Financing of Data Centers in the Context of Sustainability

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Abstract

In an interconnected world, where information is a critical asset for organizations and individuals alike, data centers as the storage locations of most of data available online and essentially the domicile of "the cloud", form the basis of digitalization. Yet, while practically everyone using the Internet personally contributes to an exponential increase in data being processed, data centers are increasingly being drawn into the public critique due to their high energy consumption and CO_2 emissions.

In this paper we attempt to dissect this critique by highlighting the crucial role that data centers play in the digital ecosystem and analyze them from a holistic, sustainability lens. Considering the digitalization goals of the German government as well as the EU in general, we stress the fact that there is no option to realize these without relying on data centers.

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Key Statements

- Digitalization leads to massive amounts of data being produced and transferred amongst consumers. Every smart phone, smart home, smart factory contributes to a multiplication of data.
- Data have to be stored securely – be it in in-house data centers of organizations or colocation data centers operated by third parties offering economies of scale.
- Outsourcing data to colocation data centers saves energy and is comparable to car sharing due to better capacity utilization and higher efficiency of professionally managed servers
- Data centers, along with fiber and towers, form part of the digitalization puzzle and represent basic essential infrastructure
- It is true that data centers consume a lot of energy to process the data underlying our individual and professional needs. Therefore, they must be as energy efficient as possible. This can be achieved through using renewable energy, waste heat usage and liquid cooled servers among others.
- Optimum efficiency in operation is not possible through data center operators' efforts alone - cooperation of all stakeholders is needed, especially when it comes to innovative solutions for example in the context of waste heat.
- Through enabling home office, virtual meetings and other digitalized aspects of our daily and professional lives data centers can contribute to a reduction of CO_2 emissions elsewhere.

1. Why are Data Centers Indispensable in a Modern World?

Our daily habits and the transformation of our economy are driving data consumption

With some form of broadband available in most of the modern world, we are constantly online, demanding services and near-instantaneous delivery of information to our computers, TVs, phones and IoT devices. Be it for work or socialization purposes we expect emails, video conferences, communication via social networks, bank transfers via app, security applications, autonomous driving vehicles and even online shopping tools to be accessible in real-time 24/7.

With digitalized data being the basis for any of the above applications, any action undertaken on a connected device triggers information transfers to and from systems of private and public servers and clouds[1], requiring massive concentrations of computer and networking power to handle an endless number of requests.

Data centers are the communication hubs that process and store data

This is where data centers come into play - as the powerhouses that:

- collect and store all documents, movies, music, manufacturing, banking or geodata broadcasted from various servers via web browsers and network connections,
- as the physical platforms hosting websites and communication services,
- as the security tool for data backup and recovery for various organizations, and

as the communication hubs that process data into optimized packets for delivery to other locations, and that decide the most suitable path for these to travel to end users' devices.

[1] When speaking about the cloud we mean the possibility to outsource data, applications from hard disks of laptops, smartphones or tablets to external servers. That saves storage capacity and enables the access to documents from different devices.

2. How Do the Pieces of the Digital Infrastructure Puzzle Fit Together

To better exemplify the above, it is helpful to keep in mind that the Internet is just a global network of computers of various types and sizes that transmits a variety of data in standardized packets. Hereby, when we receive and open an Outlook email message carrying an attachment on our phone, we essentially request a data download from a Microsoft data center (see exemplary data transmission scenario below). To do so, our mobile device sends a wireless signal to a mobile cell tower, which translates it to light pulses and forwards it via underground optical fiber cables to the nearest appropriate Microsoft data center. The latter prepares data for dispatch and selects the shortest route back to the user – again via lit optical fiber cables back to a cell tower to be finally delivered to the built-in antennas of our device in the form of electromagnetic waves.

Each checking of emails causes data packages to be transferred: down- and uploaded to and from data centers

What becomes clear from this example is that an action as simple as checking an email, requires seamless interplay of all the infrastructure components mentioned and that each piece has an indispensable role to play.

Hence, unless we are prepared to abandon our global digitalization goals, renounce the comfort of digital tools for private and professional use and turn back to old-school copper-based telephony over telecommunications with both sound and image in real time, data centers should be understood as part of the foundation of digitalization and basic infrastructure along with fiber and mobile networks infrastructure, with capacity poised to continuously expand along with the use cases of our society and the digital economy.

Data centers, along with fiber and towers, form part of the digitalization and basic infrastructure

3. Characteristics and Different Types of Data Centers

When speaking about data centers, we in general mean facilities that are used to house critical applications and data. They consist of the building, which is equipped with fiber connections, technical equipment for air conditioning, fire protection, power supply, physical security systems and the like. The servers build the heart of the data center, which – depending on the business model of the operator - can either be brought along by the customers or provided by the operators. To round off the picture ensuring connection to the outside world, all data centers are interconnected through a complex system of fixed-line cables, towers with mobile antennas and satellites.

Data centers are facilities, that house critical applications and data

Any individual, business or governmental organization uses data centers of sorts, whether they decide to build/host one themselves, lease one, rely on outsourcing via cloud storage or opt for a combination of these for higher redundancy and data security reasons. That means data centers can roughly be clustered into in-house and colocation data centers.

In in-house data centers companies are housing their servers, networking hardware, or other necessary IT equipment in a facility that is owned and run by the company itself, often within their corporate office. One of the main advantages of an in-house data center is complete control and that companies are always in touch with their data and free to change or expand on their own terms as they need it.

In-house Data centers are owned and run by each respective company

A colocation data center on the other hand is the data center option where hardware and IT equipment (while still owned by the enterprise) is housed in a secure third-party facility. Some of the biggest selling points of colocation are the expertise, 24/7 support, and world-class infrastructure it lends to clients. Furthermore, in terms of energy efficiency they are by far masterful compared to in-house solutions.

Colocation Data centers offer the opportunity to outsource data storage to specialized providers

Colocation data centers can be rented partly or as a whole as shown in the below illustration. Hereby, hyperscalers[2] are typically the well-known cloud-providers like google, amazon or Microsoft. They tend to rent whole buildings or at least major parts of them. Wholesale customers, in contrast, tend to rent separated rooms (so called “cages”) within a data center, while smaller retail customers only rent single racks.

Source: Altman Solon Management Consulting

Another type are edge data centers, which are characterized as small data centers situated close to the end user. During the next years numerous linked up technologies, that will change and automate our daily lives, will be implemented. These include 5G mobile networks, autonomous driving cars, smart factories and cities that are controlled by devices of the Internet of Things (IoT) and Industrial Internet of Things (IIoT). To use the full potential of these technologies minimal latency is needed. That’s why edge data will also play an important role, and their number will increase significantly during the coming years.

Edge data centers are situated close to the end user to reduce latency

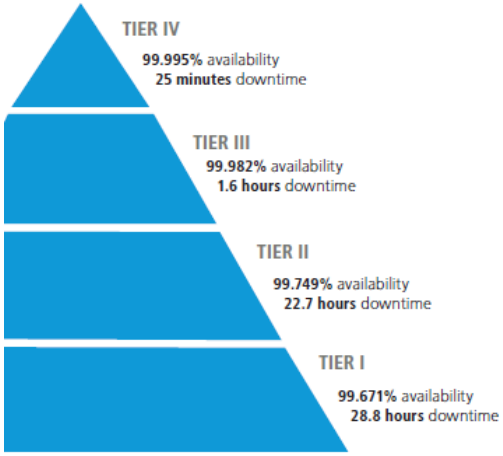
4. The importance of Uptime in the Data Center

What all types of data centers have in common is the importance of uptime. This is a mean to describe the robustness of the data center infrastructure. Uptime is the guaranteed annual availability and one of the core business goals of a data center.

Uptime is the guaranteed annual availability

As companies continue to develop new applications and technologies to remain competitive, it becomes increasingly critical that they are always operational. Major e-commerce, financial brokers and gaming companies have reported that milliseconds of latency can lead to millions of dollars in lost revenue. Delivering the Uptime required is the core activity and competence of dedicated data centers and one of the main reasons why companies continuously move their data from their own in-house systems to specialized providers.

[2] Hyperscale data centers often are also called cloud data centers.



Uptime is basically the calculation of how often a particular resource is available during all the minutes or seconds of a given year. The uptime of the data centers is generally categorized as follows (downtime depicted per annum).

Source: Uptime Institute

To reach the high standards of TIER III or even better as required by the cloud companies, data centers have to provide at least 72h (96h in case of a TIER IV data center) of power outage protection. In practice this is achieved through emergency generators, that are powered by diesel as the only technology reliably providing supply of the required magnitude. Although only needed in case of an emergency, these generators must be tested at least once a month. This is one of the reasons for criticism: Testing the generators causes noise and air pollution as well as CO_2 emissions. Although there are several projects underway to substitute diesel generators for example with fuel cells, the technology currently available would not be sufficient to reach 72h protection. Thus, further research and development is necessary and could be worth to be promoted.

Milliseconds of latency can lead to a loss of millions of dollars

Hyperscalers demand the highest power outage protection

5. Energy Efficiency of Data Centers

The services of colocation data centers are scalable and offer the opportunity to utilize available IT capacity to a higher degree compared to in-house solutions. The data centers are bigger, very efficient and process optimized. The United States Data Center Energy Usage Report concludes that cloud data centers consume 80% less energy for infrastructure like cooling and air conditioning compared to other types of data centers.

Outsourcing data to colocation data centers saves energy and is comparable to car sharing

Indeed, according to the German journal “Industrieanzeiger”, migrating data storage and processing to a professional cloud data center provider is comparable to the benefits produced by car sharing. On the one hand, the profit orientation of operators pushes for highest efficiency, while on the other, aggregating different clients in one data center ensures that existing capacity is used to an optimized extent with fewer redundancy losses.

The above benefits do not even reflect the many other positive spillover effects that are possible nowadays only through the existence of data centers. Examples range from the use of computing capacity for remote and preventive maintenance in industrial cases, (which extend the life of physical equipment and eliminate unnecessary interventions) over data evaluation for resource optimization in the fields of agriculture and enterprise processes, to the deployment of supercomputers housed in data centers for long-term climate modelling – all of which being measures for a more sustainable future, that do not work without massive computing power. Essentially, to allow various other fields of our life to become "green", modern IT consumes resources and hence – without factoring the wider picture - seems to weigh heavier on the environment than may be the case in reality.

Computing power is needed for a more sustainable future

Nevertheless, it is a fact that to fulfill their function, data centers require massive computing power and large amounts of energy. Firstly, energy is needed to directly operate the IT systems, and secondly to protect IT systems from overheating. The usage of electrical energy, which is obtained from non-renewable sources, causes CO_2 emissions and is therefore harmful to our climate. With increasing digitalization, power consumption in data centers has hence risen rapidly. In fact, according to a study of the Borderstep Institute one hour of video streaming produces as much CO_2 Emissions as driving 100 km with a regular car. Similarly, according to Google, one search causes 0.2 grams of CO_2 emissions. With approximately 103 million search queries in Germany, this results in emissions of 20 tons per day nationwide.

Data centers require large amounts of energy, the production of which causes CO_2 emissions, but a data center itself does not emit CO_2

As data centers are an irrevocable part of our digitalized world, the only conclusion can be that they must be as energy efficient as possible and that the energy used should be obtained from renewable sources. In this context, it is worth mentioning that although the amount of data transferred from 2010 to 2020 nearly twentyfold, the energy consumption only grew by around 55% - this effectively means that the efficiency of data centers has already improved significantly over that time period.

Data centers must be as energy efficient as possible

In technical terms, the efficiency of data centers is measured by the "PUE" (Power Usage Effectiveness). This value is calculated by dividing the overall energy consumption by the energy consumption of the IT equipment. The lower this value, the more energy efficient is the data center. While the average PUE in Europe is approximately 1.6 at the moment, the projects currently under construction have a PUE of 1.3 or better.

Importantly, the energy consumption of the IT equipment itself lies in the responsibility of the tenants, which bring their own servers to the building. The difference, thus the decimal place, is influenced mainly by the cooling technology deployed by a data center operator (which causes approximately 35-50% of the overall energy consumption), where the highest potential for further savings lies. The most promising resource efficiency measures in this context, are water-cooled servers (energy saving equipment) and waste heat usage (measure to productively harness the heat energy produced). A combination of both would not only decrease the energy needed for cooling down the servers but would also increase the waste heat temperature captured by the liquid medium and therefore make the waste heat usage more effective and attractive for potential offtakes (e.g. for residential or agricultural uses/vertical farming).

Water-cooled servers and waste heat offer the highest potential for an increase in efficiency

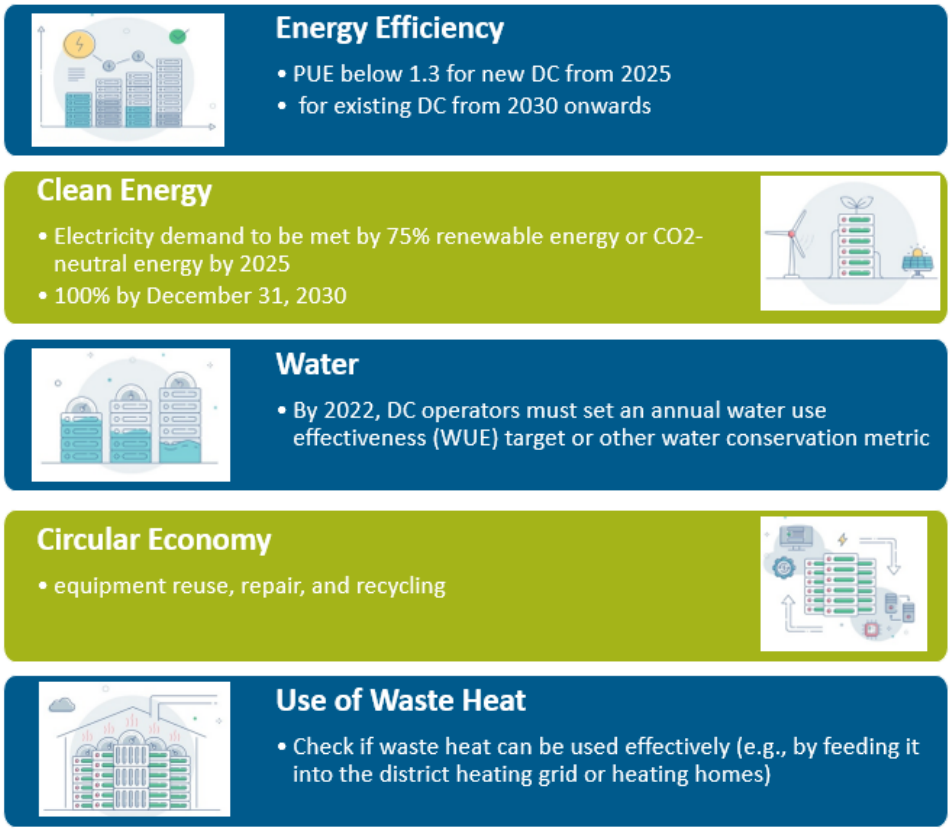
6. Sustainability of Data Centers in the Focus of the Public

In the light of the above, it is not surprising that sustainability of data centers is gaining more and more attention. Policymakers and regulators as well as industry representatives are driving the discussion forward.

European data center industry representatives themselves initiated the Climate Neutral Data Centre Pact in 2020

In the current coalition agreement, the German federal government is planning to focus on ecological sustainability and climate protection for data centers in Germany and specifies that new data centers must be operated in a climate-neutral manner from as early as 2027. By 2030, the EU is requiring CO_2 neutrality for the entire industry (without the purchase of emission certificates).

European data center industry representatives themselves initiated the Climate Neutral Data Centre Pact in 2020 in anticipation of stronger regulation at EU level already ahead of the resolution of the European Green Deal. The initiative identified the following fields of action to reach climate neutrality by 2030:



Source: Own image, based on the Climate Neutral Data Centre Pact

Due to the high energy consumption of data centers already explained above it is not surprising that energy efficiency and the use of clean energy are core elements of the proposed measures. Ideally, with a higher share of renewables in the energy mix, electricity procured by data centers would then be directly sourced by renewables providers on the basis of actual power purchase agreements, rather than – as is currently the case for many players in the market – virtually through the trade with CO_2 emission neutralization certificates. Furthermore, data centers could contribute to the energy transition through acting as power storage and

Data centers can contribute to climate transition through innovative solutions

buffer peak performances, as an energy mix focusing on renewable sources requires a more flexible network. However, for reaching the goal to meet 100% of electricity demand by renewable or CO_2-neutral energy, the supply of those energies need to increase significantly in the next years.

Usage of waste heat is only possible through a cooperation of several stakeholders

When it comes to use of waste heat, proximity to residential areas can be helpful. In fact, an interesting example for the use of waste heat can be found not far from our office in Frankfurt/Germany. The data center operator Telehouse in cooperation with Mainova AG and the project developer Instone Real Estate is implementing a flagship project for sustainability in Frankfurt's Gallusviertel. At least 60 percent of the planned approx. 1,300 newly built residential and commercial units of the new quarter Westville, with an annual demand of 4,000 MWh, will be supplied by waste heat from the neighboring data center from 2023 onwards. According to calculations by Mainova, after the final expansion of Westville, which covers a total area of around 50,000 square meters, planned for 2025, 444 tons of CO_2 will be saved per year.

However, tapping into this potential requires willingness to collaborate with data center providers on the part of various industry stakeholders. For instance, the abovementioned measure of cooling servers with heat-absorbing liquid (up to 60°C currently possible) cannot be influenced by the operators alone outside the domain of high-performance super computers – oftentimes traditional and less technologically-versed clients prefer traditional cooling out of fears that the liquid used may damage electrical equipment and lead to server outages or physical damage (rather a physiological as well as a cost factor given sufficient mitigation measures being available).

Similarly, while a large portion of operators do use excess heat to some extent, the support of energy companies and industrial off takers is urgently required to harness more of the underlying energy potential. For instance, large scale infeed of data center thermal power into heating networks often fails because current utility networks are not fit for that, or because there are no suitable off takers in the vicinity. Hence, collaboration is needed in terms of usage-proof pipe updates in heating systems and better interconnections to potential off takers. Similarly, the availability of potential heat off takers (agricultural players, residential building operators, swimming pool operators, etc.) needs to be considered ahead of construction.

7. Data Centers can Contribute to a More Sustainable World

Working from home, attendance of virtual conferences and option for remote conduct of other aspects of daily live save CO_2 emissions

Even with more efficient data centers the increasing use of digitalization inarguably causes emissions. Yet, in many cases, it can also help to reduce much more emissions than it causes: for instance, video conferences can replace business trips and commuting can be reduced through working from home. The pandemic situation clearly showed the feasibility of working models apart from the old-school office day.

To quantify the effect, Dr Sebastian Jäckle, a scientist from the University of Freiburg has taken an exemplary look at how the carbon footprint of the largest academic political science conference was reduced when it was held online in 2020 due to the pandemic. The results show that the carbon footprint of the virtual conference is only about 0.5 to 1.0 percent of what a face-to-face meeting would have caused.

Greenpeace has also examined how many CO_2 emissions can be saved thanks to working from home instead of commuting to a workplace. Their already in August 2020 published result: If 40% of German employees would work from home two days a week in one year 35.9 billion passenger kilometers and thereby 5.4 million tons of CO_2 could be saved. This is equivalent to a reduction of the emissions caused by commuting by 18% and the total passenger transport emissions by 4%.

Sustainability means more than climate protection; social and economic goals are also crucial

Finally, sustainability is a multi-dimensional approach. When looking at data centers from a sustainability perspective, it would be too narrow to focus on energy consumption and other environmental aspects such as water consumption only. Social and economic considerations are equally important. Here, the UN Agenda 2030 with its 17 Sustainable Development Goals (SDGs) gives a guideline for the central fields of action for a more sustainable future.

For example, when it comes to goal 8 “Decent work and economic growth” data centers are crucial. They are an important part of the digital infrastructure that is fundamental for solid economic development all over the world as many other industries rely on them. It is self-explanatory that data centers contribute to goal 9 (“built a resilient infrastructure”) but making digital participation possible for people all over the world is also important to reach several social goals. Digital empowerment can promote for example goals 3 and 4 (“good health and wellbeing” and “quality education”). Hence, data centers support digital and social participation and thereby empower people all over the world.

8. Conclusion

Since we cannot do without data centers, we should contribute to them operating as sustainably as possible.

Data centers are crucial for our modern world

In this paper we showed that data centers are crucial for a modern world with an increasing focus on digitalization. Therefore, when we discuss the sustainability of data centers, it does not make much sense to demand that no more of them should be built. Instead, it is much more purposeful to discuss how they can operate in a manner as green as possible.

Central points for more sustainable data centers are a more efficient use of energy, increasing the use of green energy as much as possible, reducing the use of water, recycling of IT, server and other equipment and finding innovative solutions for the use of waste heat. Data centers have made significant progress already in becoming more efficient: while the amount of data transferred from 2010 to 2020 nearly twentyfold, the energy consumption only grew by around 55%.

Let´s support the industry to become as green as possible