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INSIDE BELGIUM

Google's European hyperscale data centres and infrastructure ecosystem

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AUTHORS

Dr Bruno Basalisco, Director, TMT & Digital
Sigurd Næss-Schmidt, Partner
Erik Dahlberg, Senior Economist, Technology, Trade & Economic Growth
Holger Nikolaj Jensen, Senior Economist, Energy & Climate
Morten May Hansen, Economist
Charlotte Skovgaard Kjærulff, Analyst
Jasper Lutz, Analyst
Joshua Brown, Analyst
Laura Virtanen, Analyst
Laurids Leo Münier, Analyst

Note to reader: this research piece on Belgium follows the September 2019 pan-European research 'Google's hyperscale data centres and infrastructure ecosystem in Europe: economic impact study' (available here). The following pages provide a deep dive into the economic effects descending from Google's St. Ghislain data centre and related network infrastructure ecosystem in Belgium.

Google has invested heavily and widely in data centres and related infrastructures in Europe. Currently, it operates hyperscale data centres across Europe: Fredericia in Denmark, St. Ghislain-Mons in Belgium, Hamina-Kotka in Finland, Dublin in Ireland, and Eemshaven-Groningen and Agriport in the Netherlands.

Belgium: A vital connection in Europe

Belgium is well placed on the path of digital transformation – capitalising on their current and future infrastructure assets. Already, Belgium has the third highest level of digital connectivity in the EU, enabling everyday Belgians to remain connected to services, such as cloud computing, no matter their location. [1] The Digital Belgium initiative encourages further transformation, highlighting the Belgian government's serious and proactive stance to continue developing Belgium into a leading digital economy. It also represents a direct acknowledgment of the benefits of digital transformation.

Growth and jobs. Belgium is a gateway to Europe for global network infrastructure, as shown by the case study of Google. The company is now facilitating even greater EU-wide connectivity via Belgium. It has done so as part of a wider infrastructure programme which

- Delivered cumulative realised investments of **EUR 2.3 billion** in the St. Ghislain data centre and related network infrastructures, over the period from 2007 to 2020.
- This has supported **EUR 2.7 billion in GDP** in Belgium during the same period.
- Furthermore, **2,800 jobs per year on average** have been supported during the same period.

Network infrastructure. This digital infrastructure effort includes an important, often underappreciated, part of Google's European economic contribution, namely the investment in network connectivity such as fibre links spanning the European continent and linking Europe to the global internet.

In addition to the digital transformation supported by Google's investments, Google's St. Ghislain hyperscale data centre is on the forefront of the green transition in digital energy. The St. Ghislain data centre was the first in the world to run entirely without energy intensive refrigeration. Now, the St. Ghislain data centre is accompanied by an on-site solar farm, as well as using advanced evaporative cooling systems from the nearby canal grey water to keep energy efficiency as high as possible.

Energy efficiency. Every time we as users choose to rely on services provided online, we channel indirect demand for energy. As traditional non-digital activities continue to shift to new digital applications, the way energy is being consumed is changing. The data centre industry has **significantly raised its energy efficiency**. In fact, recent global research established that while demand for data driven services has increased exponentially (by 550 percent) over the past 10 years, data centre energy usage has remained relatively stable (increasing by only 6 percent).[2] At the same time, there is potential to improve efficiency even further. Many services can be handled through the cloud; we find that the business transition to cloud can deliver energy efficiency benefits. As an illustrative example, we

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[1] Bearing Point (2018).

[2] Masanet, E, et al. (2020), Recalibrating global data centre energy-use estimates.

estimate that, if across Europe some further business activities and related servers were to transition to cloud and be hosted by data centres as efficient as Google's, this would **save the equivalent of the annual household consumption of electricity in Ireland**.

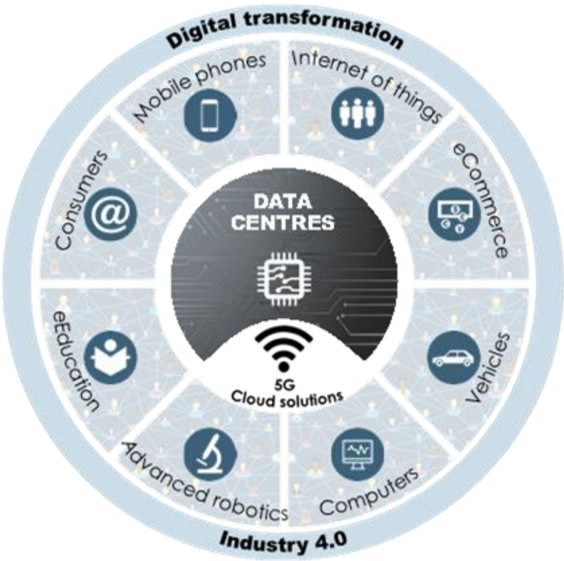
Renewable energy. Driving the green revolution forward, Google is also the largest annual corporate buyer of renewable energy sources. It does so by committing to and signing Power Purchase Agreements (PPAs), key enablers for the renewable energy project developer/investor. As of September 2020, Google had signed 24 PPAs for energy production from European wind and solar farms to match the energy consumption of its data centres. In addition, in September 2020 Google set a goal to operate on carbon-free energy, everywhere, at all hours of the day, by 2030.[3]

[3] Google (2020), Our third decade of climate action: Realizing a carbon-free future. Available at https://blog.google/outreach-initiatives/sustainability/our-third-decade-climate-action-realizing-carbon-free-future/.

1 DATA CENTRES SHAPING THE DIGITAL FUTURE THROUGH CLOUD COMPUTING

The cloud has transformed how companies purchase ICT equipment and services. Cloud computing removes the need for large up-front investments in hardware and software otherwise required for companies to compete in the market. New entrants can increasingly gain access to the storage space and computing power capacity they need in a pay-as-you-go manner and subscribe to advanced applications at an affordable price. Behind the cloud, millions of servers are quietly and efficiently operating in hyper-scale data centres. These data centres are the "brains" of digital infrastructure around the world. They are the physical assets that store, process and/or distribute the data that customers send to the cloud. Hence, to facilitate future growth in data traffic, storage and processing driven by consumers' and firms' use of cloud computing, investments in data centres need to increase.

Figure 1
Data centres at the heart of the European digital future



Source: Copenhagen Economics

Current EU-level and national policies increasingly understand the benefits that the cloud can bring. A priority of the current European Commission is 'a Europe fit for the digital age' – focusing on the advancement of Artificial Intelligence, the Internet of Things and Big Data in Europe, and harnessing the opportunities from data sharing.[4] Given the benefits linked to the cloud, there is increasing policy attention on how to support its role as part of the EU's digital transformation ambition and the building of a European data economy.

In parallel, the current European Commission has stated that it will prioritise progressing the Green Deal for Europe. Therefore, the sustainability angle will be key in underpinning each of the policy

[4] Ursula von der Leyen (2019), *A Union that strives for more – My agenda for Europe*, and European Commission (2019), *Mission letter to Margrethe Vestager, Executive Vice-President-designate for a Europe fit for the digital age*.

efforts that can contribute to the success of the European digital transformation, such as work in the areas of:

- The European Cloud initiative
- The Internet of Things (IoT)
- Building a European data economy including big data
- Artificial Intelligence (AI)
- High-Performance Computing

For these digital advancements to take place, the cloud is a key pillar. In turn, an effective, sustainable and efficient cloud needs support from well-functioning digital infrastructure with data centres at the core. National policy makers and other interested parties also vested in the development of the digital economy in the EU should thus continue to foster support for the data centre and related infrastructure layer, as discussed in our September 2019 study.[5]

Box 1 Data centres contribute to realise Belgian digital policy aims

The EU Digital Economy and Society Index shows that 30 percent of Belgian firms have incorporated cloud computing services of at least medium-high sophistication, making it the country with the sixth highest share in the EU.[6]

Belgium has a clearly formulated and documented Cloud Strategy from January 2019.[7] It contains six strategic principles that form the guideline of cloud uptake for the public administration:

- A cloud-based solution should always be the first choice.
- All entities must formulate a roadmap of cloud uptake and are then presented with a multi-cloud offer to identify the most efficient technology.
- The transition to fully public cloud computing will be smoothened by hybrid cloud computing.
- The strategy guarantees a central risk mapping and controlling.
- Finally, public cloud services will be preferred over private cloud services.

To support SMEs in their endeavours with AI technologies, the AI Policy plan[8] makes funds available for firms to scale up their adoption of AI tools and solutions. The plan emphasises that Cloud computing is the basis for the uptake of the supported AI technologies.

Belgian officials have also committed in a digital strategy to support manufacturing firms' transition into an Industry 4.0 environment.[9] The digital strategy also incorporates an AI promotion program, which has as its aim to accelerate the adoption of AI and to develop the AI ecosystem.[10]

5 Copenhagen Economics (2019), Google's Hyperscale Data Centres and Infrastructure Ecosystem in Europe.
6 European Digital Society and Economy Index 2020.
7 Vlaamse overheid (2019), Cloud strategie.
8 Vlaams Beleidsplan Artificiële intelligente.
9 Digital Wallonia 2019-2024.
10 DigitalWallonia4.ai.

The increasing demand for cloud services (data storage, machine learning, content, payments, e-commerce, etc) means that global internet companies like Google are now among the most efficient facilitators of global data centre growth. Global internet companies are especially efficient as they are able to consolidate storage and cloud-processing of data in 'hyperscale' data centres.[11] This translates to larger-scale, purpose-built facilities with a focus on operational costs and efficiency that are better positioned to meet the growth in demand for cloud services and the like. The importance of these efficiency gains is evident in global market trends. Cisco estimates that in 2021 hyperscale data centres will constitute around 53 per cent of data centre servers globally – up from 27 percent in 2016.[12] Similarly, Arizton estimates that the hyperscale data centre market will continue to expand from 2019 to 2024 at a compound annual growth rate (CAGR) of 9 per cent.[13] In terms of the entire 'datasphere' (the data lifecycle from creation, capture, and replication) growth projections from IDC suggest the total size will increase from 33 ZB[14] in 2018 to 175 ZB by 2025, representing a CAGR of 27 percent.[15]

Therefore, just as is the case for players across the industry, there is expected growth in user demand for Google services. These include many services widely used for general productivity and consumer benefit (provided with open access akin to public goods) such as Gmail, Google Maps, Search and Android. This suggests that Google's investments in data centres in Europe will continue (as observed in the past years) to increase over time as demand for and use of these services expands given the important consumer benefits delivered. As summarised below (and analysed in our September 2019 report), as users choose to rely on services provided online, cloud infrastructures play a key role in an efficient delivery of these services, including in terms of energy efficiency. Besides, we find that the data centre industry has significantly improved its energy efficiency performance, while Google's data centres outperform the industry average. Furthermore, an important recent development associated with the Covid-19 crisis is a societal push for faster and deeper digital transformation across sectors of economic activity. Consequently, **Google's economic contribution to Belgium and Europe will very likely continue to increase in importance**.

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11 Hyperscale data centres refer to those data centres that have an ability to scale their computing capacity in response to increased demand. Scaling in turn refers to the ability to increase computing power through better infrastructure, storage facilities, or memory.

12 Cisco (2018), Global Cloud Index (2016-2021), Available at https://newsroom.cisco.com/press-release-content?articleId=1908858.

13 Arziton (2019), Hyperscale Data Center Market - Global Outlook and Forecast 2019-2024.

14 This refers to 'zettabytes', were 1 ZB is equal to 1000^7 bytes.

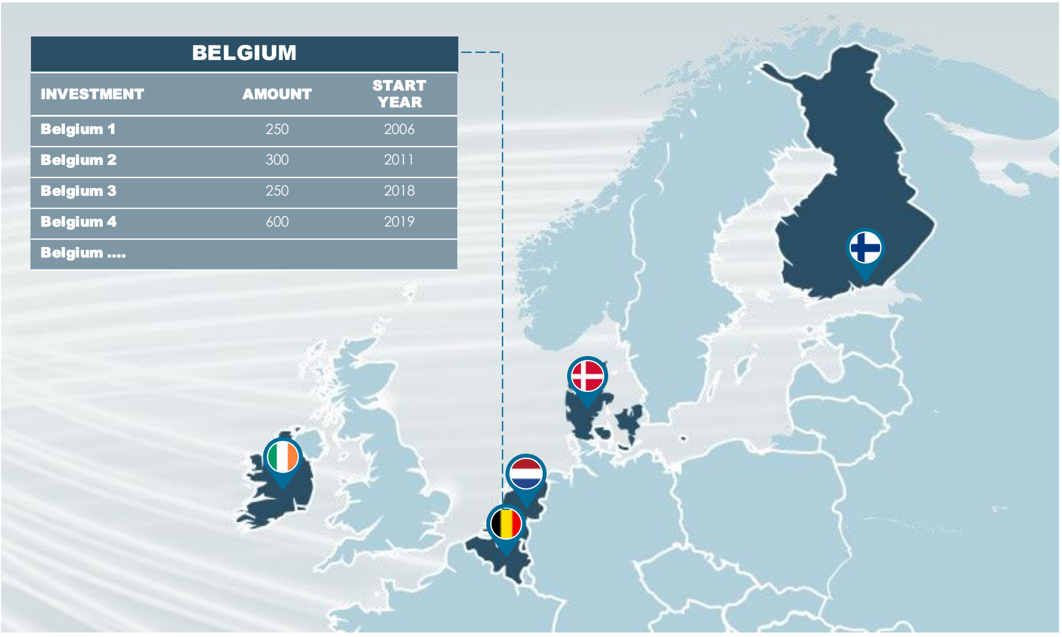
15 IDC (2018), The Digitization of the World: From Edge to Core.

2 QUANTIFYING THE GDP AND JOBS IMPACTS OF GOOGLE'S DATA CENTRE INVESTMENTS

Google's investments in digital infrastructure in Belgium help to propel the country further forward as a leading digital economy. These digital infrastructure investments include data centres, network infrastructure and equipment, management, and access and computation, as well as PPAs and wider energy contracts – elements that are vital to sustaining our increasingly digital culture.

As one of the largest technology companies in the world, Google serves a significant share of users from their data centre in Belgium. Google's data centre at St. Ghislain started construction in 2007 before becoming fully operational in 2010 (see Figure 2).

Figure 2
Ongoing and past construction investment in Google's national data centre



BELGIUM		
INVESTMENT	AMOUNT	START YEAR
Belgium 1	250	2006
Belgium 2	300	2011
Belgium 3	250	2018
Belgium 4	600	2019
Belgium		

Source: Copenhagen Economics based on Google data centre website and data provided by Google

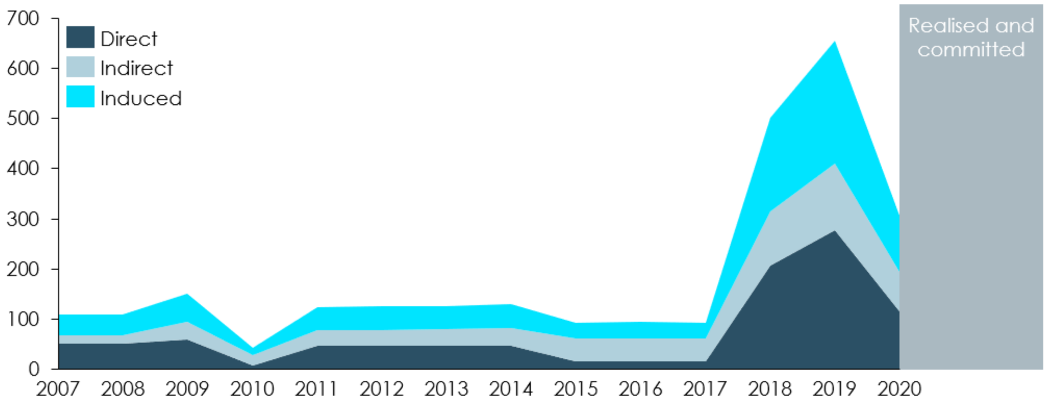
Every time a firm (domestic or foreign) invests in construction and infrastructure like Google's data centre in Belgium, it is reasonable to ask – how much of this investment will remain local versus will leave the region or country (via imports, etc)? To help answer this question, we have applied an established economic (input - output) model to measure the impact of Google's investments. We do this by measuring two dynamics – supported economic activity (GDP) and supported jobs (FTEs)[16] by Google in Belgium.[17]

[16] FTE refers to Full Time Equivalent job, where 1 FTE equals 40 hours per week.

[17] The CE input / output model compared the Google expenditure sectoral pattern and mapped it against the official national statistics, from the Belgian Federal Planning Bureau. The model is calibrated on the basis of Eurostat sectoral accounts that are built on the latest information on the EU countries' national economy and sectoral patterns, across all value chains.

We find that when considering the direct, indirect, and induced effects, Google's total investments in the St. Ghislain data centre and related infrastructures has a supported economic impact of **EUR 2.7 billion in GDP cumulatively over the period 2007-2020.** This impact has grown over time from a yearly impact of EUR 40 million to a peak yearly EUR 650 million (see Figure 3).

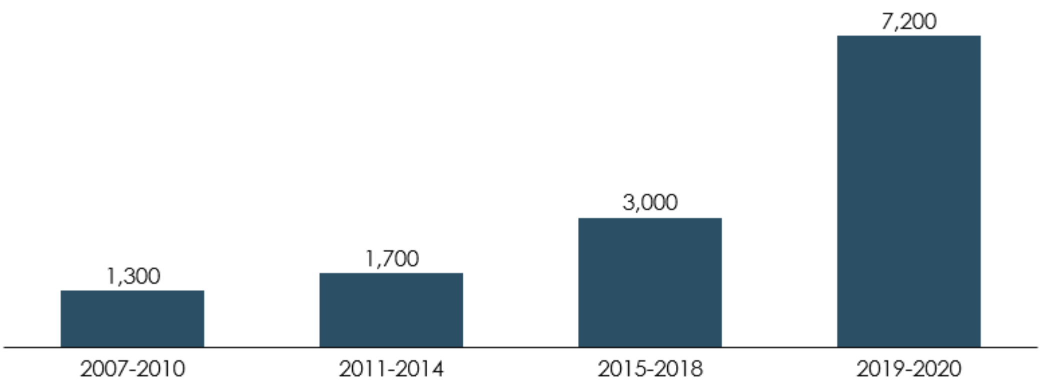
Figure 3
Economic impact supported by Google data centres and related infrastructure
EUR millions per year



Note: The figure shows the supported economic contribution in Belgium due to the construction and operation of Google's St Ghislain data centre and related infrastructures.
Source: Copenhagen Economics based on data provided by Google, Eurostat, and World Input-Output database.

Through its expenditures up until 2020, Google's St. Ghislain data centre and related infrastructures have supported an ongoing employment contribution of up to 7,200 FTE jobs per year (during 2019-2020) including direct, indirect, and induced effects (see Figure 4).

Figure 4
Jobs supported by the St. Ghislain data centre and related infrastructure
Full Time Equivalent jobs, annual averages

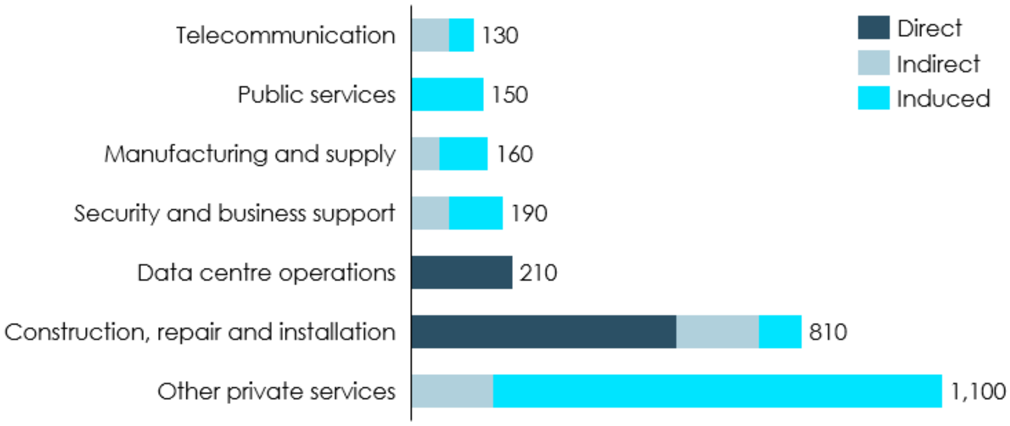


Note: Figures include direct, indirect, and induced employment associated with the expenditures in scope of this research.
Source: Copenhagen Economics based on data provided by Google, Eurostat, and World Input-Output database.

We find that the data centre construction and operation support jobs across a range of sectors of the economy. The largest of these is the construction sector, within which the supported jobs amount to approximately 800 FTEs per year, on average during the period 2007 – 2020.

The data centre activity at St. Ghislain stimulates consumer consumption, as workers spend their wages throughout the Belgian economy. These induced effects support jobs mostly in private services, as this is where employees tend to spend their wages. As a result, the overall set of supported jobs includes other private service industries, such as retail trade, transport, hotels and restaurants, real estate, legal, accounting, and employment activities, as reported below in Figure 5. In total, the supported jobs (direct, indirect, and induced) amount to 2,800 per year, on average during the 2007-2020 period.

Figure 5
Jobs supported by the St. Ghislain data centre and related infrastructure, by industry
Yearly average for the period 2007 – 2020



Note: 'Other private services' include (but are not limited to) retail trade, transport, hotels and restaurants, real estate, and legal, accounting and employment activities.
Source: Copenhagen Economics based on data provided by Google, Eurostat, and World Input-Output database.

Some of these industries, such as security, are proximity services and therefore are supplied locally, whereas other goods or services can be supplied from further afield. The jobs supported by Google will therefore not only support local employment in Wallonia around St. Ghislain but also employment in other parts of Belgium. Similarly, as supply firms and workers spend the income obtained from data centre work on other products and services, the indirect and induced ripple effects extend to both the local communities and the rest of Belgium.

3 ENGAGING WITH THE WORLD FROM THE HEART OF THE EUROPEAN UNION

The economic literature on the role of foreign direct investments in promoting a country's productivity points to skills transfers as a key channel by which a country stands to benefit from these kinds of investments, especially relative to new technologies.

In the case of data centre investments, the case study of Google shows a particular form of skill transfer, taking place via collaboration with educational institutions aimed at promoting the skill base in the local and national workforce. This delivers win-win-win benefits to students, to Google and other firms operating data centres (or industries relying on comparable skills), as well as the country as a whole, since an up-to-date skill base is key to succeed in a knowledge economy.

Box 2 Bringing data centre education to the world

Haute École Louvain en Hainaut, or HELHa, is a multidisciplinary college located in the French speaking province of Wallonia in southern Belgium. The college offers a wide range of courses designed with the goal of preparing students for the practical challenges of the future, one of which is the unique Master in Data Centre Engineering, developed with support from Google. This programme was developed in direct response to the need for both significantly more employees in the data centre industry and skills tailored specifically for the industry.

As part of the Technology and Engineering faculty, the Data Centre Maintenance programme is the only one of its kind in Belgium. The programme is offered almost entirely online over two years, where students can continue working whilst studying. English is the main tuition language, which enables student attendance from around the world. Testament to the cutting-edge nature of the programme, during the recent Covid-19 pandemic, the programme was able to continue with relatively few interruptions.

However, given the practical nature of data centre maintenance, students attend a one-week workshop in Belgium where they can directly interact with specialised equipment. One such example is a cooling tower that was built for the Data Centre programme through support from Google. This tower is now also used by other engineering and technology programmes, a positive spill-over benefiting the training of a broad set of students across disciplines and future areas of employment.

To satisfy student needs, HELHa strives to deliver a dynamic programme. It does so by working very closely with industry representatives (including Google) and past students so to improve and adapt the data centre maintenance programme. Furthermore, a core component of the programme is an 'integrated project' module. This module forces students to work practically within the data centre industry, thereby putting their theoretical knowledge to the test.

Feedback is important to stay dynamic. HELHa is focusing on the continued need to reduce the environmental impact of data centres – which it sees both as a challenge and an opportunity for the students. As a result, HELHa has included a dedicated module to energy efficiency and renewable or sustainable energy in its data centre maintenance programme. With Google support, HELHa has delivered a lecture for the European Commission on energy sustainability in the data centre industry.

Besides, via Google, HELHa is linked to other educational institutions in this field, sharing knowledge and ideas across borders. This network therefore makes it possible for students to experience the best ideas from across the EU, whilst offering the additional opportunity to gain experience and work in other data centre hubs, e.g. Denmark or Finland – all of which leads to cutting edge skills for those working in Belgium or abroad.

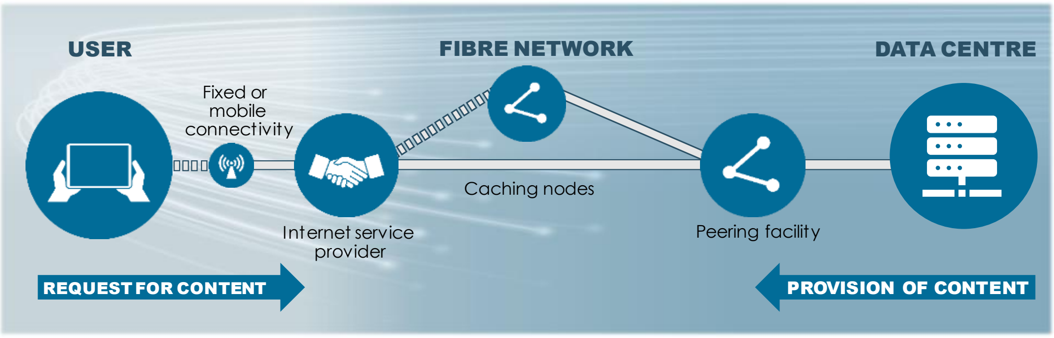
Source: Interview with Vesna Jerkovic (Research manager), Stéphanie Eggermont (Datacenter training manager) and Valérie Seront (Director of engineering school), Job roles, HELHa, July 2020

4 NETWORK INFRASTRUCTURE STRENGTHENS LINKS BETWEEN BELGIUM, EUROPE AND THE WORLD

A key driver encouraging network investment is to bring the benefits of Google computing and cloud resources closer to customers. In internet network design jargon, this is the often-underappreciated role of "edge" infrastructure – the vital links in proximity to where consumers and firms use digital services. Providing network connectivity allows Belgians to reach core cloud services by connecting with Google closer to their point of use. By facilitating this connection on dedicated infrastructure in nearby cities or towns, the speed at which these cloud services can be reached is increased. In effect, this brings the services of the harder-to-reach St. Ghislain data centre closer to Belgian consumers, ensuring a faster and more responsive cloud experience.

From a consumer's perspective, the visible reality of the internet tends to be what is regarded in the industry as internet access links. Internet access links consist mainly of Internet Service Providers (ISPs) – often telecommunications companies that provide either 1) fixed services in the home or office, often accompanied by a modem, or 2) mobile services through mobile telephone subscriptions or other similar wireless devices, see Figure 6 . Thus, some consumers might believe that ISPs are the only firms backing connectivity infrastructure – however, this is incorrect.

Figure 6
How data centres reach users: Google's design, high level view



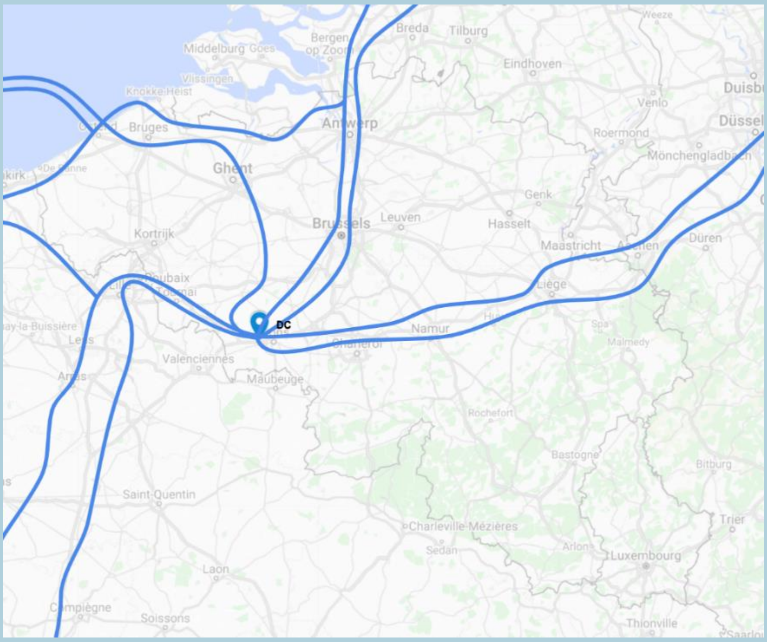
Source: Copenhagen Economics based on Google

The inner network part of the internet (less visible compared to the connections to homes and firms) is what is referred to as the backbone of the internet (split broadly onto the 'core' and 'edge'). At the core, data centres host files and apply computational processes so that the information can serve users' requests. To reach users, hosting activity needs high-capacity transport networks that connect data centres to peering facilities. This network infrastructure (increasingly fibre) reaches peering facilities, or Points of Presence (PoPs), at the 'edge', connecting Google's network to the rest of the internet. At that point, PoPs serve as the connecting points for the ISPs at the front end of the internet. From the PoPs, internet traffic is handed over to ISPs, which take over the responsibility for carrying the internet services to homes and offices. In addition to this, Google also maintains the Google Global Cache (GGC) network through caching nodes, provided to ISPs. These smaller pieces of infrastructure at the "edge" enable basic data requests to be brought even closer to consumers, providing even greater responsiveness.

As a result, **Google procures and maintains a major global network connecting key infrastructure** such as data centres, cities and towns, and network hubs. Google's network connects Europe through several major sub-sea landing points to the rest of the world. Of equal importance – and perhaps a surprise to some – Google's global network includes a **major terrestrial network spanning across Europe**. Covering the continent, this network includes key north-south and east-west connectivity corridors, extensive city-scale networks, edge networks to more regional locations, and access connectivity to more far-flung corners of Europe. Ultimately, Google's network connectivity effort reflects the business and market imperative to ensure the best experience for firms' users and customers within Belgium and abroad.[18]

Box 3 Fibre network connectivity linking St. Ghislain and Belgium to Europe and the world

Google's data centre in St. Ghislain, Belgium is a major destination for US-EU traffic traversing the Atlantic on multiple, dedicated submarine fibre optic links. It is served on low latency sub-sea and terrestrial paths from France, Germany, the Netherlands – as well as Spain and the UK.



The connection to France is particularly important, since in July 2018 Google announced an ambitious project to deliver the Dunant subsea cable project. This cable crosses the Atlantic from Virginia Beach in the US to the French Atlantic coast and will extend from there to Google's data centre in Brussels over dedicated fibre infrastructure. This cable is expanding Google's network to help it to serve users and customers. It does this by **supplementing one of the busiest routes on the global internet** with high-bandwidth, low-latency, highly secure connectivity. Google will work with Orange telecom to land the cable in France and for the onward connectivity across France. As an added benefit and spill-over, Orange will also have use of Dunant trans-Atlantic.

18 Read more about these in the main report, which can be found here.

A key European and national infrastructure policy aim has been to reuse civil engineering infrastructure so to stimulate network growth in an efficient manner. Working with local, pan-European and global providers, Google has invested so to place dark fibre assets (links enabling high-performance networking) across **multiple existing infrastructure** types in Belgium including overhead power lines, gas infrastructure as well as purpose-built duct infrastructure in data centre locales. This long-term infrastructure investment helps ensure security of connectivity supply to Google's major data centres enabling them scale to meet ever growing demand while remaining critically interconnected with European cities, countries and the rest of the world.

Furthermore, Google upgraded its network infrastructure with dedicated new diverse long-haul terrestrial optical cables ensuring long term exponential traffic growth. Google's investment delivered the CAPEX enabling a local partner vendor to tap into investment synergies and thus accelerate the fibre installation and refurbishment of several legacy telephone exchanges, as well as upgrading backbone connections in rural parts of the Walloon region. For citizens and firms in the region these synergies based on the Google data centre presence and investment bring benefits by supporting a wider / faster fibre network roll-out serving the region.

Source: Interview with Fionnán Garvey, Global Network Acquisition at Google in August 2020.
Further information on the role of subsea cables is in the Copenhagen Economics (2019) Google's Hyperscale Data Centres and Infrastructure Ecosystem in Europe.

5 DATA CENTRES HELP DIGITAL USERS CONSUME ENERGY MORE EFFICIENTLY AND SUSTAINABLY

Every time we choose to use services online, we channel indirect demand for energy. As traditional non-digital activities continue to shift to new digital applications, the way energy is being consumed is changing. Therefore, we will examine:

(i) the efficiency of this energy use;
(ii) the sustainability of its supply; and
(iii) the role of energy users' procurement in promoting renewable energy

Energy efficient provision of online services via cloud and data centres

Contrary to the belief that the rapidly increasing demand for data will lead to a one-to-one increase in energy usage, ongoing improvements in global data centre efficiency have prevented this from transpiring. In fact, **data centre energy usage over the past 10 years has remained relatively stable** (increasing by only 6 per cent), **despite the exponential growth in demand** for data driven services (by 550 per cent).[19] This confirms the energy efficient trajectory and achievements of digital solutions provided via cloud computing through hyperscale data centres.

While storing and processing data requires energy to deliver services, Google's solutions exhibit a meaningful improvement to the energy efficiency of this data-handling process. Large data centres like Google's site at St. Ghislain are significantly more energy efficient than the individual servers that they often replace. By pooling the server needs of many customers in this manner, a lot of energy can be saved. Indeed, we have analysed the yearly energy savings that moving service to a cloud-based provision delivers and we find significant savings (see calculation reported in the box below).

Sustainable supply of energy for data centres

As well as improving the energy efficiency of delivering digital services, Google also aspires to ensure that its energy consumption is as sustainable as possible. Since 2017, Google has matched 100 percent of the annual energy demand of its data centres and offices with direct purchases of renewable energy on a global basis. Continuing to operate data centres with entirely clean energy is a key objective for firms like Google, the wider corporate world and our societies.

At the same time, even though the company buys a total amount of renewable energy matching its electricity use each year, it must still contend with times and places when the sun does not shine or the wind does not blow – indeed a society-wide challenge. During those hours, Google data centres (and likely most other energy users across the economy) often must rely on electricity sources such as coal and gas power plants, which emit carbon. Tackling this societal challenge, in a significant further step, Google announced its intent to run on carbon-free energy everywhere, at all times (24/7), by 2030.[20] In other words, the company is raising further its sustainability by shifting from a 'global and annual' match, to a 'local and hourly' match of clean energy to its use – a first in the corporate world.

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19 Masanet, E, et al. (2020), Recalibrating global data centre energy-use estimates.

20 See Google (2018), Moving toward 24x7 Carbon-Free Energy at Google Data Centres: Progress, and Insights and Google (2020), 24/7 by 2030: Realizing a Carbon-free Future. Available at https://storage.googleapis.com/gweb-sustainability.appspot.com/pdf/24x7-carbon-free-energy-data-centers.pdf and https://www.gstatic.com/gumdrop/sustainability/247-carbon-free-energy.pdf.

Machine Learning and Artificial Intelligence tools can be used to help achieve this complex balancing act. Google is now integrating carbon-intelligent computing platforms into their data centres, having already tested such solutions. These systems would allow data centres to balance server usage with clean energy across time and location. This means that some percentage of that computing power can be shifted to times when – or locations where – greener sources of energy are in surplus.[21] The scale of the data centre matters in both achieving business and environmental aims, giving a socio-economic advantage to hyperscale data centres. [22]

Box 4 National energy savings of handling e-mail through the cloud

Many services can be handled through the cloud; we find that the business transition to cloud can deliver energy efficiency benefits. As an illustrative example we look at the implications of shifting e-mail handling services to cloud servers. This is, however, just one example where moving from in-house servers to data centre storage would greatly increase energy efficiency. An in-house e-mail server can use up to 175 kWh annually per user. This can be compared to the 3.3 kWh annually per user used in an average European data centre.[23] In contrast, Google's even more efficient data centres use only 2.2 kWh annually per user.[24]

For our calculation we assume that Belgian firms that are not using cloud are using in-house equipment. We estimate the related electricity for in-house storage to be 151 GWh annually. This estimate is based on official survey statistics capturing the number of staff working with computers in firms of different sizes, and the share of cloud use by firm size. Average cloud use across companies is calculated to be 37 percent.[25]

Hence, moving all e-mail services to the cloud based in data centres with an efficiency equivalent to Google's would:

- Reduce current electricity use for e-mail services in individual companies by 151 GWh
- Increase electricity consumption in data centres by 4 GWh

Based on the distribution of firm sizes in the national economy, we estimate that the above corresponds to a net reduction in current usage of 98 percent, equivalent to a decrease by 147 GWh.[26] This is broadly equivalent to about 10 percent of annual consumption of electricity by Belgium's entire transport sector in 2018.[27]

Source: Copenhagen Economics, based on Eurostat

[21] See Google, (2020), Our data centres now work harder when the sun shines and wind blows (blog). See also Google (2021) We now do more computing where there's cleaner energy (blog).
[22] Further information on energy efficiency is available in Copenhagen Economics (2019), Google's Hyperscale Data Centres and Infrastructure Ecosystem in Europe.
[23] Assuming that differences in energy use between Google's and average European data centres are due solely to overhead energy efficiency.
[24] See Google (2019), Environmental report, and Google (2011) Google's green computing: efficiency at scale.
[25] Eurostat data found in isoc_ci_eu_en2 (2018) and sbs_sc_sca_r2 (2017).
[26] Calculations assume that all the resulting new data centre activity is as energy efficient as Google's data centres (2011).
[27] StatBel, Energy Usage Statistics: Energy consumption statistics – Electricity (2020).

Renewable energy procurement supporting the Belgium digital transformation
As with other Google data centres, the St. Ghislain data centre is at the frontier of energy efficiency. Relying on an advanced evaporative cooling system from a nearby industrial canal, the site uses an on-site water purification system to avoid using water from the city. As a result, the St. Ghislain data centre was the first centre run by Google entirely without electrical refrigeration. Adjacent to the data centre is an on-site solar plant built through a EUR 3 million investment from Google. Recognising the exceptionally high energy efficiency, the **St. Ghislain data centre has twice been awarded the distinction as the most efficient large data centre in the EU** by the European Commission (in 2012[28] and 2018[29]).

The high energy efficiency of the St. Ghislain data centre is one way in which Google supports sustainable digital services in Belgium. Further improvements to the overall sustainability of these services are achieved through Google's energy procurement strategy. As noted previously, since 2017 Google has matched 100 per cent of the annual energy demand of its data centres and offices with purchases of renewable energy.[30] As part of this, Google has developed one of the largest portfolio worldwide of corporate renewable Power Purchase Agreements (PPA).

Via PPA deals, Google signs contracts with developers of renewable projects and supports the production of carbon free energy. Entering into these transactions enables wind and solar farms to secure the financing they need to get built, something that is promoted by Google's intervention and commitment. In this way Google's operations in Belgium drive the development of new renewable energy assets.

In 2019, Google invested in its largest renewable energy purchase ever, consisting of 18 individual deals globally.[31] These deals include Google's first-ever PPA for offshore wind and first PPA in Belgium, for 92 MW from the Norther project in the Belgian North Sea, approximately 23 kilometres from the Belgian port of Ostend.[32]

Across Europe, Google has signed nearly 1,700 MW of PPAs with renewable energy developers, **making Google one of the largest corporate buyer of renewable energy** in Europe (it is nearly 5,500 MW globally, equivalent to a million rooftop solar panels).[33] Google's contracts have enabled investments in renewable energy projects across the world of over EUR 6 billion, including EUR 2.3 billion in Europe. As a result, it has been possible for every kilowatt hour of electricity consumed at Google data centres to be matched, on an annual basis, by a kilowatt hour of renewable energy from a wind or solar farm.

[28] https://e3p.jrc.ec.europa.eu/events/2012-european-code-conduct-data-centre-awards.
[29] https://ec.europa.eu/jrc/en/news/eu-code-conduct-data-centres-10-years-improved-energy-efficiency.
[30] Google (2020), Our data centres now work harder when the sun shines and wind blows.
[31] See Google (2019), Our biggest renewable energy purchase ever.
[32] See Recharge News (2019), Google buys first ever offshore wind power as part of 'record deal'.
[33] See Copenhagen Economics (2019), Google's Hyperscale Data Centres and Infrastructure Ecosystem in Europe.

6 CLOSING REMARKS: A MULTI-SECTOR POLICY APPROACH TO REAP BELGIUM'S AND EUROPE'S DIGITAL INFRASTRUCTURES' OPPORTUNITY

To conclude this study, we turn back and reflect on what, as economists, we have learned as part of this research journey and what related elements could be of socio-economic and policy interest. On this basis, our September 2019 study has highlighted exploratory suggestions on what to research and discuss further.

First, environmental considerations are top of the current agenda across Europe and achieving these will depend on vision, as well as attention to detail. Regulatory impediments can block or delay the private sector's role in fostering the green transition via smart procurement of renewables. National divergence in regulatory conditions and best practices can discourage efficient PPA procurement across Europe. The latter is key to satisfy the internet users' demand for digital services to be underpinned by green ICT, as firms and citizens transform their consumption from physical (and its energy inputs) to digital products and processes (and their energy inputs).

Second, the development of pan-European digital infrastructures involves a lot of nitty-gritty at the national and local level. This includes electricity network capacity, telecom infrastructure provision, educational systems delivering up to date technical skills – as well as traditional matters such as efficient planning and permitting processes.

Last, the topic of digital infrastructures is inherently multi-disciplinary. Just as the private sector (Google is a case in point) brings together experts from different specialisations to develop and make use of infrastructures – it is very relevant for national policy makers to come together, interact, and collaborate to ensure a timely and sustainable infrastructure development supporting the digital transformation. It follows that a combination of sectoral expertise and public policy processes (areas such as education, employment, energy, environment, planning, telecoms) are key to design in theory and ensure in practice, virtuous framework conditions for the development of digital infrastructures such as those analysed in this study.

Note on Covid-19: Our calculations are based on information (public statistics such Eurostat, as well as Google expenditure data) made prior to the recent Covid-19 pandemic. While the overall method, relying on Eurostat input-output tables, remains a relevant basis to assess economy-wide effects of investments, future research may shed light on any changes in patterns of economic activity across value chains. This will rely on any updates from national statistics, as they gather retrospectively information about economic activity.

Disclaimer: the reports are Copenhagen Economics analysis based inter alia on Google publicly available investment announcements.

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