Data Centers and Decarbonization: Unlocking Flexibility in Europe's Data Centers

3.0GW

Data center power demand in five key European markets by the end of 2021

56%

Projected variable renewable generation of total European electricity demand in 2030

16.9GW

Flexible capacity that data centers could provide to the five countries' power systems in 2030

Executive summary

This is a summary version of the full report published on October 14, 2021

Data centers are a core component of the 21st century digital economy, providing the critical computing and storage infrastructure that will be needed to unlock economic growth in the coming decade. At the same time, however, data centers represent a growing source of power demand, and their power usage will continue to grow over time as data creation, processing and storage needs expand.

In Europe, data-center growth is proceeding against a backdrop of rising renewable power generation as the electricity system decarbonizes. This will create opportunities not only to operate data centers from power that is increasingly clean, but also for data centers themselves to be a force for good in helping to support the power system and its transition to high renewables and low carbon.

This BloombergNEF report, authored in partnership with Statkraft and Eaton, explores the impact that data centers could have in the power system in five European countries out to 2030. It provides a projection for how great data-center power demand could be and estimates how much flexibility these data centers could provide back to the grid, in the form of demand flexibility, distributed generation and storage resources.

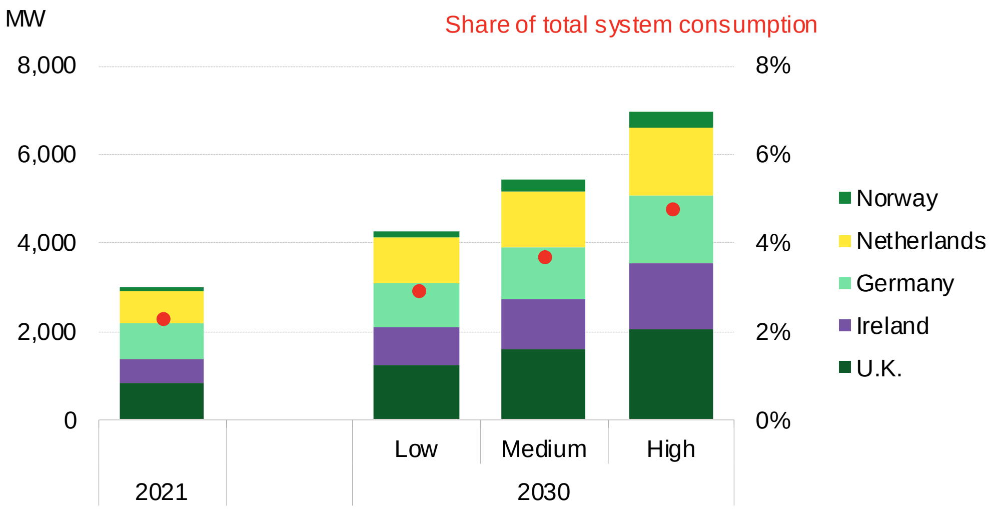
Data-center power capacity in Europe's largest markets will hit 6.9GW by the end of 2021

For the markets of Germany, Ireland, Netherlands, Norway and the U.K, hyperscale and colocation data centers will reach a total design capacity of 6.9GW by the end of 2021, and a live IT power demand of 3.0GW. We estimate that these data centers will use 26TWh of electricity in 2021, or 2.3% of the countries' total annual electricity use.

The largest owners of data centers in Europe divide into two groups: self-build hyperscale operators, such as Google and Amazon; and colocation operators, such as Equinix and Digital Realty. European data-center capacity has grown rapidly in the last two years, in part due to the coronavirus pandemic, to the point where key markets, such as Amsterdam, Dublin and London, face saturation and pushback from regulators. Seeking further growth, some data-center operators are expanding into new markets, where there is more land, cheaper power prices and easier grid connections. This includes Norway, which has seen 16% growth in data-center capacity in the past two years.

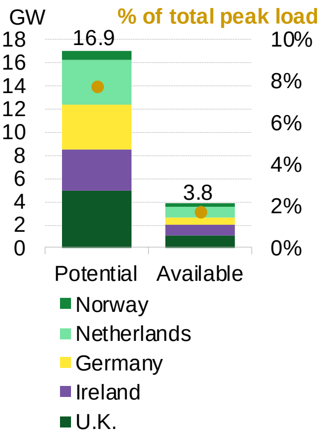
By 2030, in our medium growth scenario, data centers in the five markets rise to a design capacity of 11.9GW and a live IT power demand of 5.4GW. The 2030 capacity equates to an annual use 48TWh of electricity in 2030 – 3.7% of the countries' total annual use.

Figure 2: Data-center live IT power and share of the total annual electricity consumption of the five focus countries



Source: BloombergNEF

Figure 1: Data-center flexible capacity and share of countries' total peak load in 2030



Source: BloombergNEF

Design capacity is defined as the maximum amount of power a data center could draw if it reached its planned footprint (most data centers take years to grow as large as this initially announced capacity). This is the size of the grid connection that the data-center operator agrees with the local power provider. The 'live IT power' is the actual average power draw from the active servers installed, taking into account a utilization rate.

Variable renewables are projected to generate 56% of Europe's electricity demand in 2030, leading to a greater need for flexible resources

As data-center design capacity grows by 83% between 2020 and 2030 in the five focus countries, so does the need for greater power system flexibility. Variable renewables such as wind and solar are projected to generate 56% of Europe's electricity by 2030[1], up from 27% in 2021. This will mean greater flexibility from load centers on the grid, to better match the increasingly variable supply, to fine tune the grid for stability, and to help manage power flows on the network infrastructure. Not only will these needs become more pronounced in a renewable power system, but the conventional fossil-fuel generators used to address these flexibility issues will also become more expensive to operate. As a result, other resources, such as energy storage and demand-side management, will be needed to support the power system.

[1] Based on BloombergNEF's *European Energy Transition Outlook*, Ambitious Policy Scenario

Data centers could offer as much as 16.9GW of flexible capacity in 2030, across the five countries, aiding renewable integration

Data centers' main sources of flexibility are the uninterruptible power supply (UPS), back-up generation and in principle shifting their energy consumption by time or location. The UPS (an energy storage device) and back-up generation are there to ensure data-center operation during a grid outage. In our 2030 high growth scenario, the total flexibility that these resources could provide is 16.9GW. The different resources could be used in combination. Our analysis shows that, of this capacity, it is reasonable to assume that 3.8GW could be available for grid flexibility in 2030, based on our estimate of data-center operators' willingness to participate.

This data-center flexibility can help to stabilize the power system and integrate more renewable generation. UPS are the most sizable source of data-center flexibility and are well suited to prove frequency regulation services (which require fast response and short duration, eg, a few minutes). Data centers could offer longer-duration flexibility through shifting compute tasks to other times of the day or to other data centers, aligning with times and places of greater renewable generation. On-site generators could also be a large source of flexibility. While most of this capacity is diesel today, and therefore too emissions-intensive to run except in an emergency, lithium-ion batteries or hydrogen could replace diesel generation in the medium term.

Table 1: Data-center resource flexibility potential assessment

	UPS	Time shifting	Location shifting	Back-up gen	Back-up battery
Target application(s)	Ancillary services, eg, freq. regulation	Energy markets	Energy markets	Energy markets	Energy markets, and system services
Present in data centers?	Yes, very common	Load is present but shifting is not	Load is present but limited shifting	Yes, very common, mostly diesel	No, still in pilot stage
Power capacity available	Full, equiv. to data center capacity	30%-50%	30%-50%	Full, equiv. to data center capacity	Full, equiv. to data center capacity
Energy capacity available	Available for only a few minutes	Hours – task must be completed by a specific time	Hours – based on compute capacity in data centers	2-8 hours, depends on stored fuel	Up to 50%
Likely willingness to adopt	High, depends on battery type	Low to med, easier for hyperscale operators	Operator must run multiple data center sites	More likely for low-carbon fuel. Concern for reliability	Additional revenue is vital to business case

Source: BloombergNEF

The barriers to broad adoption of data-center flexibility are significant

Data-center operators' main goal is to serve customers with reliable computing power. For many of them, offering flexible capacity to the power grid jeopardizes this, either through poorer computation performance or a less reliable service. While there are definite economic, regulatory and climate benefits to data-center flexibility, these are not well understood and there are no government signals that currently incentivize most data-center operators to take this perceived risk. New and hyperscale built data centers are the most likely to engage with flexibility, compared with existing and colocation-operated sites.

Data-center operators in Europe are exploring new flexibility resources for data centers

While the widespread use of data-center flexibility is limited, there are examples of early adopters today in Europe. Several data center operators use or plan to use their UPS to provide grid services, such as Microsoft, DigiPlex and BaseFarm. Many data centers already shift compute tasks due to operational limits or cost advantages. Google and Microsoft furthered this application with their aim to match electricity use with renewable energy at an hourly level, though these applications are still developing. Colocation provider Iron Mountain has launched a similar product that would allow its customers to track their renewable energy use hour-by-hour. There are also a few initial projects for battery and hydrogen fuel cells as backup generation. The large hyperscale operators typically lead in these new approaches, similar to how they led in the use of renewable power purchase agreements. They also have the benefit of being their own computing customer (eg, Facebook or Google), which may make it easier to experiment.

Regions outside of the largest markets might become future hubs of green data-center development

Most European data-center capacity is in five cities: Frankfurt, London, Amsterdam, Paris and Dublin (FLAP-D). The data-center industry is often called a victim of its own success, as it has experienced pushback on further development in these markets due to pressure on local resources, such as power network capacity and land availability. In 2019, the Amsterdam area saw a year-long ban on new data center build, followed by several policies dictating new data-center locations and total capacity. Frankfurt is looking at similar policies. Ireland is a more extreme case where besides network constraints, Eirgrid, the Irish system operator is concerned data centers endanger the security of supply and the country's carbon-emission targets.

These developments have encouraged data-center operators to look to new regions to develop projects. The Nordics is one region of interest for data-center developers, where the cold climate suits data centers. Norway's clean and cheap power supply, thanks to its large hydro generation capacity, is attractive to data-center developers. The country's limited fiber connections and distance from dense populations are challenges that the Norwegian government is addressing.

Countries keen to attract data-center investment should pay attention to the rampant development in the FLAP-D countries. Managing data-center development thoughtfully will avoid the need for the types of corrective policies seen in the Netherlands and Ireland.

Table 2: Comparison of data-center development factors, by country

	Power grid emissions (gCO2/kWh)	Industrial power prices (euro/MWh)	Power grid reliability (SAIDI, hours)	Current data-center power consumption (% of total)	BNEF data-center growth forecast to 2030 (%)
Germany	350	148	0.25	1.2%	88%
Ireland	316	97	0.8	14.2%	104%
Netherlands	390	75	0.78	5.4%	80%
Norway	11	20	1.5	0.5%	205%
U.K.	230	160	0.28	2.6%	93%

Source: BloombergNEF. Note: Colors indicate favorability towards further data-center development.

Data-center flexibility has clear benefits, but more work is needed to quantify and communicate them

Data-center operators could capture several benefits by providing flexibility services to the grid:

- Financial: operators can reduce or offset energy costs by optimizing energy use against energy prices and network charges, or providing paid flexibility services to the system operator
- Environmental: reduce carbon emissions from own operations by aligning energy use with renewable generation, or displace the use of fossil fuel generation for system and network flexibility needs
- Connections: grid connections with agreed flexibility may enjoy cheaper and quicker connection times due to less infrastructure reinforcement needed
- Pre-empt regulation: data centers are large loads and further build-out could put strain on the power system, leading to regulatory intervention. Acting pre-emptively and reducing this power system strain through flexibility can offset this need for intervention
- “Green” products: customers are becoming more aware of climate change and seek new products. Low-carbon products due to flexibility measures could be a competitive advantage

Currently, these benefits are either not easily quantified and measured, or do not accrue directly to data-center operators and their customers. Over time, governments could design suitable regulations and incentives to quantify and realize these benefits, if they are to encourage data center participation in grid services

New forms of service level agreements could overcome one of the larger obstacles to data-center flexibility

Data-center operators and their customers have clear service level agreements (SLAs), which lay out the performance expectations of the computing service. These include latency, processing speed, uptime and storage capacity. Service level agreements are a key sticking point preventing colocation data-center operators from considering adopting greater flexibility. Re-examining their design could allow more operators to participate in power market flexibility. This would require the buy-in of customers. This change might start with big tech and cloud customers, which make up a significant portion of Europe’s data-center customers and have their own decarbonization goals. Aligning SLAs with the climate goals of this large customer base might accelerate data center flexibility.

Improving market signals could encourage data-center operators to act

Many data-center operators and users are not incentivized to act flexibly. Signals, such as cost and carbon emissions indicators, might encourage data-center operators to participate and help to integrate renewable into the power system. Data-center operators could charge users varying energy prices throughout the day to reflect power market conditions, for example charge cheaper prices at night when demand is low and wind output is high. Many energy suppliers already offer so called time-of-use tariffs to residential and commercial customers. While time-of-use tariffs would incentivize cost efficiency, grid carbon intensity signals would also benefit carbon efficiency.

Exposing data-center users and software engineers to these signals would encourage design of software and applications to be flexible. Ultimately, software engineers would design applications to be delay-tolerant or respond to real-time market signals.

Trials and pilot projects are needed to understand the potential of flexibility

Data-center operators have little experience with power system flexibility and need to build confidence in the concept. A series of trials or pilots would explore the potential capacity within data centers, and address concerns about the impact on performance. Information sharing and collaboration between all the parties involved would be key to build awareness within the industry. There are many lessons to learn, such as which party is at risk, who is responsible and who benefits. This may also require some sandboxing or ring-fencing to avoid breaching existing commercial contracts and service-level agreements.

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