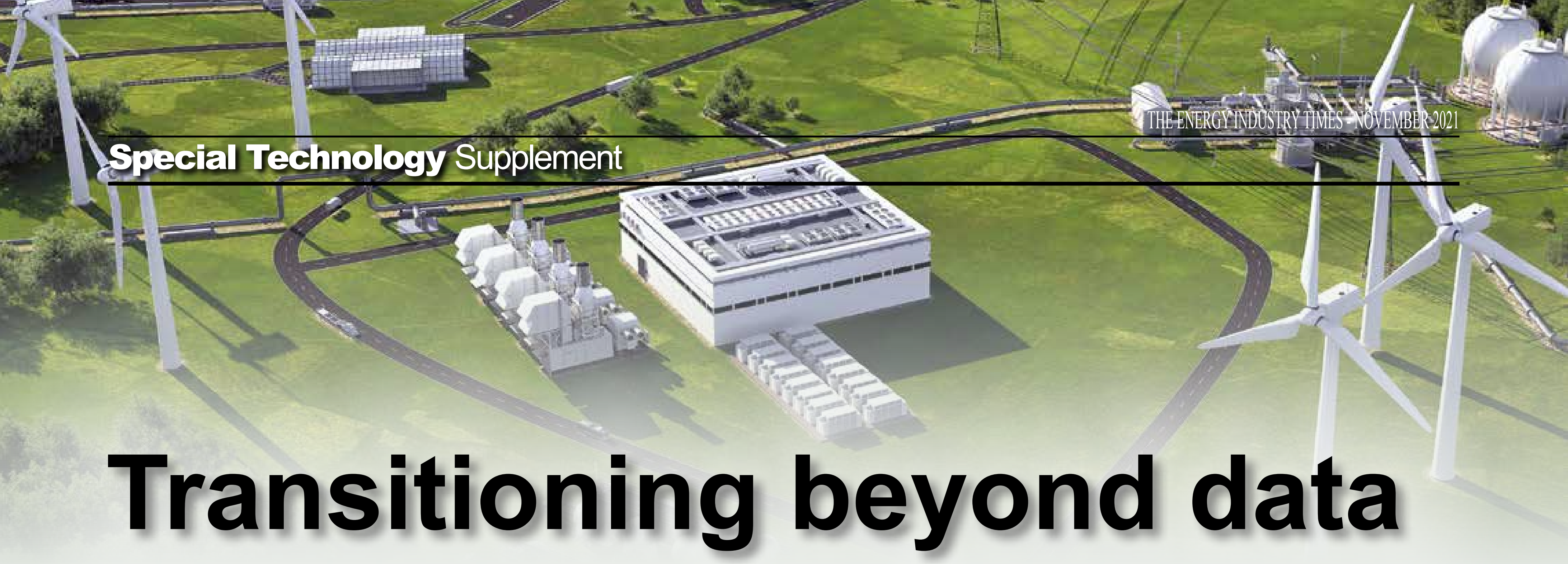


Transitioning beyond data

The growing number of data centres and their high energy consumption presents a conundrum for a world that has to cut carbon emissions while satisfying the need to handle increasing amounts of data. Siemens Energy argues that data centres can do more than just handle data; they can also be an important part of the move to a low carbon energy economy.

Junior Isles

As the world's demand for increasing amounts of data processing grows, so too does the need for data centres. In recent years, the energy consumption and corresponding carbon footprint of these facilities has come to the attention of the public. Yet, the explosive growth in data centres need not be a problem. Instead, data centres can play a positive role in the global energy transition.

The International Energy Agency (IEA) estimates that electricity demand for global data centres in 2019 was around 200 TWh, or about 0.8 per cent of global final electricity demand.

The IEA predicts an electricity demand for hyperscale and colocation data centres (where a company rents space within a data centre) to grow from 70 TWh in 2019 to 93 TWh in 2022 globally. This translates to approximately 3 GW additional demand on a yearly basis.

Today that growth, which is partly due to increasing digitalisation and cloud-based services, is being intensified by the Covid-19 pandemic's acceleration of the transition to working from home, teleconferencing, online shopping, video streaming, and other data-intensive activities.

Other potential geopolitical moves could also have an impact. For example, the EU believes that its data should be stored within the bloc instead of in the US. This will drive growth in Europe. Asia is also thinking along the same lines and the region is expected to see the most growth globally.

According to a report released this year by French think-tank, The Shift Project, the annual electricity usage of just five tech groups – Amazon, Google, Microsoft, Facebook and Apple – is about as much as New Zealand's, at more than 45 TWh. As demand continues, so too does the potential for generating carbon emissions. According to the report, carbon emissions from tech infrastructure and the data servers that enable cloud computing now exceed those of pre-Covid air travel.

Estimates suggest tech-related emissions are rising by 6 per cent annually, and public pressure is prompting some companies to act. Big tech companies are investing in renewable power like solar panels on their roofs and solar fields nearby or even wind farms mostly connected via virtual Power Purchase Agreements (PPAs).

Hyperscale (bigger than 5000 servers and 10 000 ft²) data centre operators in particular are leaders in corporate renewables procurement, particularly through PPAs. The top four corporate off-takers of renewables in 2019 were all ICT companies, led by Google.

Christoph Schuenemann, who leads Siemens Energy's Competence Centre for data centres in the Generation Division, has been working with a growing number of companies on how to decarbonise the power supply of their data centres.

He commented: "This [data centre] sector is very interesting from two aspects. Firstly, almost every day we are seeing new megawatt-scale data centres – typically between 25 MW and 400 MW – either being planned or erected somewhere. The IEA has forecast this will call for an additional 3 GW per year but we think it could be more, based on the drivers.

"In addition to these hyperscale and colocation data centres, there's another trend that will come in the future – edge data centres. These will be smaller, in the kW range, setup so data is close to the users, for example in urban situations and industrial locations.

"Secondly, we are seeing those big tech companies like Google, Apple and Microsoft, sign up for renewable PPAs to help meet their zero carbon targets – most have targets for 2030. So on one hand, there is this boom in data centres and power demand, and on the other there is this need for decarbonisation via low and better zero carbon power supply solutions for existing and future projects.

"This decarbonisation plan is now becoming even more concrete, so to speak. Instead of buying green certificates on an annual basis, companies are really analysing what part of their energy is really green and what is grey by monitoring their consumption hour-by-hour."

Earlier this year more than 100 global companies, including PwC, Microsoft and Google, announced they are taking part in a new worldwide initiative led by the independent non-profit EnergyTag, aimed at verifying clean energy sourcing on an hourly basis.

Typically data centres are built in locations based on internet nodes, where there is a high latency of data, so cities such as Frankfurt, London, Amsterdam, Paris Dublin (FLAPD markets) are the most popular with increasing growth in the Asia Pacific region. The data centre owner also has to look at how it will be powered, so the electricity connection – connection point, generation, voltage level, etc., – has to be assessed before power is purchased from the supplier. At the same time backup power solutions are installed, e.g. small diesel or gas engines along with fuel tanks supported by signed contracts to ensure fuel supply is always available.

If the data centre is in a more remote area, it may be that the owners build their own decarbonised hybrid generating facility. "In the US, for example, a company is planning data centres in areas where there is space to locate solar PV, with batteries for backup," noted Schuenemann. "But this can't work if the data centre is in a location where there is a high latency of data required, which is usually in metropolitan areas where limited space is available."

Building and operating a 25-400 MW power plant to serve a data centre is usually not the business of a big tech company. Nevertheless, securing firm power contracts from utilities is often a challenge.

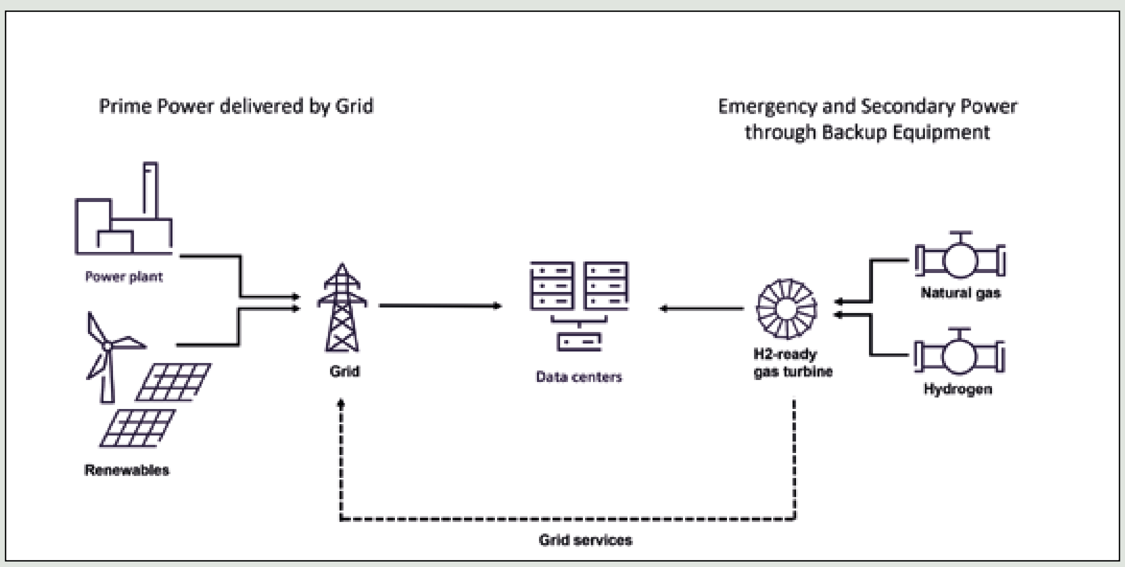
"Ireland's EirGrid has published a data centre connection policy, which says that a data centre connection customer can get a connection and receive power, but only on a flexible basis. So you don't know when or how much power you will get," said Schuenemann. "However, they have said that if you want a firm contract, you need to install reliable and dispatchable gas-based power generation at your data centre."

This, he says, is an "interesting move" by EirGrid in terms of how the power sector is developing in Ireland "because the data centre now becomes part of the solution and not the problem".

Offshore wind will play a significant role in Ireland's decarbonisation. According to its National Energy & Climate Plan, Ireland aims to develop 5 GW of offshore wind by 2030. And with its newly published climate bill, the Irish government aims to reduce total carbon emissions by more than 50 per cent by 2030 compared to 2018. It also commits Ireland to climate neutrality by 2050.

According to Schuenemann, every data centre will help this push for more green power. "Green power fluctuates – the wind is not always blowing and the sun is not always shining. So with this policy that the data centre will have its own generation, it will not only provide power for the data centre to operate but also support stabilisation of the grid. So essentially the data centre can be

Schuenemann says there is a boom in data centres and power demand, at the same time as a need for decarbonisation



Backup power solutions such as gas turbines can be installed to ensure power is always available

part of the solution in a decentralised electricity grid on the way to decarbonisation.”

According to the Sustainable Digital Infrastructure Alliance, by the beginning of 2030, data centres are estimated to account for up to 13 per cent of global electricity consumption, noting that the inefficient use of equipment is creating unnecessary waste and costs. On a global average, eight out of ten servers are idling while still consuming energy, it says. Yet it sees digital technology as one of the keys to solving the world’s most pressing problems, be it the distribution of resources, social mobility or climate change.

Certainly cooperation between data centre owners, governments, utilities and power plant technology suppliers could help optimise the overall energy system and address climate change. To ensure data centres are an integral part of the sustainable future of Europe, the European Data Centre Association (EDCA), an organisation comprised of data centre operators and trade associations, have agreed to make data centres climate neutral by 2030. Their aim is to leverage technology and digitalisation in support of the European Green Deal’s goal of making Europe climate neutral by 2050.

Aeroderivative SGT-A05: Gas turbines have a higher power density than reciprocating engines

This self-regulatory initiative focuses on, among other things, energy efficiency and clean energy.

Under its ‘Climate Neutral Data Center’ pact, the EDCA says data centres and server rooms in Europe shall meet a high standard for energy efficiency, which will be demonstrated through aggressive power use effectiveness (PUE) targets. PUE describes the ratio of IT power vs. total power including cooling power.

By January 1, 2025 new data centres operating at full capacity in cool climates will meet an annual PUE target of 1.3, and 1.4 for new data centres operating at full capacity in warm climates. Existing data centres will achieve these same targets by January 1, 2030. These targets apply to all data centres larger than 50 kW of maximum IT power demand.

In recognition of the European Commission’s interest in creating a new efficiency metric, trade associations will work with the appropriate agencies or organisations toward the creation of a new data centre efficiency metric. Once defined, trade associations will consider setting a 2030 goal based on this metric.

“There are various ways to increase PUE, including avoiding transmission losses by, for example, direct current to direct current connections from the power source to the servers” Schuenemann mentioned.

On clean energy, data centres will match their electricity supply through the purchase of clean energy. Data centre electricity demand will be matched by 75 per cent renewable energy or hourly carbon-free energy by December 31, 2025 and 100 per cent by December 31, 2030.

Although data centres are making serious steps to power their operations by green energy, typically they often still have diesel gensets for backup power if the grid fails. However, in many parts of the world these engines are not permitted to run for more than 300 hours per year due to their high emissions. This means diesel gensets are not a suitable technology to firm up fluctuating renewable power.

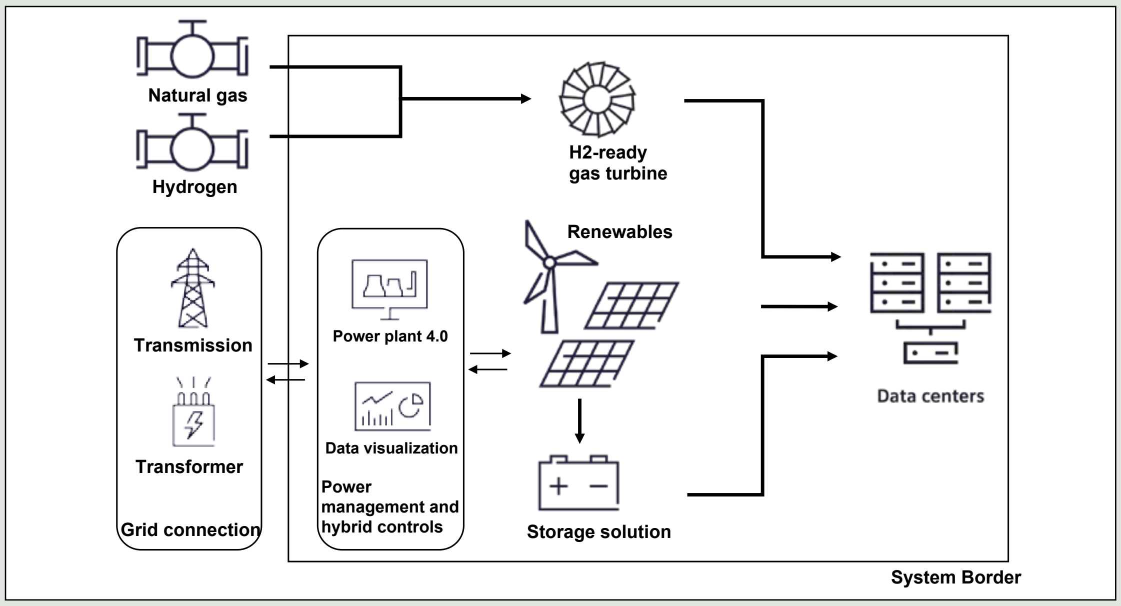
In terms of reliable, self-generation alternatives, large lithium-ion batteries may become the default in the future but there will still be situations when battery storage is insufficient – Li-ion batteries cannot be refilled with fuel and therefore can only cover power supply for periods of hours to a day. Schuenemann says there are several alternatives in such scenarios.

“We are applying existing technologies such as gas turbines and also looking to work with customers on new technologies in our focus area, for example, storage and hybrid power plants, and other forward looking technologies like hydrogen fired gas turbines or fuel cells,” he said.

Schuenemann notes, that the natural gas option is attractive because not only is it lower carbon than diesel, but it also offers the possibility of being easily converted to a carbon-free fuel in the future. Gas turbines have a higher power density than reciprocating engines and are also fuel flexible; they can run on liquid fuels including bio diesel as well as gaseous fuels such as natural gas and hydrogen. This ability to run on hydrogen brings a big opportunity to decarbonise gas.

“Natural gas is a fossil fuel but with lower carbon dioxide emissions than diesel. Also, gas turbines compared to gas engines have lower methane slip and so release less methane into the atmosphere,” he explained. “Gas turbines can start quickly without major pre-warming, are dense in power and have high availability and reliability and also have the versatility to switch fuels online. This makes them attractive.

“Ireland, for example has a vision to have 50 per cent of its gas demand carbon-free by 2050,” noted Schuenemann. Part of the plan for achieving this is by investing in new technologies to facilitate substitution with a sustainable gas (e.g. hydrogen), into the gas network. “This approach by Ireland may also be valid for other



countries,” Schuenemann added.

The use of hydrogen as an energy vector is gaining momentum as the amount of renewables on the grid rises and sustainable hydrogen and its derivatives (e-ammonia, e-fuels) are being introduced in several other sectors such as industry and mobility. Eventually, hydrogen is also expected to play a role as a fuel for gas turbines – replacing fossil fuels for the residual load to enable large-scale, long-term seasonal storage of renewable energy and deep decarbonisation of the power sector.

“Even if re-electrification of hydrogen is not cost-economical today, with green hydrogen likely being used in other sectors of the economy first, we expect new gas turbine plants being built today to switch gradually to hydrogen over their life time. This requires provisions for a later retrofit to hydrogen as a fuel, a concept called H2 readiness”, said Schuenemann.

Siemens Energy has been working on adapting its gas turbines to run on hydrogen for a number of years now, and has released a hydrogen blending capability with natural gas in DLE (dry low emissions) mode between 30 and 75 per cent by volume, depending on the gas turbine model. The company has set out a roadmap for achieving a 100 per cent hydrogen capability in DLE mode by 2030 at the latest.

Notably, Siemens Energy has a demonstration project under execution in France known as HYFLEXPOWER that will play a key role in demonstrating full decarbonisation of its gas turbines. The project, which is being hailed as the world’s very first industrial-scale power-to-X-to-power demonstrator with an advanced 13 MW SGT-400 hydrogen turbine, will demonstrate the importance of using hydrogen as a long-term energy storage technology for a grid that has a high renewables penetration.

Where provision and storage of sustainable hydrogen is not possible, other decarbonised fuels like synthetic e-fuels or biofuels may – albeit more expensive or less sustainable – also become an option for gas turbines.

The high cost of green fuels can be mitigated by configuring these turbines as high efficiency combined cycle plants. But with such fuels not yet widely commercially on viable,

Siemens Energy is applying existing technologies such as gas turbines and also looking to work with customers on new technologies in its focus areas, for example, storage and hybrid power plants

The SGT-A05 is compact and easily transported

Fuel cells are another clean option for data centres. BBC Studios Natural History Unit has used a GeoPura solution in place of diesel gensets for critical and back-up power

Siemens Energy says natural gas would be today's fuel to allow low emissions per electricity unit generated, with the e-fuel being mixed in as it becomes available. With waste heat utilisation overall energy conversion efficiency can be in the order of 80-90 per cent. Such solutions, however, are complex and may only be suited to very specific requirements of a data centre.

Siemens Energy says fuel cells are another clean option for data centres. Through its partnership with GeoPura, the company can deliver such systems for events and other situations where green onsite power is needed. In September last year, the partners delivered a hydrogen-powered fuel cell to provide off-grid power and heat to National Grid's UK Viking Link construction site in Lincolnshire. The installation served the site for eight months when the remote site was without a grid connection. Also BBC Studios Natural History Unit have used a GeoPura solution in place of diesel gensets for critical and back-up power whilst filming on location.

"With improving economies of scale, this is becoming an interesting solution, especially when considering its high efficiency, modularity and potential high power density," said Schuenemann. "Its modularity means you can size the installation to better match the power needs at high efficiency."

The other interesting technology for data centres, is waste heat utilisation. Data centres generate significant amounts of heat and therefore require cooling systems.

Schuenemann explained: "It may be there is air conditioning and cooling of the servers. If you have a 100 MW data centre, depending on the location, you will need to add 40 per cent for the air conditioning and cooling. The waste heat released to the atmosphere from the cooling system outside of the building should be better re-used via heat pumps, which can boost the heat to a higher temperature level so it can be sold to an industrial customer or fed to a district heating network."

He noted that waste heat is currently not subject to carbon taxes in most countries where it is produced by fossil power plants and is a more sustainable form of producing heat than just burning fossil fuels. This can provide a business opportunity in the future for facilities like data centres, which together with local partners such as municipalities, can sell otherwise wasted heat to further drive decarbonisation.

As the world goes through the energy transition, it is clear data centres have a role to play. Looking at technologies to support the power needed for their burgeoning growth, combined with the business opportunities presented by the implementation of those technologies, data centres no longer need to be seen as part of the climate challenge. On the contrary, they could be integral to helping the world meet those challenging climate targets.

Waste heat released to the atmosphere from the cooling system outside of the building should be better re-used via heat pumps, says Schuenemann

As the world goes through the energy transition, it is clear data centres have a role to play

Satisfying the thirst for data

According to an International Energy Agency (IEA) report, global internet traffic surged by almost 40 per cent between February and mid-April 2020, driven by growth in video streaming, video conferencing, online gaming, and social networking. This growth comes on top of rising demand for digital services over the past decade: since 2010, the number of internet users worldwide has doubled while global internet traffic has grown 12-fold or around 30 per cent per year.

Demand for data and digital services is expected to continue its exponential growth over the coming years, driving massive growth in demand for data centre and network services. Global data centre electricity demand in 2019 was around 200 TWh, or around 0.8 per cent of global final electricity demand.

The report, 'IEA (2020), Data Centres and Data Transmission Networks', notes, however, that rapid improvements in energy efficiency have helped to limit energy demand growth from data centres and data transmission networks, which each accounted for around 1 per cent of global electricity use in 2019. Strong government and industry efforts on energy efficiency, renewables procurement, and RD&D are necessary to limit growth in energy demand and emissions over the next decade, it said.

If current trends in the efficiency of hardware and data centre infrastructure can be maintained, global data centre energy demand can remain nearly flat through 2022, despite a 60 per cent increase in service demand, according to the IEA.

Strong growth in demand for data centre services continues to be offset by ongoing efficiency improvements for servers, storage devices, network switches and data centre infrastructure, as well as a shift to much greater shares of cloud and hyperscale data centres.

Hyperscale data centres are very efficient large-scale cloud data centres that run at high capacity. They enable data centre operators to deliver greater work output with fewer servers. According to Statista hyperscale data centres have doubled their energy demand between 2015 and 2021.

SIEMENS energy

How can we provide power for the data of the future?

The solution to power availability and quality lies within the reach: flexible distributed generation and storage technologies with carbon emissions cut to zero.

LET'S MAKE TOMORROW DIFFERENT TODAY.

siemens-energy.com