

**Louvain School of Management**

**Economic and Environmental Aspects of  
the Walloon Colocation Data Centre  
Industry in Early 2021**

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## Abstract

Data centres are key infrastructures in the digital economy era. They play an important role in supporting cutting-edge technologies such as cloud computing and the Internet of Things, in a rapidly changing landscape. These digital infrastructures are constructed almost anywhere around the world and aim to and process data on the Internet. This qualitative study aims to understand the data centre industry offering B2B hosting in Wallonia, called colocation data centres. This analysis starts by selecting several assets for an attractive data centre market as the key success factors. These factors are the cloud offer, fibre connectivity, market importance, ecosystem, sustainability, and government incentives. Then, there is an analysis of these factors in the Walloon colocation data centre industry. In addition, the analysis uses the Porter diamond model composed of four main attributes (factor conditions, demand conditions, related and supported industries and firm strategy, structure and rivalry). This model brings together the assets of Wallonia that constitute the national environment in which companies compete. The conclusion is not advantageous. Wallonia does not have enough key success factors to attract investors wanting to install a data centre. The results show different assets acquired such as a favourable tax system, the presence of Google which invests a lot in the region, optic fibre network, availability of land. However, negotiations and obtaining building permits take time in a weak ecosystem. The main limitations of this study are the state of an industry in a short period, a geographical area that does not have much scientific research due to the small size of the Walloon market. Some future research can be done, mainly about another category of data centres such as enterprise or micro data centre which is a promising technology.

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“The computer industry is the only industry that is more fashion-driven than women's  
fashion.”

– Larry Ellison,

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## **Introduction**

All services requiring an Internet connection use data centres infrastructure. Their purpose is to store data while making it accessible on the Internet without interruption. The industry has experienced strong growth for several years. Mr Lea, data centre manager, confirms that "[...] the data centre market will continue to grow for some time because the demand is there, it is exploding" (Annexe 4: Interview 1 Comarch).

Unfortunately, most people do not know technologies used in the digital sector such as data centres. Yet businesses and individuals depend on them. Recently, the COVID-19 pandemic has demonstrated the importance of online services to the global economy. Therefore, the industry of these digital infrastructures requires a broader understanding.

Currently, Belgium has a total of 416 data centres on its territory among 62,582 in the 28 European Union (EU) member states in 2020 (JRC Science for Policy Report, 2020). Three regions compose Belgium: the Walloon Region, the Flemish Region, and the Brussels-Capital Region. Each region has its government which legislates several areas, including the economy and the environment (Belgium, s.d.). On a regional level, the Walloon Region has its own strategy concerning the development of data centres.

In 2007, Google chose Wallonia to set up one of its first data centres in Europe (Google, n.d.). The assets of this area may have influenced this decision. However, it remains the only major data centre to have chosen this location, the other GAFAM companies (Google, Apple, Facebook, Amazon, and Microsoft) preferred other European markets, mostly in the FLAP-D markets. The FLAP-D markets are areas with the highest concentration of data centres in Europe and include the cities of Frankfurt, London, Amsterdam, Paris, and Dublin (Zhang, 2021).

In addition to Google, Wallonia has other, smaller data centre operators. These offer colocation services, which are hosting services for IT infrastructure, to companies.

This study examines the Walloon colocation data centre industry by evaluating the efficiency of its factors according to key success factors which creates an attractive market for a data centre operator. The analysis summarises the Walloon assets in Porter's diamond model to understand this business environment.

There are three parts of this paper: the literature review, the empirical analysis, and the conclusion.

Four chapters constitute the literature review. The first one on technology explains the theoretical framework of data centre infrastructure and highlights five elements including building and IT equipment, power connection, cooling system, redundancy, and security. The second chapter provides an understanding of the size of the markets in Europe and the current trends in the industry. The third chapter develops the two environmental impacts increasing the carbon footprint of a data centre including excessive electricity consumption and heat production and discusses some existing solutions.

The second part starts with an explanation of the methodology including a list of companies interviewed, the choice of the key success factors and some useful strategic tools. Next, there is the field study with different subsections related to the key success factors. These parts develop the assets or inconveniences of the Walloon colocation data centre industry.

Finally, the third part of this study concludes this thesis by presenting a synthesis of the results, limitations, and recommendations for future research as well as a discussion of the data centre industry.

## First Part: Literature Review

### Chapter 1: Data Centre Technology

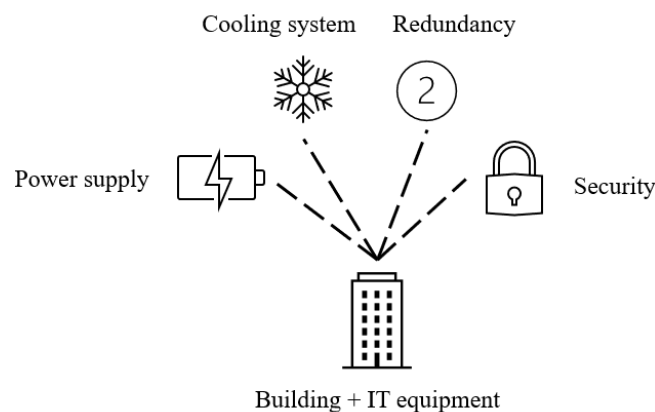
#### 1.1 Infrastructure

According to the European Commission, the definition of data centres is:

Structures, or groups of structures, dedicated to the centralised accommodation, interconnection and operation of information technology and network telecommunications equipment providing data storage, processing, and transport services together with all the facilities and infrastructures for power distribution and environmental control and the necessary levels of resilience and security required to ensure the availability of the desired service (European Commission, 2020, p. 3).

More simply, the infrastructure of a data centre comprises the building, the computers and all the components including the electrical and the mechanical systems that allow it to function properly. Five essential elements compose a data centre such as shown in Figure 1.

**Figure 1: Key Elements of a Data Centre**



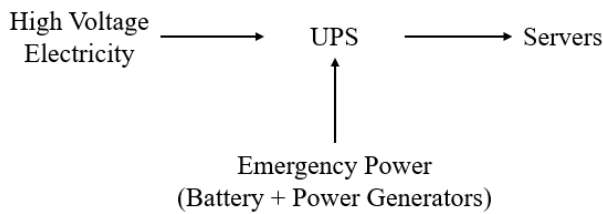
The **infrastructure** needs to be big enough to contain the **information technology (IT) equipment**. Three main elements compose the IT equipment (IBM, 2020): the first is the compute element, the servers supplying the memory and processing power needed to run applications. The second is the storage element including primary and backup storage devices. The third element is the networking equipment ranging from routers and switches to controllers and firewalls. These materials need to be supported by specific equipment such as racks for the servers or cabling for connectivity to the Internet.

The size of such infrastructure can vary from microscale to hyperscale. The International Data Corporation defines a hyperscale data centre as one which exceeds 5,000 servers and 1,000 m<sup>2</sup> (Kidd, 2018). According to a study (Synergy research group, 2021), the total number of such data centres in the world has reached 597 at the end of 2020. Among the operators, Amazon, Microsoft, and Google account for more than half of all large data centres. As an example, the largest data centre in Europe, called Kolos Data Centre, locates in a village in Norway. It opened its doors in 2018 and covers an area of approximately 600,000 m<sup>2</sup>. The centre is hyper scalable and consumes up to 1,000 megawatts (MW) of power, and will function with 100% renewable energy by 2027 (Perlman, n.d.).

Thereafter, technological advances such as the Internet of Things (IoT) have enabled a new host of applications. The Cambridge Dictionary website defines the IoT as: “objects with computing devices in them that can connect and exchange data using the internet” (The Internet of Things, para. 1). Augmented reality, traffic monitoring, vehicle tracking, and interactive video streaming are some examples of IoT. These applications require a real-time response. This is a constraint for remote data centres as being remote can cause delays in their responses. Solutions such as cloudlets and micro data centres have emerged with a new computing paradigm: edge computing. In edge computing, the computing takes place at the proximity of data sources (Ali, Babar, Imran, Khan, & Shoaib, 2021). It ensures shorter response time and better reliability. Microsoft Research introduces the notion of micro data centres as a complement to big data centres. Cloudlets and micro data centres have a size range from 1 to 100 kilowatt (kW). Their design meets the demands of applications that require lower latency or face constraints in terms of autonomy or computation (Bilal, Erbad, Khalid, & Khan, 2017).

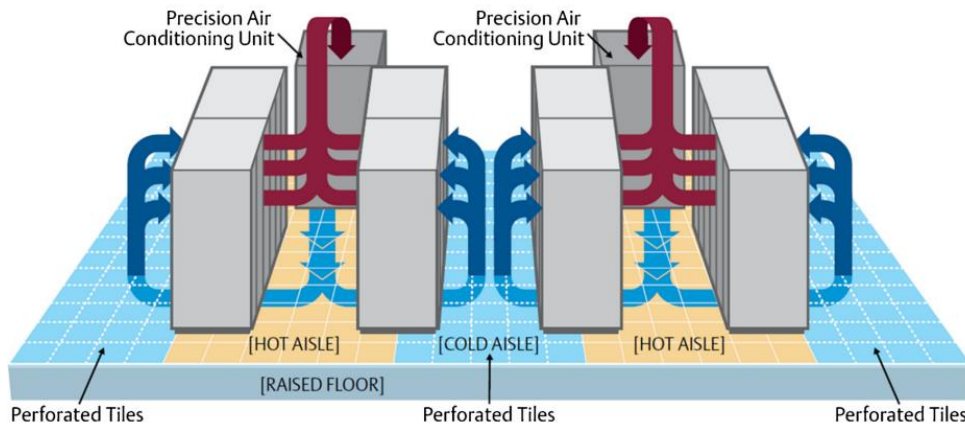
After the building, the second element of a data centre is the **power supply**. The IT equipment must be permanently powered which is why data centres are critical infrastructures. More precisely, disruptions to the flow of information occur due to a loss of computing or network function in the event of a loss of power. For this reason, Uninterruptible Power Supplies (UPS) systems are used as a backup to protect the sensitive load against line frequency variations. UPS is an alternate source of power located between the main power supply and end critical loads (Bekiarov & Emadi, 2002). Moreover, data centres have battery-based backup power systems able to compensate for short-term power outages as shown in Figure 2 (Pen, Yang, Wang, & Zhao, 2018).

**Figure 2: Power Supply Representation of a Data Centre**



When the IT equipment runs, the energy supplied to the equipment is largely converted into heat. Every data centre needs a **cooling system** to maintain optimal air temperature in order to provide a safe environment for electronic equipment. Large industrial equipment such as pumps, chillers and cooling towers are part of this cooling equipment, but this is a major source of energy used in data centres. A study (Bai & Ni, 2017) reports an average of 38% of facility energy consumption for a cooling system, with a range from 21% for the most efficient system to 61% for the least. The most widespread technique used is the hot-aisle/cold-aisle configuration as shown in Figure 3. However, other more efficient cooling technologies improve heat ejection such as free cooling using natural fluid (air or water) from the outside environment to cool the equipment (Nadjahi, Lemasson, & Louahlia, 2018).

**Figure 3: Hot-aisle/Cold-aisle Configuration of a Cooling System** (Nadjahi, et al., 2018)



In addition, to achieve high levels of reliability in the operation of the data centre, the infrastructure topology is a configuration with **2N or N+1 redundancy** where N stands for the duplicate unit i.e. a generator, an UPS, or a cooling unit (Keke, 2020).

- 2N: fully redundant system with two independent distribution systems,
- N+1: an additional component to the quantity N equivalent to the capacity needed to operate the installation.

Thus, redundancy is a concept involving the duplication of a component to avoid damage to the computer equipment and services in the event of a failure. For example, to avoid a power failure, the power supply is redundant. It can be a duplication of the equipment or a dual building. When there is an installation of two systems, each can only be loaded up to 50% (JRC Science for Policy Report, 2020). This solution ensures that the remaining system avoids overloading in case of failure.

Finally, **security** is crucial. Data centres store private data safeguarded under very strict regulations defined by the country of residence. Consequently, to provide secure storage, data centres must be designed to maximize protection from various security threats such as human interruptions, intentional or not, but also natural disasters. The concept of defence-in-depth is one approach with multi-levelled security where processes penetrate deep into an organization. It proposes layers of security offering both redundancy and diversity to protect from threats. For instance, there may be up to seven layers of physical security before access to a computer. These varied layers include biometrics, gates, fences, guards, identity cards and even ditches and hills around the building (Barner, Denney, & Knapp, 2011). There is also the protection of the information such as data access control, encryption, incident detection and multiple lines of defence such as firewalls, intrusion defence, and protection of each host (Glott, Husmann, Sadeghi, & Schunter, 2011).

There are Tier Performance Standards to categorize the design of the data centres infrastructure, summarised in Table 1 (Raftar, 2007). Each tier level has different expectations for site availability. Availability is an optimizing process and availability of a production system that accurately measures, analyzing, and reducing lost time on the system of production. It has two states: uptime and downtime. Uptime is when the system production fully runs production activities. This is the guaranteed annual availability of a data centre. And downtime is a condition in which the disturbance occurs on a production system which must be stopped until the resolution of the disorder. To build high availability, a data centre needs a disaster recovery plan (DRP) which establishes how a company can reinstate its systems after a significant interruption (Dhanujati & Girsang, 2018).

- Tier I: non-redundant capacity components and non-redundant single path distribution paths serving the site's IT equipment. The data centre has a computer room, cooling and power distribution but may or may not have a UPS or a generator.
- Tier II: redundant capacity components and unique non-redundant distribution paths. It has uninterruptible power supplies and generators.
- Tier III: redundant capacity components and numerous distribution pathways supplying the site's IT equipment.
- Tier IV: redundant capacity and multiple distribution paths. There is a dual powered in all IT equipment.

**Table 1: Tier Classification of Data Centre (Rafter, 2007)**

Tier level	Developed in	Availability downtime (hours per year)	Availability uptime (%)
Tier I	Early 1960's	28.8	99.67
Tier II	1970's	22.0	99.75
Tier III	Late 1980s	1.6	99.98
Tier IV	Mid-1990	0.4	99.99

## 1.2 Services

Data centres provide cloud-based digital services: the customer pays for a service and the vendor provides and operates the equipment needed to deliver it. Businesses use a variety of cloud services models.

There are three types of data centres: enterprise, colocation and managed service providers data centres (European Commission, 2020).

An **enterprise data centre** belongs to a company that delivers and manages services to its employees and customers. This type allows enterprises to store their data in a private area of the company. A **colocation data centre** is where multiple customers locate their networks, servers and storage equipment. This is an outsourced data centre solution that companies typically use to expand their own data centre capacity. **Managed service providers (MSP) data centres** offer servers and data storage services where the customer pays for a service and the vendor provides and manages the required information and communication technology (ICT) software and data centre equipment. It is thus similar to a standard data centre but provides features and functionality through a managed service platform.

In this study, the term cloud refers to cloud computing. The definition of cloud computing by the National Institute of Standards and Technology (NIST) is:

Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction (Grance, 2009, p.1).

The most common cloud services are Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS) (European Commission, 2020):

- IaaS offers access to storage, networking, servers, and other computing resources.
- PaaS provides access to a cloud-based environment in which users can build and deliver applications. The providers supply the underlying infrastructure.
- SaaS delivers software and applications via the Internet.

The main differences between these three cloud models are their offerings and purposes, as well as the amount of control over cloud computing resources. Table 2 shows the level of control over data that customers have in each business model. In IaaS, users have more control than in SaaS or PaaS (Hasan & Zawoad, 2013).

**Table 2: Customers' Level of Control in the Different Service Models** (Hasan & Zawoad, 2013)

SaaS	PaaS	IaaS
Access control	Access control	Access control
Application	Application	Application
Data	Data	Data
Operating system	Operating system	Operating system
Servers	Servers	Servers
Network	Network	Network
Customers have control		
Customers don't have control		

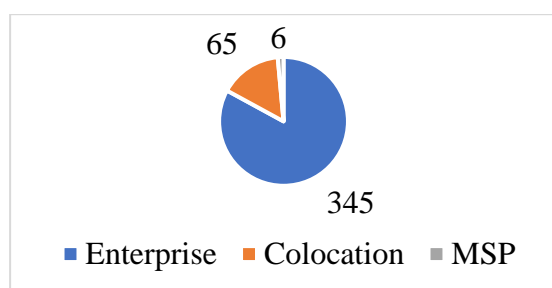
Besides the storage of data, data centres can also provide data processing, i.e. calculations to analyse the information. Data mining is the name of this function. This is the technology of discovering structures and patterns in large data sets. At a microarchitecture level, this is a specialization or domain-specific hardware/software codesign. A specialized architecture such as an ASIC (application-specific integrated circuit) allows customizing the conception for a specific application. For instance, bitcoin mining uses ASIC (Ranganathan, 2020).

## Chapter 2: Data Centre Market

After defining the theoretical framework of a data centre, this section provides an overview of the sector's market in Europe with certain trends for the year 2021.

The number of data centres in Europe is huge. According to a study, there are 60,215 enterprise, 2,215 colocation and 152 MSP data centres among the 28 EU Members States (JRC Science for Policy Report, 2020). To get a better idea of the markets in Europe, there is a table with the number of data centres in each European country in the appendix (Annexe 1: Comparison of Belgium with Major Data Centre Markets in Europe). In Belgium, there are 345 enterprise, 65 colocation and 6 MSP data centres as shown in Figure 4.

**Figure 4: Types of Data Centres in Belgium in 2020** (JRC Science for policy report, 2020)



Their increase goes hand in hand with the demand for data services which rising exponentially (IEA, 2020). Demand for digital services will continue to grow over the coming years. Global internet traffic will double by 2022 to 4.2 ZB/year (zettabytes per year). In addition, during the Covid-19 pandemic lockdown, global internet traffic surged by almost 40% driven by growth in video streaming, video conferencing, online gaming, and social networking (IEA, 2020).

The market volume of data centres is represented according to the white space. The white space refers to the area of the IT equipment. The average white space for enterprise is 60m<sup>2</sup>, 1,152 m<sup>2</sup> for colocation and 1,123 m<sup>2</sup> for MSP among the 28 EU Members States (JRC Science for Policy Report, 2020). Note that this report excludes data centres with IT capacity equal to or lower than 25 kW. Table 3 represents the white space of Belgian data centres.

**Table 3: White Space of Belgian Data Centres** (JRC Science for Policy Report, 2020)

	Enterprise	Colocation	MSP
<b>Total (m<sup>2</sup>)</b>	61,500	31,900	3,700
<b>Average per data centre (m<sup>2</sup>)</b>	178.26	490.77	616.67

A report (Lawrence & Ascierio, 2020) outlines five key digital infrastructure trends for the year 2021: accountability of companies, smarter data centres, edge computing, sustainability, and a surge of innovation.

The first trend is the importance of **corporate responsibility**. Companies want to use more outsourcing and to be more agile. It has become a strategy to outsource the requirement to own and operate a data centre. It does not mean outsourcing responsibility for incidents, outages, security breaches or carbon emissions. Thus, it obliges companies to examine the secure transfer of their data and to ensure the transparency of their operator's operational practices and technical infrastructure.

The second trend is about data centres which become **more intelligent**. The adoption of remote automation systems, which has been slow and cautious, will accelerate in the wake of the Covid-19 pandemic. Indeed, operators are keen to reduce staffing levels and increase the ability of data centres to operate with fewer teams. New technologies can achieve this, but it requires investments with organisational change being the main obstacle.

The third trend concerns **edge computing** as explained above. New technologies such as IoT create a new type of demand with infrastructures under development. This will create new alliances and new investments.

The fourth trend is **sustainability**. This is no longer an option for data centre operators. For many years operators have claimed environmental progress in small incremental steps which are seen as greenwashing. Climate change issues will play a role in operators' strategic decision making, regardless of their beliefs, as stakeholders, governments, customers, and others want more action to reduce their impacts.

Finally, the fifth trend is **innovation**. Hyperscale operators like Google have gained a competitive advantage through technology. This contrasts with smaller data centre operators who are more cautious or even late adopters of new technologies. The big companies have tested for several years several technologies. Now, these are maturing and are enabling major advances in the field for all levels of operators.

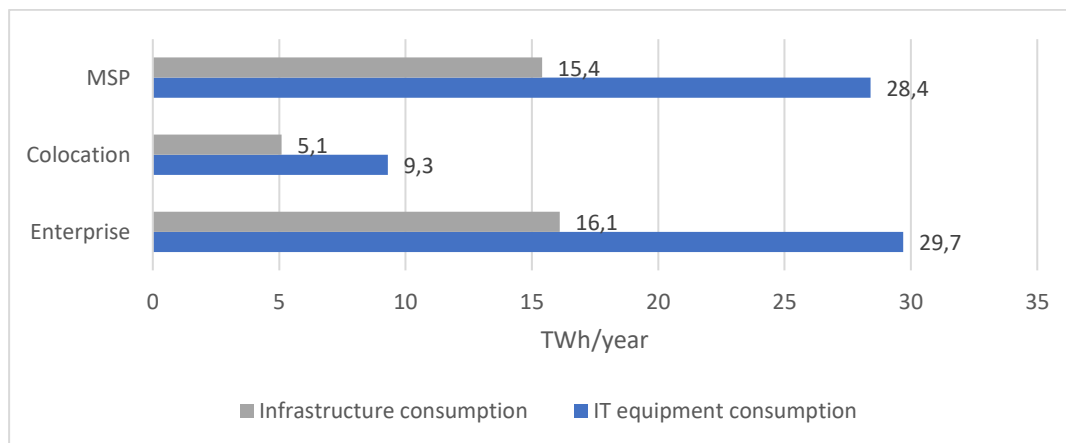
## Chapter 3: Environmental Impact of Data Centres

Data centres operate by using electronic devices continuously. This means constant power consumption and heat generation, which are the two main disadvantages that increase the production of carbon footprint, but various solutions exist to reduce the carbon footprint of these facilities.

### 3.1 Electricity Consumption

The IT equipment and infrastructure of data centres consume a lot of electricity. Indeed, they account for around 1% of the world's electricity consumption (Masanet, Koomey, Lei, Shehabi, & Smith, 2020). The overall energy consumption of the 28 EU data centres for the period 2010 to 2030 show that in 2015, the amount of electricity consumed was 74 TWh/year (Terawatt hours per year), around 2.25% of the total EU electricity (European Network of Transmission System Operators for Electricity, 2018). This will reach 160 TWh/year by 2030 (JRC Science for Policy Report, 2020). As an example, Figure 5 illustrates for the year 2020 the internal energy consumption breakdown for the European data centres.

**Figure 5: Estimated Internal Breakdown of Data Centre Energy Consumption in the EU in 2020** (JRC Science for Policy Report, 2020)



Different power metrics exist for data centres computing. The most used is the Power Usage Effectiveness (PUE) developed by The Green Grid, for calculating and reporting the energy efficiency of a data centre (JRC Science for Policy Report, 2020). PUE is the ratio of total data centre input power to the power used by the IT equipment. It is greater than or equal to 1. Thus, the more efficient the data centre, the closer PUE is to 1.

$$PUE = \frac{\text{Total Facility Power}}{\text{IT Equipment Power}}$$

Various factors can increase the energy consumption of a data centre.

The **climate** greatly influences the use of electricity. Hot climatic conditions added with warming equipment increase cooling demand and thus energy consumption of air conditioners.

The **use of the equipment** is another factor. Older data centres (over 3 years old) have significantly higher annual energy consumptions, which can be higher than the embodied energy of manufacturing new IT equipment (JRC Science for Policy Report, 2020).

Optimising IT equipment (e.g., hardware replacing or increased utilization) can sometimes save more energy in a data centre than focusing on lowering the PUE (Bashroush, 2018).

Finally, the **size of the data centre** has an impact. Cloudlet offloading can reduce energy consumption by 30%–40% (Cao, Shi, & Zhang, 2016). This approach locates the data centre near the source of electricity and thereby reduces transmission losses (Li, Menaud, & Orgerie, 2017).

Furthermore, the electricity used by most data centres is brown energy such as fuel fossil, coal, and oil. These energies generate high carbon emissions. As a solution, governments set up laws and regulations to reduce brown energy utilization, forcing companies to turn toward renewable energies. Their advantages are their free availability and sustainability. There are several types of renewable energies such as solar, wind, biomass, hydroelectric and geothermal. The two most common are solar and wind energy (Khambadkone, Khosravi, Quan, & Srinivasan, 2015). The sun provides solar energy thanks to solar radiation that is converted into electricity using photovoltaic cells. Wind energy is the conversion of kinetic energy from the wind into electricity, using wind turbines located onshore or offshore. There is one other growing power supply sector, ocean energy, which includes tidal, wave, thermal and osmotic energy. The most attractive of these is tidal energy, as the predictability of the currents makes it easy to manage and market the electricity produced. This energy consists of harnessing the energy extracted from tidal currents and converting it into electricity (Lazaar, 2021). However, renewable energies are not able to provide a continuous power supply and cannot adapt their production to variations in demand. They are intermittent and fluctuating over time. Numerous research studies propose solutions for optimizing renewable energy use through algorithms or batteries (Lazaar, 2021).

Google is a successful example of reduced energy consumption by installing a new cooling system and an automatic learning system. The Google data centre is the most important one in Belgium which is in Saint-Ghislain. In 2017, this centre had an average PUE of 1.09.

The first innovation is their **cooling system**. This site uses water evaporation to cool all the servers. The water used in the cooling towers is non-potable. This is the grey water of the nearby industrial canal Nimy-Blaton that comes from households. In Belgium, the household water goes to the sewers and include the water from laundries, bathrooms, washbasins, kitchen sinks, dishwashing, and toilets (Environnement Wallonie, s.d.). Google treats the water before using it. Subsequently, the centre began injecting carbon dioxide into the cooling tower water to control the pH scale. It allows the pH to be finely adjusted thanks to its weak acid properties. This innovation allows the water to be reused up to four times instead of only twice before it is rejected in the canal. In 2018, the European Commission awarded the Saint-Ghislain data centre with the European Code of Conduct for Energy Efficiency Award, which recognises the best results achieved over the last ten years in the category of large data centres (Google, n.d.).

For their **electricity**, Google has signed a contract with Engie in Belgium for a capacity of 92 MW. This agreement enables part of the consumption of the data centre in Saint-Ghislain to be covered by renewable energies from the northern offshore wind farm in the North Sea (Vande Weyer, 2019). These offshore wind turbines are twice the size of the onshore ones and provide more clean, low-cost electricity. In addition, Google continues to innovate and will soon replace the diesel generators used during grid failures with electric batteries (Martin, 2020). In addition, the site in Saint-Ghislain has 10,665 photovoltaic solar panels which generate 2.9 GWh of renewable energy each year (Google, n.d.).

Moreover, Google has applied the DeepMind **automatic learning system** in the management of their data centres. DeepMind is a system of neural networks trained to different scenarios and operating parameters. This has enabled them to reduce the amount of energy used for cooling by 40% (Gao & Rich, 2016). To develop this system, DeepMind uses the reinforcement learning architecture. Initially, an agent has a goal or rules to follow to interact with an environment, which can be a physical domain, a commercial environment, or a robotic environment (Bastien, 2020). In this case, DeepMind's networks learn to forecast the temperature and pressure outputs of the centre 60 minutes ahead of time. This system extracts data every five minutes from thousands of sensors in the cooling system such as temperatures, power, pump speed, set points. Then, it implements the set of actions to reduce energy consumption based on a future average PUE (George, 2018).

### **3.2 Heat Production**

The second large issue concerns the heat produced by IT equipment. Several techniques exist to reuse this heat, but they face some complications. The data centre heat has a low quality (e.g. low temperature or unstable heat source) and there are high investment costs to develop solutions (Manner, Pärssinen, Rinne, Syria, & Wahlroosa, 2018). Temperatures are around 75-120°C in the district network. As a solution, improved insulation systems can lower these temperatures to 50°C. This will make it easier to supply heat because the residual heat from the data centre is < 85°C and therefore cannot be fully utilised in the current network. Another drawback is that this solution must be attractive to both the heat supplier and the district heating system operator. The heat supplier, i.e. the data centre, provides heat continuously, whereas the district heating system operator prefers to get the residual heat when the heat demand is highest (Manner, Pärssinen, Syri, & Wahlroos, 2017). This does not prevent the development of many waste heat recovery techniques. According to a study (Ebrahimi, Fleischer, & Jones, 2014), absorption cooling is the most promising technology for reusing waste heat from data centres. Absorption cooling uses a liquid solution of absorbent fluid and refrigerant instead of the traditional vapour compression system. It results in considerable power savings since liquids have much lower specific volumes than vapours.

### **3.3 Key Environmental Factors**

Data centres can prioritise four key environmental factors to reduce the environmental impact generated by their two main disadvantages (Zhang, 2021). The four key areas are greenhouse gas emissions, renewable energy, energy sustainability and water sustainability.

The first key environmental factor is greenhouse gas emissions. The carbon intensity measures these emissions. This is a metric that provides a comparison of greenhouse gas characteristics after factoring in the scale of a business through energy use and the emission rate relative to the primary energy source.

The second key environmental factor concerns renewable energy sourcing. To this end, data centres partner with energy providers or build the necessary equipment, but the latter requires high investments.

The third factor is the power sustainability of data centres. The PUE measures it as explained above.

Finally, water sustainability can include projects such as reducing the use of drinking water for cooling purposes, on-site water treatment, rainwater harvesting and water restoration, particularly in vulnerable areas where water stress is high. There is an efficiency measure for water sustainability called Water Usage Effectiveness (WUE). WUE measures the water used to cool equipment in a data centre and is the ratio of annual water consumption to the energy consumption of the IT equipment in kilowatt-hours (Kwh).

## **Chapter 4: Regulations**

### **4.1 Europe**

In Europe, laws about data protection and cybersecurity regulate the management of data centres and ensure reliable cloud computing.

First, confidentiality laws aim at protecting Personally Identifiable Data (PID). Article 8 of the European Convention on Human Rights (ECHR) provides the right to privacy (Glott, Husmann, Sadeghi, & Schunter, 2011). The EU Data Protection Directive (Directive 95/46/EC) reinforces this right by considering the Organisation for Economic Co-operation and Development (OECD) Privacy Principles. These principles are a limited collection of data, authorisation to collect data either by law or by the informed consent of the person whose data are processed, the right of correction and deletion as well as the need for reasonable security safeguards for the data collected (OECD, s.d.).

These laws allow data to be controlled by individuals or companies and thus prevent any extra-territorial data loss. The legal framework for the processing of personal data is the General Data Protection Regulation (GDPR). It applies to businesses established in any EU Member State as well as outside the EU if they process data of EU residents, since 25 May 2018 (European Commission, 2018). Since data centres are companies processing personal data, they are subject to this regulation.

There are two types of data in a data centre. On the one hand, there are personal data held by the operator, for instance, access authorisation data with associated individual biometric data. For the management of this type of data, the data centre is a company like any other. It must ensure compliance as soon as the data is collected and the processing processes are finalised, anticipate measures in the event of a security breach and be capable of reactivity and transparency in the event of a request from the individuals concerned regarding their data.

On the other hand, there is data stored on the servers themselves within the data centre. If these servers are in a colocation data centre, the customer who owns the data bears the legal responsibility, not the data centre operator. In the case of company-owned data centres, the responsibility for data management does not lie with the data centre operations team, but with the relevant IT departments (Stephya, 2019).

The increasing use of digital services of companies brings with it an increased risk of cyber-attacks. The EU has strengthened Internet and computer network security with the establishment of a cybersecurity competence centre in Bucharest (European Council, n.d.). Recently, the European Council adopted measures on the European Cyber Security Strategy for the Digital Decade (Neves, 2021). This sets out a framework for action to protect citizens and businesses against cyber-attacks. The strategy accelerates the adoption of standards and supports the development of fundamental rights protection and digital security. For example, a measure ensures the security of 5G networks and future generations of networks.

As previously explained, data centres have negative impacts on the environment. These environmental degradations are an existential threat to the world. To overcome these challenges, Europe has established a climate action plan. The first goal is to cut greenhouse gas emissions by at least 55% by 2030 to become climate neutral by 2050 (European Commission, 2020). Data centre operators and trade groups have agreed to take steps to make data centres climate neutral by 2030. This initiative concerns actions about energy efficiency, clean energy, water, circular economy, and circular energy systems. More precisely, data centres must meet a high standard such as an annual PUE target of 1.4 for new data centres operating at full capacity in warm climates by 2025, and for existing data centres by 2030. These targets apply to data centres larger than 50 kW of maximum IT power demand. Regarding the electricity supply, it will consist of 75% renewable energy or hourly carbon-free energy by December 31, 2025, and 100% five years later. The conservation of water is also an important point that will set an annual target for WUE. A high benchmark for circular economy principles will also be established, with 100% of their spent server equipment being reused, repaired, or recycled. Finally, they will investigate the reuse of data centre heat to determine if opportunities to feed captured heat from new data centres into nearby systems are practical, environmentally efficient, and cost-effective (Climate Neutral Data Centre, n.d.).

Furthermore, Europe has launched a new project in 2019: GAIA-X. It is a proposal for a new generation of European Data Infrastructure. This project is the creation of an open and transparent digital ecosystem, where data and services are gathered and shared in a trusted environment. It is an open digital ecosystem to enable European companies and business models to compete globally. Many dialogues are underway and will be further intensified (Gaia-x, s.d.). The first services should be available by the end of 2021 to counter the dominance of the American cloud systems in the European market (Noyan, 2021). This project, therefore, takes the form of an open network of data centres allowing the deployment of cloud services with an emphasis on security, data confidentiality and identity management (Bastien, 2020).

## 4.2 Belgium

The focus of this study is Wallonia, a region in Belgium, which develops several initiatives following European regulations.

Wallonia promotes through some initiatives several digital technologies for businesses such as DigitalWallonie4AI. This programme aims to accelerate the adoption of artificial intelligence in Wallonia and the development of its Walloon ecosystem (Digital Wallonia, 2020). The region has launched numerous projects in a plan for the period 2019-2024 (Wallonia, 2019). At the federal level, Belgium has committed to invest in this through programmes coordinated by the EU. For example, the creation of EuroHPC company which is a partnership of several European countries about blockchains and cooperation in the field of artificial intelligence (European Commission, 2020).

Table 4 exposes different international rankings of Belgium compared to other countries. The DESI monitors overall digital performance and tracks the progress of EU countries in their digital competitiveness (European Commission, 2020). The NCSI measures the preparedness of countries to prevent cyber threats and manage cyber incidents (National Cyber Security Index, n.d.). The Speed test ranks mobile and fixed broadband speeds from around the world monthly (Speedtest, n.d.).

**Table 4: Summary of International Index**

Index	International ranking
Digital Economy and Society Index (DESI)	9/29
National Cyber Security Index (NCSI)	7/160
Speed Test Global Index, Fixed Broadband	38/181

## **Second Part: Empirical Analysis**

### **Chapter 1: Methodology**

This study is an exploratory approach that aims to understand the position and state of the colocation data centres industry in Wallonia, to determine the challenges they face and establish whether the key success factors are assimilated by the region. These factors are based on the economic and environmental aspects developed in the literature review and on a specific report.

The first step consists of the research of published scientific articles as well as specialised websites. The period of investigation is between July 2020 and May 2021 included. As this sector is constantly evolving, it is important to specify this time frame as the basis for this study.

Subsequently, the analysis explores how this industry functions. There was first a visit to a data centre to visualise the infrastructure before the interviews with experts. During the interviews, questions are technical before becoming strategy oriented. As the discussion progresses, questions evolve to be more relevant and specific to the research areas. Data in the field are qualitative and made up of ideas proposed by the stakeholders and therefore subjective.

#### **1.1 Qualitative Methodology**

The methodology is qualitative with data collection through semi-structured individual interviews and data analysis according to Miles and Huberman (1984).

To constitute the sample, there is an application of the principle of diversity, including actors from both private and public sectors. The size of the sample depends on the actors present in the Walloon Region and the framework of the study which is the colocation data centre industry.

This study applies the individual semi-directive interview (Herbert, 2008). The semi-structured interview allows for preparation with an interview guide containing a series of open questions. There is no order of questions but rather broad predefined themes relating to the different chapters in the literature review. In addition, questions asked during the interview depending on the answers, allowing for more freedom which leads to subjective results as the data collection is mostly face to face or in video calls (Gavard-Perret,

Gotterland, Haon, & Jolibert, 2008). This allows exploratory and unstructured responses within each question to have the open-ended nature of the qualitative interview (Mccracken, 1988). Each actor has a unique guide of questions which is in the appendix. The transcription of these interviews is verbatim to avoid unconscious selection of ideas.

Finally, the analysis of the qualitative data in this study follows the methodology of Miles and Huberman. The authors suggest methods for condensing the raw data including interview summary sheets, coding the field notes according to classification, which is here following the interview guide, and writing a theoretical reflection on the codes used and the relationships between them (Miles & Huberman, 1984).

## **1.2 Data Collection**

The analysis begins with a visit to a data centre in Lille. Two employees in different departments were interviewed, an IT engineer in the IT infrastructure department and a business engineer in the sales department. At that time, other actors outside Wallonia were also contacted, including data centre audit experts and data centre operators in France and Luxembourg. They did not respond.

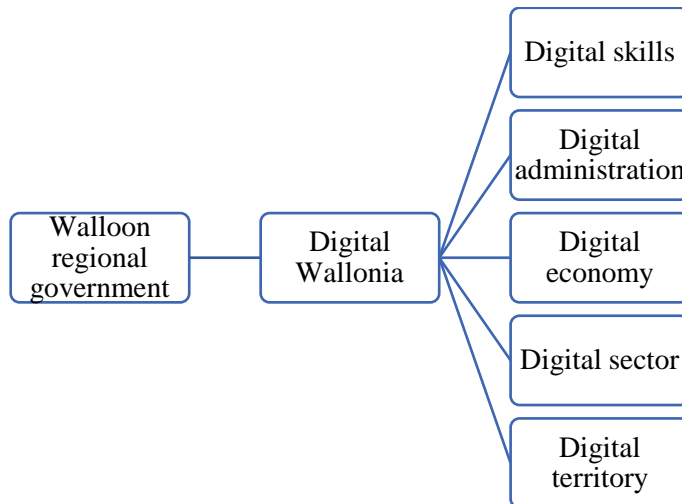
Subsequently, the data centre operators in Wallonia were contacted. There are currently six according to the data centre sector sheet of the Digital Wallonia platform: Network Research Belgium (NRB), Belgium DC<sup>1</sup>, Wallonia Data Centre (WDC), Engie<sup>2</sup>, Google and IBM (Digital Wallonia, 2019). Google does not offer colocation services and is outside the scope of this study. The remaining five companies were all contacted. Two companies accepted to participate in interviews, the WDC and the NRB.

The next relevant actors for the analysis are those from the public sector. The agency contacted is the Digital Agency (French acronym: AdN), which is a public limited company dedicated to the implementation and development of the digital strategy of the Walloon regional government. Digital Wallonia is the name of the Walloon strategy with five structuring themes as shown in Figure 6.

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<sup>1</sup> owned by NRB (Bollinger, 2017).

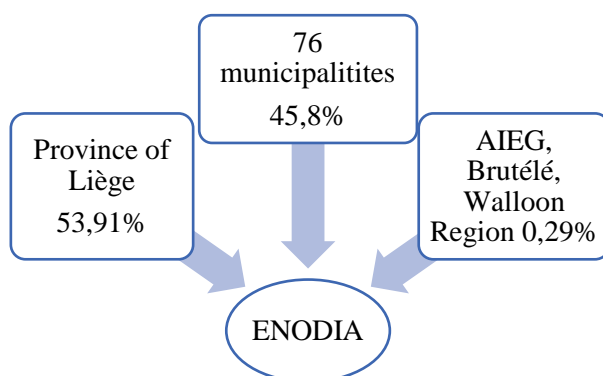
<sup>2</sup> The company LCL has acquired ENGIE Solutions' data centre in Gembloux in June 2021, through the acquisition of Cofely Data Solutions (LCL, n.d.).

**Figure 6: Themes Structuring the Strategy Digital Wallonia**

Among these themes, the selection is according to their different projects. The digital territory proposes a relevant project for the development of data centres: the Giga Region project. Different employees were contacted, and one manager responded favourably for an interview. Another agency was also contacted, The Walloon Export and Foreign Investment Agency (French acronym: AWEX) being the Walloon export and foreign investment agency but the company did not respond. This agency follows the same strategy as the AdN.

The first company interviewed was **Comarch SA**, founded in Poland in 1991. This company develops and supplies modern information systems. Its' managers are Janusz Filipiak, founder and chief executive officer (CEO) and Konrad Taranski, chief financial officer (CFO) (Bloomberg, n.d.).

The second interviewee was the Wallonia Data Center (WDC) acquired by **Win SA** in 2013 (Win, n.d.). Win, founded in 1998, is the ICT and B2B division of the Nethys SA group since 2009 (Win, n.d.). Nethys is a Liège-based holding company belonging to Enodia (ex-Publifin) held by municipalities as shown in Figure 7 (Vande Weyer, n.d).

**Figure 7: Structure of Enodia Holdings** (Vande Weyer, n.d)

The third data centre operator is **Network Research Belgium (NRB) SA**, part of the NRB Group, the third-largest group in Belgium in the IT sector. Since 2010, NRB's growth strategy is that of acquisitions (NRB, n.d.). Ethias SA, the insurance group, is the majority shareholder (68%) of NRB. Ethias is owned by 4 shareholders: the Federal State, the Walloon Region, the Flemish Region and the cooperative company EthiasCo (Ethias, n.d.).

Finally, the fourth interviewee is the Digital Agency (French acronym: AdN) which is a limited company under public law dedicated to the implementation and development of Wallonia's digital strategy, called Digital Wallonia. It succeeded the Walloon Telecommunications Agency (French acronym: AWT) in 2015 (Wallonie, 2020). This agency works in close collaboration with the Walloon Government, the various public services and public interest organisations of Wallonia, the competitiveness clusters, the federations and representatives of the economic sectors, but also all the actors of the digital ecosystem in Wallonia (AdN, n.d.). The Board of Directors is composed of Mr John Lewis, President and Mr Thierry Castagne, Vice-president as well as 7 administrators and 2 government commissioners. Since 13 September 2019, the supervising minister is Mr Willy Borsus, Vice-President of Wallonia, Minister of Economy (AdN, n.d.). The Digital Wallonia strategy for 2019-2024 defines the directions that Wallonia should take to seize the socio-economic opportunities of the digital transformation for those five years, without locking it into an exhaustive list of predefined measures whose relevance cannot be guaranteed long term (Digital Wallonia, 2018).

### **1.3 Key Success Factors**

The knowledge gained in the literature review with the attributes of the *Data Centre Global Market Overview* produced by Cushman & Wakefield (2020), allows the selection of several key success factors about data centre market development (Cushman & Wakefield, 2020).

Cushman & Wakefield is among the largest real estate services firms (Bloomberg, 2020). The company evaluates 1,162 data centres across 38 global markets and chooses twelve weighted criteria in three distinct categories as shown in Table 5 as key factors. The first category includes real estate and physical considerations. The second category regroups ecosystem advantages and the third one includes a policy and regulatory review. These criteria are ranked according to their importance in each category.

**Table 5: Weighted Criteria for Data Centres Market** (Cushman & Wakefield, 2020)

Real Estate and Physical considerations	Ecosystem advantages	Political and Regulatory review
Development pipeline	Cloud availability	Government Incentives
Environmental risk	Fibre connectivity	Political stability
Land price	Market size	Power cost
Market vacancy	Sustainability	Taxes
High weight		
Mid weight		
Low weight		

Selected factors which are the key success factors in this study do not include the low weight criteria of the Cushman & Wakefield report. Table 6 shows the chosen key success factors according to the chapters of the literature review.

**Table 6: Key Success Factors for Development Data Centre Market**

Chapter 1: Data centre technology	Chapter 2: Data centre market	Chapter 3: Environmental Impact of Data Centres	Chapter 4: Regulations
Cloud offer	Market size	Sustainability	Government incentives
Fibre connectivity	Environment		

In each key factor category, some questions are the research avenues for the analysis.

Firstly, the factor is the **cloud offer** which includes the available colocation operators in Wallonia. Here, the research tends towards an understanding of the services offered.

- What are the colocation services in Wallonia?
- How do they differentiate from big cloud companies?

Secondly, the **fibre connectivity** factor is the fibre optic network essential for the operation of data centres. Even if it only needs access to one network to operate, the more networks there are, the more the facility can thrive and grow in the region.

- What is the fibre optic network in Wallonia?

Thirdly, the **market** has importance. Local market knowledge and an established network of partners facilitate market development.

- What are the criteria used to choose a data centre market?
- What are the competitive advantages of the main data centres markets in Europe?
- What are the assets put forward by Wallonia?

Fourthly, the **ecosystem** factor regroups the availability of land, electricity, the prospect of financing for the project and an interest in the facility.

- What are the ecosystem factors of data centres in Wallonia?

Fifthly, there is the **sustainability** factor. Data centres have a particular responsibility to consider due to their excessive energy consumption.

- How do data centres limit their environmental impact?

Sixthly, **governments** give several **incentives** to companies to help them set up data centres for example in the form of tax relief.

- What are the government incentives in Wallonia?
- What are the best incentives abroad to attract data centre operators?

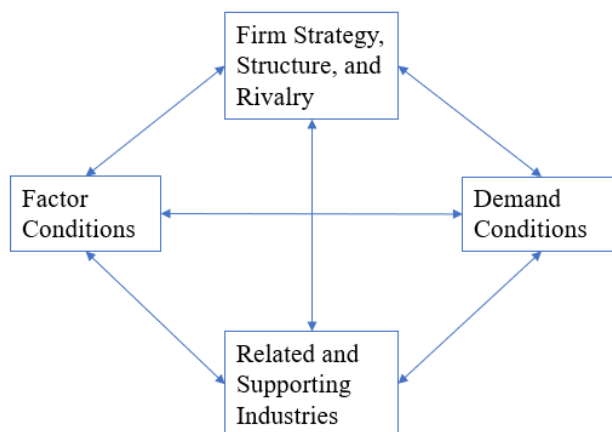
## 1.4 External Factor Analysis

To analyse the data centre sector in Wallonia, this study uses Porter's diamond model and Bowman's strategic clock to position the various data centre operators.

### *Porter's Diamond Model*

The ability of a country's industry to innovate determines its competitiveness. Firms gain an advantage through competitive pressure which is created through a highly localised process. Each country develops different competitive models specific to each industry. Thus, to succeed in international markets, companies employ different strategies but include the same modus operandi based on four main attributes. These attributes as a system constitute the diamond of national advantage developed by Porter (Porter, 1990). These determinants constitute the national environment in which companies are founded and learn to compete as shown in Figure 8.

**Figure 8: The Determining Factors of the Diamond Model (Porter, 1990)**



Among these four attributes, there are **factor conditions**. These are factors of production acquired through heavy investment. Factors of production may include skilled labour, infrastructure, land, natural resources, and capital.

The next attribute concerns **demand conditions**. Each country has its domestic demand with different buyer needs. When an industry segment is more important in the domestic market than in foreign markets, a nation gains a competitive advantage.

Then, the determinant is the presence in the country of **related and supporting industries**. Indeed, domestic suppliers create advantages in industries by providing cost-effective inputs but also enabling close working relationships. The proximity between firms and their suppliers accelerates the pace of innovation.

The last attribute groups the conditions of the region for the creation and organisation of enterprises, the national **rivalry according to their strategies and their structure**. Indeed, the national context creates trends in the management of enterprises as well as in national rivalry.

In addition to this, the government has a role to play as a catalyst and challenger. The government does not create competitive industries but rather encourages companies to improve their aspirations. Its role is indirect in creating the right environment for businesses to gain a competitive advantage.

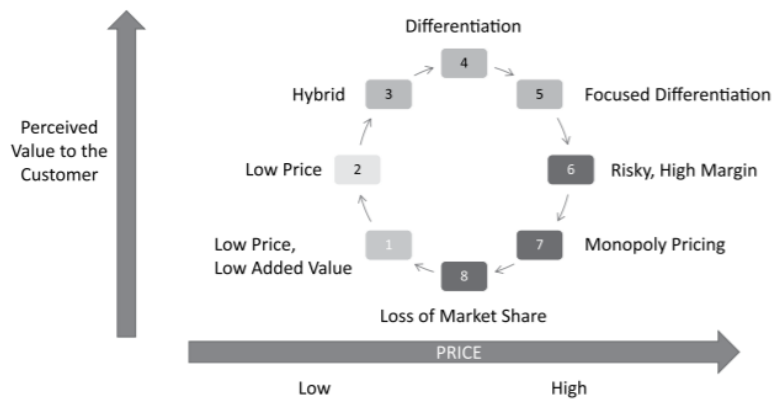
This model will help the analysis of the Walloon region by listing the assets of this industry.

### *Bowman's Strategy Clock*

The second model used in this study is based on Faulkner and Bowman's 'customer matrix' (1995). This matrix is based on Porter's generic strategies which highlight costs and differentiation as sources of competitive advantage. This tool is presented in the form of a clock in Figure 9 and relates the costs and benefits of the Corporate Social Responsibility (CSR) measure to the different competitive positions that companies can adopt.

Walloon data centre operators will be position in this strategy clock to evaluate their different strategies.

**Figure 9: Bowman's Strategy Clock (Desai, 2019)**



## Chapter 2: Field Study

### 2.1 Cloud Offer

This part starts by summarising why companies go to data centre operators with a brief overview of the demand in Belgium. Next, there is the explanation of B2B hosting services in Wallonia.

Companies choose data centre operators for several reasons summarised in Table 7.

The first criterion is **economic**. An interviewee compared computing resources for applications and storage with electricity production (Annexe 8: Interview 5 Comarch). In this example, a person who decides to produce his own electricity will have more costs instead of buying it. He would need to own a nuclear reactor or a generator, manage all technical complexity and have the qualified people to do it. Unlike, a simple connection into the grid with a producer. According to Mr Defourny, it is a pooling of resources for companies that have the need but not the means to invest several million euros in the construction of a data centre (Annexe 5: Interview 2 Wallonia Data Centre).

The second is **security** which is a crucial point as explained in the literature review. Data are safer with an expert operator with physical and IT security, than in the company building. Companies also prefer to secure their data in several regions to ensure business continuity in the face of any risk. An example is a Belgian financial company that decided to choose a second data centre in France at Comarch in addition to its first in Belgium. This company preferred to avoid any general power cut in one country (Annexe 8: Interview 5 Comarch).

The third reason is **availability**. Applications are used daily and must always be available. For this purpose, companies want to have several data centres.

There is also the possibility of extending the resources when the company needs them (Annexe 8: Interview 5 Comarch). Indeed, companies want to be **agile**, i.e. to be fast and reactive. The cloud offers this advantage because it allows access to different services and IT tools in a matter of minutes, whereas in a private environment it can take several months to order servers and install them (Annexe 8: Interview 5 Comarch).

After the understanding of these benefits, companies go to operators with a well-defined strategy including a choice of an application and data protection requirements in addition to the regulations imposed. According to Mr Khnite, if there is an audit and the company does not protect its data, the fine can be worth 2-3% of the company's turnover (Annexe 8:

Interview 5 Comarch). Companies, therefore, prefer to go to professionals who know laws and the regulations in the field.

**Table 7: Cloud Advantages for Businesses** (Annexe 8: Interview 5 Comarch)

<b>Less expenses</b>	Costs less than building a data centre
<b>Security</b>	Secure data in several regions to avoid local power cuts
<b>Availability</b>	Permanently available data
<b>Agility</b>	Fast and responsive company
<b>Governance</b>	Respect of data regulations

Then, it is also necessary to understand the different services. As a reminder, there are three main services in the cloud: Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS).

Sometimes, companies want to use standardised SaaS for convenience. This includes Enterprise Resource Planning (ERP) software, business software that allows them to manage their sales, their stocks, customer loyalty, counting points for customers, etc. It is a whole suite of software that revolves around unified business management.

Companies sometimes need to exploit their data on infrastructures that require a lot of computing power and storage. In this case, companies will look for external hosts. It is no longer software that they are looking for but infrastructures, service platforms dedicated to Big Data, analytics, or artificial intelligence as examples. This need will be directed towards PaaS offers where the company will just bring its data and the chosen tool will be configured by the cloud provider.

Finally, companies that want a higher level of control, i.e. down to the operating system level, will move to IaaS offerings. IaaS offerings are among the most widely used today. Companies migrate their data and specific applications to virtual machines that they set up themselves.

According to Mr Khnite, large companies will mostly use IaaS and PaaS: they have the skills needed to set them up (Annexe 8: Interview 5 Comarch). As their IT departments have enough resources and experience to be able to manage custom SaaS software, these companies want to keep their IT resources and skills and can migrate to the cloud without using new applications.

Subsequently, this study moves towards a brief understanding of the demand for cloud offers in Wallonia. According to Statbel, the Belgian statistical office, about half of the companies with more than 250 employees buy cloud computing services, including email services (41.6%), file storage (40.0%) and office software (34.2%). Compared to 2018, this represents an increase of 12.9% (from 40.2% to 53.2%) (Statbel, 2020). Demand is strong for all IT services and will grow in the future.

Among the Walloon operators summarised in Table 8, the first company presented is **NRB**. NRB is a B2B IT supplier which provides optimal end-to-end IT solutions and services through a close and long-term partnership with its public and private sector clients to simplify technological, economic, and societal transformation. NRB provides a range of ICT services: consultancy, software, infrastructure & cloud services, and managed staffing. The company has several data centres, including one at the Herstal site (Parc Industriel des Hauts Sarts) and one at the Villers-le-bouillet site (Belgium DC) since 2018 (NRB, n.d.). The first has been in operation since 2014 and has 600 m<sup>2</sup> of IT space. The second, Belgium DC, is a 1,396 m<sup>2</sup> complex with 300 m<sup>2</sup> of IT space that can be expanded to 900 m<sup>2</sup> and is managed by intelligent software. Their data centres have reached a Tier III level. It is a company of about 3,500 people with several acquisitions in Belgium, Luxembourg, France and Greece. According to Ms Rebbouh, the company's clientele comes from Wallonia and France from both the public and the private sector, and the service most requested is mainframe hosting (Annexe 6: Interview 3 Network Research Belgium).

The second company **WDC** offers housing, DRP and services & support. The term housing means the provision of a highly secure environment in a private or shared area. This includes empty racks for the customer to install and manage their entire IT infrastructure. This data centre has reached a Tier III level. WDC's services are the delivery of the rack and the guarantee of the environment, i.e. temperatures and electrical availability. The smallest unit is 1/3 of a rack and holds about ten servers in it. A full rack is 47 U high, U being the unit, so up to 47 units. Sometimes companies rent cages with access security or even a whole room with up to 60 racks. Customised support is provided by an experienced team of technicians and electricians for certain cabling operations or equipment installation, configuration, and maintenance. WDC has 1,300 m<sup>2</sup> of IT space. Their largest customer sector is IT companies (Annexe 5: Interview 2 Wallonia Data Centre).

The third company, the former data centre of Cofely Data Solutions with Tier III level in Gembloux now belongs to **LCL data centres**, which has 4 other data centres, in Flanders and Brussels. LCL offers colocation in an IT space of 1,500 m<sup>2</sup> and hosting services with a choice of over 40 telecom operators and additional services through partnerships such as Equinix (LCL, n.d.). Equinix, founded in 1998 in Silicon Valley, is the world's leading provider of data centre and infrastructure hosting services with more than 220 data centres in over 60 markets on five continents (Equinix, s.d.). LCL offers a hybrid cloud solution. This is a combination of public and private clouds that allows developers to install their applications in the most suitable environment. The public cloud is more appropriate for rapidly scalable applications. The private cloud is for workloads that do not need to be scaled (LCL, n.d.).

Finally, the last company to own data centres in Wallonia is **IBM**. IBM has two data centres in Bastogne of 1,500 m<sup>2</sup> each with the possibility of extending to 5,000 m<sup>2</sup>. There is no information about the services of data centres on the IBM website. Ms Rebbouh explained that NRB uses these data centres because they have a strong partnership with IBM (Annexe 6: Interview 3 Network Research Belgium).

**Table 8: Summary of Hosting Offers in Wallonia**

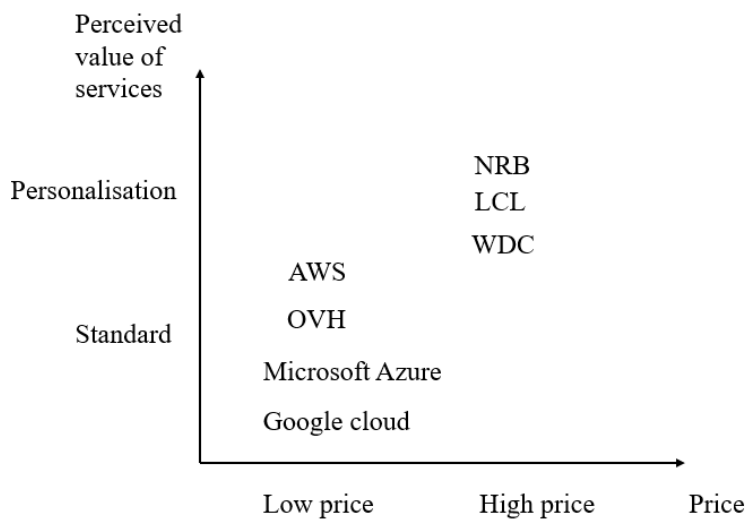
Companies	Offers	IT space (m <sup>2</sup> )	Tier level
NRB Belgium DC IBM	Consultancy, software, infrastructure & cloud services, managed staffing	600 300 → 900 1,500 → 5,000	III
WDC	Housing, DRP, support	1,300	III
LCL data centres	Housing, Hybrid cloud, co-creation & ecosystems	1,500	III

Nowadays, public cloud space has become a commodity, altered by companies such as Google, Amazon Web Services (AWS), Microsoft Azure, and OVH. These companies are part of the biggest public cloud providers. There is a difference between public and private cloud companies. Public cloud companies provide access to online storage, for instance, and private cloud companies provide exclusivity to cloud computing resources for an organization. To differentiate themselves, data centre operators which are private cloud operators, will not propose standard offers but customization according to the customer's needs. This includes upstream support with the identification of the company's needs and requirements. According to Mr Defourny, companies know the weaknesses and advantages of each provider. The difference may be in the service offered. At OVH, if there is a problem

with a server, the company does not allow access to the customer to the server. The difference is also in the security offered if there are fire detectors in the rooms (Annexe 5: Interview 2 Wallonia Data Centre). The choice is up to the companies according to their risk-taking. Some customers decide to take these services while others find it too expensive to have a disaster recovery centre (DRC), a twin infrastructure that is available in the event of a problem so that no data is lost (Annexe 4: Interview 1 Comarch).

Figure 10 positions some public cloud companies and data centre operators in Wallonia along two axes: the price of colocations services with ordinal variables and the value perceived by the consumer, i.e. the quality aspects including standard services or customisation. The price is not precise as the rental contract is very individual and depends on whether the company wants a rack or a cage. Data centres are positioned in different locations according to the perceived value of their services. WDC offers basic housing services. LCL offers more customised services with different clouds and NRB offers customised software in addition. Different sources allow positioning public cloud companies (Lota Cloud, s.d.; Blog Arc Optimizer, 2018; Integral Choice, 2021).

**Figure 10: Bowman's Strategy Clock of Private and Public Cloud Providers**



## 2.2 Fibre Connectivity

The second important point concerns the development of the fibre connection with key points summarised in Table 9.

In Belgium, the internet infrastructure is highly developed. According to a report (SPF Economie, 2020), 99.98% of Belgian households are covered by basic broadband internet and

99.08% by fixed broadband of at least 30 Mbps (megabits per second). This report is based on data from official statistics for the year 2019. The impact of the Covid-19 pandemic is not yet measurable.

According to Mr Compère, Wallonia has a very good telecom network and at the European level, Belgium is in the top 10 of DESI index even if there are white zones and problems in certain places (Annexe 7: Interview 4 Agence du Numérique). Moreover, Google spent €1.1 billion to connect optic fibre networks in Europe (Junius, 2018). Their presence is a real advantage for Wallonia.

At the telecom level, there is a fixed network with fibre optics installed by operators such as SOFICO, an organization linked to the SPW, i.e. the Walloon public service for infrastructure and mobility services. And there is a whole series of distributors who only provide services on the network. The region has the map of the optic fibre network provided by SOFICO (Annexe 2: Map of the Walloon Fibre Optic Network). It has more than 4,000 km of optical cable throughout Wallonia. This figure will increase as it is the region's objective to complete this network with the Giga Region project. This network is a very important asset because it is important for operators, but also if one day Wallonia finds itself in an extremely complicated financial situation, it is an asset that Wallonia could sell at a very high price (Annexe 7: Interview 4 Agence du Numérique). To improve the network, the region has carried out a map to find out which business parks still need to be connected to optic fibre, but this map is confidential because it comes from a partnership between several telecommunication operators. Before this, the region did not know whether the areas have a connection and by which operator (Compère, 2018).

The region highlights two other assets about their connectivity:

- The latency between Wallonia and the capitals of neighbouring countries is barely 5 milliseconds. On average, the latency is 6 times faster than in the northern regions of Europe.
- Due to its proximity to Brussels, Wallonia benefits from the connectivity of the BNIX high-speed hub (Wallonia, 2019).

BNIX (Belgian National Internet eXchange) is the Belgian Internet Exchange Point founded in 1995 by Belnet which is the national research and education network in Belgium. It allows for a better exchange of data between 57 interconnected members. An Internet Exchange

Point (IXP) is a physical infrastructure that allows local Internet traffic to be exchanged, resulting in enhanced Internet speed and lower data transit costs (BNIX, s.d.).

Unfortunately, according to the Arcadis report, Belgium has a great distance between overseas optic fibre connections (Arcadis, 2020). In fact, Belgium has 6 submarine connections From Ostend or Zeebrugge to the Netherlands and the United Kingdom (Annexe 3: Submarine Cables Map of Belgium). These interconnections with submarine cables support global data activities. Belgium has connections with other countries where it can capture traffic and create an interconnection node. This is the case in Flanders which has a point part of the 39,000 km SeaMeWe-3 route. This point links Ostend to Goonhilly Downs in England which then connects many countries as far as Australia (Site Selection magazine, 2020).

In general, data centre operators only talk about optic fibre. According to Mr Defourny, coaxial is hardly used anymore; a data centre is mainly wired with optic fibre (Annexe 5: Interview 2 Wallonia Data Centre). But Wallonia is also covered by a coaxial network that is old but can be modernised. At Voo, a Belgian Internet, TV, mobile and fixed telecom operator, these networks can already carry speeds of at least 100 Mb. Proximus is currently installing new optical cabinets as close as possible to the nodes of these networks to increase the capacity for users. This is a solution for modernising these networks. Mr Compère hopes that the sale of Voo will be made to an operator with an industrial plan to modernise the entire network and not a plan only based on profit (Annexe 7: Interview 4 Agence du Numérique).

**Table 9: Key Points of Connectivity in Wallonia**

<b>Advantages</b>	Belgian households covered: 99.08% with fixed broadband of at least 30 Mbps 99.98% with basic broadband internet
	Optical fibre network map (SOFICO)
	Fixed network of fibre optics (4000 kilometres) (SOFICO)
	Latency (5 milliseconds) between neighbouring countries
	Connectivity of the BNIX
<b>Disadvantages</b>	No direct fibre optic connections overseas
	Covered by an old coaxial network
	No fibre optics connections in each business park (white zones)

## 2.3 Market Importance

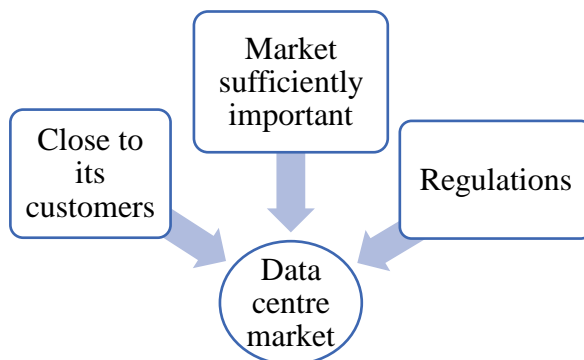
In this section, there are some examples of major markets in Europe, the FLAP-D. This is not a comparison to Wallonia, but it allows knowing their assets as an attractive market.

According to Mr Khnite, there are two important criteria as shown in Figure 11 to consider when choosing a data centre market.

The first is whether the operator is geographically **close** to its users which allows a faster connection. Comarch, for example, chose to build its data centre in the north of France to show its implementation to its customers. The market chosen must be sufficiently important to justify the investment. An investment such as a data centre costs €7.5 million, in the case of Comarch in Lille. When the market does not justify the cost, data centre operators will install their IT equipment in an existing local data centre (Annexe 4: Interview 1 Comarch).

The second reason is the country's **regulations**. The country where the data is located will have to comply with the laws of the country where the data is collected. As an example, Belgium does not have the same requirements in a medical application as France (Annexe 8: Interview 5 Comarch).

**Figure 11: Criteria of Choice for a Data Centre Market**



Currently, there is demand in the Walloon market. Mr Compère mentions several future projects with large international operators. It is not possible to know more at this time because it is a confidential market (Annexe 7: Interview 4 Agence du Numérique).

Then, each country of FLAP-D is analysed with Porter's diamond model to know their competitive advantage.

**Frankfurt** is positioned as one of the major financial and commercial centres in Europe. The city offers strong network connectivity and a strong power supply market as represented in Table 10. This makes it an attractive market and has led to a growing demand for data centre investment (Wiredre, n.d.).

**Table 10: Porter's Diamond Model of Frankfurt** (Arcadis, 2020)

<b>Factor conditions</b>	Power supply network and strong connectivity DE-CIX node with fast data transmission High levels of energy security Good mobile broadband usage and cyber security
<b>Demand conditions</b>	One of Europe major financial and commercial centres
<b>Related and supporting industries</b>	Leading the way in the adoption of renewable energy
<b>Government</b>	Government strategy for the establishment of data centre

**London** is one of the largest markets in Europe, mainly due to the London Internet Exchange (LINX) as shown in Table 11. LINX connects around 900 members from over 80 countries around the world.

**Table 11: Porter's Diamond Model of London** (Arcadis, 2020)

<b>Factor conditions</b>	LINX High cybersecurity High energy security 50 submarine cables with North America
<b>Demand conditions</b>	A decent domestic market size
<b>Related and supporting industries</b>	One of the world's leading financial centres

**Amsterdam** has one of the world's leading IXPs, the Amsterdam Internet Exchange (AMS-IX). This city has become a key point for the development of data centres and a landing point for more than 10 transatlantic submarine cables. This has enabled the city to create an ecosystem rich in interconnections of data centres and cloud users. These users benefit from a Europe-wide connection to sell their services as shown in Table 12.

**Table 12: Porter's Diamond Model of Amsterdam** (Arcadis, 2020)

<b>Factor conditions</b>	Connectivity with 10 transatlantic subsea cables High cybersecurity High energy security Several important internet exchanges (AMS-IX, NL-IX)
<b>Government</b>	Proactive state intervention in optic fibre expansion Supportive government
<b>Related and supporting industries</b>	Key European transportation hubs such as Amsterdam Schiphol Airport and the Port of Rotterdam One of the most reliable energy networks with low prices relative to other markets Ecosystem of suppliers

**Paris** has also become an increasingly popular market over the years with some advantages as shown in Table 13.

**Table 13: Porter’s Diamond Model of Paris** (Arcadis, 2020)

<b>Factor conditions</b>	Cybersecurity Reliable energy grid
<b>Government</b>	Investment of 20 billion € in high-speed broadband coverage by the government
<b>Related and supporting industries</b>	Third largest information and communications technology market in Europe
<b>Demand conditions</b>	Tenth globally in domestic market size

Finally, the market in **Dublin** is heavily dependent on American companies including IT, Internet, financial and pharmaceutical companies which are the main demand for data centres in the city. The difference with other European cities is that Dublin has many data centres offering services to individuals such as Amazon Web Services, Facebook and TikTok as shown in Table 14.

**Table 14: Porter’s Diamond Model of Dublin** (Arcadis, 2020)

<b>Factor conditions</b>	Prime access to undersea cable routes Fourth highest GDP per capita Cold climate Skilled workforce
<b>Government</b>	Tax code which incentivizes investment
<b>Related and supporting industries</b>	European headquarters of American companies such as Google, AWS, Microsoft, and Facebook

Given the high concentration of data centres in FLAP-D markets, it may no longer be feasible for companies to build hyperscale data centres as these markets are highly concentrated and may be difficult to enter such as Frankfurt which has power limits and Amsterdam has zoning limits. It is therefore companies’ interest to look beyond these major markets when building a hyperscale (Zhang, 2020).

For **micro data centres**, the market is different. This trend offers a great opportunity for companies in the future. One of the strategies developed in the USA is to locate these micro data centres at the base of company towers (Zhang, 2020).

Thereafter, the analysis focuses on the assets in **Wallonia**. Wallonia is in an interesting position because it is located near a saturated area and has a lot of available lands. There are

292 business parks and many of these parks have empty land at very attractive prices compared to London, Paris, or Amsterdam (Annexe 7: Interview 4 Agence du Numérique). As an example, Laurens van Reijen, CEO of LCL, explains the choice of Wallonia thanks to the space available but also because the Walloon market interests them (LCL, n.d.). Wallonia and Flanders highlight their advantages in six points as shown in Table 15 (Wallonia, 2019). Wallonia emphasises the taxation system in contrast to Flanders which emphasises its various financial aids in addition to the advantageous taxation system. Factors such as the connection, the available space and the price of land are cited by Wallonia. Flanders puts more emphasis on its environment and expertise in the digital sector.

**Table 15: Comparison of Assets in Wallonia and in Flanders**

<b>Wallonia</b> (Wallonia, 2019)	Very fast connection Ideal climatic conditions Low seismic risk Lot of available land Low operating costs Highly qualified workforce Advantageous tax system
<b>Flanders</b> (Flanders, s.d.)	Digital ecosystem Strong expertise in many digital fields Digital talents Ideal position in Europe One of the largest IT centres in Europe Smart financing strategies Aid for R&D

More precisely, Belgium is characterised by:

- Low risk of earthquakes
- Available and cheap land (about 35 €/m<sup>2</sup>) for large-scale projects
- Electricity prices of 0.05 to 0.08 €/kW (including supply, transport, and taxes)
- Negotiable prices in the sector's "framework agreement" and sites connected to the 150V-380V grid with an available power of 50 to 300 MW.
- An ecosystem of skills, including 13.9% of graduates from scientific or engineering courses among the 6 universities and 19 higher education establishments, a new master's degree in data centre engineering developed in partnership between HELHa, Google and 22 research centres including Cetic (computer science), Multitel (ICT) and SIRRIS (technology industry).

## 2.4 Ecosystem

A data centre market needs a suitable environment for the possibilities of partnership in construction and financing.

Google, for example, the company continues to invest in several assets that the region's environment offers. These include a skilled workforce, large availability of land, an ideal climate and excellent connectivity as highlighted by Wallonia. Google recently approved the establishment of its 5th data centre in their business park. Their investments in Belgium now amount to more than 2 billion € (Google, n.d.). The arrival of Google is also thanks to the Digital Innovation Valley project, a cultural project developed in Mons in 2015. This project has enabled the creation of a favourable ecosystem for companies in the technological sector. It aims to create a cluster of high-tech companies and to place technological and language skills at the heart of the education system (Basalisco, et al., 2015).

This project has allowed the creation of prestigious centres specialising in digital innovation:

- The Microsoft Innovation Centre (MIC) supports start-ups in the development of Microsoft products.
- The Technological Business Centre hosts a business incubator and a dozen SMEs.
- The Euro Green IT Innovation centre is the result of a collaboration between the Walloon Region and several private companies active in the IT and communications sector. One of their missions is the development of pilot projects demonstrating the impact of new technologies on the respect and preservation of the ecological balance and the development of a more sustainable world (Mons, n.d.).

The Walloon region works to have a good environment with partnerships opportunities. Each digital Wallonia project has a specific environment including universities and research centres. Regarding the Giga region project, there are many partnerships between operators who used to be competitors. At this time, there are discussions underway between SOFICO and very high-level international investors including investment funds (Annexe 7: Interview 4 Agence du Numérique).

A report, the *Data Centre Location Index* published by the consultancy firm Arcadis at the end of 2020 places Belgium in 32nd place on a list of 50 countries. Their advice is to develop micro data centres as a solution to gain a competitive advantage over neighbouring countries (Arcadis, 2020). Indeed, the investments for the construction of large data centres are very

important and amounts to several million. As a result, companies want these infrastructures to be quickly operational, but the construction of these centres is greatly slowed down by the permit policy in Belgium which is one of the causes of this low ranking. In comparison, the city of Dublin has categorised data centres as strategic infrastructure. This category means that data centres construction is a priority including infrastructures such as hospitals, motorways, and railways.

Thereafter, an interviewee explained her example of the ideal strategy to promote IT development. According to Ms Rebbouh, the ideal strategy should follow the development of Imec, a research centre in Flanders (Annexe 6: Interview 3 Network Research Belgium). Imec, founded in 1984 in Leuven, aims to shape the future by enabling innovation in nanotechnology and digital technologies that have a significant impact on quality of life. With partners from business, government, and academia, Imec focuses on three pillars of research and development (R&D): a unique infrastructure, over 5,000 scientists from 95 countries, an ecosystem of over 600 leading industry partners and a global academic network (Imec, n.d.).

In addition, the future of the sector was discussed. Three points emerged from the interviews. Firstly, according to Mr Khnite, the near upcoming trend in this sector is **security**, with for example ransomware. Most cloud providers today do not have this cybersecurity expertise and must rely on outside resources. The trend is thus to put more resources into data protection (Annexe 8: Interview 5 Comarch). It should be noted that colocation data centres do not provide cybersecurity, this remains the responsibility of the company.

Secondly, there is no risk of a shortage of **demand** because the more digitalisation there is, the greater the need for data centre services. The need for IaaS and PaaS offerings will not disappear. SaaS will also continue to gain market share, but to a lesser extent, since companies have understood that if they move towards PaaS, they will lower their costs not only on infrastructure but also on human resources. According to Mr Lea, the sector will continue to grow as some companies are set to outsource their infrastructure (Annexe 4: Interview 1 Comarch).

Thirdly, the problem that emerges is the **price** of these services, which is likely to increase given the crisis in minerals, including GPU cards that were temporarily unavailable (Annexe 6: Interview 3 Network Research Belgium). According to Mr Defourny, companies have turned to Asia because labour cost is lower there. All the factories, the knowledge, the

production capacity is in Asia which allows it to develop its ecosystem very strongly. Europe is now dependent on them which is a problem when there is a shortage of microprocessors (Annexe 5: Interview 2 Wallonia Data Centre). Europe has developed a solution with the Gaia-x project.

Finally, the impact of the Covid-19 pandemic was discussed during the interviews. The crisis did not impact investments in the data centre industry but rather the means of interconnection allowing all employees to be remotely connected. This was especially the time for companies to think about outsourcing their infrastructures to a supplier, as it was becoming complicated to have people in-house to manage this. For the moment there is a slowdown in investment but the interest in the cloud will always be there and it will not disappear (Annexe 8: Interview 5 Comarch).

## **2.5 Sustainability**

Another key point that should not be overlooked in the development of data centres is the technologies improving their environmental impacts. Although these technologies are promising, there are many challenges to overcome.

For the Walloon data centres:

- WDC has installed 1,800 photovoltaic panels which cover 10% of their electricity consumption while the remaining 90% are purchased from a supplier who provides green electricity (Annexe 5: Interview 2 Wallonia Data Centre).
- The office buildings of NRB in Herstal have 940 photovoltaic panels and a wind turbine. This wind turbine has a maximum capacity of 2.99 MW, of which 90% is consumed by the company and 10% is redirected to the grid. This covers 40% of NRB's electricity needs (NRB, 2020).
- The LCL data centre is powered by a solar park comprising 2,000 photovoltaic panels generating about 1 MW of electricity, which corresponds to 80% of the infrastructure's energy needs. LCL wants to be carbon neutral by 2030 and signed, along with 24 companies and 17 European associations, the Climate Neutrality Pact for Data Centres which aims to reduce the energy impact of the sector (Samain, 2021).

These technologies are highly dependent on weather conditions. This reduces the reliability of the system and can lead to issues with the quality of the electricity supplied, due to fluctuations in the power. Consequently, other reliable energy sources are needed for the lack

of production. According to Mr Defourny: “the panels should not be seen as a source of electricity, but as a means to reduce the impact on the environment. The data centre can never depend solely on it because it causes a lot of problems” (Annexe 5: Interview 2 Wallonia Data Centre). In fact, there can be breakdowns and it can cause lightning strikes. Series of technical measures exist to protect the power supply such as a renewable energy generation and prediction model or green data centre capacity planning (Deng, Jin, Li, Li, & Liu, 2014).

Moreover, the price of renewable energies including the cost of production and the purchase price is high compared to electricity from fossil fuels. WDC has done extensive research into the installation of wind turbines and the cost-effectiveness of this technology. Their findings are not favourable. Currently, the only reason to install this is the financial incentives. It used to be the same for solar panels except that now the price of solar panels pays for itself in the very short term. Some engineers also think that wind turbines are oversized and run at about 20% of their maximum capacity (Annexe 5: Interview 2 Wallonia Data Centre).

Consequently, the majority of data centres do not build renewable energy systems and prefer to buy green energy from suppliers. In this case, the choice is made by a broker who will call for tenders from various suppliers. He produces a report in which he lists the three best suppliers to help the operator decide. As the price of electricity is very volatile and as operators need stability to operate, data centres sign contracts ideally for 3-5 years. These are renewable energy certificates (RECs), but they can be poor-quality products, as they do not guarantee 100% renewable energy use (Mytton, 2021).

Another sustainable solution is to use cooling systems that use natural resources. For the use of water, this can be waterways in the vicinity of infrastructures, such as the industrial canal in Mons used by the Google data centre. This solution involves a strategy to anticipate any risks, such as drought. In this case, water is pumped from the nearby canal, which is fed by pumping from the river Escaut. Given the pumping volumes for this data centre, there is a risk of repercussions on the river system and the flow of the Escaut, with impacts on the navigability of the river (Warnant, 2020). It is, therefore, best to avoid dependence on rivers and to focus more on water from rainfall which is relatively abundant in Wallonia (between 800 and 1,300 mm/year).

Wallonia has a good location for the installation of cooling systems using outdoor air because the weather conditions are ideal with average temperatures between 8-10°C (Wallonia, n.d.).

NRB data centres use a free cooling technology (NRB, 2020). According to Mr Defourny, this is possible 80% of the time of the year. As long as the outside air is equal to or below 22 degrees, the outside air can cool the computer rooms without any special treatment. If it is too cold outside, the air is mixed with the warm air that is expelled by the servers and the cold air that is drawn in from outside. And if it is over 22 degrees, fans are needed but they wouldn't consume much (Annexe 5: Interview 2 Wallonia Data Centre).

Other cooling solutions are much more environmentally friendly, except that the companies offering these solutions are not local as Mr Lea explained (Annexe 4: Interview 1 Comarch). In the event of a problem, the technicians have to come from Italy, for instance, whereas a data centre must be repaired within 4 hours. Furthermore, the solutions must be proven and tested. Data centre operators have to provide an impeccable service and do not have the means like Google to test innovative solutions.

As mentioned in the theory, systems exist to recover heat, but they are rarely installed. Only one company, NRB, used the hot air produced by the data centres for ventilation and heating of the offices (NRB, 2020). Their rarity can be explained by two reasons: a specific building is needed, and it creates dependencies between the heated building and the data centre which the operators want to avoid. The more external parameters there are such as a heat recovery system or a wind turbine, the more risks are added according to Mr Lea (Annexe 4: Interview 1 Comarch).

Finally, the technology must be cost-effective. A solution may be technically better for the environment but if it is expensive, it will not be chosen. A financial gain must be made by using a certain technology to push companies to invest. Green investments are more expensive at the outset, but this pays for itself afterwards because it reduces the impact, the energy use, by a certain percentage. For instance, at the WDC, the rows of racks have been modernised with hot and cold containment. These are cold corridors that have been glazed to the ceiling and have doors and walls. The cold corridor vendors advertised a 15 or 20% gain, but in reality, it was more like 5-7%. A row of 20 racks with a roof and doors on each side can cost around 40,000€ and this does not pay for itself within 3 years (Annexe 5: Interview 2 Wallonia Data Centre).

## 2.6 Government Incentives

In the digital sector, governments provide several types of incentives to ensure companies to create data centres, such as reduced property and sales tax rates for infrastructure, equipment, and electricity subject to certain investment and employment thresholds (Soni, 2020). Table 16 summarises relevant incentives in Wallonia.

In Wallonia, the digital sector has the same strategy with different agencies. The region uses a Digital Wallonia platform to disseminate its projects. The region has a 5-year development plan (2019-2024) with 4 measures relevant to the industry (Digital Wallonia, 2019).

The first measure consists of helping digital Walloon companies increase their **visibility internationally**. The program is in collaboration with AWEX including international missions and implementation of a network of international hubs. The network has 10 hubs located in San Francisco, Barcelona, Shenzhen, Montreal, Berlin, Tel Aviv, Singapore, London, Stockholm and Paris (Butera, 2019). This provides a privileged point of contact that can accelerate the growth of companies' activities and facilitate their relations with local communities. Among the missions, there will soon be the GITEK 2021 event, bringing together Walloon companies and digital start-ups at the largest technology fair in the MEASA region (Middle East, Africa and South Asia) (Digital Wallonia, s.d.).

The second measure is the creation of the **Smart Region project** which is a new governance model for Smart Cities in Wallonia. Among these actions, there is the mapping of companies and projects on the platform and the setting up of events for the development of partnerships between companies and cities (Rawart, 2019).

The third is an **investment fund** WING (Wallonia Innovation and Growth) for the creation of digital start-ups. Its mission is to promote investments in sectors with a high barrier to entry due to high price or technological innovation such as artificial intelligence, the Internet of Things and SaaS software. The SRIW, Wallonia's regional investment company, manages this investment fund and includes investments between 50,000 and 2,500,000 € (Wing, s.d.). In 2019, more than €7 million was invested in nearly 60 start-ups (Blavier, 2019).

Finally, there is the **Giga Region project** which aims to create a high-performance connected territory. Various actions of the programme exist, including the development of very high-speed connectivity (optical fibre) in regional public economic activity zones (Compère, 2019). They plan to wire 154 additional areas, by investing 81.08 million euros via SOFICO

on 3 development axes, spread over 10 years (of which 63 million euros in the first 5 years), to reach a final total coverage of 257 areas over a total distance of 1,494 km (Compère, 2020). The three areas of development are mobility (to continue to deploy a network in line with the new Intelligent Transport Systems (ITS) and the development of connected cars), the economy and the general interest. For the moment, the AdN has established a map representing the state of connectivity of the 292 Walloon public business parks. This mission will be continued by a second phase which will consist of the development of dynamic cartography and a tool for monitoring the connectivity of the zonings (Compère, 2019).

Furthermore, companies benefit from an advantageous tax system in Belgium. Corporate tax can be reduced from 34% to 20% (Wallonia, 2019). There is also a reduction in labour taxes, a premium for night work and an expatriate status including expatriation allowance, reimbursement of expenses and reimbursement of expenses abroad.

Everything including the price of land and taxation is negotiated at a very high level. As with Google, there is no list of government incentives but there were negotiations to make it attractive enough for them (Annexe 7: Interview 4 Agence du Numérique).

Data centres operators did not specify their negotiations about this topic but mentioned subsidies which are complicated for companies to obtain because they are calls for projects (Annexe 6: Interview 3 Network Research Belgium). Moreover, there is some criticism about a weak strategy to promote IT development and weak ecosystems (Annexe 6: Interview 3 Network Research Belgium). On the one hand, this strategy is a form of sprinkling from the point of view of private companies - a bit of government bashing. On the other hand, even if it is little, the public authorities have put things in place.

**Table 16: Relevant Incentives from Wallonia in the Digital Sector**

<b>Development plan (2019-2024)</b>	Network of 10 international hubs + International missions
	Open data portal with over 400 open public data sets
	Smart Region project
	Investment fund for digital start-ups
	Giga region project with the development of very high-speed connectivity
<b>Advantageous taxation</b>	Lower corporate tax Labour tax cuts Work premium Expatriate status Private negotiation

## Third part: Conclusion

### Chapter 1: Findings

#### 1.1 Summary of Findings

In this section, Table 17 summarise the assets of Wallonia in the colocation data centre industry following Porter's diamond model and Table 18 represents the evaluation of its key success factors.

Porter's diamond model highlights the assets of Wallonia, placed in order of importance. Although the government is not a factor in Porter's system, it has an important influence through its various agencies and financial support in the digital sector.

This model brings together the region's assets in an internationally competitive environment. The main assets of Wallonia are in the two first parts, its connectivity, its tax system and its different agencies including Digital Agency and AWEX.

**Table 17: Porter's Diamond Model of Wallonia**

<b>Factor conditions</b>	Map of the network 4000 kilometres of fibre optical cable 5 milliseconds latency between capitals of neighbouring countries Availability of land
<b>Government</b>	Digital Wallonia (Development plan) Digital Agency & AWEX Investment fund W.I.N.G Advantageous tax system Incentives for renewable energies
<b>Related and supporting industries</b>	Digital Innovation Valley project Electricity network 292 business parks Network of 10 international hubs Environment of each Digital Wallonia project
<b>Demand conditions</b>	Strong demand of cloud computing services Cloud advantages for businesses
<b>Firm strategy, structure, and rivalry</b>	Confidential market Investment with incentives in renewable energies Acquisition (development strategy of data centre operator)

The key success factors allow finding the assets and inconveniences of the Walloon data centre market for attracting operators.

First, the cloud offer factor includes only three data centre operators in Wallonia, but they offer different services and can be further expanded according to demand. In addition, the presence of Google is an asset. Google invests a lot in the region and continues to expand its site. Although this is not a private cloud company, Google's presence can attract new investors.

Second, good positioning for connectivity in a ranking is not everything. When an investor wants to set up a data centre in Belgium, he benefits from the fibre optics network in Wallonia, but the business parks do not all have this connection. There is also no overseas connection with major data centres. In addition, the coaxial network is old.

Third, the ecosystem factor has some advantages, but the disadvantages weigh more. Having space, electricity and a low price are not useful if it takes a long time to obtain a building permit with a high investment in a too low market.

Fourth, the data centre market in Wallonia is small compared to FLAP-D markets. This comparison is disproportionate given the size of the markets being compared but it does show the strengths of these large markets, which are often financial centres (London, Frankfurt) or have very advantageous assets such as taxation and climate in Dublin and connectivity in Amsterdam.

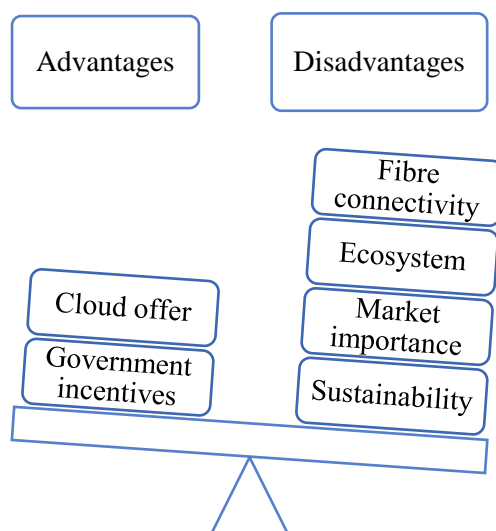
Fifth, the sustainability factor is not developed by the region. Data centres in Wallonia have all implemented some technologies to improve their environmental impact, but this is minimal compared to the improvements that can be made in this area.

Sixth, the government incentives are positive. The cost is very high for the development of these infrastructures and the advantage of lower taxation combined with private negotiations is an asset.

In conclusion, Wallonia does not have enough key success factors to attract investors wishing to build a data centre as shown in Figure 12 which is why there are few data centre operators. Globally, the data centre market has red ocean characteristics. It is a very confidential niche market in an industry where companies are fighting for market share and thus, data centre companies become very sensitive to confidentiality (Chan Kim & Mauborgne, 2010).

**Table 18: Key Success Factors of Wallonia**

Factors	Advantages	Disadvantages
Cloud offer	Presence of Google Medium-sized data centres with different services	Only 3 data centre operators
Fibre connectivity	4000 km of optical fibre Connectivity of the BNIX Latency (5 milliseconds) between neighbouring	No optical fibre in all business parks No direct fibre optic connections overseas Old coaxial network
Ecosystem	Several ongoing projects Availability of land Electricity Environment Ideal climate	Slowness in granting building permits Weak ecosystem
Market importance	Centre of Europe Several ongoing projects with multinationals Close to saturated regions	Very small
Sustainability	Government incentives Weather conditions (cooling system)	High price
Government incentives	Development plan (2019-2024) To increase visibility of digital Walloon companies at the international level Smart Region project Investment fund W.I.N.G Giga Region project Advantageous tax system	Scattering (weak strategy & ecosystem) Call for projects

**Figure 12: Balance of Key Success Factors of Wallonia**

## **1.2 Limitations**

This study involves several limitations.

Firstly, there is a limitation in time and space. It represents the state of a sector at a given moment, the period between July 2020 and the end of May 2021 and which will certainly evolve rapidly. The geographical framework is Wallonia, a region in Belgium.

For the literature review, there is a lot of research on advanced technologies, but this study has limitations in the technical aspect. In addition, scientific research about the Belgian data centre market is little due to the small size of the market.

In the field study, the aspects analysed are economic and environmental and they are not fully developed as this requires work that is beyond the scope of this study. There are no social or ethical implications and not all environmental impacts which are only about the impact on the carbon footprint in Belgium.

Moreover, the key success factors come from one study. Other rankings of data centre markets can have different factors. Those constitute complex factors such as the capacity of the electricity grid which are not developed. The market analysed focuses on the medium-sized colocation data centres which are very specific.

Sometimes, information during interviews was not relevant and reflect only one person's point of view. As there are private negotiations when implementing a data centre, there is a lack of information such as the price of government subsidies or the development strategy of operators.

## **1.3 Recommendations for Future Research**

In the future, the demand for cloud services will continue to increase, as will the associated impacts. Future research can:

- Analyse the new trends in the colocation data centre market
- Analysing projects that are in progress for the establishment of new data centres
- State the data centres market in Belgium including Flanders and Wallonia
- Analyse social aspects about the development of data centre
- Increase the number and diversity of participants
- Analyse the enterprise data centres industry
- Analysing micro data centres market

## Chapter 2: Discussion

The conclusion is not advantageous for the Walloon Region, but some disadvantages are open to discussion with avenues of research to make Wallonia an attractive and competitive location for data centre investors.

Among the disadvantages, there is fibre connectivity. The Giga Region project is ambitious. They started by making a map of the network to see where the business parks lack connections. This is the first step, but Wallonia should not forget to act for the implementation of the cables afterwards by encouraging providers to invest in upgrading the network with incentives or by investing in the SOFICO network. As BNIX is not far from Wallonia, there is no need to invest in an international connection. The international connectivity is explained as a key factor that encourages global actors to consider the region as a privileged destination, but Wallonia has the potential to develop its market by taking advantage of the FLAP-D saturated neighbouring regions.

One solution to take advantage of the saturated neighbouring regions is to install micro data centres. This trend grows worldwide. Studies even suggest that the region should develop its edge computing market. It would be a development opportunity for the region to position itself in this market by helping to develop micro data centres in each industrial park next to the companies and end-users. These micro data centres will be connected to hyperscale data centres in the FLAP-D markets.

To attract investors, a framework can be used with the assets of Wallonia. This can take the form of a dynamic map including the network map, possible locations to build a data centre with the price of land and electricity. Given the importance of these infrastructures, the region can reserve a dedicated data centre location in industrial parks. It can demarcate specific areas with direct connection to fibre optics, electricity, and water and can include prior authorisations as the region needs to speed up its construction authorisation process by simplifying it. Although taxation is low in Belgium, the addition of other reduction measures can include a reduction in taxes on electronic components used in data centres or on electricity used subject to certain investment and employment thresholds.

Moreover, the Walloon Government validates the Digital Wallonia strategy (2019-2024) for 5 years and updates this strategy according to its priorities. The budget of projects, therefore, varies according to the government, and this may cause a slowdown in the development of the sector.

An example of a long-term strategy for the sector is the growth of the sector's environment with the availability of clean and cost-effective electricity. To this end, different objectives would be:

- To encourage the efficient use of energy by promoting innovative energy management techniques and solutions to reduce the carbon footprint of data centres
- To facilitate data centre parks to set up their power generation units to ensure power quality
- To identify mechanisms to ensure long-term availability of electricity at reasonable rates

Regarding this environmental point, data centre operators think about solutions when there are government incentives. Currently, there is a lot of technology for improving their energy consumption, but operators mentioned only incentives for wind turbines. Data centres consume a lot of electricity. Instead of proposing solutions to improve the consequence, incentives could be for solutions that reduce consumption at the base of the problem. As an example, the climate of Wallonia is perfectly appropriate for free cooling technology, but it is rarely used. During the interviews, data centre operators discussed innovative technologies as complicated parameters in the process of a data centre. However, scientific articles outline maturing technologies proven to be effective. In Europe, there is also a climate plan that should be signed by each data centre operator.

## Glossary

Abbreviation	Meaning
<b>AdN</b>	Digital Agency of Wallonia
<b>AMS-IX</b>	Amsterdam Internet Exchange
<b>ASIC</b>	Application-specific integrated circuit
<b>AWEX</b>	Walloon Export and Foreign Investment Agency
<b>AWS</b>	Amazon Web Services
<b>AWT</b>	Walloon Telecommunications Agency
<b>B2B</b>	Business to Business
<b>BNIX</b>	Belgian National Internet Exchange
<b>CEO</b>	Chief Executive Officer
<b>CFO</b>	Chief Financial Officer
<b>COVID-19</b>	Coronavirus disease 2019
<b>CSR</b>	Corporate Social Responsibility
<b>CPU</b>	Central Processing Unit
<b>DE-CIX</b>	Deutscher Commercial Internet Exchange
<b>DESI</b>	Digital Economy and Society Index
<b>DRC</b>	Disaster Recovery Centre
<b>DRP</b>	Disaster Recovery Plan
<b>ECHR</b>	European Convention on Human Rights
<b>EPM</b>	Enterprise Performance Management
<b>ERP</b>	Enterprise Resource Planning
<b>EU</b>	European Union
<b>FLAP-D</b>	Frankfurt, London, Amsterdam, Paris, Dublin
<b>GAFAM</b>	Google, Apple, Facebook, Amazon et Microsoft
<b>GDP</b>	Gross Domestic Product
<b>GDPR</b>	General Data Protection Regulation
<b>GPU</b>	Graphics Processing Unit
<b>IaaS</b>	Infrastructure as a Service
<b>IBM</b>	International Business Machines Corporation
<b>ICT</b>	Information and Communication Technology
<b>IoT</b>	Internet of Things
<b>IT</b>	Information Technology

<b>ITS</b>	Intelligent Transport Systems
<b>IXP</b>	Internet Exchange Point
<b>kW</b>	Kilowatt
<b>kWh</b>	Kilowatt-hours
<b>LINX</b>	London Internet Exchange
<b>Mbps</b>	Megabits per second
<b>MIC</b>	Microsoft Innovation Centre
<b>MSP</b>	Managed service provider
<b>MW</b>	Megawatts
<b>NL-IX</b>	Neutral Internet Exchange
<b>NCSI</b>	National Cyber Security Index
<b>NIST</b>	National Institute of Standards and Technology
<b>NRB</b>	Network Research Belgium
<b>OECD</b>	Organisation for Economic Co-operation and Development
<b>PaaS</b>	Platform as a Service
<b>pH</b>	Potential of Hydrogen
<b>PID</b>	Personally Identifiable Data
<b>PUE</b>	Power Usage Effectiveness
<b>R&amp;D</b>	Research and Development
<b>REC</b>	Renewable Energy Certificate
<b>SaaS</b>	Software as a Service
<b>SME</b>	Small and Medium-sized Enterprises
<b>SOFICO</b>	Walloon Financing company of infrastructure
<b>SRIW</b>	Wallonia's regional investment company
<b>TWh/year</b>	Terawatt hours per year
<b>UPS</b>	Uninterruptible Power Supplies
<b>USA</b>	United States of America
<b>V</b>	Volt
<b>WDC</b>	Wallonia Data Centre
<b>WING</b>	Wallonia Innovation and Growth
<b>WUE</b>	Water Usage Effectiveness
<b>ZB/year</b>	Zettabytes per year

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