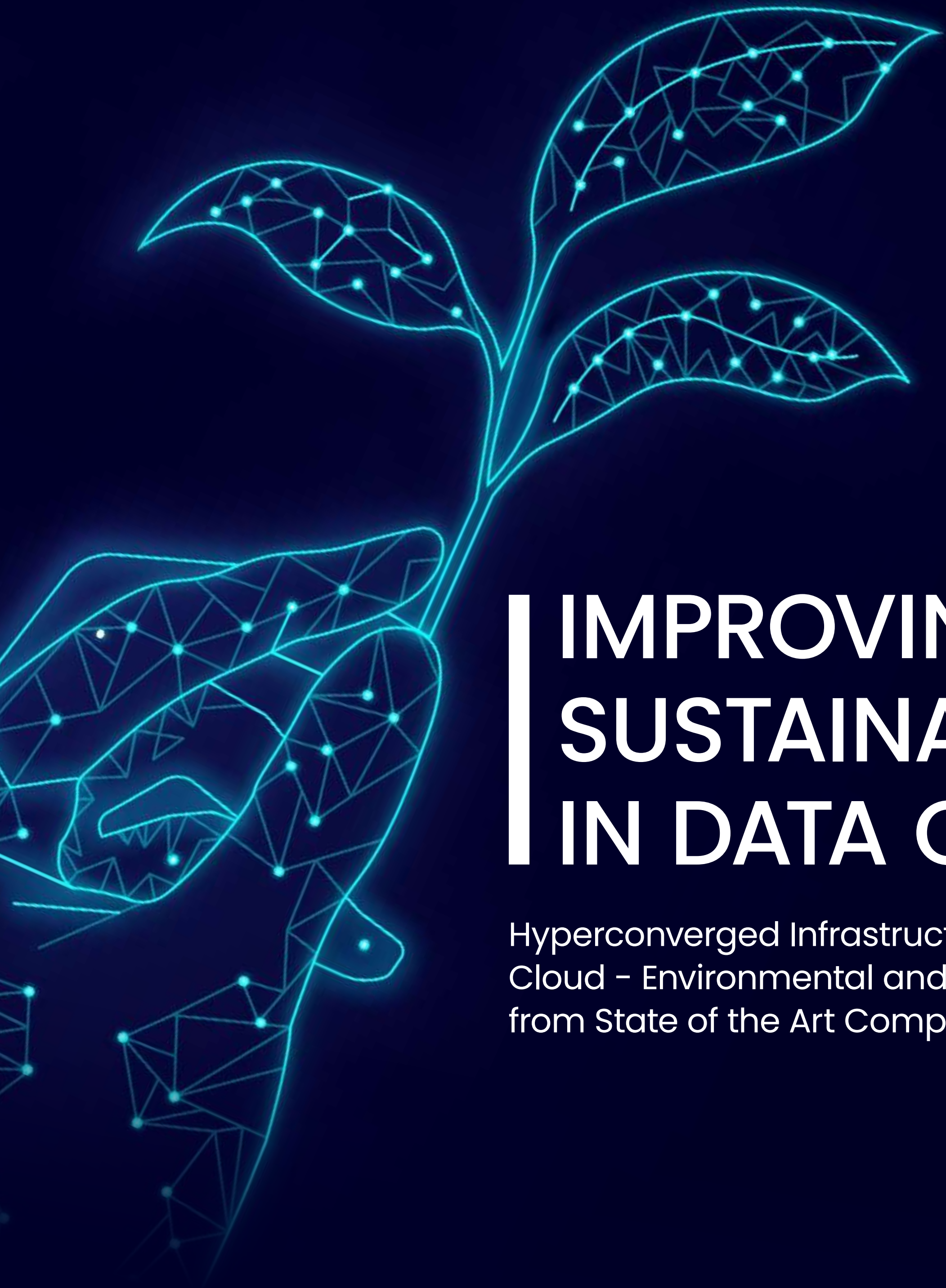
ATLANTIC VENTURES



IMPROVING SUSTAINABILITY IN DATA CENTERS

Hyperconverged Infrastructure and Hybrid Cloud - Environmental and Economic Impact from State of the Art Computing Concepts

Commissioned by

NUTANIX™

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Agenda

Foreword

Dear Readers,
Dear Digital Leaders,

an unprecedented energy crisis following the war in Ukraine and rising interest rates combined with a weak macroeconomic outlook created a "perfect storm" affecting many firms in Europe. At the same time, business leaders had to address regulatory, shareholder, and public pressures to transform their company's operations towards sustainability and disclose their plan for "net zero" targets to 2050.

CIOs and digital executives are facing similar challenges. They have to provide the digital infrastructure scaling with the fast-growing demand for compute power and storage capacity in the aftermath of the "Post-Covid" digitization and the current momentum in the field of AI. As IT budgets are under pressure and electricity prices are soaring, energy efficient data center and cloud operations are key levers for profitability and sustainability.

With this report, we would like to provide you with ideas and design options for a highly energy efficient and climate-friendly IT infrastructure. Based on a model calculation we will examine the potential effects of a Nutanix hyperconverged infrastructure (HCI) and hybrid cloud platform on energy costs and CO_2 emissions in a corporate data center. Additionally, Atlantic Ventures forecasts the aggregated saving potential at an EMEA (Europe, Middle East, and Africa) level and provides further insights into utilizing the hyperconverged concept in a hybrid cloud or disaster recovery setting.

We hope you enjoy reading!

Dr. Carlo Velten
CEO Atlantic Ventures

Hamut H. Pascha
Director Cloud Economists EMEA Nutanix

Report results at a glance

~2 %
of world wide energy consumption

Data Center industry continues to require a significant share of the world wide energy, with a major environmental footprint

27 %

Modern technologies like hyperconverged infrastructure (HCI) have the potential to reduce the energy demand in data centers by over 27 % compared to traditional 3-Tier Infrastructure

In the EMEA region this could potentially save up to 92 TWh from 2024 to 2030. Nearly the same energy demand as for Belgium in 2022

Source: www.ember-climate.org/insights/research/european-electricity-review-2023

From 2024 to 2030 this could save up to 19 million tCO_2e in the EMEA region, an equivalent of almost 4,1 million cars annual emissions

Source: www.epa.gov

This would translate into a potential saving of 25 billion euros in the period between 2024 and 2030

Especially in Europe, where energy prices have surged in recent years, efficiency in data centres plays an important role in meeting sustainability goals and saving costs.

As sustainability in data centers is increasingly subject to regulatory standards, hyperconverged infrastructure may provide an effective contribution

HCI in public cloud or co-locations could further increase the sustainability potential compared to on-premise due to more efficient power usage and on demand scaling capabilities

Executive Summary

- Cloud computing and AI, in the form of newly released Large Language Models (LLM) like ChatGPT, are accelerating the speed of digital transformation across companies in Europe and reinforce overall digital growth - and the energy consumption in global and European data centers.

- Data centers account for roughly 2 % of the world's total energy consumption. Data centers in the EMEA region alone were calculated to consume over 98 TWh of energy in 2023 and are expected to increase to 121 TWh by 2030[1].

- A weak economic outlook and increasing energy prices put CIOs and digital leaders under additional pressure as data center and cloud operations costs are on the rise (EU energy prices for commercial use: from 0,13 €/kWh in 2020 to over 0,23 €/kWh in 2023).

- This puts energy efficiency on top of the agenda for CIOs and data center managers alike. At the same time, energy efficiency could have an additional impact on the carbon footprint and overall IT sustainability.

- Alongside automation, innovative cooling systems and renewable energies, the transformation of traditional 3-Tier architectures towards next generation data center architectures – like hyperconverged infrastructure (HCI) – can be key in reducing the energy consumption and carbon footprint of data centers.

- As CIOs are faced with new environmental and ESG-regulation (e.g. CSRD[2] and EED[3]) and additional internal pressure to "green" their IT operations and uplift their IT strategy towards sustainability, hyperconverged architectures could help to achieve higher levels of energy efficiency and reduce the overall footprint of data center infrastructure.

- Based on the calculation of a representative case study (a model company of a global automotive manufacturer in Western Europe with 11.000 employees) the transformation from a traditional on-premise data center (3-Tier architecture) towards a HCI-based approach cloud provide an efficiency potential in regard to energy consumption and carbon emissions of 27 % per year.

- In the EMEA region hyperconverged architectures have the potential to reduce energy consumption up to 92 TWh from 2024-2030 and save up to 25 billion euros in electricity costs in the same period for companies and data center providers undertaking a complete transformation towards HCI[4].

- The potential climate impact of a complete transformation of traditional 3-Tier architectures within on-premises data centers towards HCI-based approaches in EMEA could be forecasted at roughly 18,7 million tons of saved CO_2e emissions from 2024-2030, equaling nearly 759 million trees required to capture this carbon in one year[5].

1 Calculated by Atlantic Ventures
2 https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en
3 https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-directive_en
4 Calculated by Atlantic Ventures
5 A tree can capture around 24,62 kg of CO_2 per year: https://www.fortomorrow.eu/en/post/co2-tree

Executive Summary

- Relocating a HCI-based platform from an on-premise data center towards a modern co-location site could bring an additional saving potential of 13 % based on lower Power Usage Effectiveness (PUE). Compared to 3-Tier on-premise, a saving potential from 39 % could be realized when using HCI in more power efficient co-locations.

- The migration of a HCI-based platform on-premise towards a public cloud provider like Amazon Web Services (AWS) or Microsoft Azure could magnify the efficiency and saving potential up to 27,96 % as hyperscale data centers tend to offer the lowest PUE in the industry (1,2 or lower). Compared to 3-Tier on-premise, a saving potential from 54 % could be realized when using Nutanix HCI-based software running on public cloud bare metal services.

- Customers could also benefit from implementing lean disaster recovery solutions based on hyperconverged architectures in the public cloud. Here the advantage is based on a small infrastructure footprint at the hyperscaler that could easily be scaled in case of emergency.

Energy, Growth and Environmental Impact – CIOs new Paradigms

It is often stated that executives have to make decisions under uncertainty and that business leaders are living in a so-called "VUCA-world", meaning that volatility, uncertainty, complexity and ambiguity are shaping our environment. That is true. But also true is that CIOs and digital leaders can rely on some fundamental assumptions and long-term trends when planning for the future.

It seems that

- **rising energy prices,**
- **digital growth and innovation**
- **and the transformation towards sustainability**

are among these strategic trends that will influence tech investments and decision-making in the next 5-10 years.

These trends come into play especially when it comes to designing new architectures and operating models for data centers and cloud infrastructures. Let us have a closer look!

Energy, Growth and Environmental Impact – CIOs new Paradigms

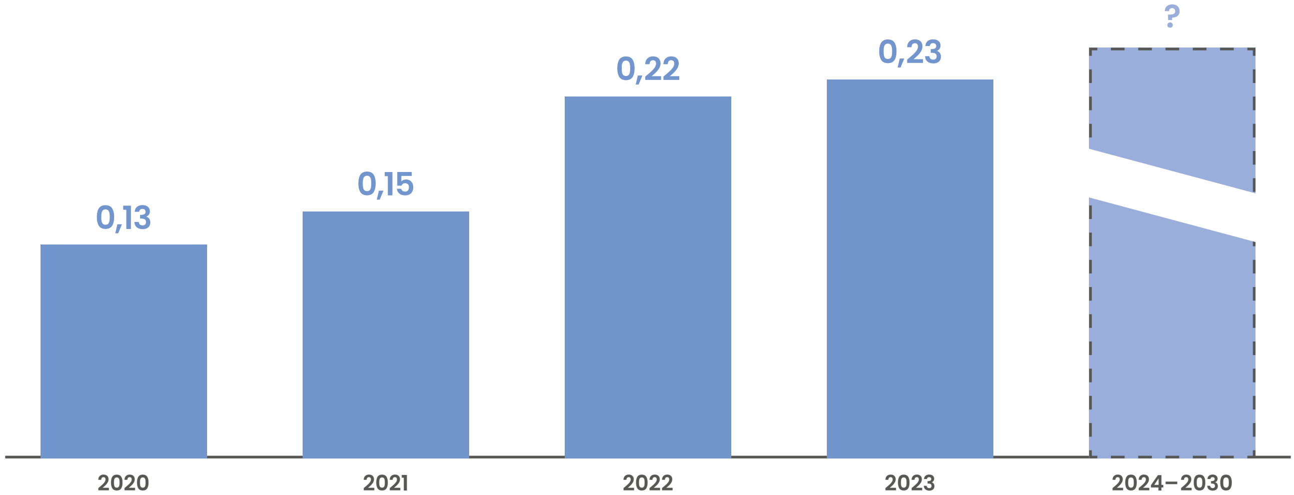
Energy Prices, Renewables and Resilience

One of the critical factors influencing the European economic recovery after the Covid-pandemic is the surge in energy prices. While the post-pandemic phase initiated the energy crisis through a rapidly increasing demand for energy - which the supply side could not meet fast enough - the crisis was significantly accelerated by the Russian invasion in the Ukraine in early 2022. Besides the terrible humanitarian consequences, the Ukraine war also had a severe impact on many countries in the European Union and beyond.

- **Rising Energy Prices:** On a European level the average electricity price soared since 2020[6]. Given the ambitious plan of the EU to become "net zero" by 2050 and to transform its fossil-fueled economy into a climate-friendly "green economy" the demand for clean energy is likely to continue to rise, along with electricity prices. As a result, CIOs and data center managers could face additional costs for their data center operations and should anticipate this within their strategies and contract renewals with providers. Thus, substantial innovation in the field of energy efficiency is needed.

- **Shortage of Renewable and Low Carbon Energies:** For the first full month ever recorded, in May 2023 production of renewable energies from solar and wind in the European Union exceeded those from fossil fuels[7]. While some countries, especially in the Scandinavian region, are pioneering in the adoption of renewable energies, other countries lag behind. In those territories, the energy transition is progressing rather slowly and it is to be expected that the increased demand can only be covered to a limited extent by the supply side. As long as no other disruptive innovation like fusion energy becomes market-ready, these circumstances are causing

EU Electricity Prices in €/KWh (Average Prices for Commercial Use)



Source: Eurostat, 2024 (All energy prices are calculated incl. tax and excl. grid charges)

[6] https://www.euronews.com/business/2023/10/31/energy-crisis-who-has-the-priciest-electricity-and-gas-in-europe#:~:text=Electricity%20and%20gas%20prices%20in%20the%20EU&text=These%20are%20the%20highest%20prices,gas%20prices%20rose%20by%2037.9%25

[7] https://ember-climate.org/press-releases/wind-and-solar-overtake-fossil-generation-in-the-eu

energy prices to rise in the short term due to high investments needed to finance the renewable energy transition[8].

Other factors also come into play. While nuclear energy in the EU has been included in the Sustainable Finance Taxonomy and therefore labeled as "green" energy[9] since 2022, in April 2023, Germany announced a shut down of all remaining nuclear power plants. Other countries may follow this approach. In the upcoming years data centers will compete with electric cars, heat pumps and manufacturing sites for renewable energy. Regional availability of wind, solar and hydro power and also "buying power" will determine if CIOs and data center managers will be able to secure enough "green energy" to power their IT infrastructure.

- **Grid Resilience & Reliability of Power Supply:** For several years, the energy sector has been grappling with supply chain disruptions, highly fluctuating energy demand in short periods of time, and geopolitical tensions in oil- and gas-producing regions. The future reliability of power supply will also be influenced by the investments into the grid itself. Utilities need enough capital and political backing to upgrade their core infrastructure into a "smart grid" that is able to intelligently match decentralized renewable energy supply and flexible consumption patterns. In order to adapt, CIOs and data center managers need to modify their digital infrastructure and daily operational practices to be more responsive to the accessibility of renewable energy. This involves the capability to flexibly move compute-intensive workloads to "carbon-free" time slots when renewable energy is more viable.

Cloud and AI Accelerating Digital Infrastructure Growth

In today's digitally-driven world, the demand for data centers has been experiencing an unprecedented surge. From the exponential growth of the internet, the increasing reliance on cloud computing and Internet of Things (IoT), to the rapid expansion of technologies like artificial intelligence (AI), the need for robust and efficient data storage and processing capabilities has become indispensable. CIOs and data center managers will have to adopt scalable architectures and strategies while at the same time introducing various measures for automation and energy efficiency to keep rising costs under control.

> Post-Covid digitalization, Large Language Models, and IoT solutions are among the main drivers for increased demand in reliable and scalable computing infrastructure that CIOs have to provide.

8 https://www.iea.org/reports/world-energy-outlook-2022/key-findings#abstract

9 In addition, in 2022, nuclear energy in the EU has been included in the Sustainable Finance Taxonomy and therefore labeled as „green" energy.

Energy, Growth and Environmental Impact – CIOs new Paradigms

- **Public & Hybrid Cloud Dominance:** According to various sources the global cloud market (IaaS, PaaS, SaaS) reached a volume of more than 500 Billion USD in 2022. Experts estimate that by 2025 cloud computing will surpass traditional IT and architectures in annual investment volume and become the dominant form of enterprise computing.[10] CIOs and data center managers will thus be challenged to intelligently design hybrid cloud architectures and operating models to transform their legacy IT and become more innovative.

- **Rise of AI and Large-Language Models:** Another factor driving compute capacity is the strong increase of so-called Large Language Models (LLM) including ChatGPT from OpenAI and Google Gemini. With almost 100 million users after only two months, ChatGPT has set the record for the fastest growing customer application since its launch.[11] While the potential of these applications is huge, the increased demand for computing capacity is also staggering. As more and more companies start to build custom AI models[12] or use open source models within their own infrastructure (on-prem or hybrid cloud within their public cloud tenants) to keep sensitive data safe and compliant, CIOs and data center managers should anticipate this additional driver in compute capacity and energy consumption.

"Across the tech sector, we need to recognize that data centers will rank by the middle of the next decade among the large users of electrical power on the planet."

Brad Smith,
President of Microsoft

10 https://www.gartner.com/en/newsroom/press-releases/2022-02-09-gartner-says-more-than-half-of-enterprise-it-spending

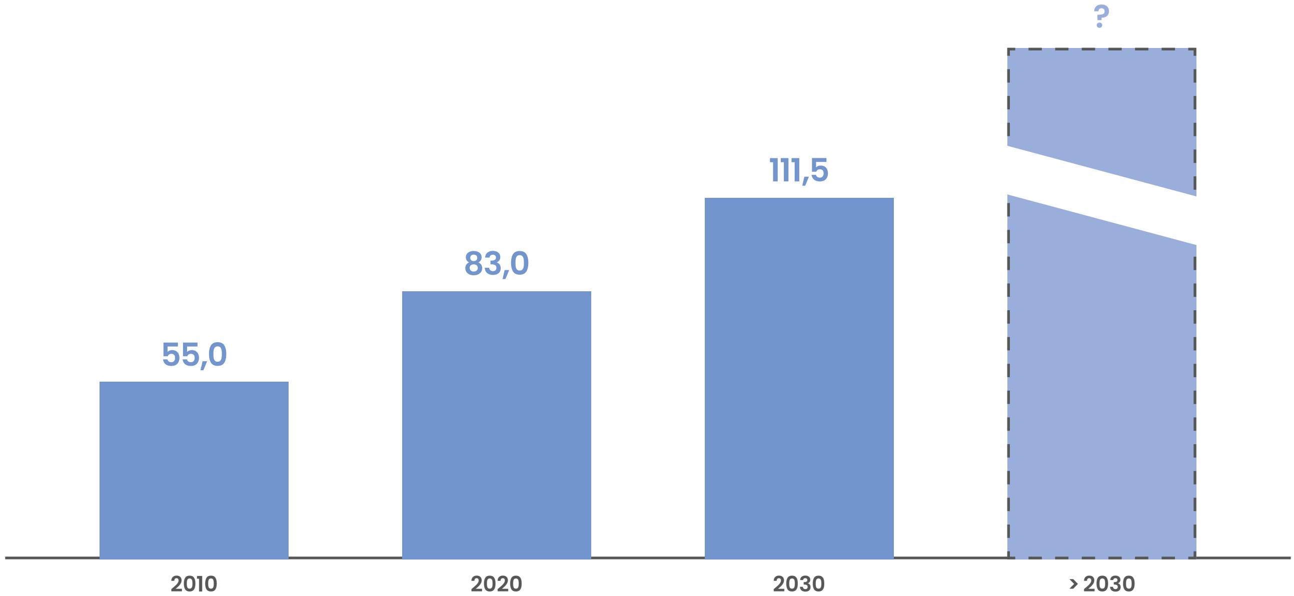
11 https://www.reuters.com/technology/chatgpt-sets-record-fastest-growing-user-base-analyst-note-2023-02-01

12 https://leam.ai

Energy, Growth and Environmental Impact – CIOs new Paradigms

- **Data Center Energy Demand & Efficiency:** The aggregated energy demand of data centers worldwide in 2020 was around 375 billion KWh or 375 TWh corresponding to around 1.5 % of the total global energy demand[13]. In 2023 data centers in Europe (on-premise, hosting & hyperscale) are calculated to consume 90,7 TWh of electricity[14]. Given the projected continued growth of digital workloads, cloud and AI, corporate CIOs and data center managers will need to invest heavily in new technologies and architectures to increase energy efficiency and bring down TCO of their digital infrastructure. Beside new cooling systems and waste heat management, hybrid cloud strategies and hyperconverged architectures can play a vital role in transforming on-premise data centers into highly-efficient cloud operations.

Energy Demand of Data Centers in Europe in TWh (On-Prem, Colocation & Hyperscale)



Source: Borderstep Institute, 2015 (2010–2020); Forecast Atlantic Ventures

13 https://www.datacenterfrontier.com/energy/article/55019791/doe-study-ai-boom-breeds-localized-energy-constraints-but-grid-can-meet-long-term-demand

14 Calculated by Atlantic Ventures

Energy, Growth and Environmental Impact – CIOs new Paradigms

The Rise of the Sustainable Data Center

Companies and consumers have come to expect climate-friendly and sustainable products. This expectation increasingly applies to digital products and services. In the future, enterprises, especially the partners and suppliers of multinational corporations and global brands, must be able to measure, analyze and report the carbon footprint over the entire life cycle (Scope 1, 2 and 3) of their processes – including the IT infrastructure[15].

CIOs and data center managers should therefore deal intensively with the approaches, standards and solutions for automated and software-supported "carbon management". The same applies to the senior management of hosting and managed service providers, since climate and sustainability criteria (e.g. Power Usage Effectiveness[15], share of renewable energies, recycling) will play an increasingly important role in future tenders and customer inquiries.

As a result, more and more CIOs will need to take the path to transform their IT towards sustainability and climate neutrality. Sustainability has already elevated towards a leading spot on the CIO agenda and meanwhile has become a cornerstone in corporate IT strategies. Beside aspects like hardware circularity, green coding and smart data retention policies, energy efficient data centers and cloud operations are still the dominant factors when it comes to the climate impact of corporate IT.

The data center and tech industry has been facing increasing environmental regulation and at the same time actively pursuing sustainable practices to reduce its environmental footprint. Implementing energy-efficient technologies, such as advanced cooling systems, server virtualization, and power management tools, can significantly minimize energy consumption and help to guide computing towards a more sustainable future. Additionally, data centers are exploring renewable energy sources including solar and wind, to shift towards carbon-neutral energy sourcing in operation.

Increasing energy demand of digital infrastructure speeds up the development of eco-conscious data centers. At the same time, energy efficient technologies enable considerable cost savings in daily operations.

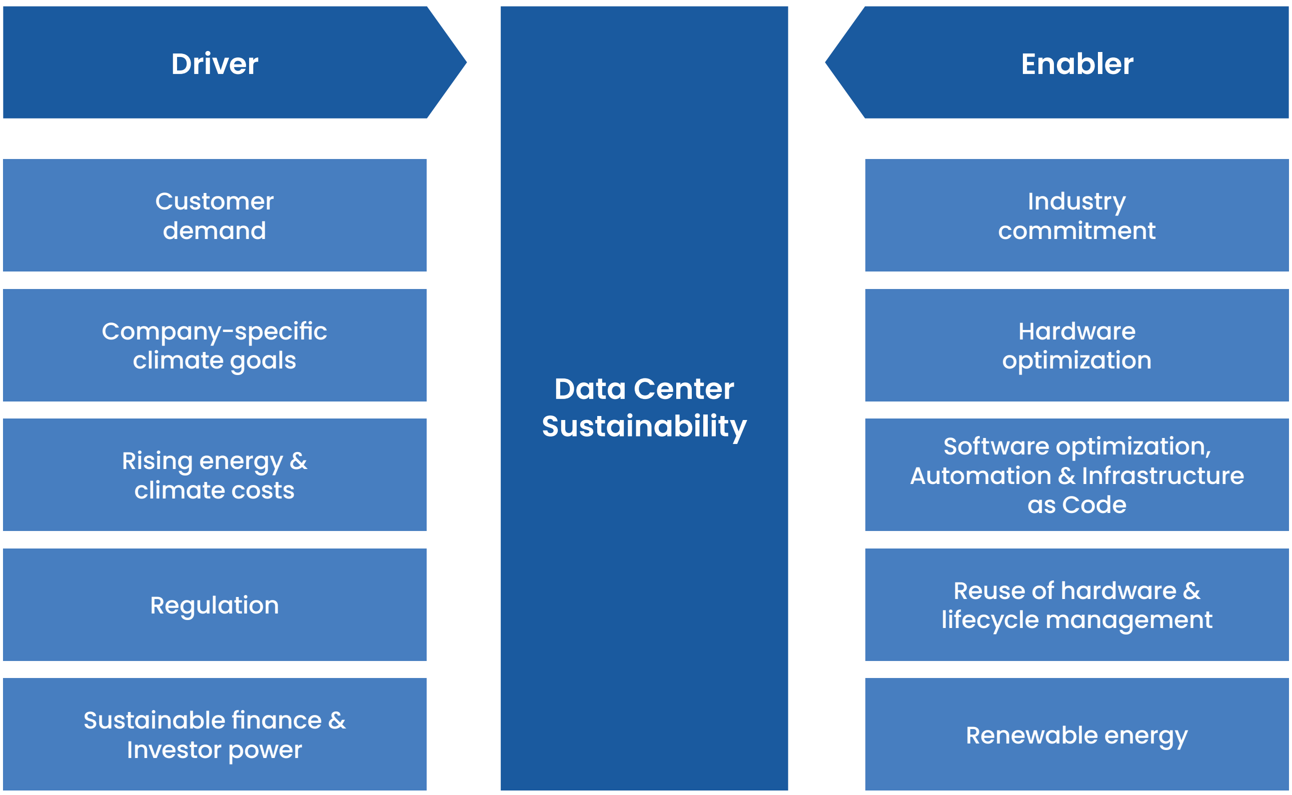
15 https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf

16 Power Usage Effectiveness (PUE) is a metric used to quantify the energy efficiency of a data center by dividing the total amount of energy consumed by the data center (including IT equipment and supporting infrastructure) by the energy consumed solely by the IT equipment. Lower PUE values indicate higher energy efficiency, as less energy is being used for non-computing functions.

Energy, Growth and Environmental Impact – CIOs new Paradigms

At the same time, sustainable data centers not only help mitigate climate change but also contribute to cost savings and improved operational efficiency in energy and resource consumption. The sustainability aspect is therefore important and relevant for CIOs from various perspectives and once again evidence that corporate environmental responsibility and economic profitability in the business world can be very well aligned with each other. In general, the sustainability trends in the industry are coming from different directions, which can be classified in "Drivers" and "Enablers".

Driving forces for Data Center sustainability



The past year has once again seen a number of developments in areas that will move the computing industry into a more sustainable direction in the medium and long term. A selected number of these topics are discussed in more detail below.

Energy, Growth and Environmental Impact – CIOs new Paradigms

Driver

Rising energy & climate cost
Electricity prices climbed sharply as a result of the Covid-19 pandemic, the Ukraine conflict with associated sanctions against Russia, and ongoing disputes in the Middle East[17]. After an initial industry slowdown there was a strong increase in demand for energy after Covid-lockdowns, resulting in increasing energy prices. Together with a slowly progressing expansion of renewable energies, this trend is expected to continue.

Regulation
Especially within the EU, there are discussions about new regulations and standards that are expected to have a far-reaching impact across multiple industries.

These include the "Corporate Sustainability Reporting Directive" (CSRD), which obliges companies with more than 250 employees or 40 million euros in revenue to perform extended sustainability reporting and disclose strategies to lower the climate impact of the business.[18] This regulation will have far reaching impacts on companies across Europe.

The data center, cloud and hosting industry will face the "Energy Efficiency Directive" (EED), which was formally agreed on by the European Union in July 2023.[19] The EED is a comprehensive legislative initiative introduced to enhance energy efficiency and reduce energy consumption across various sectors, including data centers. The main objectives of the directive are to promote sustainable energy use, decrease greenhouse gas emissions, and achieve the EU's energy efficiency targets.

Enabler

Industry commitment
The tech industry is also increasingly recognizing the importance of more sustainability and efficiency in data centers and is providing concrete measures and initiatives to promote eco-friendly solutions. In early 2022, the "iMasons Climate Accord" initiative was founded[20]. The program is intended to achieve carbon neutrality in the digital infrastructure, as well as to define uniform standards for carbon accounting in the industry. The initiative already counts 200 companies, including hyperscalers, colocation providers, product manufacturers, service companies and many others.

Other major initiatives are the Climate Neutral Data Center Pact (CNDCP), a collaborative initiative in the European Union that aims to make data centers across Europe climate-neutral by 2030[21].

While these developments are not the first in the area of data center sustainability, they and others address the environmental impact of digital infrastructure and actively seek solutions and standards from within the industry.

17 https://www.reuters.com/markets/global-markets-middle-east-graphic-2024-04-19
18 https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en#legislation
19 https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-directive_en
20 https://www.interglobixmagazine.com/one-on-one-with-the-chairman-and-founder-of-infrastructure-masons-dean-nelson
21 https://www.climateneutraldatacentre.net

Energy, Growth and Environmental Impact – CIOs new Paradigms

Hardware optimization
In the realm of the data center industry, significant strides in hardware technology have taken center stage, particularly in the area of next generation architectures like highly efficient CPUs and storage solutions as well as liquid cooling systems. Energy efficiency emerges as a primary driving force behind these advancements. Thanks to significant innovative progress in the energy efficiency of data centers, greenhouse gas emissions have increased relatively modestly in recent years compared to the overall exponential increase in demand for computing capacity.

Software optimization
Software plays a pivotal role in enhancing sustainability within data centers through software-defined infrastructure and AI-driven optimization. By decoupling hardware from software, software-defined infrastructure allows for dynamic allocation of resources, enabling energy-efficient scaling and consolidation based on workload demands. Highly automated processes streamline operations and reduce energy losses. AI can enable improvement of resource utilization, predicting usage patterns and optimizing cooling, power distribution, and workload placement. This synergy of software-defined infrastructure and AI-driven automation maximizes server efficiency, minimizes energy consumption, and reduces the carbon footprint of data centers.

Renewable energy
The geographic location of a data center determines the availability of renewable energy sources. While in some regions (e.g. Nordics and France) renewable energy like solar, wind and other sustainable sources are more available other geographies are more reliant on fossil fuels.

Since the carbon performance of a data center is largely a function of the local energy mix, it is likely that the data center industry will continue to actively support the transition to renewable energy and invest in corresponding initiatives[22]. More information can be found in the Nutanix Carbon and Power estimator tool[23].

Hyperscalers already have long-term contracts with energy providers - e.g. Power Purchase Agreement (PPA) - committing to major sourcing of renewable energy to run their data centers. Regulations like the Energy Efficiency Directive will also impact the demand and use of renewable energy in other data centers, including co-locations and enterprise solutions.

22 https://www.forbes.com/sites/siemens-smart-infrastructure/2023/03/13/how-data-centers-are-driving-the-renewable-energy-transition/?sh=1745f6824214
23 https://www.nutanix.com/carbon-and-power-estimator

Next Generation Data Center – Hyperconverged meets Hybrid Cloud

Infrastructure in a Hybrid Multi Cloud World

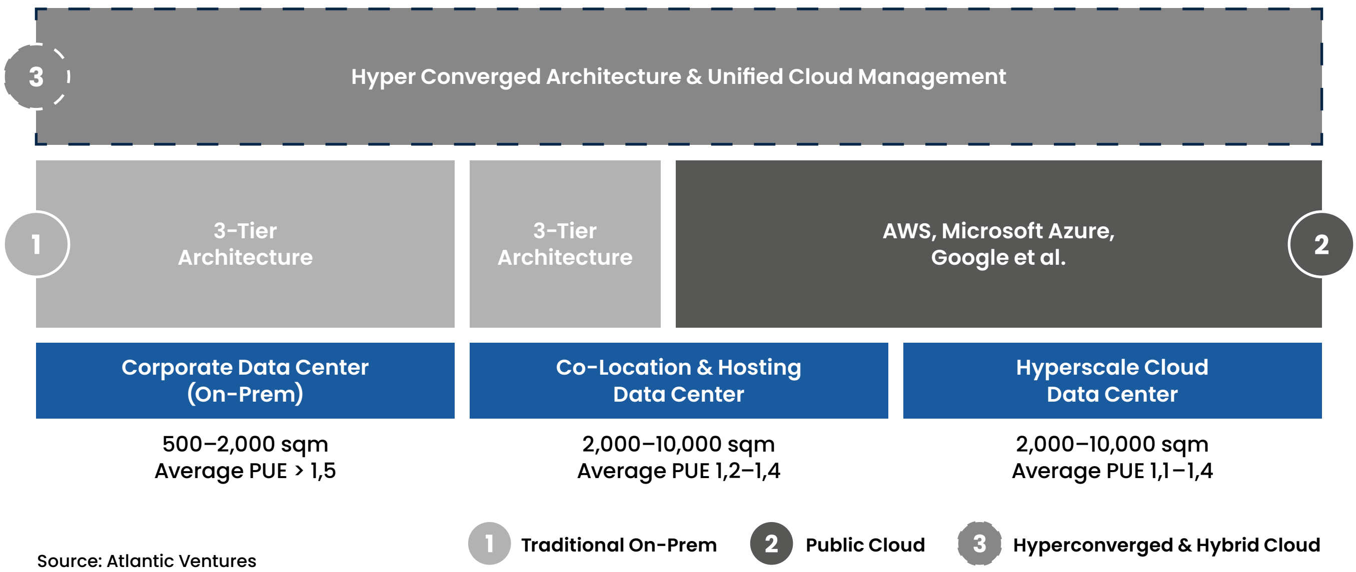
Companies are facing a broad variety of options to run their digital applications and business processes ranging from on-premise data centers equipped with traditional 3-Tier architectures over next generation infrastructures like hyperconverged-based architectures (HCI) deployed in internal or external data centers. The latest generation of hyperconverged-based solutions also offer the possibility to be deployed on various public clouds like for example Microsoft Azure and Amazon's AWS service - thereby providing unprecedented flexibility and automation potential. Hyperconverged architectures provide customers with the opportunity to combine the advantages of a true cloud-like, highly automated IT infrastructure with the flexibility to host it in any location - or on any cloud. As a result, data sovereignty and data privacy requirements can be met on an application and service level.

By operating hyperconverged-based platforms within large-scale co-location data centers or on hyperscale public cloud platforms, customers could also largely benefit from better energy efficiency levels (PUE), futureproof ESG-ratings and renewable energy supply.

Hyperconverged at a Glance - Architectural Benefits and Ecological Impact

For a long time, the 3-Tier infrastructure has been the standard in the design and operation of data centers; it still offers a high level of reliability today. However, with the environ-

Strategic Options for Data Center Operations in a Hybrid Multi Cloud World



Source: Atlantic Ventures

Next Generation Data Center – Hyperconverged meets Hybrid Cloud

mental awareness of companies and new regulatory restrictions (e.g. CSRD) data centers have come under increasing pressure to move towards sustainable technologies, especially considering their immense demand for electricity. This includes the traditional 3-Tier setup, which with its three main components - servers, storage and network switches - requires a particularly high level of energy for operation.

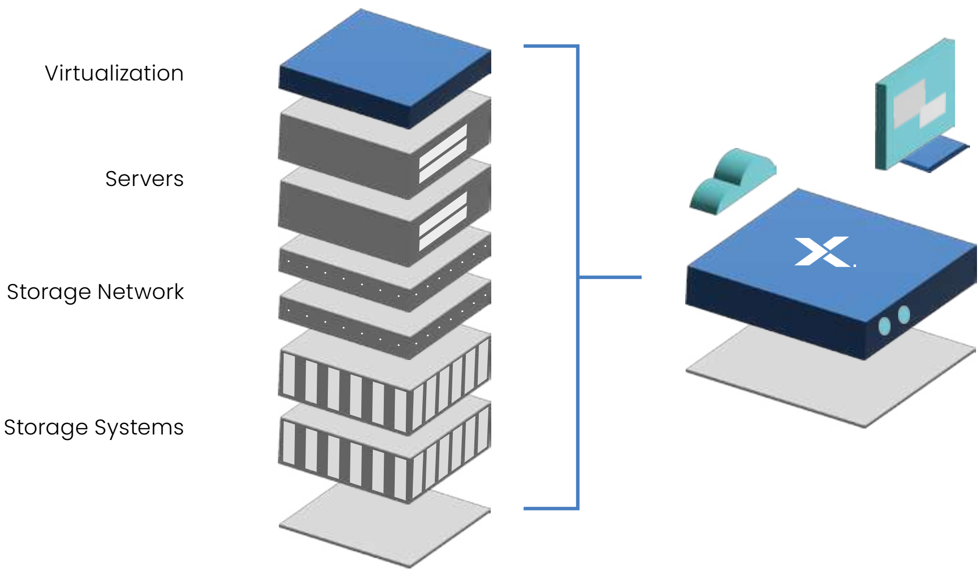
Additionally, due to the large hardware volumes required, not only the operation, but also the manufacturing, transportation and end of life (EoL) leave a significant environmental footprint and add to carbon emissions in the overall 3-Tier product lifecycle.

Hyperconverged infrastructure, in contrast, combines the server and storage units into a single unit and virtualizes them through software-defined functionalities. In addition, a central management solution coordinates the components for optimal performance. This approach provides considerable benefits.

First, the amount of hardware required in the data center can be reduced significantly. This has a major impact on space and the required energy to run the IT-infrastructure.

Secondly, the positive effects go beyond the underlying infrastructure. For the operation of data centers, not only the IT infrastructure itself plays an important role, but also other components within the data center to keep it running. The operation of the IT-infrastructure emits a significant amount of thermal heat, which has to be compensated by energy-intensive cooling. What's more is there is a significant difference in the energy consumption of cooling between traditional 3-Tier

3-Tier vs. HCI Infrastructure[24]



[24] https://www.nutanix.com/hyperconverged-infrastructure

infrastructure and HCI, in favor of the latter. Because hyperconverged infrastructure uses less hardware and generates less waste heat, there is also less need for cooling.

In summary, the design of hyperconverged architecture not only offers the possibility of saving hardware and space, but also represents considerable saving potentials in terms of energy, related carbon emissions, and costs.

From a sustainability point of view, this is an important aspect on the journey of decarbonizing data centers. Quantifying these potentials and determining the positive influence of hyperconverged-based approach on the carbon footprint of data centers is the purpose of the following model calculation.

The key advantages of modern hyperconverged architectures can be summarized as follows:

- **Automation & Utilization:** Enabling advanced capacity & utilization tooling as well as reduction of IO-traffic within racks and data center
- **Hardware Footprint:** Architecture design that eliminates storage arrays and separate storage networking leading to lower number of rack units
- **Energy Efficiency & Rack Density:** Aggregated energy savings due to smaller hardware footprint and positive effects on cooling
- **Carbon Footprint:** Significant lower carbon emissions due to energy efficiency and smaller hardware footprint
- **Leveraging Hyperscale and Co-Location (capacity on-demand):** Extending hyperconverged architecture design and automation patterns towards co-location data centers or public clouds, customers could leverage the given energy efficiency and emissions reduction benefits.

Hyperconverged infrastructures could be an enabler for operating cost efficient and more sustainable data centers. Also in a hybrid cloud setup, corresponding technologies can support more eco-friendly operations.

Case Study – Energy Efficiency Potential and Carbon Impact of Hyperconverged

Methodology and Scenarios

Technological innovation in digital infrastructure is one of the main reasons why energy demand in data centers has increased only moderately compared to the exponential increase in digital workload. HCI is one of these innovations allowing to run data centers more efficiently.

In order to calculate the efficiency potentials of hyperconverged-based solutions compared to traditional 3-Tier, similar to the 2022 report "Improving Sustainability in Data Centers"[25], a mid-sized company is modeled. When it comes to efficiency, two major aspects are being considered. Firstly, efficiency gains in energy consumption and secondly, reductions in carbon emissions of the data center. Let's have a look at the current data center setup of the company, a global automotive supplier (fictive) located in Europe.

Company Profile	
Industry	Global Automotive Supplier
Shareholder	Family Owned Company
Employees	11.000
Headquartered	Western Europe
Locations	85
Revenue	2,4 bn Euro
IT staff	190
IT user base	6.500
IT budget	55,2 mio. Euro

IT Budget Split	
IT Innovation, Projects & Governance	6.624.000 €
Digital Workplace & Collaboration	4.416.000 €
Business Applications & SaaS	26.496.000 €
Network & Connectivity	5.520.000 €
Infrastructure & Data Center	12.144.000 €

[25] https://www.nutanix.com/uk/go/improving-sustainability-in-data-centers

Case Study – Energy Efficiency Potential and Carbon Impact of Hyperconverged

The company operates its own, campus-based data center and onsite backup facilities within a 600 sqm facility including UPS and a traditional cooling system:

Description Data Center	
Data Center	Own, Campus-based DC (plus Onsite Backup Facility)
Size	600 sqm
UPS	Available
Cooling	Traditional Cooling System
PUE	1,59

The corporate IT-infrastructure is setup as a 3-Tier architecture including a traditional, primarily disk-based NAS/SAN storage array with the corresponding controllers and switches:

Description of current IT-infrastructure	
IT-infrastructure	Traditional 3-Tier Architecture (Server, Storage, Network)
Number of Servers	400
Type of Server	X86 Rack Server, Industry Standard, Medium Size
Storage	Traditional NAS/SAN Storage Array & Controllers, 9 PB
Age of Infrastructure (avg.)	4 years
Bandwidth	100 Gbps
Operations	24/7

Case Study – Energy Efficiency Potential and Carbon Impact of Hyperconverged

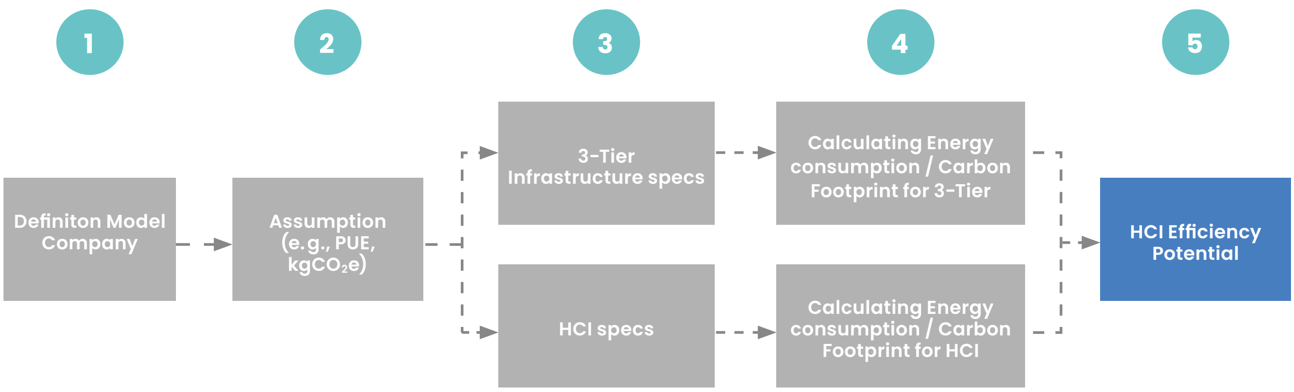
As part of the sustainability strategy and due to the outdated infrastructure in the data center, an overall refresh of the on-premise infrastructure is planned in order to bring it to a state of the art setup. The company is evaluating two different options and would like to focus on the data center efficiency potentials that can be achieved in order to ensure alignment with the corporate sustainability strategy:

1. Modern 3-Tier infrastructure: The company decides to stay with the traditional infrastructure setup. This means that the existing 3-Tier infrastructure will be replaced by a new, state of the art 3-Tier setup, including servers, storage and network equipment.

2. Total HCI-based Switch: The company decides to modernize the infrastructure platform with a full switch from 3-Tier to a HCI-based platform.

Let's have a look at how the efficiency potentials from HCI will be calculated. After the model company and the key assumptions ("1" and "2" in the following figure) are derived, two comparable infrastructure solutions are configured ("3") aligning with the needs of the model company. The energy consumption of a data center remains the main driver of carbon emissions and therefore the sustainability of a data center. Energy is required to power the IT infrastructure itself as well as the cooling and other facility systems (e.g. UPS, security, monitoring) which can be expressed in the Power Usage Effectiveness (see table "Description Data Center" above). Based on the overall power consumption the emitted carbon dioxide will be calculated using the carbon intensity. Since the model company is located in western Europe, the average carbon intensity[26] for Europe is used (0,300 kgCO_2e/kWh in 2023, see Appendix 1).

Methodology Model Company



[26] Carbon intensity measures the amount of carbon dioxide (CO2) emissions produced per unit of energy or economic output. It is used to evaluate the environmental impact of energy sources and economic activities, with lower carbon intensity indicating cleaner, more efficient energy use or production.

Case Study – Energy Efficiency Potential and Carbon Impact of Hyperconverged

In addition to the carbon emissions caused by the energy required to run the data center, the carbon emissions from the other stages of the product life cycle - manufacturing, transport and recycling / end of life - are taken into account. For a server, these account for roughly 22,6 % of the overall emissions and have a noticeable impact on the overall environmental footprint.

Carbon emissions of a server over the product lifecycle

Source HPE: https://www.hpe.com/psnow/doc/a50002430enw (Case: Performance & Europe)

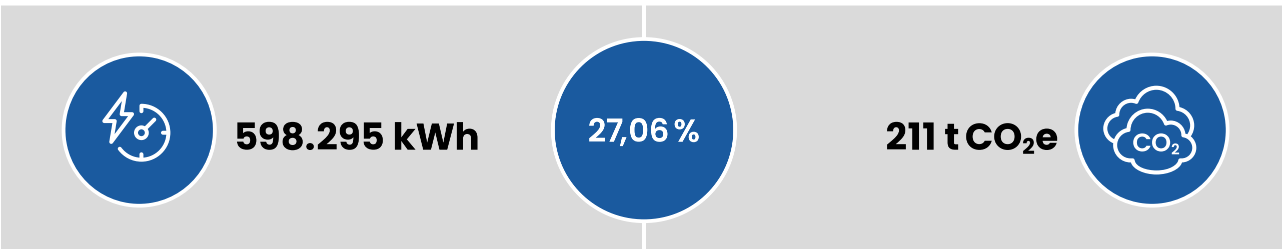
Hyperconverged vs 3-Tier On-Premise

Now that the theoretical sustainability aspects of HCI-based approach have been discussed in detail, it's time to take a closer look at the actual numbers and compare the different infrastructure setups in more detail.

Assuming that all other factors besides the infrastructure remain unchanged (e.g. cooling and UPS[27]), the efficiency potential from a HCI-based platform is significant. Having a look at the model company, a 27,06 % efficiency potential could be realized by HCI when comparing it to the latest 3-Tier solutions[28].

This also directly reflects in the savings in energy and the related carbon emissions by the latter technology: In total, almost 600000 kWh energy could be saved per year, resulting in carbon emissions reductions of over 212 tCO_2e (considering usage, manufacturing, transport, EoL).

HCI saving potential in the model company



[27] Energy saving potentials from less cooling required due to more efficient HCI are not considered here. These would add additional efficiency potentials by HCI.

[28] Calculated by Atlantic Ventures. Since we are comparing two similar technology solutions, the percentage difference was calculated: https://au.indeed.com/career-advice/career-development/percentage-difference-calculator

Case Study – Energy Efficiency Potential and Carbon Impact of Hyperconverged

If the two infrastructure setups are compared in more detail, the differences quickly become apparent. In the 3-Tier infrastructure, storage remains one of the main energy guzzlers with 20 % of the total energy consumption. (The energy demand in the HCI nodes is higher than for the servers in the 3-Tier case because they combine the server and storage together).[29]

Yearly Energy Consumption and Carbon Emissions for modeled Data Center

	3-Tier Infrastructure		HCI	
Energy Consumption - Use (kWh)	Server	925.038	HCI Node	1.121.866
	Storage	503.735		
	Storage Switches	69.379		
	Network Switches	80.522	Network Switches	80.522
	Cooling & Facilities	931.418	Cooling & Facilities	709.409
	Total energy consumption	2.510.091	Total energy consumption	1.911.797
	Energy saving potential: 598.295 kWh			
Carbon Emissions (t CO_2e)	Carbon Emissions (Use)	753	Carbon Emissions (Use)	574
	Carbon Emissions (Manufacturing, Transport, EoL)	138	Carbon Emissions (Manufacturing, Transport, EoL)	105
	Total Carbon Emissions	891	Total Carbon Emissions	679
	Carbon saving potential: 212 t CO_2e			

Source: Atlantic Ventures, 2024

Therefore, overall significant savings could be achieved by making use of hyperconverged technologies and thereby improving the efficiency of the digital infrastructure.

Besides running a corresponding infrastructure completely on-prem, there are also additional interesting use cases in which technologies such as HCI are utilized in the company, likewise with the corresponding sustainability impact. Some of these are described in a short excursus below.

29 A detailed overview of the Infrastructure setup is explained in Appendix 2.

Case Study – Energy Efficiency Potential and Carbon Impact of Hyperconverged

Hyperconverged in Co-Location

Efficiency potentials of a HCI-based platform can be realized in the enterprise-owned corporate data center. However, modern computing approaches nowadays go beyond on-premise solutions. The efficiency potential from hyperconverged architecture could also be leveraged in other environments like in a co-location site. Modern co-location data centers not only offer reliable and secure housing of infrastructure but also a high resilience in regard to energy supply and the option to benefit from renewable energy.

Additionally, most modern and newly build co-location data centers offer a highly competitive PUE of 1,4 or even less (compared to a current EU average of 1,6) which translates into lower overall energy and operating costs.

Given the infrastructure set-up of the described case study (see above), an additional energy efficiency potential of 13 % could be realized when the same configuration of hyperconverged pods is migrated from an on-premise data center with a PUE of 1,59[30] into a modern co-location site with an PUE of 1,4.

Energy Consumption in kWh	Hyperconverged On-Premise	Hyperconverged Co-Location[31]
Hyperconverged Infrastructure*	1.202.388 kWh	1.202.388 kWh
PUE	1,59	1,4
Data Center Operations (Cooling, UPS)	709.409 kWh	480.955 kWh
Total Energy Consumption	1.911.797 kWh	1.683.343 kWh
Additional Saving Potential of HCI in Co-Location compared to HCI on-premise		228.454 kWh (13,0 %[32])

Source: Atlantic Ventures, 2024

*sizing and configuration see model company

30 For the Model Company we assumed a PUE of 1,59. Many data centers have significantly higher PUEs, meaning that the saving potential would be even more substantial here.

31 Assuming same Infrastructure as HCI on-premise

32 Since we are comparing two similar technology solutions, the percentage difference was calculated: https://au.indeed.com/career-advice/career-development/percentage-difference-calculator

Case Study – Energy Efficiency Potential and Carbon Impact of Hyperconverged

Hyperconverged in the Public Cloud

A company can leverage a hybrid cloud approach by combining on-premise private cloud infrastructure with public cloud resources through a single control and data plane to optimize their IT operations. This setup allows them to dynamically balance workloads between the two environments, offering flexibility, scalability, and cost-effectiveness. Hybrid cloud deployments can be customized to suit specific business needs, allowing sensitive data to be kept on-premise while utilizing cloud resources for other workloads. As mentioned before, a HCI-based platform can be extended to the cloud by deploying it on bare metal instances. This involves running HCI software directly on dedicated physical servers in the cloud environment.

From a sustainability perspective, HCI-based solutions on bare metal services (either from a public cloud, co-location or hosting provider) can reduce energy consumption and carbon footprint even further compared to the on-premise case in the model company. This is due to the low PUE of Public Cloud Providers as well as the flexibility in providing on-demand computing capacity. To calculate these additional efficiency potentials of HCI in the Cloud relative to HCI on-premise, we assume that the same infrastructure is used in both settings. Of course, hybrid cloud in reality means that a part of the infrastructure would stay on-premise. This calculation solely intends to show the efficiency potential in the public cloud.

Energy Consumption in kWh	Hyperconverged On-Premise	Hyperconverged Public Cloud (NC2)[33]
Hyperconverged Infrastructure*	1.202.388 kWh	1.202.388 kWh
PUE	1,59	1,2
Data Center Operations (Cooling, UPS)	709.409 kWh	240.477 kWh
Total Energy Consumption	1.911.797 kWh	1.442.865 kWh
Additional Saving Potential of HCI in Co-Location compared to HCI on-premise		468.932 kWh (27,96 %[34])

Source: Atlantic Ventures, 2024

*sizing and configuration see model company

33 Assuming same Infrastructure as HCI on-premise

34 Since we are comparing two similar technology solutions, the percentage difference was calculated: https://au.indeed.com/career-advice/career-development/percentage-difference-calculator

Case Study – Energy Efficiency Potential and Carbon Impact of Hyperconverged

Hyperconverged for Disaster Recovery in the Cloud

Disaster recovery in data centers belongs in the standard repertoire of many companies, but is often under the radar in terms of efficiency and sustainability potential. However, due to the very infrastructure-heavy nature and the extensive operational effort, considerable efficiency potentials can be realized by moving the recovery environment to a public cloud provider.

But, let's start at the beginning: Disaster recovery is typically realized through a comprehensive set of strategies and technologies aimed at ensuring business continuity, and minimizing downtime & data loss after a catastrophic event. One critical aspect involves maintaining a secondary data center copy at a different geographic location. This off-site data center serves as a backup that houses hardware, and copies of data necessary to restart business applications and services in the event that there is an issue with the primary site.

Typically, the setup requires substantial resources to mirror the primary data center's infrastructure and keep it powered. Additionally, regular data replication & synchronization, testing and simulation of disaster scenarios are crucial to verify the effectiveness of the recovery plans.

These processes and infrastructures require significant amounts of energy and thus also have a substantial economic and environmental impact. Instead of operating cost- and energy-intensive infrastructure in an own on-premise data center, disaster recovery can instead be moved to the public cloud leveraging a HCI-based platform, with significant advantages on the efficiency, scalability and sustainability side.

- **Energy Efficiency:** Cloud providers optimize energy usage through efficient data center management, benefiting from economies of scale. This reduces the carbon footprint compared to individual company data centers. Also, the PUE in public cloud data centers is usually better due to huge investments in modern technologies and processes improving energy efficiency of computing infrastructure, cooling and UPS.

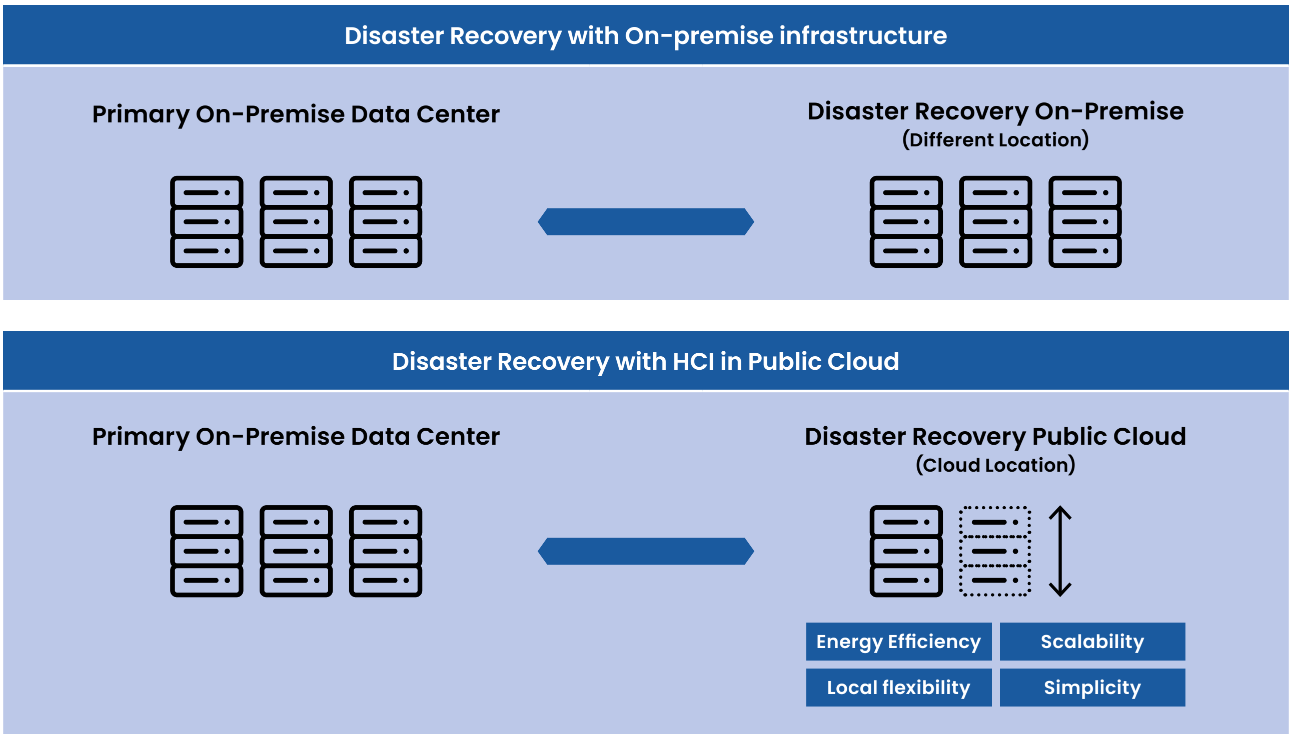
- **Scalability:** Cloud services scale resources as needed, using only required hardware and energy. This reduces the amount of hardware needed in the first place (also reducing manufacturing related carbon footprint). This contrasts with traditional data centers, where capacity is maintained for disaster cases, leading to unnecessary energy consumption.

Case Study – Energy Efficiency Potential and Carbon Impact of Hyperconverged

- **Location Flexibility:** Cloud providers choose data center locations based on factors like energy availability and cooling efficiency, often resulting in environmentally optimized facilities. They also have long-term power purchase agreements (PPAs) for sourcing renewable energy. Especially in times of energy crisis, the sourcing of energy for companies running an on-premise data center can be risky in terms of availability and significantly higher costs.

- **Simplicity:** By utilizing a HCI-based solution to define, set up and manage their disaster recovery environments, customers could substantially benefit from consistent tooling and system management. All storage and compute is being managed through the same interface and API endpoints providing a much simpler policy management and disaster recovery orchestration for administrators and IT managers. The automated nature and opportunity to manage "infrastructure as code" in both HCI and the public cloud reduces manual testing and configuration effort within the core Disaster recovery processes.

Disaster Recovery on-premise and in the Public Cloud



Source: Atlantic Ventures, 2024

Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

The impact of modern computing architectures could be significant on a global scale, making data centers around the world more efficient and climate friendly while at the same time operating at lower cost.

Forecast Methodology

The large global energy demand for data centers is directly correlated to the carbon emissions being emitted. In total - including embodied emissions - data centers and data transmission networks worldwide accounted for roughly 330 million tons of CO_2 equivalent in 2020, according to the International Energy Agency (IEA)[35].

Even though the overall share of enterprise data centers is declining in the last decade and many companies are moving (at least partly) to the cloud or pursuing hybrid concepts, on-premise solutions remained relevant in 2023 and beyond. Enterprise data centers remain popular, especially among industries with strict data privacy and security requirements. Some companies prefer to keep sensitive data on-site to maintain greater control and compliance over their information. In recent years, there's even been a noticeable trend of companies shifting from public clouds back to on-premise or hosted locations[36]. Among other things, control over applications, data sovereignty, complexity in the provisioning of workloads and hidden costs are among the main drivers to staying with on-premise solutions. Again, hybrid use cases are coming into focus, with organizations carefully assessing what is maintained in the cloud and what is kept on-premise.

Enterprise data centers often use the less efficient 3-Tier infrastructure. The positive environmental impact due to the efficiency potentials of HCI described in the model company above (around 27%) could therefore be significant on a global scale. After having a closer look at the impact of HCI on the sustainable operation of data centers in one model, we will now focus on the impact on a regional level. The focus will be on the total switch to a HCI-based platform described in the model company, i.e., migrating all 3-Tier infrastructure to HCI. Considered will be selected countries in the EMEA region, which we will examine using local conditions (e.g. carbon emissions in energy production & energy prices). The following forecast is based on a calculation by Atlantic Ventures.

[35] https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks
[36] https://www.datacenter-insider.de/zurueck-aus-den-wolken-trends-gruende-und-hintergruende-a-71704fd2cda1ed2a5c14a6d93b2ec3aa

Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

The following list details the basis of the analysis:

- **Regions**
  The forecast will consider the following regions: France, United Kingdom, Netherlands, Germany, Spain, Italy, Sweden, Other Europe, Middle East / North Africa (MENA)

- **Forecast period**
  In the European Union, many of the regulations and self-imposed environmental goals of companies target 2030 as a milestone in their sustainability agenda. In order to be able to take a closer look at the path to more sustainability, the forecast will be considered for the years of 2024 to 2030.

- **Energy demand growth in data centers**
  With the fast-paced developments in the tech industry (such as LLMs), the digital workload is increasing at an exponential rate[37]. Fortunately, with the benefit of rapidly advancing data center technologies, the energy demand of digital infrastructure can be kept comparably low. As a result, an increase in energy demand of data centers with a compounded annual growth rate of 3% will be assumed.

- **Energy efficiency gains by HCI**
  In chapter 5 we calculated a HCI-based solution efficiency potential of 27,06% compared to 3-Tier Infrastructure. This potential will also be considered for the regional forecast.

- **Energy prices & Carbon equivalents**
  The rising energy prices and at the same time falling carbon intensity in energy production (due to renewable energies) are detailed in chapter 3. The respective developments are considered individually for the different regions. The table in Appendix 1 provides an overview.

  For 2021 and 2022, the sharp increase in energy prices are taken into account[38]. For some countries, energy prices decreased again in 2023, other countries recorded a further increase (see Appendix 1). The price developments in the coming years depend on a number of factors. In order to ensure the same basis for calculation for all regions considered, a compounded annual growth rate of 5% is assumed from 2024 to 2030. This takes into account the continuous energy transition and mid-term price increases due to scarcity of resources as well as market uncertainties.

  In order to meet the sustainability trends of increasing regulations, access & transition to renewable energies, industry commitment and also self-imposed sustainability goals, the emission equivalents will be reduced over time. According to a new study from the IPCC, it is feasible to halve carbon emissions by 2030[39] (compared to 2019). This reduction in emissions will also be assumed in the model calculation. The development of emission equivalents is attached in Appendix 1.

- **Share of traditional 3-Tier infrastructure vs. Cloud & Edge**
  We will consider the ongoing trend of cloud transformation, meaning a shift from traditional IT architecture to the Cloud for the forecast period. While companies still rely to a certain degree on their own infrastructure, there is a clearly visible shift towards cloud computing. This shift towards Cloud will be considered for each region individually.

37 https://www.goldmansachs.com/intelligence/pages/AI-poised-to-drive-160-increase-in-power-demand.html

38 All energy prices are calculated incl. electricity tax and, excl. grid charges. The detailed energy prices development is listed in Appendix 1. Source: Eurostat (2023)

39 https://www.ipcc.ch/2022/04/04/ipcc-ar6-wgiii-pressrelease

Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

EMEA

The data center industry in the EMEA region is experiencing rapid growth and transformation. Countries such as Germany, the UK, France, the Netherlands, and the UAE are leading in attracting data center investments and expanding their digital capabilities. The region's strategic location also makes it an attractive hub for international data traffic.

Sustainability and renewable energy have become key priorities for data center operators in the EMEA region and companies are adopting energy-efficient technologies and exploring renewable power sources to reduce their environmental impact and meet sustainability goals. Especially in Europe, regulations that are on the way are having a major impact on future data center operations. Furthermore, data protection regulations, such as the GDPR, have significantly influenced the industry. Data center operators must ensure strict compliance to protect user information and avoid hefty fines.

Overall, data center activities in EMEA are flourishing, which also means significant energy consumption. In total, over 101 TWh of energy is expected to be consumed in 2024 in order to meet the overall energy demand in the region. Around 53 TWh (52%) of that load is still coming from traditional infrastructure.

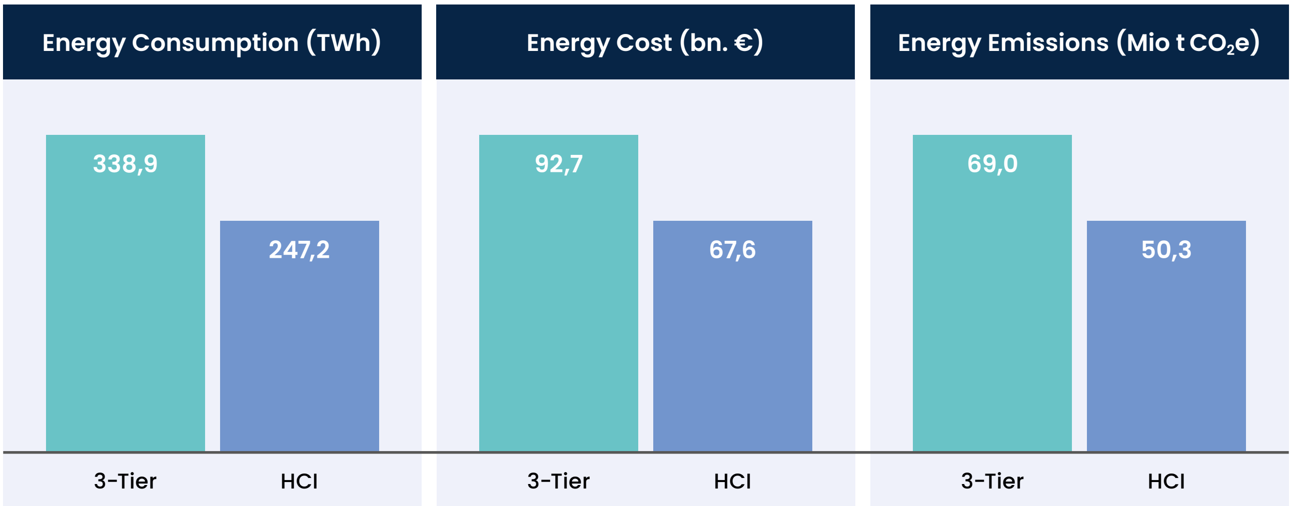
EMEA	2024	2025	2026	2027	2028	2029	2030
Overall DC energy use per year (TWh)	101,3	104,3	107,5	110,7	114,0	117,4	121,0
Energy consumption 3-Tier DC (TWh)	52,7	52,2	50,6	48,9	47,0	45,0	42,5
Energy efficiency potential by HCI (TWh)	14,3	14,1	13,7	13,2	12,7	12,2	11,5
Cost saving potential by HCI (bn. €)	3,3	3,5	3,6	3,6	3,7	3,7	3,7
Carbon saving potential by HCI (Mio. t CO_2e)	3,6	3,3	3,0	2,6	2,3	2,1	1,8

Source: Atlantic Ventures, 2024

Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

EMEA

Aggregated potential Energy Consumption, Cost and Carbon Emissions 3-Tier vs. HCI-based architecture (2024-2030)



Source: Atlantic Ventures, 2024

Many computing activities in the EMEA region still take place in traditional on-prem data centers. When it comes to cloud transformation, Europe in particular does not yet have a share in public Cloud quite as high as for example North America, resulting in considerable additional energy consumption. In the period from 2024 to 2030, a complete switch to HCI-based platform could save up to 91,7 TWh of energy in the EMEA region.

This also comes with a hefty price tag. By 2030, the given HCI switch could potentially save nearly 25,1 billion euros in the EMEA region. Especially with the sharp increase in energy prices in Europe, HCI represents an important tool that CIOs and digital decision makers need to consider in their long-term strategy.

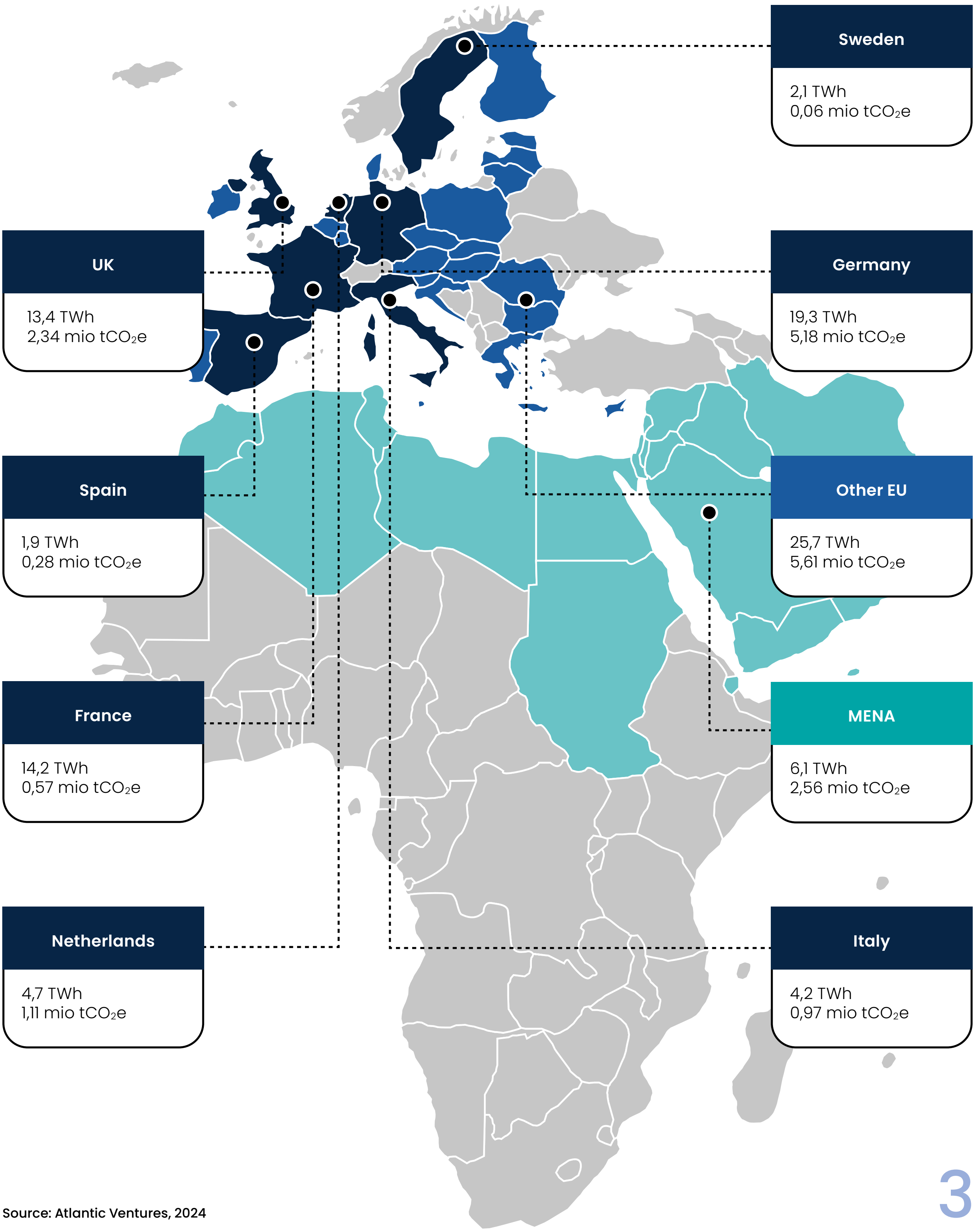
And of course, the potential positive environmental impact of Hyperconverged architecture should not be neglected. Across the entire region, by 2030 18,7 million tons of CO_2e could be saved. To put this in perspective: A tree can sequester an average of about 24,62 kg of carbon per year[40]. This means that it would take almost 759 million trees to capture the 18,7 million tons of CO_2e that could be saved by moving from 3-Tier to HCI.

In the following section a detailed analysis of different countries will provide insights into potential energy and carbon savings when entirely switching from 3-Tier to HCI-based architecture.

[40] https://www.fortomorrow.eu/en/post/co2-tree

Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

Potential HCI-based platform savings within selected EMEA regions (2024–2030)



Source: Atlantic Ventures, 2024

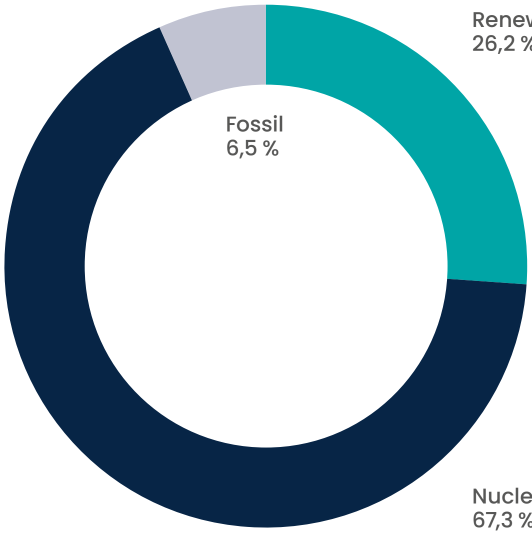
Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

France

Even during the recession, data center activities in France continued to grow. This growth is also reflected in the overall data center energy consumption, which is forecasted to reach almost 14 TWh in 2024, over 8 TWh resulting from data centers with traditional infrastructure. By 2030, overall data center energy consumption in France is expected to increase to 16.5 TWh.

The share of traditional data centers will decrease from an estimated 59 % in 2024 to 41 % in 2030. Due to the already very low carbon intensity in the French energy mix, the potential carbon savings from switching to HCI-based platform are comparatively small versus other countries in the European Union.

Public net electricity generation France 2023



Source: Frauenhofer ISE, 2024 - Energy Chart

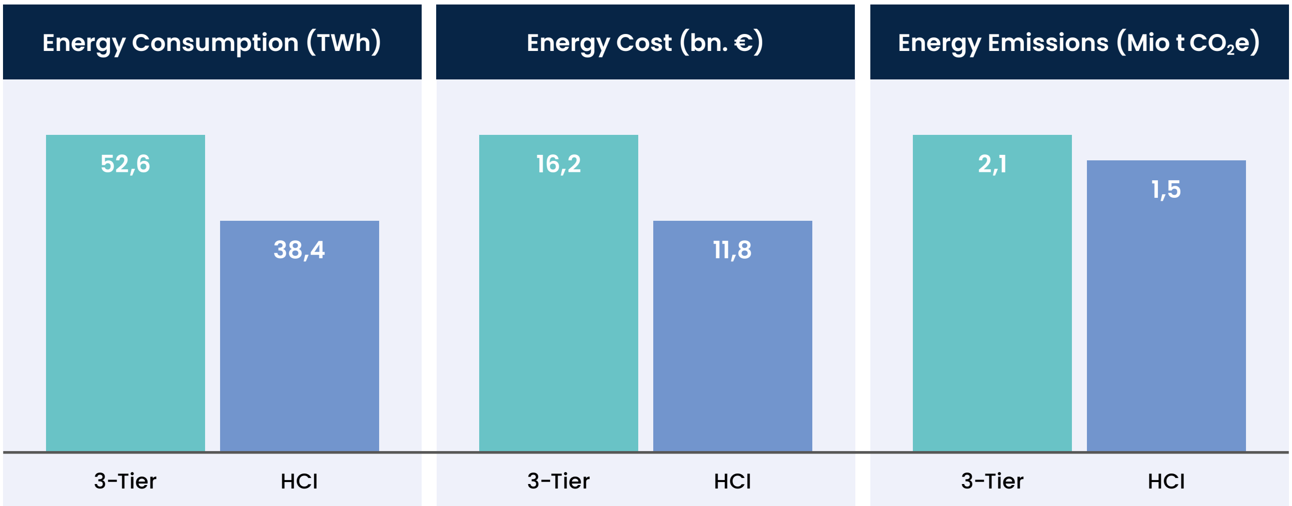
France	2024	2025	2026	2027	2028	2029	2030
Overall DC energy use per year (TWh)	13,8	14,2	14,7	15,1	15,6	16,0	16,5
Share of Traditional DC (Non-Hyperscale & Edge)	59 %	56 %	53 %	50 %	47 %	44 %	41 %
Energy consumption 3-Tier DC (TWh)	8,2	8,0	7,8	7,6	7,3	7,1	6,8
Energy efficiency potential by HCI (TWh)	2,2	2,2	2,1	2,0	2,0	1,9	1,8
Cost saving potential by HCI (Mio. €)	589,6	605,3	619,5	632,1	642,6	650,6	655,7
Carbon saving potential by HCI (thousand t CO_2e)	113,1	101,1	90,2	80,1	71,0	62,6	55,0

Source: Atlantic Ventures, 2024

Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

France

Aggregated potential Energy Consumption, Cost and Carbon Emissions 3-Tier vs. HCI-based architecture (2024-2030)



Source: Atlantic Ventures, 2024

For the period from 2024 to 2030, the efficiency potential that could be realized with a complete transition from 3-Tier to HCI-based platform would result in a saving of 14,2 TWh.

Until 2022, France recorded relatively low prices for electricity with 0,142 €/kWh, but these increased sharply in 2023 reaching over 0,254 €/kWh (see Appendix 1). The savings that could be achieved through HCI amount to 4,4 billion euros in the considered forecast period.

Due to the high share of nuclear energy (67 %) and renewable energies such as wind, solar and hydro (over 26 %), France has a very favorable energy mix with low carbon emissions. Accordingly, the efficiency potentials over the forecasted period are relatively modest compared to the other European countries, but nevertheless still present. When completely switching from 3-Tier to HCI-based architecture over 0,57 million tCO_2e could be saved in the forecasted period.

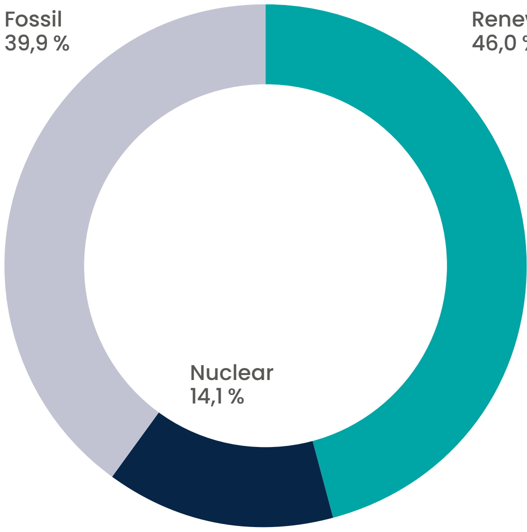
Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

United Kingdom (UK)

The UK offers a favorable business environment, robust connectivity, and reliable power infrastructure, making it an attractive location for business and data center investments. The computing industry plays a crucial role in supporting various sectors, including finance, technology, healthcare, and government by providing secure and scalable computing solutions.

At the same time, the industry has been impacted by the BREXIT, causing uncertainties regarding data regulations and international data flows and posing a challenge of losing market access to other European countries and businesses. Despite these challenges, the UK's strategic position and tech infrastructure continue to attract investments, making it a significant player in the worldwide data center landscape. The energy consumption of traditional Infrastructure is estimated to decrease from 7,7 TWh in 2024 to 6,1 TWh in 2030, with cloud solutions having the major share of roughly 68 % in 2030.

Public net electricity generation UK 2023



Source: www.ember-climate.org

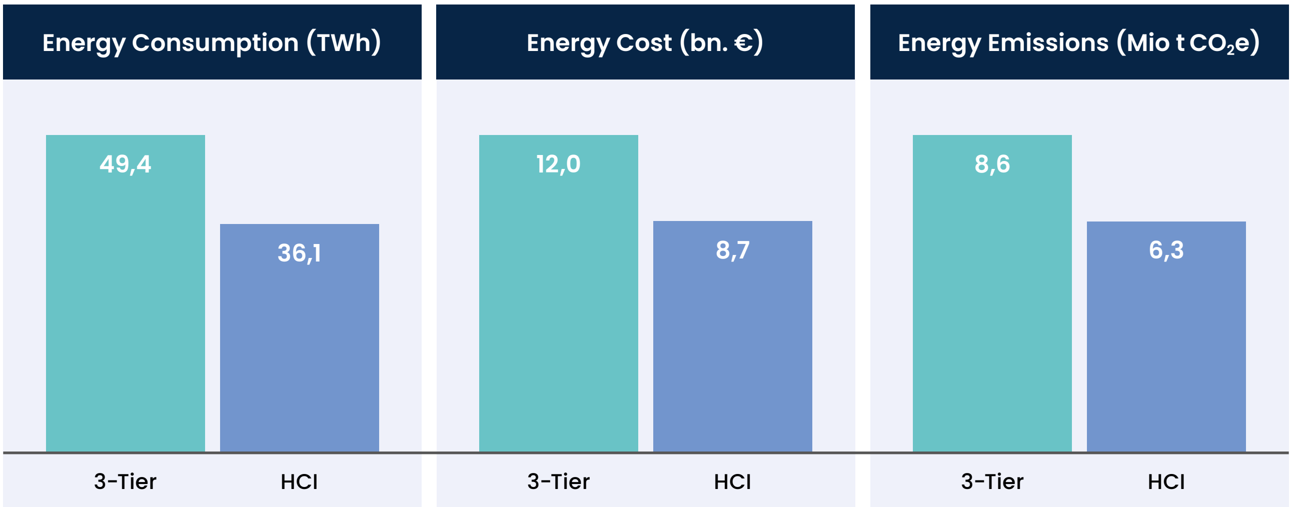
UK	2024	2025	2026	2027	2028	2029	2030
Overall DC energy use per year (TWh)	16,0	16,5	16,9	17,5	18,0	18,5	19,1
Share of Traditional DC (Non-Hyperscale & Edge)	48 %	47 %	44 %	41 %	38 %	35 %	32 %
Energy consumption 3-Tier DC (TWh)	7,7	7,7	7,5	7,2	6,8	6,5	6,1
Energy efficiency potential by HCI (TWh)	2,1	2,1	2,0	1,9	1,8	1,8	1,6
Cost saving potential by HCI (Mio. €)	434,6	460,3	466,0	469,6	470,7	468,9	463,7
Carbon saving potential by HCI (thousand t CO_2e)	454,2	421,3	373,6	329,8	289,6	252,7	218,9

Source: Atlantic Ventures, 2024

Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

United Kingdom (UK)

Aggregated potential Energy Consumption, Cost and Carbon Emissions 3-Tier vs. HCI-based architecture (2024-2030)



Source: Atlantic Ventures, 2024

Undertaking a total shift to HCI-based platform could result in over 13,3 TWh energy reduction in the period of 2024 to 2030.

Due to relatively high price levels for electricity (0,20 €/kWh in 2023) the potential electricity cost savings for companies and service providers in the UK could be as much as 3,3 billion euros in the considered forecast period.

Over 60 % of energy in the United Kingdom is coming form low-carbon energy sources including Wind, Solar, Biomass, Hydro and Nuclear[41]. Further transformation to renewables is expected in the future, but is facing challenges at the moment due to missing investments and rising construction prices. Nevertheless, innovative and sustainable technologies like HCI can also have a significant Impact on the environmental side. The overall carbon saving potential through 2030 could sum up to 2,3 million tCO_2e. Almost 95 million trees would be required to capture this amount of carbon.[42]

[41] https://ember-climate.org/countries-and-regions/countries/united-kingdom
[42] https://www.fortomorrow.eu/en/post/co2-tree

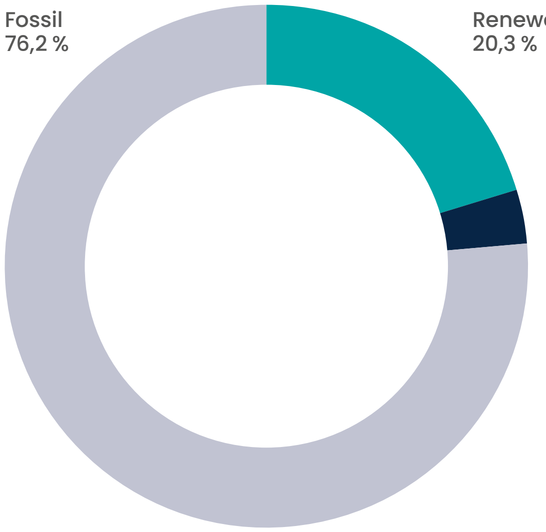
Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

Netherlands

The Netherlands has established itself as a leading data center hub. In addition, the country provides a strong digital ecosystem for young companies and has therefore become one of the largest startup hubs in the world. Its strategic location & advanced digital infrastructure have contributed to its success. Also incumbent companies, especially in the logistics sector due to the access to the largest trading ports in Europe, continue to be strongly rooted in the Netherlands maintaining the economic importance of the country.

With strong data privacy regulations in place, the country remains a prominent player in the data center landscape within the EMEA region. Accordingly, the overall energy demand for data centers is forecasted to increase to 8.7 TWh by 2030, with the share of traditional data centers dropping to 23% due to a strong cloud transformation.

Public net electricity generation the Netherlands 2023



Source: Frauenhofer ISE, 2024 - Energy Chart

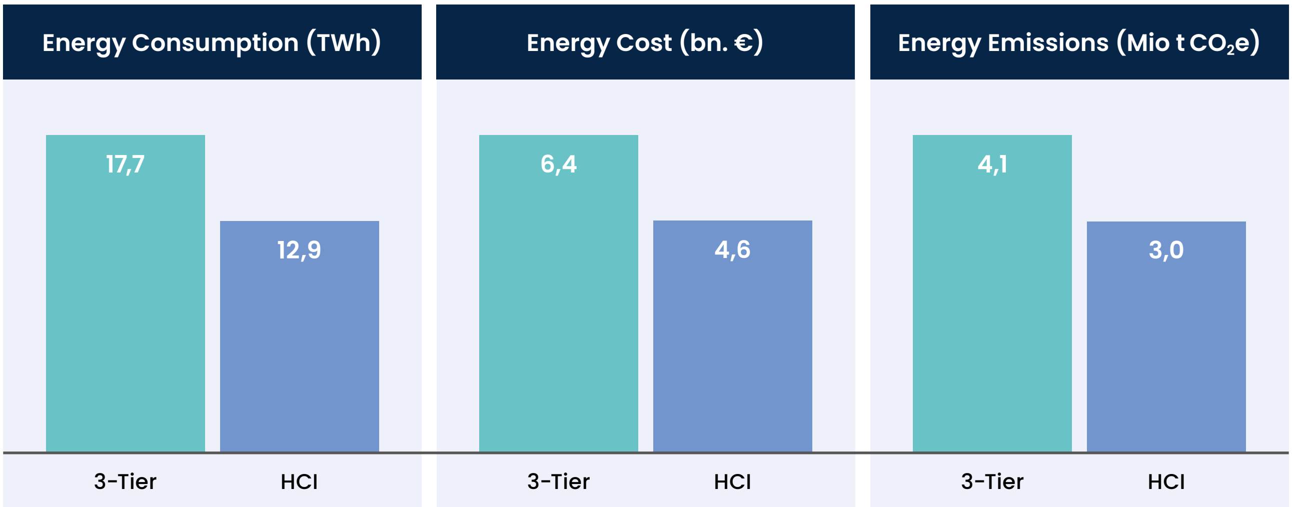
Netherlands	2024	2025	2026	2027	2028	2029	2030
Overall DC energy use per year (TWh)	7,3	7,5	7,7	8,0	8,2	8,4	8,7
Share of Traditional DC (Non-Hyperscale & Edge)	41 %	38 %	35 %	32 %	29 %	26 %	23 %
Energy consumption 3-Tier DC (TWh)	3,0	2,9	2,7	2,5	2,4	2,2	2,0
Energy efficiency potential by HCI (TWh)	0,8	0,8	0,7	0,7	0,7	0,6	0,5
Cost saving potential by HCI (Mio. €)	253,3	253,9	253,0	250,1	245,1	237,7	227,4
Carbon saving potential by HCI (thousand t CO_2e)	208,5	191,6	174,9	158,5	142,4	126,6	111,0

Source: Atlantic Ventures, 2024

Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

Netherlands

Aggregated potential Energy Consumption, Cost and Carbon Emissions 3-Tier vs. HCI-based architecture (2024-2030)



Source: Atlantic Ventures, 2024

From 2024 to 2030, the efficiency potential would lead to an energy saving of 4,8 TWh if a complete switch to HCI-based platform is performed.

Over 1,7 billion euros in energy costs could be saved in enterprise data centers in this period.

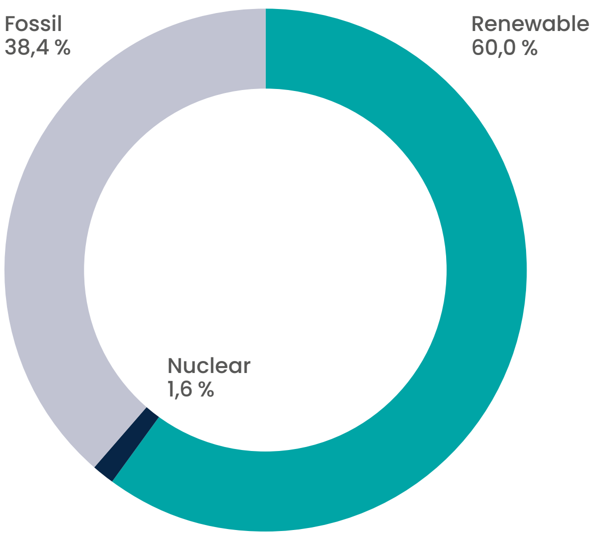
While the Netherlands is still above the European average in terms of carbon intensity in energy production, it is at the same time one of the few European countries that has been continuously expanding renewable energies and is increasingly investing in green technologies since the Corona pandemic. As a result, carbon emissions from energy production have been steadily decreasing since 2020 due to an improving energy mix (see Appendix 1). Nevertheless, in the mid-term the potential efficiency gains by HCI are significant. The fact that the energy mix still consists largely of Fossil energy means that significant carbon reductions could be achieved. When undertaking a total HCI-based architecture switch, this can potentially save up to 1,1 million tCO_2e. Over the seven years forecast, roughly 45 million trees would be necessary to capture the emitted carbon dioxide.

Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

Germany

The data center industry in Germany is witnessing strong growth, driven in part by the „German Mittelstand" - small and medium-sized enterprises (SMEs) that form the backbone of the country's economy. These companies are increasingly embracing digital transformation, necessitating secure and reliable data storage solutions. As a result, on-premise data centers are still a popular choice among German companies, allowing for more control over sensitive data while ensuring compliance with local regulations. Thus, the share of traditional enterprise Infrastructure is still relatively high with an estimated 61% in 2024.

Public net electricity generation Germany 2023



Source: Frauenhofer ISE, 2024 - Energy Chart

The rise of 5G technology, the Internet of Things (IoT), and artificial intelligence (AI) will lead to further growth in data generation and storage needs. Consequently, data centers will play a crucial role in accommodating these developments, making Germany a central player in the global digital landscape.

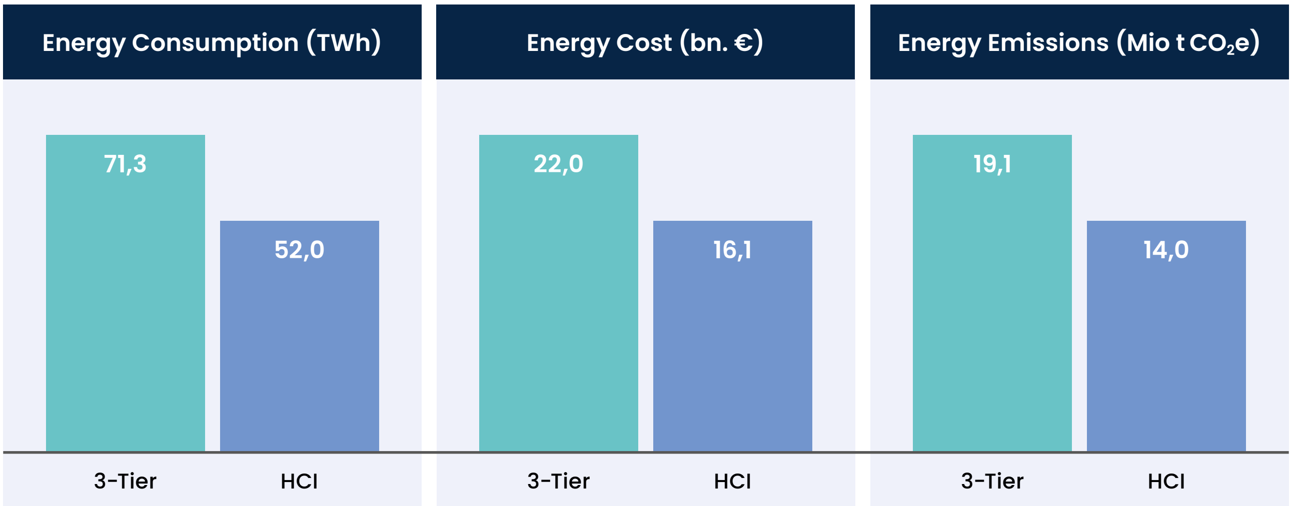
Germany	2024	2025	2026	2027	2028	2029	2030
Overall DC energy use per year (TWh)	18,0	18,6	19,1	19,7	20,3	20,9	21,5
Share of Traditional DC (Non-Hyperscale & Edge)	61%	58 %	55 %	52 %	49 %	46 %	43 %
Energy consumption 3-Tier DC (TWh)	11,0	10,8	10,5	10,2	9,9	9,6	9,3
Energy efficiency potential by HCI (TWh)	3,0	2,9	2,8	2,8	2,7	2,6	2,5
Cost saving potential by HCI (Mio. €)	794,0	816,5	837,4	856,2	872,6	885,9	895,7
Carbon saving potential by HCI (thousand t CO_2e)	1031,2	918,4	815,8	722,5	637,7	560,7	491,0

Source: Atlantic Ventures, 2024

Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

Germany

Aggregated potential Energy Consumption, Cost and Carbon Emissions 3-Tier vs. HCI-based architecture (2024-2030)



Source: Atlantic Ventures, 2024

Due to the strong data center industry in Germany and the high energy demand, the potential energy savings through HCI-based platform are substantial. A total of 19,3 TWh could be saved in the period covered.

Germany has always had relatively high energy prices compared to other European countries. Since 2020, these have increased even further reaching a long-term high of 0,254 €/kWh in 2023. Consequently, the HCI-based platform efficiency potentials are also quite high and could amount up to over 5,9 billion euros by 2030.

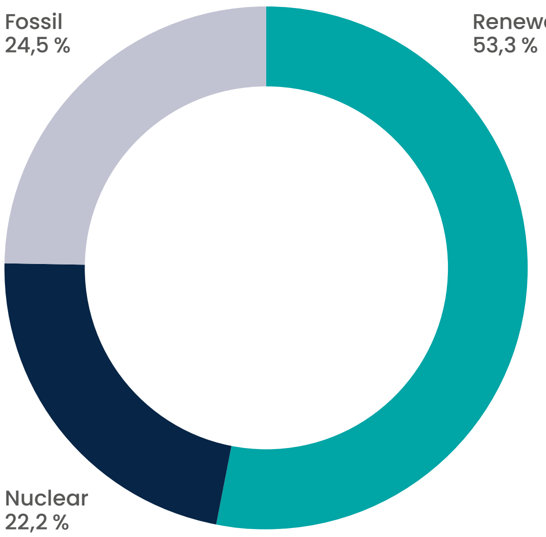
Germany is one of the European countries that for a long time had a strong dependency on raw materials from foreign countries. Already since the Corona pandemic in 2020 - and afterwards driven by the Russian sanctions - Germany had to increase other fossil fuels in the energy mix to cover the energy demand. This has of course significant environmental impacts. With 0,381 kgCO_2e per kWh in 2023, it is almost 30 % above the European average when it comes to carbon intensity in the energy production. The efficiency potential of a HCI-based platform could have significant impacts in the mid term, saving over 5,1 million tCO_2e until 2030. Over 210 million trees would be necessary to capture these carbon emissions.

Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

Spain

In recent years, the Spanish computing market has experienced a surge in demand for IoT, analytics and cloud computing solutions. The country is experiencing a digital upswing, significantly supported by the government through strategic initiatives like „Digital Spain 2025"[43] to accelerate the digital transformation and boost its global competitiveness in the digital economy. With a focus on enhancing digital infrastructure, promoting digital skills, and implementing e-government services, the initiative seeks to create a thriving digital ecosystem that drives economic growth. The data center market is expected to grow in order to meet this growth. At the same time, the expansion of climate-efficient and sustainable data centers is being forced. Due to the high share of renewable energies in the national energy mix, data centers can already be operated with relatively clean energy today having a positive impact on the industries carbon footprint. Energy demand in Spanish data centers will increase to 2.8 TWh by 2030. The share of traditional data centers is estimated to drop from 46 % (2024) to 34 % (2030).

Public net electricity generation Spain 2023



Source: Frauenhofer ISE, 2024 - Energy Chart

Spain	2024	2025	2026	2027	2028	2029	2030
Overall DC energy use per year (TWh)	2,3	2,4	2,5	2,6	2,6	2,7	2,8
Share of Traditional DC (Non-Hyperscale & Edge)	46 %	44 %	42 %	40 %	38 %	36 %	34 %
Energy consumption 3-Tier DC (TWh)	1,1	1,1	1,0	1,0	1,0	1,0	0,9
Energy efficiency potential by HCI (TWh)	0,29	0,29	0,28	0,28	0,27	0,26	0,26
Cost saving potential by HCI (Mio. €)	51,0	52,7	54,4	56,1	57,6	59,0	60,3
Carbon saving potential by HCI (thousand t CO_2 e)	48,2	45,2	42,3	39,5	36,8	34,2	31,7

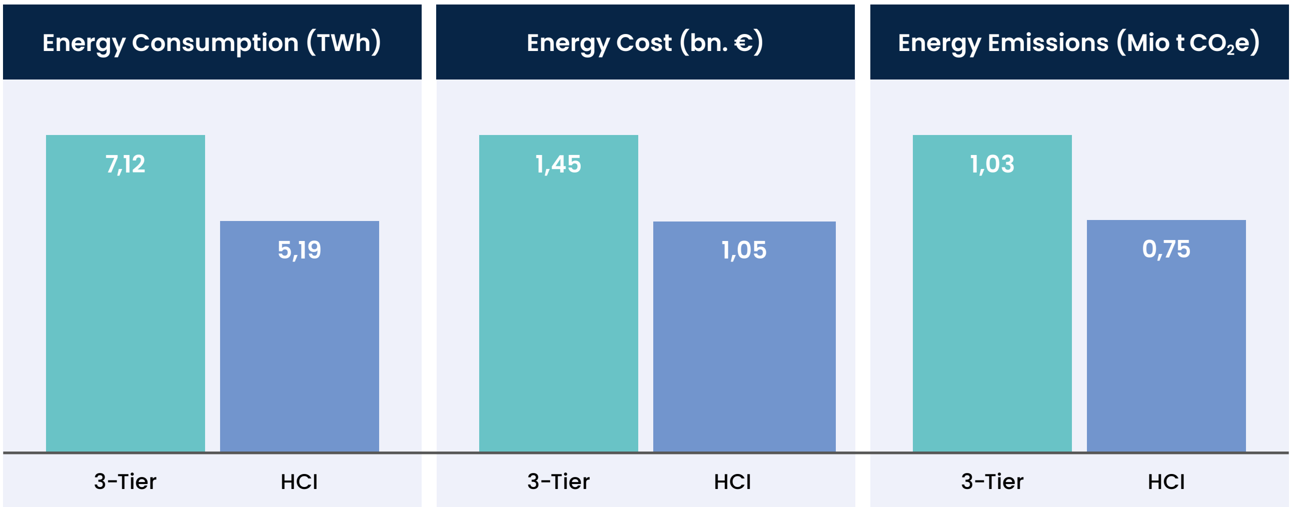
Source: Atlantic Ventures, 2024

[43] https://www.oecd-events.org/smart-data-and-digital-technology-in-education/session/fdf4dff7-23fd-ec11-b47a-a04a5e7cf9da/espana-digital-2025-digital-spain-2025-#:~:text=Digital%20Spain%202025%20contains%20a,Commission%20for%20the%20new%20period

Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

Spain

Aggregated potential Energy Consumption, Cost and Carbon Emissions 3-Tier vs. HCI-based architecture (2024-2030)



Source: Atlantic Ventures, 2024

The increasing relevance of the data center industry in Spain also results in growing energy demand. A transition from 3-Tier to HCI-based platform could save a total of 1,9 TWh of energy between 2024 and 2030.

This could save a total of more than 391 million euros in energy Costs until 2030. Money that can be very well invested in the further expansion of the digital Spain.

Spain has been promoting the expansion of renewable energies and low-carbon technologies for quite some time, with great success. Spain is well below the average carbon intensity in Europe. As early as 2023, more than 53% of the country's energy comes from renewable sources, a further 22% coming from nuclear energy. Due to the "green" energy mix and the relatively low share of traditional data centers the savings potential is comparatively small, but nevertheless evident. Overall 277 thousand tons of carbon could be saved by switching to HCI-based architecture.

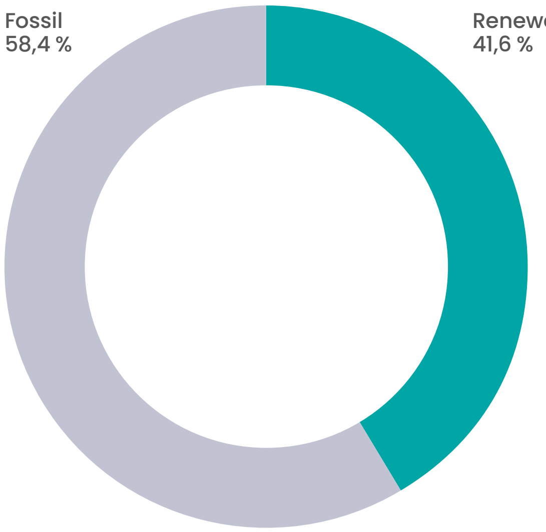
Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

Italy

While the digital ecosystem & -transformation is not yet very progressive in Italy compared to other European countries, the sunny country in the south of Europe has been able to realize some considerable growth of data center activities in recent years.

Recently, increasing investments have been pouring into Italian data center hubs like Milan, both from the public sector and from large hyperscalers, in order to further strengthen local data center activities. By 2030, about 55 % of all data center operations in Italy are expected to be in the cloud.

Public net electricity generation Italy 2023



Source: Frauenhofer ISE, 2024 - Energy Chart

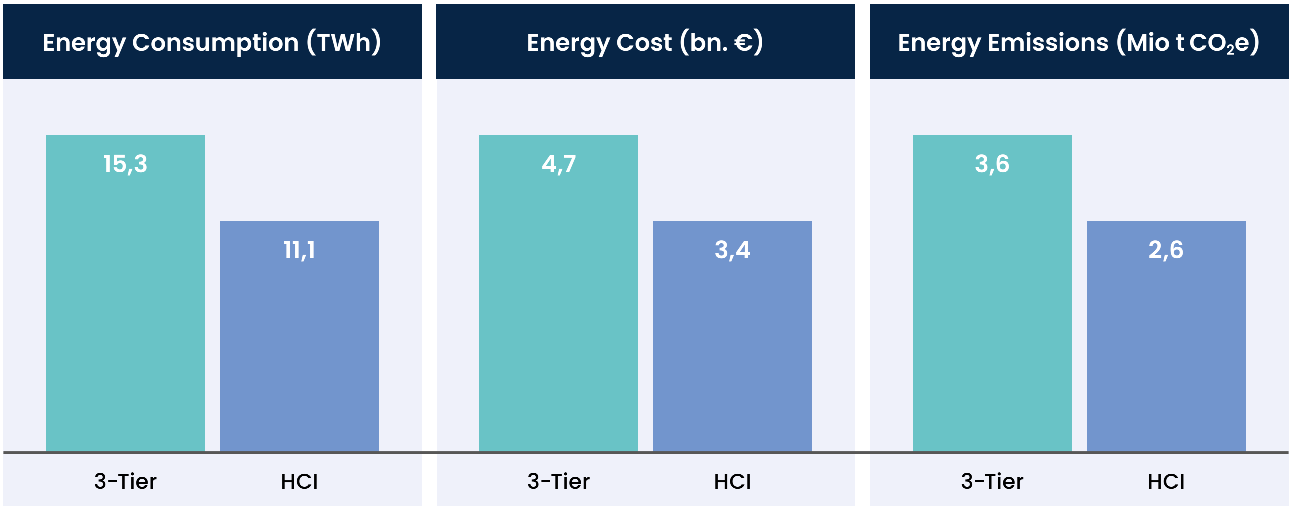
Italy	2024	2025	2026	2027	2028	2029	2030
Overall DC energy use per year (TWh)	3,9	4,0	4,2	4,3	4,4	4,5	4,7
Share of Traditional DC (Non-Hyperscale & Edge)	57 %	55 %	53 %	51 %	49 %	47 %	45 %
Energy consumption 3-Tier DC (TWh)	2,2	2,2	2,2	2,2	2,2	2,1	2,1
Energy efficiency potential by HCI (TWh)	0,6	0,6	0,6	0,6	0,6	0,6	0,6
Cost saving potential by HCI (Mio. €)	159,9	166,9	174,0	181,0	188,1	195,1	202,1
Carbon saving potential by HCI (thousand t CO_2e)	183,0	166,1	151,0	136,3	123,2	111,2	100,1

Source: Atlantic Ventures, 2024

Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

Italy

Aggregated potential Energy Consumption, Cost and Carbon Emissions 3-Tier vs. HCI-based architecture (2024-2030)



Source: Atlantic Ventures, 2024

Due to the estimated relatively high share of traditional infrastructure in Italian data centers (57 % in 2024 and 45 % in 2030), the saving potential of a HCI-based platform could be significant. A total of almost 4,2 TWh of electricity could be saved by 2030 with a complete switch to HCI-based architecture.

Italy was strongly affected by the energy crisis in 2022, which led to one of the highest energy prices in Europe at 0,31 €/KWh (0,165 €/KWh in 2021, see Appendix 1). The saving potential of a HCI-based platform is therefore quite high. The corresponding savings for energy costs would amount to almost 1,3 billion euros in the period between 2024 and 2030.

A large part of the energy in Italy, over 58 %, still comes from fossil fuels that emit high levels of carbon. This has a corresponding impact on the energy mix, which at 0,331 kgCO_2e per kWh in 2023 is above the European average (0,300 kgCO_2e per kWh, see Appendix 1). With a total HCI switch, 0,971 million tCO_2e might be avoided, with an equivalent of 39 million trees needed to sequester the carbon[44].

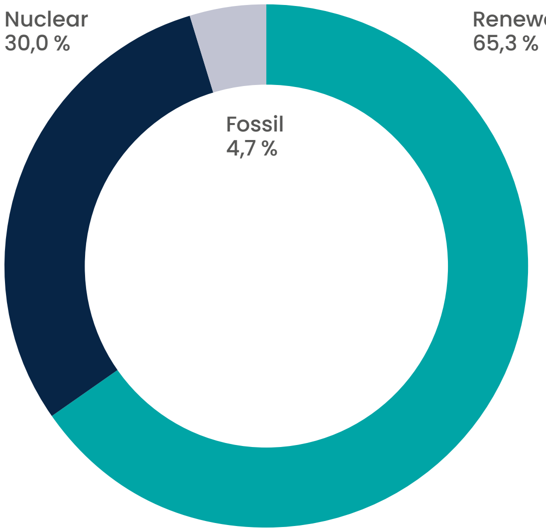
[44] https://www.fortomorrow.eu/en/post/co2-tree

Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

Sweden

Sweden is home to a diverse range of businesses, with a focus on technology, manufacturing, services, and innovation. The country's entrepreneurial spirit and supportive ecosystem encourage startups and creative ventures from around the world.

Public net electricity generation Sweden 2023



Source: Frauenhofer ISE, 2024 - Energy Chart

Sweden's data center industry continues its upward trend, solidifying its position as a global leader. Fueled by sustainable energy sources and a favorable climate, the industry experiences remarkable growth, attracting major international players. Collaborations between tech giants and local authorities further bolster infrastructure and regulatory frameworks, ensuring efficient operations and reduced environmental impact. Advanced cooling technologies, such free-air cooling, optimize energy efficiency at large scale. The energy demand for data centers is calculated at 2,7 TWh in 2024 and 3,2 TWh by 2030. Sweden already has a fairly large share of computing power in the cloud, with traditional data centers estimated to drop from 44 % to 32 % in 2030.

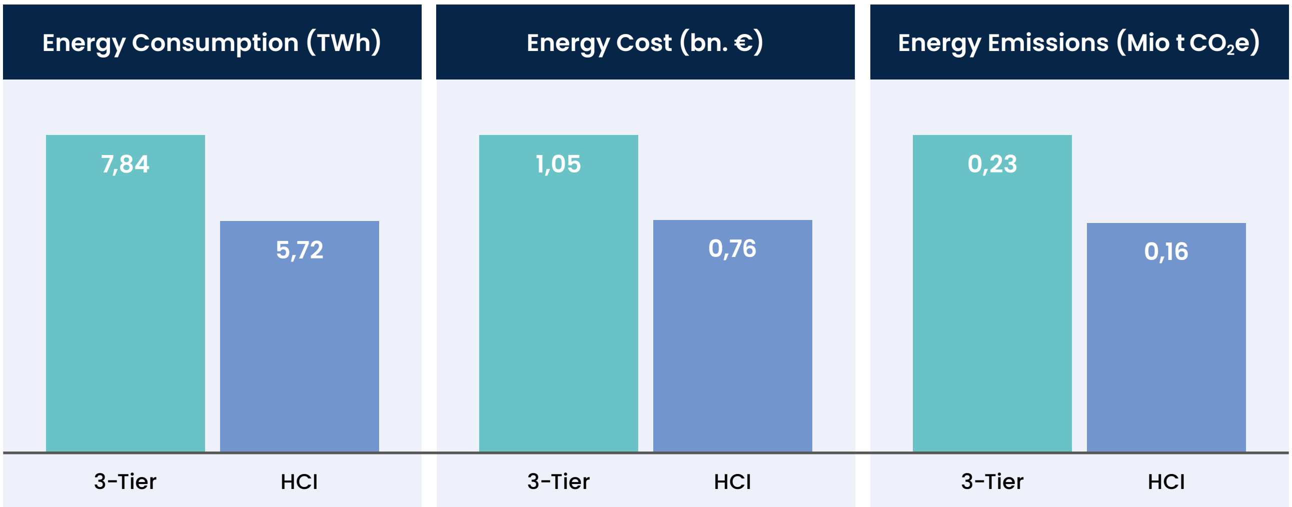
Sweden	2024	2025	2026	2027	2028	2029	2030
Overall DC energy use per year (TWh)	2,7	2,8	2,9	3,0	3,0	3,1	3,2
Share of Traditional DC (Non-Hyperscale & Edge)	44 %	42 %	40 %	38 %	36 %	34 %	32 %
Energy consumption 3-Tier DC (TWh)	1,2	1,2	1,1	1,1	1,1	1,1	1,0
Energy efficiency potential by HCI (TWh)	0,3	0,3	0,3	0,3	0,3	0,3	0,3
Cost saving potential by HCI (Mio. €)	37,3	38,5	39,6	40,7	41,7	42,6	43,4
Carbon saving potential by HCI (thousand t CO_2e)	12,0	10,7	9,6	8,5	7,6	6,7	5,9

Source: Atlantic Ventures, 2024

Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

Sweden

Aggregated potential Energy Consumption, Cost and Carbon Emissions 3-Tier vs. HCI-based architecture (2024-2030)



Source: Atlantic Ventures, 2024

Due to rather cold climate and advanced technologies, cooling demand in Swedish data centers is comparatively low. These factors have a positive impact on the sustainable operation of data centers and result in comparatively low energy demand. Still, with a complete HCI-based architecture switch, up to 2,1 TWh of energy could be saved by 2030.

From 2023 to 2030, a complete switch to hyperconverged infrastructure-based platform would yield savings potentials of around 283 million euros.

Scandinavia, and Sweden in particular, is already well ahead in the field of renewable energies and is therefore becoming increasingly attractive as a data center location. With a large share of low-carbon energy from nuclear, wind and hydro (all together over 95% in 2024), it is currently the European country with the "greenest" energy mix when it comes to sustainability. Due to the excellent energy mix in Sweden, the potential reductions in carbon emissions are comparatively modest. But still a great opportunity to further pursue and strengthen the "net zero path" in the north of Europe. In total, almost 61 thousand tCO_2e could be saved between 2024 and 2030.

Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

Middle East & North Africa (MENA)

The data center industry in the Middle East and North Africa (MENA) region is experiencing rapid growth and transformation. The region has become a significant hub for data center development and investment, fueled by increased digitization, cloud transformation, and expanding internet adaptation across the region. Countries like the United Arab Emirates, Saudi Arabia, and Qatar are leading the way, attracting both regional and international data center providers. The industry's expansion is driven by the growing demand for data storage, processing power, and enhanced connectivity to support emerging technologies like AI, IoT, and smart city initiatives.

The MENA region is already quite advanced in terms of cloud transformation. In 2024, 47% of computing activity is estimated to be in traditional data centers, by 2030 this share is expected to decrease to 29%.

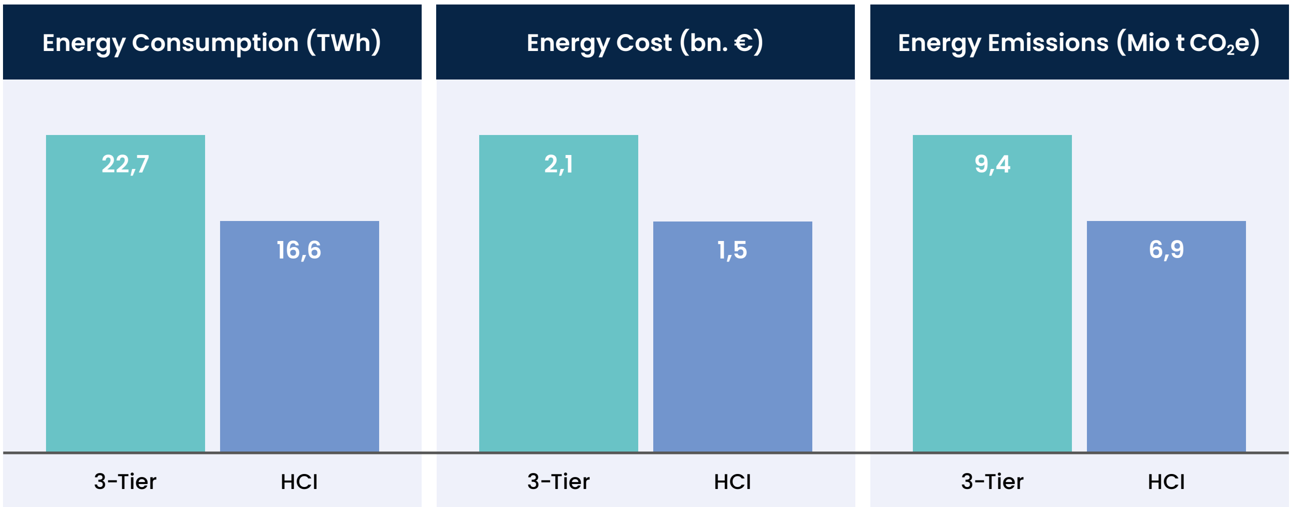
MENA	2024	2025	2026	2027	2028	2029	2030
Overall DC energy use per year (TWh)	7,9	8,1	8,4	8,6	8,9	9,1	9,4
Share of Traditional DC (Non-Hyperscale & Edge)	47%	44%	41%	38%	35%	32%	29%
Energy consumption 3-Tier DC (TWh)	3,7	3,6	3,4	3,3	3,1	2,9	2,7
Energy efficiency potential by HCI (TWh)	1,0	1,0	0,9	0,9	0,8	0,8	0,7
Cost saving potential by HCI (Mio. €)	79,5	80,5	81,2	81,4	81,0	80,1	78,5
Carbon saving potential by HCI (thousand t CO_2e)	472,0	434,6	398,3	363,0	328,9	295,7	263,6

Source: Atlantic Ventures, 2024

Forecast – Energy Efficiency Potential and Carbon Impact of Hyperconverged 2024–2030

Middle East & North Africa (MENA)

Aggregated potential Energy Consumption, Cost and Carbon Emissions 3-Tier vs. HCI-based architecture (2024-2030)



Source: Atlantic Ventures, 2024

From 2024 to 2030 the aggregated energy efficiency potential of a full transformation towards HCI-based architectures in the MENA region is expected to result in 6,1 TWh of energy reduction.

Due to relatively low price levels for electricity (0,076 euros in 2023, see Appendix 1) the potential energy cost savings for companies and service providers in the MENA region are rather low totaling at 562 million eurosuntil 2030.

Due to the very high share of fossil fuels in the region, the energy mix is loaded with a high share of carbon emissions. With almost 493 grams of CO_2e per kWh of electricity in 2023, it is the highest in the regions considered (see Appendix 1). Accordingly, the efficiency potential of switching to a HCI-based platform is substantial. A total of 2,56 million tons of carbon emissions could be saved here by 2030. Over 103 million trees would be necessary to capture the carbon emitted in the forecasted period[45].

[45] https://www.fortomorrow.eu/en/post/co2-tree

Sources and Acknowledgments

Those are the major sources for key values and assumptions building the basis of the report. All other sources are stated directly in the text as footnotes and are not presented in the table above.

Energy Prices	
Eurostat (2024)	https://ec.europa.eu/eurostat/databrowser/view/nrg_pc_205__custom_12417628/default/table?lang=en
Carbon Emissions	
Our World in Data (until 2022)	https://ourworldindata.org/grapher/carbon-intensity-electricity?tab=chart&country=EU-27~EU~DEU~OWID_EUR
Energy Mix	
Fraunhofer Institut (Energy Charts)	https://www.energy-charts.info/index.html?l=de&c=EU
Ember Climate - Energy Mix United Kingdom	https://ember-climate.org/countries-and-regions/countries/united-kingdom
Energy Consumption Data Centers	
Bordersteps Institute 2015	https://www.borderstep.de/wp-content/uploads/2015/01/Borderstep_Energy_Consumption_2015_Data_Centers_16_12_2015.pdf
Borderstep Institute 2020 & Deutscher Bundestag	https://www.borderstep.de/wp-content/uploads/2021/03/Borderstep_Rechenzentren2020_20210301_final.pdf https://www.bundestag.de/resource/blob/863850/423c11968fcb5c9995e9ef9090edf9e6/WD-8-070-21-pdf-data.pdf
IEA International Energy Agency	https://www.iea.org/reports/data-centres-and-data-transmission-networks
Nature / Anders Andrae	https://www.nature.com/articles/d41586-018-06610-y
Energy Consumption & Carbon Emissions of Hardware	
Various technology vendors	

Appendix 1

Energy Price (€)[46] and Carbon intensity (gCO_2e/kWh)[47] in different regions (incl. electricity tax and, excl. grid charges)

Energy	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Germany Price	0,191	0,199	0,243	0,254	0,267	0,280	0,294	0,309	0,324	0,341	0,358
Carbon intensity	0,356	0,395	0,420	0,381	0,346	0,315	0,287	0,261	0,237	0,216	0,196
France Price	0,099	0,104	0,142	0,254	0,267	0,280	0,294	0,309	0,325	0,341	0,358
Carbon intensity	0,059	0,060	0,079	0,056	0,051	0,047	0,043	0,039	0,036	0,033	0,030
UK Price	0,150	0,150	0,190	0,200	0,209	0,220	0,231	0,242	0,255	0,267	0,281
Carbon intensity	0,244	0,269	0,256	0,238	0,219	0,201	0,185	0,170	0,157	0,144	0,133
Netherlands Price	0,119	0,141	0,218	0,298	0,313	0,329	0,345	0,363	0,381	0,400	0,420
Carbon intensity	0,343	0,352	0,325	0,268	0,258	0,248	0,239	0,230	0,221	0,213	0,205
Spain Price	0,102	0,142	0,255	0,167	0,175	0,184	0,193	0,203	0,213	0,224	0,235
Carbon intensity	0,199	0,194	0,218	0,174	0,166	0,158	0,150	0,143	0,136	0,130	0,124
Italy Price	0,145	0,165	0,309	0,252	0,264	0,277	0,291	0,306	0,321	0,337	0,354
Carbon intensity	0,334	0,339	0,378	0,331	0,302	0,276	0,252	0,230	0,210	0,192	0,176
Sweden Price	0,065	0,093	0,146	0,110	0,116	0,121	0,127	0,134	0,140	0,147	0,155
Carbon intensity	0,039	0,042	0,041	0,041	0,037	0,034	0,031	0,028	0,025	0,023	0,021
EU Price	0,132	0,149	0,224	0,234	0,246	0,258	0,271	0,284	0,299	0,314	0,329
Carbon intensity	0,305	0,314	0,328	0,300	0,275	0,252	0,231	0,212	0,195	0,178	0,164
MENA Price	0,060	0,063	0,066	0,076	0,079	0,083	0,088	0,092	0,096	0,101	0,106
Carbon intensity	0,569	0,542	0,517	0,493	0,471	0,450	0,429	0,410	0,392	0,374	0,357

46 Eurostat (2024): https://ec.europa.eu/eurostat/databrowser/view/nrg_pc_205__custom_12417628/default/table?lang=en
47 https://ourworldindata.org/grapher/carbon-intensity-electricity?tab=chart

Appendix 2

Infrastructure Setup for Model company

The two tables below provide an overview of the energy demand and the quantity of the individual components in the 3-Tier and HCI-based architecture setup being considered to replace the existing 3-Tier Infrastructure in the model company. We will assume a capacity in both setups for up to 30.000 VMs since the given model company intends to build a scalable IT Infrastructure in order to be able to respond to the innovative pace and dynamic markets in the automotive industry. Due to new and highly energy efficient CPU technology, the number of servers in both setups can be significantly reduced.

Infrastructure component		Energy demand per unit (kW)	Quantity in model company
Server		0,587	180
Storage	Dell Power Max 8000 (Engine 1)	0,947	12
	DAE1	0,341	12
	DAE2	0,292	12
	Ethernet Switches	0,015	24
	Service Tray	0,050	12
	Dell Power Max 8000 (Engine 2)	0,930	12
	DAE3	0,341	12
	MIBE	0,150	24
	Dell PowerMax 8000 (Engine 3)	0,930	12
	DAE4	0,341	12
	DAE5	0,292	12
Storage Switches		0,330	24
Network Switches		0,383	24

Compared to the 3-Tier infrastructure, a a HCI-based platform bundles the activities of server and storage on the HCI node and virtualizes these functions. By omitting the storage hardware, significant energy savings can be achieved and efficiency potentials leveraged. The energy consumption of the HCI-based platform underlying the model company is listed in the following:

Infrastructure component	Energy demand per unit (kW)	Quantity in model company
HCI Node - HPe DX365	0,667	192
Network	0,383	24

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About

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