leaders, Ireland has a unique opportunity to become a centre of excellence.

Skilled technicians need specialist training to work in the data industry. We will need more data scientists. Efforts are required in order to ensure there is a pipeline of trained people available to meet the industry demand.

Planning & Rates

Time-certainty on the planning system is needed to ensure the preservation of Ireland's reputation as a top-tier hosting location. This is a national issue. Commercial rate increases in some areas have impacted the operational costs of data centres.

District Heating

The capture of heat from free-air cooled data halls is technically feasible, but it is not simple. The energy is low-grade (25°C – 40 °C) and would need mechanical systems to convert the heat energy into a useful resource. Such systems bring inefficiencies and risk. Microsoft recently included district heating connections in its planning application for developments at Grange Castle.

Finding customers for this heat is more challenging. Greenhouses might seem like a good candidate, but the warm air dispersed from computer equipment is very dry and would need energy-intensive humidification for such an application.

District heating systems would need to have more than physical pipes in place to make them feasible. They need trusted contractual and financial mechanisms before we can realistically capture heat from data centres. New homes need less heat than older ones because of improved insulation regulations. Examples in other European countries are interesting, but they are isolated pilot projects and are unlikely to become mainstream.

Future adoption of direct liquid cooling for servers might provide more suitable heating energy, but this technology is likely only to apply to certain applications. Combined Heat and Power (CHP) is an option where on-site generation is implemented, but again this requires a customer to take the heat. None of Ireland's existing fossil fuel generation plants sell their waste heat. Most large CHP users have an on-site heat demand (e.g., Rusal Aughinish Alumina built 150MW of CHP in 2005, but they use the heat on site and sell the electricity to the grid). Dairy and brewing operations also utilise CHP, but they have the in-house heat demand to make this technology economically feasible.

Conclusions

As the "Connected Planet" becomes a reality, the need has arisen to securely store and forward the "oxygen" on which this growth is based. Data is a global challenge. Ireland is in a unique position and has built on its sixty years of experience to be considered a Tier 1 EU hosting location and "Home of the Hybrid Cloud". The products and services that are hosted, stored, and exported from Ireland's Data centres are very much part of the €71 Billion ICT services export industry.

The two most important aspects of any business are costs and time certainty. The data hosting industry is no different. The demand for Ireland's hosting product is putting strains on our ability to deliver on the supply. This is particularly true in the metropolitan Dublin area. The provision of power through the national grid is struggling to match the global demand. The recent decision by the Irish Government to include data centres as an asset class into the Strategic Infrastructure Act is intended to provide more time certainty on the planning process and allow data centre business owners to plan with more accuracy.

The metropolitan Dublin area in the near term will continue to be the focal point for expansion due to the clustering effect and access of the off-island fibre networks to the market (EU). With the new and proposed off-island fibre connectivity in Cork, many of the initial ingredients are building. Irish colocation and managed service data centre providers are showing very sustainable growth of 50% over the next six years. The addition of hyperscale and wholesale colocation is providing the greatest challenge as they are anticipating a 100% increase over the same period.

Data centres are designed and built to operate as efficiently as possible with more visibility and certainty on cost and availability. By their nature, they never use the full power capacity of their grid connections. This is at odds with how the Irish utility operators finance grid infrastructure upgrades.

With up to 70% of post-construction operating costs allocated to energy, the relationship between the energy generation, distribution, and supply needs to improve to allow both the provider of the energy and the purchasers (data centres) to develop a model that provides both sides with more visibility and certainty on cost and availability.

Sustainability measures already apply across the full spectrum of the industry. Digital companies are under increasing pressure to demonstrate efficiency and renewable energy procurement. More tangible links between the data and renewable energy industries are becoming evident. This presents a new opportunity to accelerate the deployment of wind and solar projects at commercial scale without requiring REFITs. Recent government-backed energy incentives to attract data centres in the Nordic countries are likely to increase the price delta on the unit price of energy in Ireland compared to Nordic regions. Most of the data stored in Ireland's data centres are exported within the EU28 countries. Ireland is essentially a data exporter. Data has a much higher economic value than the energy that powers it. We should recognise this when trying to evaluate the sustainability of the data industry.

Investment in data centres is significant, and the data industry supports many jobs across the economy. There are also opportunities in the content of the data. We are only at the beginning of the digital age, and Ireland needs to be ready to leverage future trends in data.

Collaboration between the data centre operators, the state utilities, renewable developers, researchers, state agencies, and local authorities will be key to unlocking future opportunities.

David McAuley

Founder & CEO, Bitpower
Host in Ireland Advisory Council

Appendix I

Survey Questionnaire

Host In Ireland

Measuring the Sustainability of Ireland's Data Industry

seai SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Survey

Company	
Contact	
Date	
Survey by	

Topic	Question	Pick
Company Details		
Geographic Details:	Number of sites in Ireland	
	Data Centre Size	
	Physical Location(s) In Ireland:	
	• *Dublin North*	☐
	• *Dublin South*	☐
	• *Cork*	☐
	• *Other (please provide details)*	☐
	How Long in Ireland?	
	Location is Sensitive Information	☐
Parent Company	Location of Parent Company	
	Percentage of global data centre capacity located in Ireland	
	Investment in Ireland (€) to date	
	Planned Investments (€) in Future	
Business Model	Hyperscale (Own Data Centre)	☐
	One Client Lease (To Hyperscale)	☐
	CoLocation Wholesale	☐
	CoLocation Retail	☐
	Software as a Service (SaaS)	☐
	Other	☐

Appendix I

Survey Questionnaire

Topic	Question	Pick
Why Ireland?		
Highlight the key reasons why your organisation is located in Ireland.	Low Corporation Tax	☐
	Skilled Workforce	☐
	Power Availability / Reliability	☐
	Connectivity	☐
	Clustering / Ecosystem	☐
	Policy	☐
	Political Stability	☐
	Research Capacity	☐
	Investment friendly	☐
	Other	☐
Employment		
Number of Jobs associated with your data operations.	Number of Direct Employees in Ireland	
	Number of Indirect Employees (Contractors)	
	Construction Jobs	
	Parent Organisation employees in Ireland	
Energy		
Energy Details:	Electrical Grid Capacity (MVA)	
	% Utilisation (optional)	
	Growth pattern	
On-site generation	On-site Generation Capacity (MW)	
	• *Natural Gas (grid)*	☐
	• *LNG*	☐
	EPA Licensed	☐
	Waste Heat Availability	☐
	Waste Heat Temperature	☐
Renewable Energy procurement	• None - Grid standard renewable 28% (i.e. 22% wind)	☐
	• Power Purchase Agreements (PPA) with renewable generators in Ireland	☐
	• Certificates from Utility	☐
	• Direct Renewable Energy Generation on-site	☐

Appendix I

Survey Questionnaire

Topic	Question	Pick
Sustainability		
Energy Efficiency Metrics	• PuE	☐
	• DCIM	☐
	• ISO 27001	☐
	• ISO 50001	☐
	• EN50600 CENELEC	☐
	• UPTIME Tiers	☐
	• TIA-942	☐
	• ASHRAE TC 9.9	☐
	• BCA-IMDA Green Mark	☐
	• LEED	☐
	• BREEAM	☐
	• EU CODE OF CONDUCT	☐
	• EnergyStar	☐
	• Carbon Disclosure Project (CDP) Reporting	☐
	• Dow Jones Sustainability Index	☐
	• Other (please provide details)	☐
	• Corporate Standard(s)	☐
Technology		
Cooling Technology	• Free Air Cooling	☐
	• Adiabatic Cooling	☐
	• Packaged Chillers / Cooling Towers	☐
	• DX Units	☐
	• Direct Rack Cooling	☐
	• Direct Server Cooling	☐
	• Rotary Heat Exchanger	☐
	• Other (please provide details)	☐
Battery (UPS) Technology	• Lead-Acid	☐
	• Lithium-Ion	☐
	• Magnesium	☐
	• Sodium	☐
	• Flywheel	☐
	• Fuel Cell	☐
Data Centre Design & Innovation	• Raised Floor	☐
	• Contained Hot Aisle	☐
	• Contained Cold Aisle	☐
	• Heat Recovery for office heating	☐

Appendix I

Survey Questionnaire

Topic	Question	Pick
Government Supports You have or plan to avail of.	• Energy Credits (EEOS) - Energy Suppliers	☐
	• Accelerated Capital Allowance for Procurement of Energy Efficient Equipment	☐
	• SEAI EXEED Efficient Design	☐
	• Other (please provide details)	☐
Operational Support Mechanisms	• Demand Side Unit (reduce demand)	☐
	• Run on Diesel (reduce visible demand)	☐
	• Frequency Response	☐
	• Do you understand I-SEM?	☐
	• District Heating	☐
Content		
Sectors Served (Customers)	Government	☐
	Banking	☐
	Pharmaceutical	☐
	Retail	☐
	Telecoms	☐
	Consumers	☐
		☐
Content Type	• Video	☐
	• Search	☐
	• Enterprise	☐
	• eCommerce	☐
	• Gaming	☐
	• VR	☐
	• Gaming	☐
	• Other	☐
	• Unknown	☐
Markets Served	Ireland	☐
	Not Ireland	☐
Trends		
Data Trends		
Energy Trends		
Ireland Trends		
Barriers to development		

Appendix II

Assumptions

Assumptions made in calculating the numbers presented in this report are detailed below. We have made every effort to ensure that the numbers stack up with various top-down and bottom-up strategies. Taking our sample of over 50 constructed and planned facilities, we believe we have collated sufficient information to validate our assumptions. We are confident that the numbers are reliable for use in assessing the power demand and investment in the industry.

Assumptions:

- White space makes up 70% of a data centre building.
- Power density of white space ranges between 1.0 and 4.0 kW/m2, with an average of 1.76 kW/m2 used across the analysis.
- We assume a design PuE (ratio of total power to IT Power) of between 1.25 and 1.4 to allow for worst conditions.
- An IT rack requires 30 square feet of space - 2.79m2/rack. This includes access and aisles etc.
- Data centre construction costs estimated to be between €3m/MW and €8.5m/MW, depending on age and type.
- Average annual power utilisation assumed to be 45% for all data centres.
- CO2 assumed to be 0.45kg/kWh.

Validation of assumptions:

Throughout the data analysis process, we continuously checked our numbers against available information. The resulting model is flexible and can be used for future projections. Some of the methods we used to validate the data included:

- Survey information from participants on energy demand and investment.
- Cross-referencing of power and floor areas available in public domain planning documents.
- Cross-referencing reports of total investment cost by data centre operators.
- Comparison with industry metrics - our numbers tell us that the average data centre uses 5.0 kW per rack, with only a few deviating from this. The trend in the industry is moving towards 30kW per rack, but this only for the latest designs. The trend may be a significant factor as the industry develops.
- Comparison with EirGrid projections (See Appendix IV)
- Our model can be updated as new data centres come on line.

Methodology:

The bottom-up approach to measuring data centre power involves relating the building size to common metrics.

1. Identify the data centre on publicly available satellite maps.
2. Measure the size of the facility's enclosed buildings (i.e., excluding generators and car parks, etc.)
3. Calculate the area (square meters), and reduce to 70% to estimate "white space" - i.e., space for computer servers. We compared this number with planning documents.
4. Apply a metric of kW/m2 of white space. The metric we have used varies from 1.0 to 3.6 depending on the type of operator, with the average at 1.7 kW/m2.
5. Assume a design PuE of 1.4 for worst-case design (i.e., warm conditions with full data utilisation).
6. This gives the total design MW of the building as a data centre.
7. Compare the numbers against other information, including survey results.
8. Fine tune the metrics. This was an iterative process, continuously validating the data against other sources.

We have used conservative factors where possible, and our assumptions are in line with industry norms.

Appendix III

Fibre Connectivity

The Importance of Connectivity

Sub-sea cables are the backbone of the internet. The number of submarine cables across the world has grown dramatically in recent years to meet the demands of the cloud. The time-lapse video linked below shows the growth of international fibre connections since 1990.

Figure 22 - Fibre map of subsea cables since 1990[xvi]

Ireland has been well served with fibre connections to the USA and the UK, many of which were laid in the late 1990s. In recent years, connectivity has increased even more so. In 2015, Cork was connected to Halifax, Nova Scotia, Canada. In 2016, a new fibre connected Killala, Co Mayo with New York. In 2018, a new connection between Ireland and France is due to be completed. These new connections cement Ireland's position in the global Internet, providing the bandwidth through which data makes its way into and out of Ireland's data centres.

Figure 23 - Fibre connections to Europe

In the national context, fibre plays a major role in deciding appropriate locations for data centres. Dublin is very well served by the T50, the Metro Express, and the Dublin Fibre Network. Indeed, the existing clusters of data centres are all located near the T50 network. This offers affordable and resilient connectivity.

Figure 24 - Map of Dublin's Fibre routes, including the T50

Colocation data centres require multiple Points of Presence (PoPs) to offer choice to their customers. PoPs comprise physical connections to telecoms providers, which cannot be easily replicated in remote locations. This is one reason that data centres have clustered in key Dublin regions as opposed to more rural locations.

There are several regional fibre networks serving areas outside of Dublin. These include networks constructed along key utilities: Electric Ireland; Gas Networks Ireland; and Irish Rail.

INEX provide the local traffic management for all data hosting facilities and are a world-class internet exchange with nodes in Dublin, Cork, and Galway.

Appendix IV

Electrical System & Grid Connections

EirGrid and ESB Networks are responsible for the management of the electricity network and the delivery of new power capacity in Ireland. Data centres of scale apply to EirGrid for grid connections. ESB Networks is also part of the connection process. Analysis of the aggregate numbers provided by the grid operators helps us to validate our assumptions.

EirGrid Comparison

We have compared the numbers predicted by our model with those in the latest EirGrid generation adequacy statement[xvii]. There is a close correlation of the data, with our model fitting within the EirGrid low and probable connection scenarios by 2020. See Figure 25.

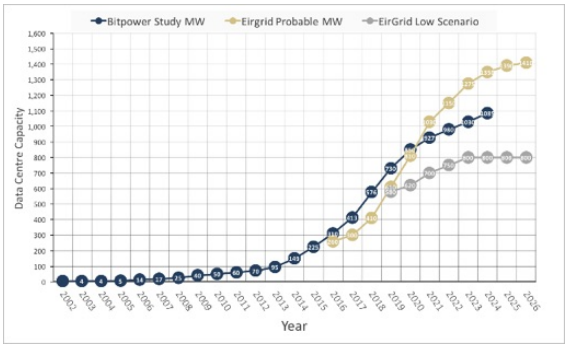

Figure 25 – Bitpower model compared with EirGrid Scenarios.

ESB Networks Connections

ESB Networks have experienced a *"dramatic increase over the last number of years in the ESB Networks North Region (which includes Dublin)"* - see Figure 26.

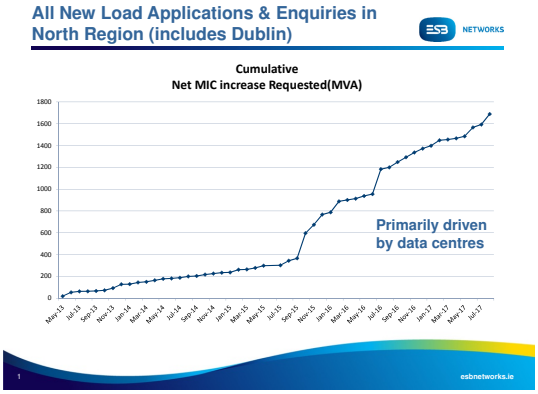

Figure 26 - ESB Networks New connections applications

"Approximately 1400MVA of the enquiries relate to data centres, and although not all of these will come to pass, it is feasible to assume that 1000MVA of new load would come on stream in the Dublin region in the coming years. Overall, the level of customer load connection applications and enquiries that ESB Networks are seeing equate to 30 years' typical load growth compressed into 3-5 years. Data centre-driven load growth alone has the potential to almost double Dublin's load in the next number of years."

"To put the 1000-1400MVA in context, the winter peak for the Republic of Ireland recorded last December was c.6200MVA and load in Dublin is around 1200MVA – this load has built up over the last 90 years of ESB's existence yet the potential step-change in load growth from data centres is required over the next number of years."

Appendix V

On-site power generation capacity potential for supporting the energy system

On-Site Power Generation

Data centres have full power backup facilities on-site. These are for use if the grid supply fails. Batteries provide quick response, and diesel generators provide up to 72 hours' power at full capacity. The generators are licensed by the EPA. For a data centre operator, these assets are under-utilised and represent a stranded asset.

Across our survey, the standard battery technology used is Lead-Acid. Lithium-Ion and Magnesium batteries are gaining in popularity, offering the advantage of lower cooling requirements. One facility has a flywheel system that can offer system services. Parent companies are trialling fuel cells and other storage technologies for integration into their designs.

Natural Gas Grid

Some data centre developers are looking to natural gas to provide on-site generation. This reduces the impact on the electricity grid. They will operate completely off-grid, eliminating the need for an electricity grid connection. They will not export electricity to the grid. Gas Networks Ireland recognise this trend and have identified data centres as an area of strategic growth.

A national biogas market is expected to emerge in 2018. Soon farmers and co-ops will be able to inject biogas into the national gas grid. With the potential for PPAs to be established with off-grid data centres, this could offer a new energy model.

System Services

Our survey reveals that demand-side measures are, as yet, not attractive to data centre operators. Options included reducing demand at system request, running on backup engines, and frequency response. Some operators indicated that frequency response might be worth exploring further.

Key observations:

- Data centres tend to be built to corporate specifications. Any deviations from these can introduce additional complexity and therefore increased risk. There is, however, a growing recognition by tech companies that the power resilience model will need to evolve to accommodate the energy system better.
- For colocation facilities, the power availability is included contractually in service level agreements with third parties. This power capacity is not always available for system services.
- Also for colocation facilities, the cost of energy is often passed on directly to third parties. Different contractual arrangements offer different incentives.

The opportunities available under the soon to be implemented Integrated Single Electricity Market (I-SEM) are unclear to data centre developers and operators.

Electricity grid upgrades

The mechanisms by which electricity infrastructure providers achieve a return on their investment and the regulatory framework (compared to other European locations) is predicated on kWh consumption (rather than kVA capacity), and therefore they are not incentivised to provide large capacity network reinforcement where utilisation is low.

Without significant changes in regulation where network operators can convert capacity (especially stranded) into revenue, ESB Networks and EirGrid will, understandably, be slow to deliver the power density that the DC community believes it needs to grow.

More collaboration is needed with the energy supply, transmission, and distribution systems.

Appendix VI

Power Use Effectiveness metric

Power use Effectiveness (PuE) Metric for Data Centres

PuE is a metric commonly used to compare the facility's overhead power to the IT equipment power use of a data centre. It is most useful in monitoring the long-term performance of an individual data centre, and less reliable for comparing different data centres. It acts more as an indication of performance than a reliable efficiency comparison metric. It is still useful in that it is industry recognised, and it has helped to drive efficiencies.

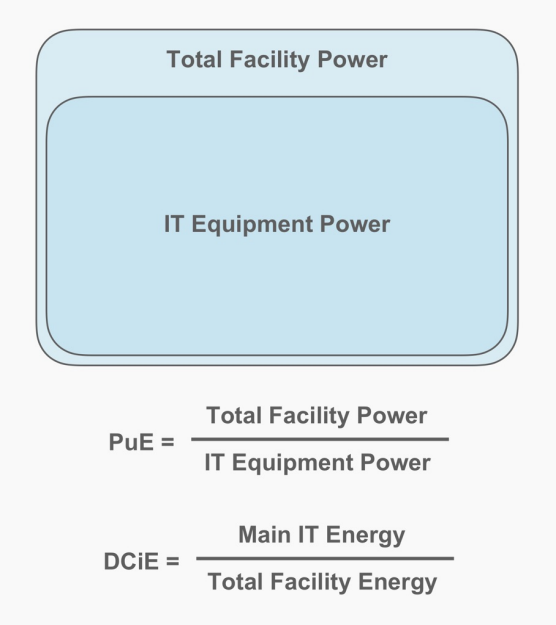

Figure 27 - PuE and DCiE metrics for data centre efficiency.

PuE is the inverse of Data Centre Infrastructure Efficiency (DCiE), another common metric. The perfect data centre would have a PuE of 1.0, but this is impossible in practice. Reported PuEs have improved drastically over the past decade from PuEs of 2.7 in 2010 to PuEs of 1.15 in 2016. (a PuE of 1.15 means that the site requires 15% additional power above the IT load to provide ancillary services, including cooling, UPS, small power, and lighting.

Things that will improve the PuE include:

- Cool climate
- High IT utilisation (economy of scale)
- More efficient UPS and power systems
- Efficient cooling systems. e.g., VSDs, free cooling, adiabatic cooling.
- Ancillary area efficiency
- LED Lighting

In practice, PuE for an individual facility will vary over the seasons, typically lower in winter, and higher in summer. An average PuE over the course of a full year can be used. As a new facility ramps up, the PuE will also improve.

In this study, we have assumed a PuE of between 1.25 and 1.4 when calculating the maximum design power capacity for data centres.

The PuE metric was developed by **The Green Grid**[xviii]. Several other new metrics and methodologies are under development at the Green Grid, in collaboration with Industry leaders, such as Interxion. These include, for example, Infrastructure Utility Effectiveness (IUE).

Infrastructure Utility Effectiveness (IUE)

"This new metric is intended to help determine how much design infrastructure capacity an operational data centre is able to use. It will measure data centres for effectiveness with a range between 100% (indicating design capacity can be fully used) and 0% (not unusable) with a real IUE between 0% and 100% showing some level of infrastructure usage deficiency or stranded capacity. Data centre owners/operators will be able to gauge capacity usage effectiveness and where inefficiencies are and how to find ways to improve resource efficiency." – The Green Grid.

Other **metrics under development** by The Green Grid include IT power; data centre availability; cooling efficiency; and data centre automation using Data Center Infrastructure Management (DCIM).

Appendix VII

Participant & Contributor Acknowledgements

Host in Ireland

www.hostinireland.com

Host in Ireland is an industry-led initiative established to promote Ireland as a world-class location for hosting digital assets. It fosters collaboration in Ireland's data industry amongst organisations who would otherwise compete with each other. This co-opetition approach helps members to find areas of common interest which can be explored to the benefit of the industry. Members include operators of international colocation facilities, and data centre supply chain partners.

We would like to extend our thanks to Host in Ireland's member organisations, and members of the executive and advisory councils for their inputs and insights while developing this report.

Special thanks to Diane Hodnett & Bernard Geoghegan (Host in Ireland Advisory Council), Gary Watson (Keppel DC), Paul Cranfield (Digital Realty), John Shorten & Maurice Mortell (Equinix), Karl Mulhall & Tanya Duncan (Interxion), Eddie Kilbane (Dataplex), Aiden Cawley (Siemens), Barry Rhodes (INEX), Ciaran Hyland (Primary Integration), and Ivan Habovcik (Schneider) for their inputs.

Sustainable Energy Authority of Ireland (SEAI)

www.seai.ie

SEAI is the National Energy Authority. The Energy Research, Development and Demonstration (RD&D) Fund encourages the introduction of innovative solutions which can improve the future market scenarios for Ireland's sustainable energy prospects. The R&D fund can help to accelerate the development of Ireland's research landscape and energy sector.

Thanks to Joanne Sheahan (SEAI) for her support with funding this research.

Bitpower

www.bitpower.ie

Bitpower is a specialist consultancy focusing on power and sustainable solutions for data centres. Founded by David McAuley, Bitpower aims to connect the worlds of energy and digital. In researching this report, we have begun the journey of better understanding the challenges and opportunities these intersecting industries face as they adapt to each other in the coming decade.

Other Contributors

This research would not have been possible without the contributions and insights of state agencies, academic researchers, utilities, and industry bodies. Special thanks to Sean Crowley (Gas Networks Ireland), Leo Clancy (IDA), Martin McCarthy (EirGrid), Clare Duffy & Marguerite Sayers (ESB Networks), Bryan Coyne & Eleanor Denny (TCD Economics), Declan Meally (SEAI), and Haley Elliott (Construction Network Ireland).

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