# Data centre dispatchable capacity: a major opportunity for Europe's energy transition

How data centre microgrids can reduce grid infrastructure spending, emissions, and wasted energy, while providing a balanced path for the transition to zero carbon

# Contents


**Section 1**

**Setting the scene: a challenging climate for European data centre operators** **5**

The surge in power demand 6

Impacts: refused connections, AI slowdown 7

Workaround: the rise of the microgrid 8

Dispatchable power and microgrids 9

**Section 2**

**Simulations: global power generation and AI data centre microgrid models** **10**

Macro modelling: global power generation 11

Micro modelling: a typical AI data center 15

**Section 3**

**Putting theory into practice: opportunities and challenges** **23**

The size of the opportunity 24

Benefits of backing up the grid 25

New ways of working 26

Microgrids in action 27

Key market considerations 28

**Conclusion: grasping the grid opportunity** **30**

**Glossary of power terms** **31**

**Sources & further reading** **34**

# Giving back to the grid

**Ben Pritchard**
Chief Executive Officer

I have always maintained that sustainability is a journey, not a destination, and in a long journey there are many different routes. Sometimes you have to stop, take stock, and pick a better way.

Combining Wärtsilä's deep knowledge of energy transition strategies with AVK's expertise in power solutions for the data centre industry, this paper expresses our vision for the future of microgrids for data centres. The key argument of the paper is one of converting a challenge into an opportunity. As data centres experience growing power demands and increasing grid constraints, microgrids offer a scalable and flexible solution that has the potential to accelerate the journey to net zero via a balanced energy transition path, as defined by our expert partner Wärtsilä.

Please take the time to read this. As with many of the challenges that we face in combatting climate change, the answers are at least as much about changing behaviours as they are about developing new technologies. And the key to behavioural change is the recognition that there are different ways of doing things.

The solutions we outline here are not impractical, they are based on real-world cases and calculations. All that is needed to make them more widespread is for readers - whether they are investors, operators, equipment suppliers, planners, policy makers, or other influencers - to recognise the widespread benefits that sharing dispatchable data centre capacity with the grid can bring, and pass that knowledge on. I hope that once you have read this paper, you too will become an agent of change.

**Ben Pritchard**
CEO, AVK.

## About AVK

AVK is the largest and fastest-growing supplier of innovative power solutions for data centres and leading organisations in the UK and Europe. We specialise in all aspects of design, planning, implementation, and continuing maintenance.

At AVK, we power tomorrow's data. We are transforming the way the data industry connects to and consumes energy by developing innovative and sustainable solutions. We deploy leading-edge solutions for our clients, helping them to meet their power demands alongside their sustainability goals.

With offices and hubs across the UK and Europe, AVK is in a unique position, in terms of operational scale and delivery capabilities to tackle complex, large-scale, and groundbreaking engineering and energy projects.

AVK – Powering Tomorrow's Data

# Building flexibility & resilience to support renewables

**Anders Lindberg**
President, Wärtsilä Energy

As artificial intelligence (AI) adoption accelerates, data centres are being deployed at unprecedented speed and scale across Europe. While this growth could unlock transformative benefits for the economy, the technology risks being constrained by high energy costs and lengthy grid connection delays.

To overcome these challenges, developers are increasingly turning to off-grid solutions like microgrids to power these assets. Amid these rapid developments, it is critical that microgrids are designed holistically, ensuring that they are backed up by affordable, reliable and sustainable sources of energy.

This white paper finds that a combination of renewables, grid balancing engines and energy storage offers the optimal solution to power microgrids, supporting the AI boom. Leveraging low-cost renewable energy, backed up by balancing technology, can support the energy-intensive needs of data centres, regardless of changing weather conditions.

The flexibility of these systems can later be harnessed to provide benefits beyond the secure energy supply of data centres. When grid connection is obtained, these microgrids can create a significant bank of dispatchable capacity for balancing the European grid, accelerating the energy transition and enabling the integration of vast amounts of new renewable energy.

Europe's data centre industry is predicted to grow rapidly - backed by major capital and led by power solutions providers like AVK. Therefore, it is essential that we act decisively on these findings to keep global net zero targets within reach.

As the Wärtsilä's Crossroads to Net Zero report outlines, it is in our hands to create affordable, low carbon and reliable power systems for all, and to eradicate renewable curtailment.

Reaching this goal relies on harnessing the unique strengths of different flexible balancing technologies – and ensuring they work seamlessly together.

I hope that this paper helps to transform the way we power data centres, while supporting a more balanced, inclusive path to net zero that delivers lasting benefits for people, communities and businesses.

**Anders Lindberg**
President, Wärtsilä Energy and Executive Vice President Wärtsilä Corporation

## About Wärtsilä Energy

Wärtsilä Energy is at the forefront of the transition towards a 100% renewable energy future. We help our customers and the power sector to accelerate their decarbonisation journeys through our market-leading technologies and power system expertise. Our solutions include flexible engine power plants, energy storage and optimisation technology, and services for the whole lifecycle of our installations. Our engines are future-proof and can run on sustainable fuels. Our track record comprises 79 GW of power plant capacity and over 130 energy storage systems in 180 countries around the world. Over 30% of our operating installed base is under service agreements.

www.wartsila.com/energy

Section 1

# Setting the scene: a challenging climate for European data centre operators

# The surge in power demand

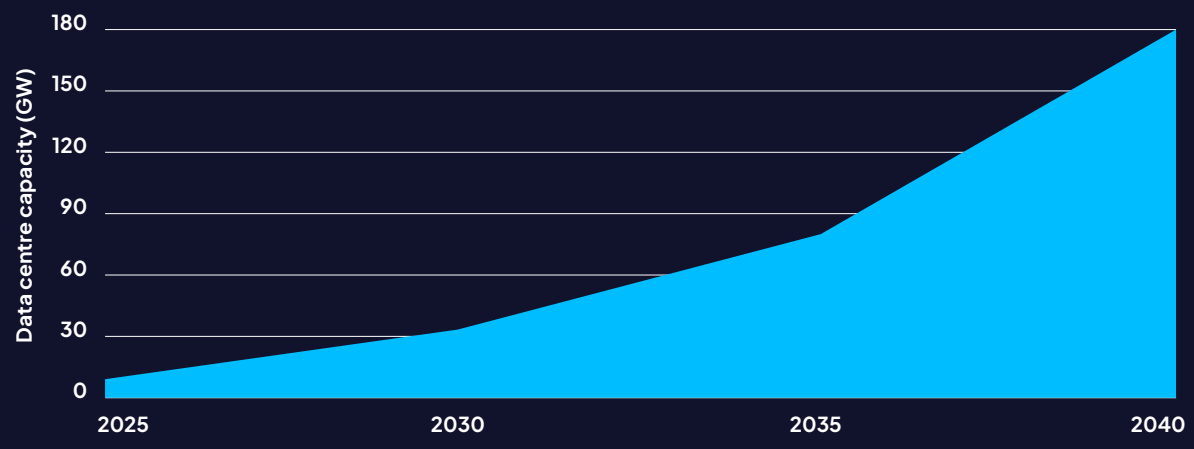
## Europe, driven by a combination of cloud growth and high-density AI infrastructure demand, faces a massive surge in data centre power needs.

In the immediate future, McKinsey estimates that demand for data centre capacity will grow by approximately 25 GW by 2030, from 10 GW today - in other words from 62 TWh (2024) to over 150 TWh (2030) of power.

In the medium term Goldman Sachs estimates a potential 10-15% boost - over and above existing growth - in Europe's power demand over the coming 10-15 years, with a data centre pipeline amounting to around 170 GW. This is equivalent to about one-third of Europe's current power consumption.

**Fig. 1: Estimated European data centre capacity demand 2025 – 2040 (GW)**

Estimated data centre demand (IT load), Europe, gigawatts (GW)




Sources: McKinsey, Goldman Sachs (lower end of forecast)

# Impacts: refused connections, AI slowdown

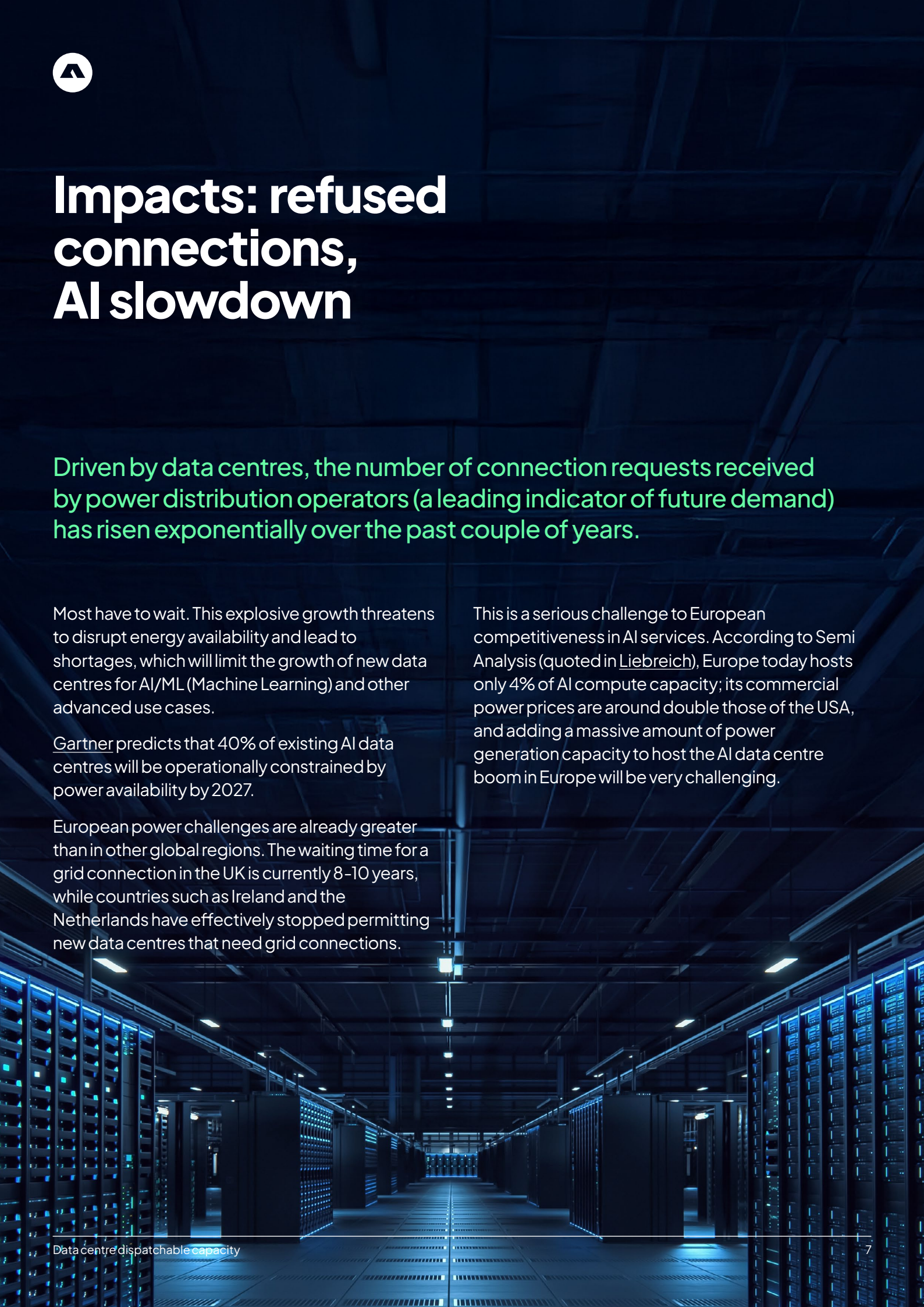
## Driven by data centres, the number of connection requests received by power distribution operators (a leading indicator of future demand) has risen exponentially over the past couple of years.

Most have to wait. This explosive growth threatens to disrupt energy availability and lead to shortages, which will limit the growth of new data centres for AI/ML (Machine Learning) and other advanced use cases.

Gartner predicts that 40% of existing AI data centres will be operationally constrained by power availability by 2027.

European power challenges are already greater than in other global regions. The waiting time for a grid connection in the UK is currently 8-10 years, while countries such as Ireland and the Netherlands have effectively stopped permitting new data centres that need grid connections.

This is a serious challenge to European competitiveness in AI services. According to Semi Analysis (quoted in Liebreich), Europe today hosts only 4% of AI compute capacity; its commercial power prices are around double those of the USA, and adding a massive amount of power generation capacity to host the AI data centre boom in Europe will be very challenging.



# Workaround: the rise of the microgrid

While waiting for a grid connection, the digital infrastructure industry is responding to the problem by generating its own power in microgrids. In a growing number of Europe's more constrained markets, this is the only way to unlock land parcels for planning.

## Market size and potential

The European microgrid market was estimated at about €3.3 billion in value last year, according to Global Market Insights (GMI). This is around 20% of the size of the market in the USA.

Europe is generally regarded to be ahead of the USA when it comes to smart grid technologies improving efficiencies and responsiveness on the larger grid, but there is a lack of proactive collaboration at the utility and regulatory level which is slowing development. However, the market has been moving faster recently, and GMI forecasts significant growth over the next seven years to more than $16 billion (€ 13.7 billion), driven in particular by the recent movement towards local energy communities (LECs).

LECs are still early in the adoption phase in Europe but these clusters of grid-connected Distributed Energy Resources located close to the load could also provide ancillary services to the main grid, which could make them more attractive to investors. They have the potential to become a key tool to alleviate problems in distribution and transmission networks, including congestion management, voltage and frequency problems and flexibility in planning by allowing cost-efficient infrastructure replacement strategies.

The USA is already actively promoting data centre microgrid adoption: the Electric Power Research Institute recently launched the DCFlex Initiative to explore how data centres can support and stabilise the grid.

# Dispatchable power and microgrids

## What is dispatchable power?

Dispatchable power refers to electricity generation that can be turned on or off, or adjusted, on demand by the grid operator or data centre facility manager. It is the opposite of (and therefore complements) intermittent sources like wind or solar.

A dispatchable power source:

- can respond to demand (you can "dispatch" it when needed)
- is reliable and controllable
- can support grid stability or serve critical loads when the grid is unavailable or insufficient

In the context of the data centre industry, dispatchable power is on-demand energy that data centres can control. It includes both prime and standby power solutions, ensuring resilience and flexibility across all operating scenarios.

Prime power is the main power source for a facility´s continuous power. This can be dispatchable as primary supply, or to support or boost the grid during peak load or instability

Standby power is the backup power source during grid failure. The data centre industry already operates a very large amount of dispatchable standby power that has the potential to be activated during emergencies or outages.

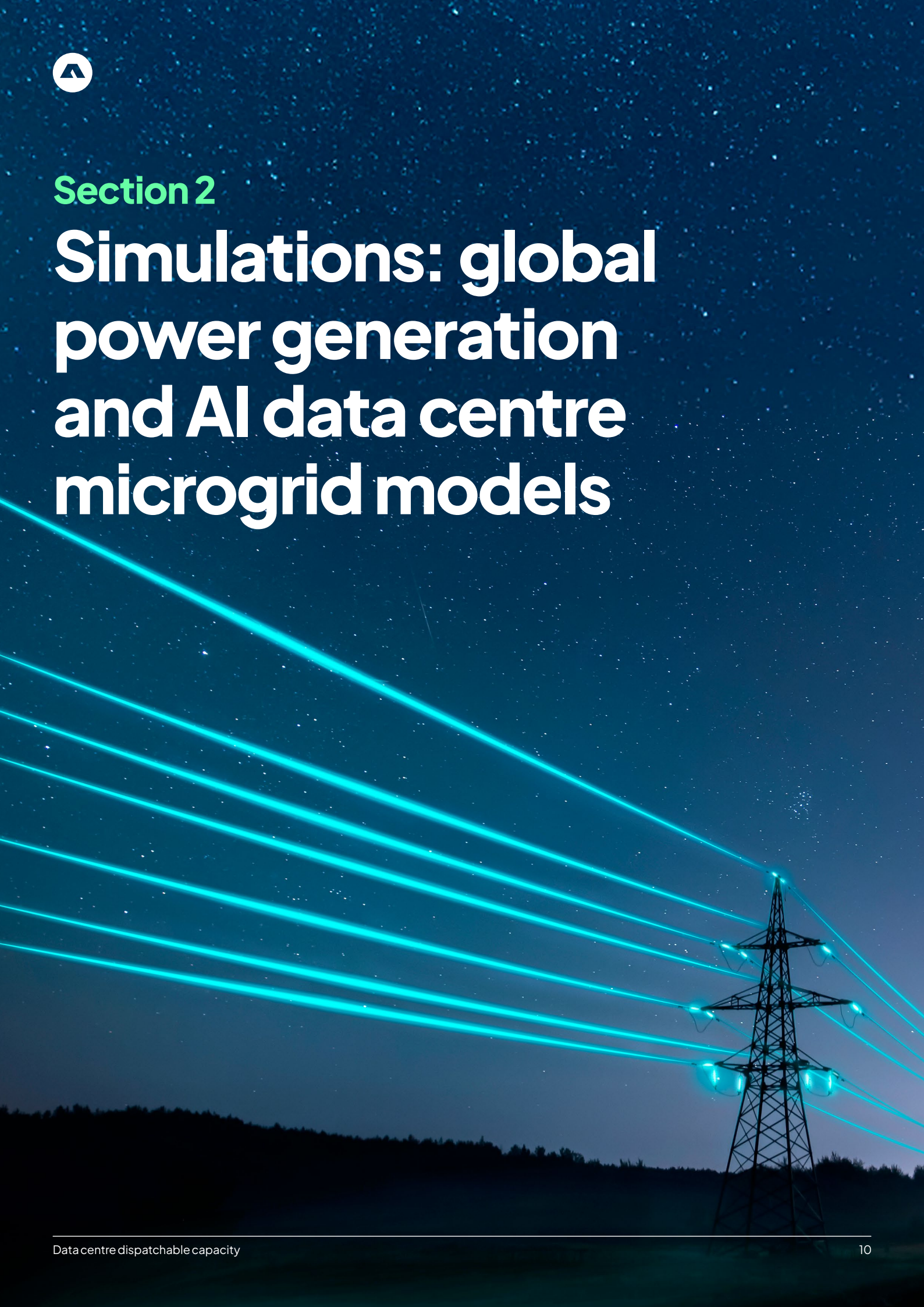
## What are microgrids?

Microgrids are small-scale power grids that operate independently to generate electricity for a localised area. They generally consist of a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that act as a single controllable entity. Microgrids can work in conjunction with more traditional large-scale power grids, but because they are self-contained, they can also operate in "island mode," meaning they function autonomously and deliver power on their own. They are usually made up of several types of distributed energy resources (DERs), such as solar panels, wind turbines, fuel cells and energy storage systems. Their power generation resources can also include more traditional sources such as diesel/HVO generators and natural gas-powered combined heat and power (CHP) systems.

See the Glossary for brief explanations of these and other terms.

Section 2

# Simulations: global power generation and AI data centre microgrid models



# Macro modelling: global power generation

Wärtsilä recently published Crossroads to net zero: Choosing the optimal path to a renewable energy future, in which the company modelled global power generation as a single, aggregated system.

The paper explores the impact of two different power and storage mixes on the path to net zero by 2050 - one powered entirely by renewables and the other using a mix of renewables and power plants. While this is a very high-level and simplified approach, it is useful for focusing on system-wide trends and technology integration.

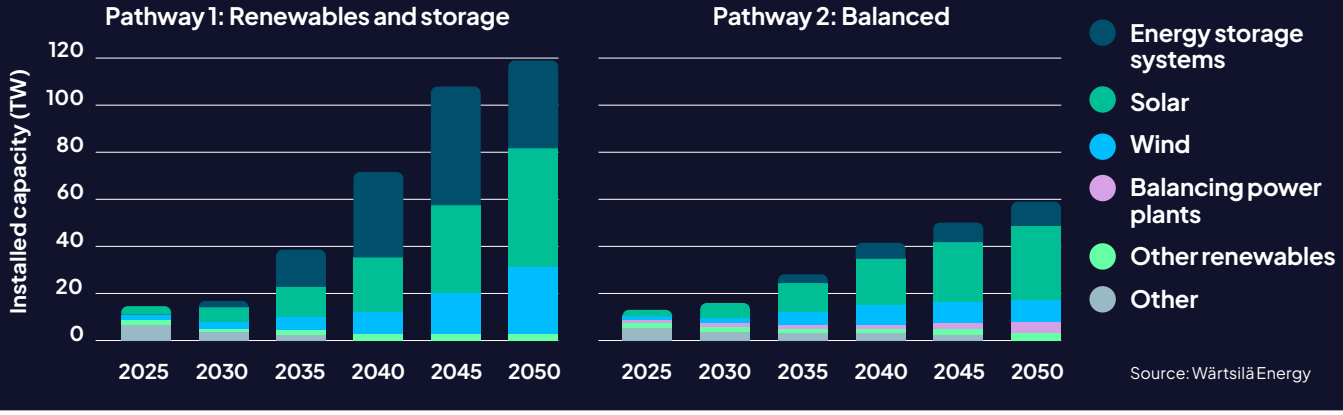
**Pathway 1: 'Renewables and storage':** where the installed capacity of variable renewable energy (solar and wind) increases to over 79 TW by 2050 , while energy storage capacity expands to more than 37 TW. These are 31-fold and 441-fold increases respectively, compared to total installed capacities in 2023. The monumental increase of renewable and energy storage capacity required for this pathway highlights the impracticality and constraints of a 100% renewable energy approach to net zero.

**Pathway 2: 'Balanced':** where variable renewable energy capacity reaches over 41 TW by 2050, with energy storage capacity expanding to over 10 TW - 16-fold and 123-fold increases respectively. This path also incorporates nearly 4 TW of balancing power plants as part of the optimal capacity mix.

## Parameters

In both paths, variable renewable energy meets the majority of total electricity demand by 2035, and by 2050 the Renewables and storage path provides 90% of total net power generation, while the Balanced path provides 85%. Carbon emission limits were imposed to ensure compliance with Paris Agreement targets, with both pathways achieving net zero by 2050 at the latest.

**Fig. 2: Capacity mix models 2025–2050**




Source: Wärtsilä Energy

# Key findings

## Storage requirements

The share of demand met by energy storage in 2050 reaches 6.5% in the Renewables and storage pathway, while in the Balanced pathway it reaches nearly 13.5%. In the Balanced pathway, the share of demand supplied by balancing power plants gradually decreases from approximately 23% in 2025 to 3% in 2050.

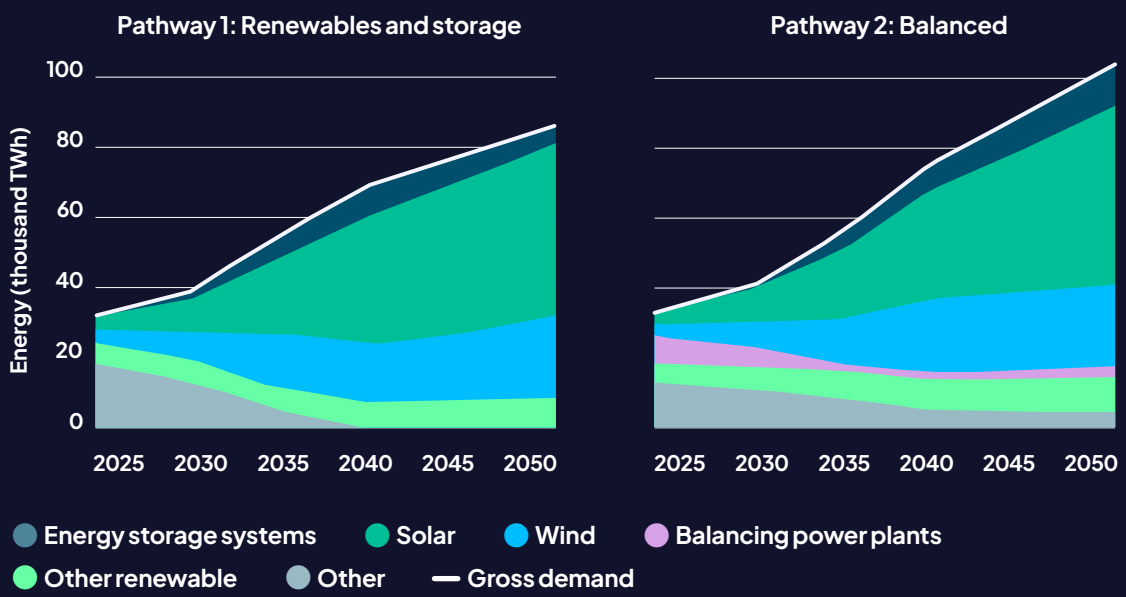
## Role of balancing power

Although balancing power plants play a key role in optimising the system, the modelling results show they will be operated with relatively low running hours. However, their operational profiles are characterised by high ramp rates and frequent starts and stops. This indicates that a high degree of operational flexibility is essential for these assets to effectively support renewable balancing, making inflexible assets, such as legacy baseload plants, ill-suited.

## Land use

A notable outcome in the Renewables and storage pathway is the vast scale of renewable expansion required. The land needed for the wind and solar infrastructure alone would cover an area comparable to the size of continental Europe.

**Fig. 3: Energy mix v demand modelling 2025–2050**




Source: Wärtsilä Energy

## Curtailment

On the Renewables and storage pathway, renewable energy curtailment (the reduction or temporary shutdown of production due to excess supply) rises sharply in 2035 and beyond, reaching approximately 55% of total renewable energy generation by 2050, compared to only 5% on the Balanced pathway. To contextualise this, the cumulative curtailed energy in the Renewables and storage pathway from 2025 to 2050 would be enough to meet the entire global power demand in 2023 (based on current electricity consumption) for more than 15 years.

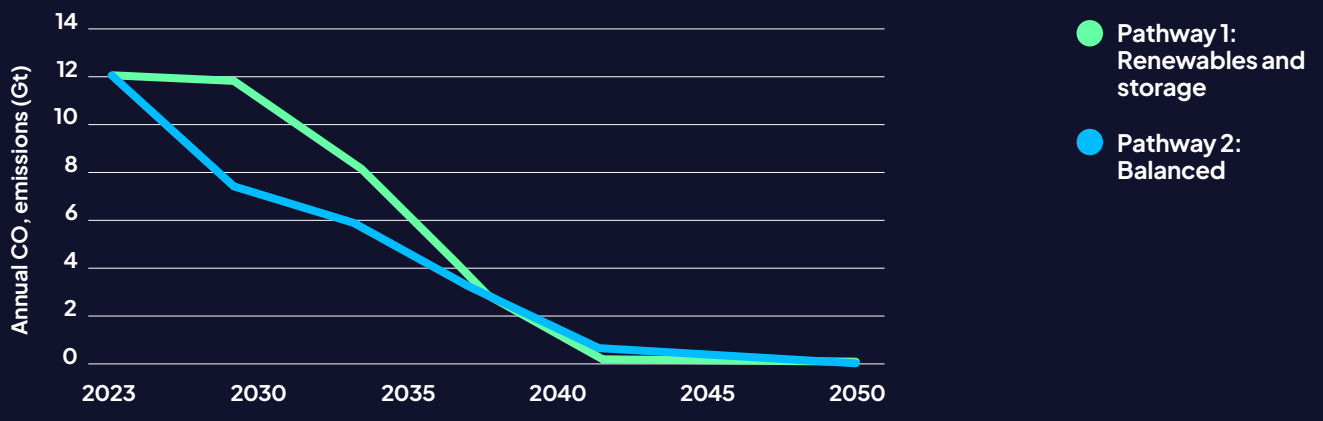
## Fuel demand/sustainable fuels

On both pathways, the power sector plays a critical role in the production of sustainable fuels, especially in hard-to-electrify sectors like industry, marine transport, and aviation. In the Balanced pathway, more hydrogen and other green fuels are incorporated from the mid-2030s onward . Given the relatively high cost of these future fuels, they are used exclusively for low-running-hour balancing power, providing additional system flexibility when the installed energy storage reaches its power or storage limits.

## Emissions

On the Renewables and storage pathway, the rate of emissions decline is more gradual, due to the lack of long duration flexible capacity necessary to completely eliminate the need for legacy inflexible power plants. By contrast, the Balanced pathway sees a more rapid decline in emissions as inflexible assets are phased out and replaced by renewables supported by energy storage and sustainable-fuel-ready balancing power plants to provide firm, reliable power over long durations. Consequently, the Balanced pathway achieves a near 21% (19 Gt) additional reduction in cumulative emissions by 2050 compared to the Renewables and storage pathway, equivalent to over 1.5 years of current global power sector emissions.

**Fig. 4: Annual $CO_2$ emission modelling comparison (power sector)**




Source: Wärtsilä Energy

## Cost

Overall, the total system cost between 2025 and 2050 is estimated at approximately €155 trillion for the Renewables and storage pathway and €90 trillion for the Balanced pathway. This translates to a cumulative saving of over €65 trillion for the Balanced pathway - equivalent to more than 60% of current global GDP.

These cumulative costs translate to a levelised cost of electricity (LCOE) of € 93/MWh for the Renewables and storage pathway and € 60/MWh for the Balanced pathway. The significant cost disparity between the two pathway is largely due to the substantial overcapacity of renewables in the Renewables and storage pathway and the high volume of wasted energy due to curtailment. The relatively small amount of balancing power plants added to the Balanced pathway achieves a cost-optimal system.

### Key findings: The significant advantages of adding balancing power plants

**€65**
**trillion reduced costs.**

Compared to a renewables pathway, the deployment of balancing power plants reduces the total cost of future power systems by as much as 42%, approximately € 65 trillion.

**21%**
**reduced emissions.**

Adding balancing power can reduce the total accumulated power sector $CO_2$ emissions by 21% by 2050 compared to the renewables path.

**88%**
**less wasted energy.**

The use of balancing power allows for enhanced power system optimisation, resulting in 88% less wasted energy due to renewable curtailment by 2050.

**50%**
**less renewable capacity and land needed.**

Adding balancing power plants can halve the required renewable capacity and significantly reduce the land needed for infrastructure, which would otherwise cover an area the size of Europe.

# Micro modelling: a typical AI data center

Wärtsilä's "Crossroads to Net Zero" report shows that balancing power plants, alongside battery energy storage and renewables, can play a crucial role in driving cost-effective global decarbonisation and ensuring power system resilience.

However it is important to point out that the report's calculations were intended for the global energy industry and as such did not focus on the specific details of third-party providers.

For this paper, Wärtsilä has gone a step further, modelling the options available to data centre operators with dispatchable power at a typical AI facility. This makes it possible to calculate the most beneficial mix of fuels/storage in terms of energy sources, cost to deploy and operate and emission impact.

## Microgrid Models

In this data centre-focused scenario, we evaluate four possible power solution configurations, in terms of cost effectiveness and reliability, to assess the most viable options available to an 80 MW AI data centre located in Northern Europe operating under real-world conditions. For all models, the capacity of each technology is sized to meet the full potential power demand while minimising total system costs.

### Notes on data centre power modelling approach

Modelling of the different power solution options was carried out using PLEXOS, a leading energy market modelling tool. The simulations were undertaken at a 5–minute resolution to capture the high variability of AI data centre loads and fluctuations in renewable output at a sub-hourly level.

The AI data centre's load profile fluctuates between 20 MW and 80 MW, exhibiting significant sub-hourly variations. Short-term demand spikes, including inrush currents, are managed by internal systems such as the UPS.

The battery energy storage systems (BESS) in Models 2 - 4 are sized for the system's instantaneous reserve requirements during an outage, assumed to be the size of a single Internal Combustion Engine (ICE) or Combined Cycle Gas Turbine (CCGT) unit. Model 1's BESS sizing is optimised to achieve cost-effective system reliability, given the variable nature of solar and wind generation.

In Models 2 - 4, the ICE and CCGT are sized to meet peak demand. Additionally, two further units (i.e. N+2) are included as maintenance reserves to ensure uninterrupted power supply during both scheduled and unscheduled maintenance periods in line with Tier III facility specifications.

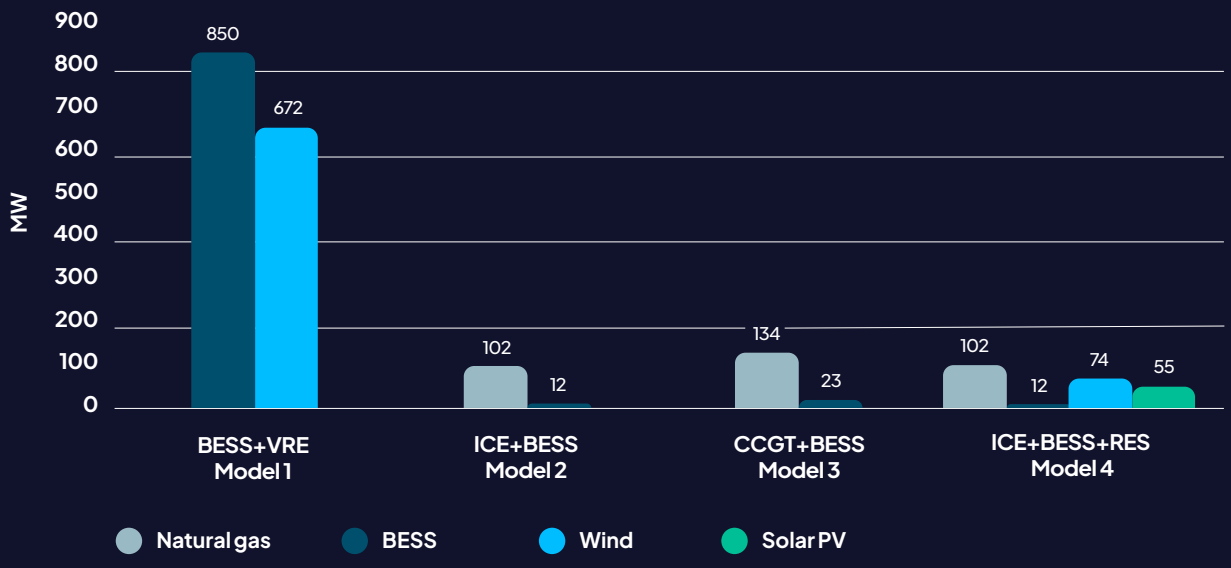
The technical and cost assumptions are based on publicly available sources. Renewable generation yields and fuel prices are derived from historical data and forecasts for Northern Europe. A carbon price of €70/ton is applied for cost calculations, with a shadow carbon price of €130/ton applied for capacity and dispatch optimisation.

## Models & Results

| Model Criteria | Simulation Results |
|---|---|
| **1 renewables + batteries** | |
| In this option only renewable energy, comprising onshore wind, together with battery energy storage systems are deployed to power the data centre. Note that solar was considered in the optimisation method, however the results indicated that wind alone was the optimum solution to achieve the lowest Levelised Cost of Energy (LCOE). | The resulting mix here uses a combination of 672 MW of wind and 850 MW / 3,400 MWh of battery energy storage. As with Pathway 1 in the "Crossroads" paper, Model 1 highlights the impracticalities and constraints of a 100% renewable energy approach for a data centre, mainly due to the sheer size of the installations required. |
| **2 internal combustion engines + batteries** | |
| This includes build options for medium-speed gas internal combustion engines (ICE) and battery energy storage (BESS). The deployment of renewable energy is not considered, reflecting scenarios where constraints such as limited land availability prevent the installation of renewable capacity. | The optimal configuration in this option, which is also renewable-free, is 102 MW of internal combustion engine capacity, consisting of a total of 9 units (including the N+2 requirement), each rated at 11.3 MW. Battery energy storage is sized accordingly at approximately 12 MW/12 MWh. |
| **3 combined cycle gas turbines + batteries** | |
| In this option, only combined cycle gas turbines (CCGTs) and battery energy storage (BESS) are used. As in Model 2, the deployment of renewable energy is not considered. | For this renewable-free model the optimal configuration was found to be 134 MW of turbine capacity, consisting of four units in a 1×1 gas turbine/steam turbine setup, each rated at approximately 23 MW with two additional combined cycle gas turbines to meet the N+2 criterion. Battery energy storage is sized accordingly at 23 MW/23 MWh. |
| **4 renewables + internal combustion engines + batteries** | |
| In this model, the internal combustion engine (ICE) and battery energy storage (BESS) are sized to align with those in Model 2. However, unlike Model 2, the deployment of renewable energy is permitted. The level of renewable capacity is determined based on system cost minimisation. | According to our simulation, the most cost-effective configuration for this model includes 74 MW of wind and 55 MW of solar capacity. The internal combustion engines and battery energy storage components are sized identically to those in Model 2, i.e. 102 MW and 12 MW respectively. |

# Observations

**Fig. 5: Installed capacity and generation mix models 1– 4 for 80 MW data centre**



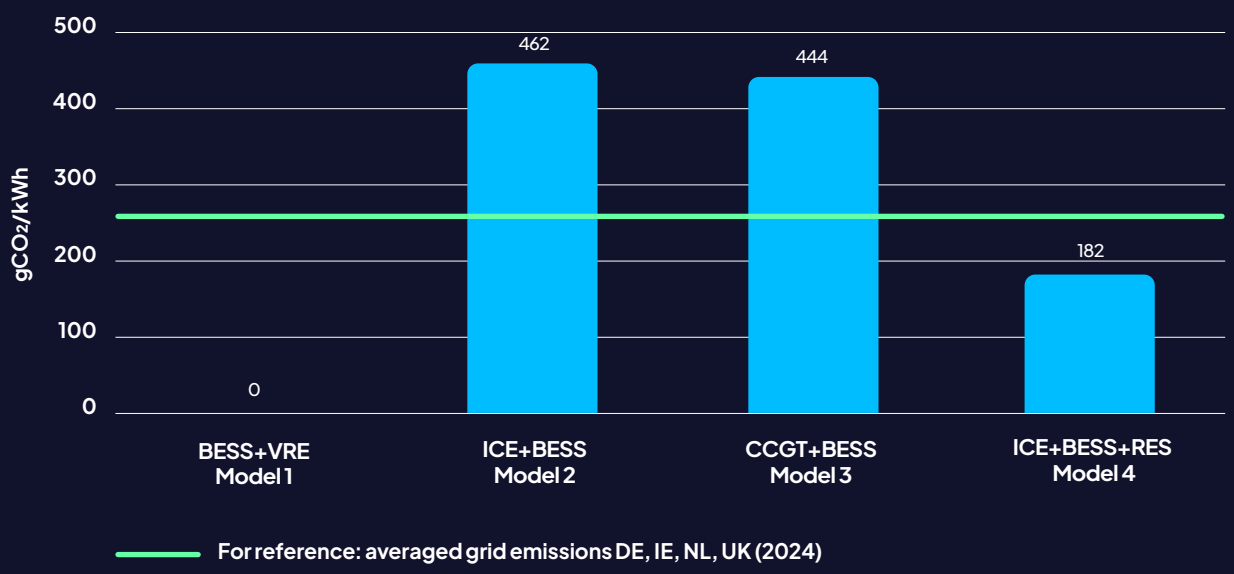

Source: Wärtsilä Energy

## i) Capacity mix

To run an 80 MW data centre on renewables alone (Model 1) over 1.5 gigawatts of renewables and battery storage systems would be required. This is a phenomenal amount of overcapacity, rivalling some of Europe´s largest grid-connected assets, which creates its own serious environmental implications.

In Model 4, the resulting mix of renewables is optimal for the 80 MW data center, maximising the utilisation of low-cost renewables while minimising curtailment.

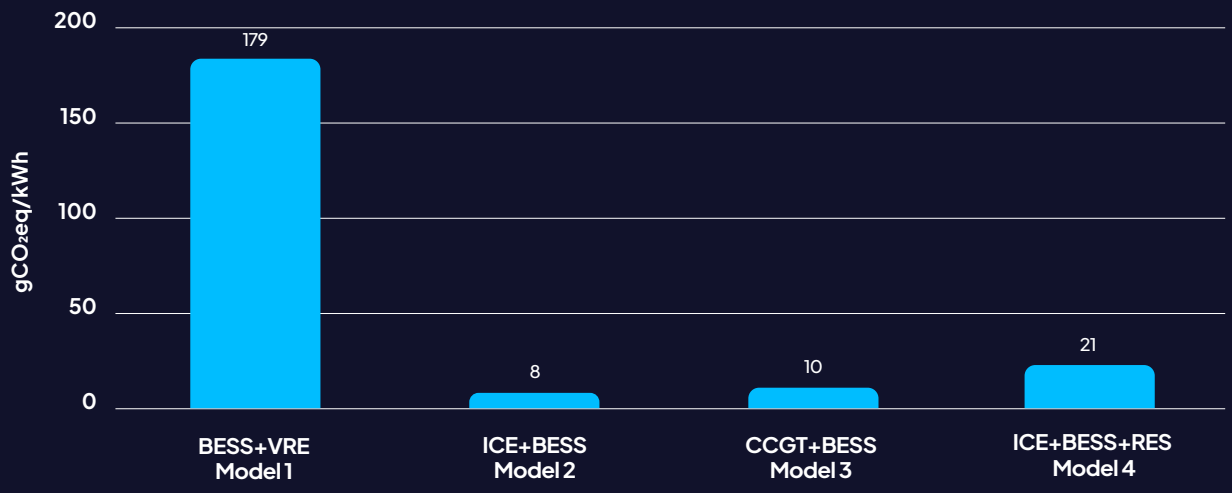
## Fig 6: Operational emissions models 1–4 for 80 MW data centre




## ii) Operational emissions

The operational emissions of Model 2 are comparable to those of natural gas power generation, which is 450 $gCO_2eq/kWh$. With the integration of renewables, as demonstrated in Model 4, carbon intensity can be reduced by over 60%, reaching approximately 180 $gCO_2eq/kWh$, or 200 $gCO_2eq/kWh$ including embodied emissions. As the green indicative line in the chart above shows, this is lower than the averaged 2024 grid generation emission levels of Germany, Ireland, the Netherlands or the UK.

**Fig 7: Embodied emission intensity models 1– 4 for 80 MW data centre**

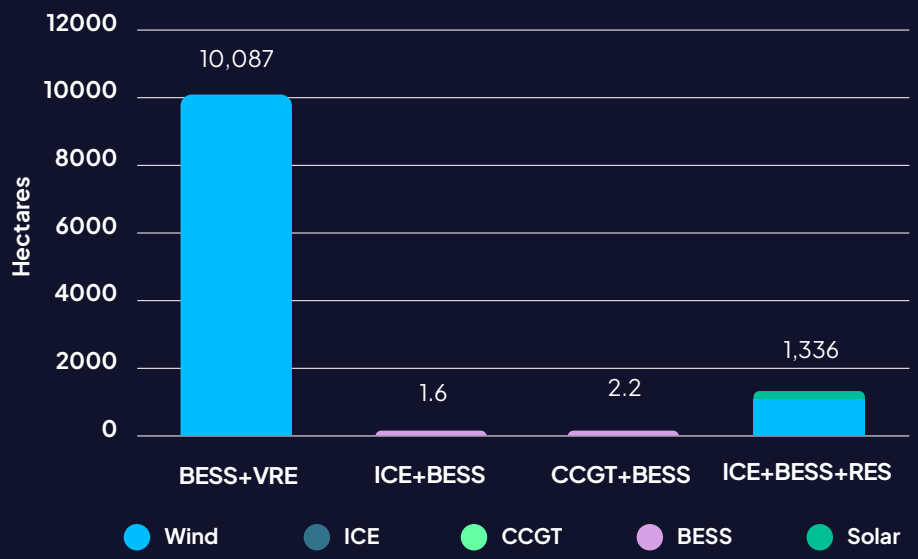



## iii) Embodied emissions

Due to the scale of mining, manufacturing, transport and construction required, Model 1 would generate an estimated 180 $gCO_2eq/kWh$ from embodied emissions. It is also important to take into account the shorter lifecycle of battery energy storage systems, which would have to be replaced after 12 years as opposed to the typical 25-year lifecycle of other energy delivery systems.

Due to the scale of mining, manufacturing, transport and construction required, Model 1 would generate an estimated 180 $gCO_2eq/kWh$ from embodied emissions, which is significantly above the typical range. In normal deployment scenarios, without excessive overbuild, the embodied emissions of renewables generally remain around 10 $gCO_2eq/kWh$.

## Fig 8: Land use models 1– 4 for 80 MW data centre



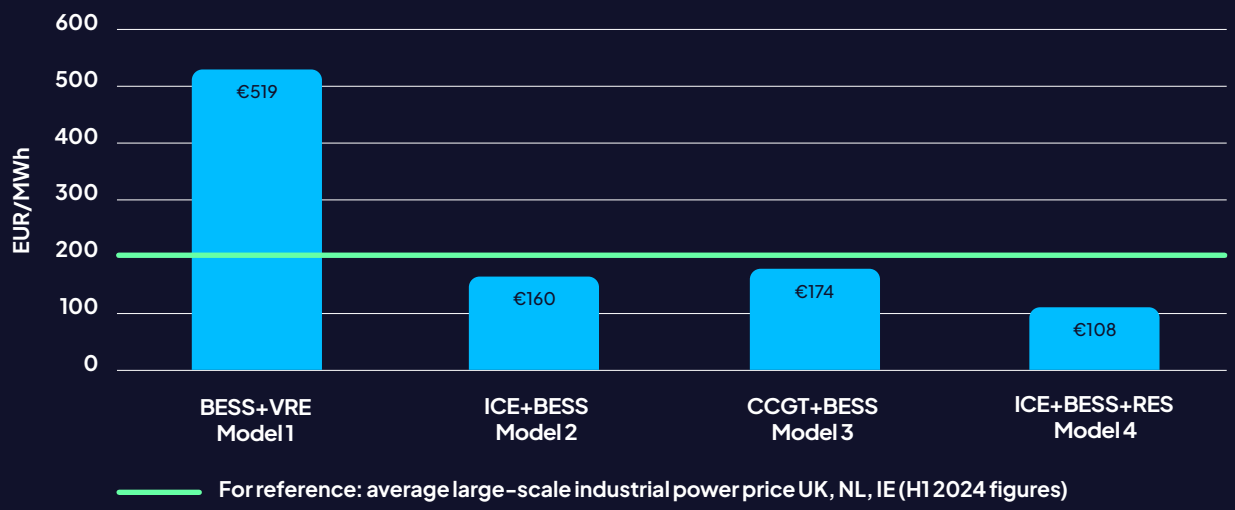


For reference: Paris covers just over 10,000 hectares

## iv) Land use

A substantial overbuild would be required to ensure system reliability when relying exclusively on renewable energy and battery energy storage. In the absence of balancing power plants, this overcapacity is essential to maintain supply during extended periods of low renewable generation. An 80 MW data centre would require more than 10,000 hectares (100 square kilometres) of 3 - 6 MW onshore wind turbines, an area the size of Paris (105.4 km²), making it practically impossible in most cases.

**Fig. 9: Levelised cost of energy (LCOE) models 1– 4 for 80 MW data centre**




## v) Cost

Calculating the Levelised cost of energy (LCOE) of the models produces some interesting results.

**Model 1 (renewables + batteries)** has by far the highest cost at €519/MWh, due to the substantial capital investment and curtailment associated with overbuilding capacity to ensure reliability without the support of balancing power plants.

**Model 2 (internal combustion engines + batteries)** has a lower cost of €160/MWh, leveraging the modularity of internal combustion units to closely match peak demand, minimise redundancy-related investments and achieve high part load efficiency.

**Model 3 (combined cycle gas turbines + batteries)** costs €174/MWh, driven by the need for oversized capacity, larger maintenance reserves, and higher BESS capacity. Additional costs also stem from reduced fuel efficiency during part-load operations and high start-up costs.

**Model 4 (renewables + internal combustion engines + batteries)** achieves the lowest cost of all at €108/MWh, benefiting from low-cost renewables combined with multiple forms of flexibility that reduces overall system cost.

For context, and as shown in figure 9, average electricity prices for very large consumers between January and June 2024 in the UK, Ireland and Netherlands all exceeded €200/MWh (Source: UK Department for Energy & Net Zero). All options, except Model 1, fall well below these market rates, highlighting the strong economic competitiveness of microgrid solutions.

## Analysis: modelling impacts for data centre microgrids

Clearly, balancing power plants with dispatchable power - particularly medium speed engine-based solutions - offers the most cost-effective approach for powering AI data centres in off-grid settings. These systems provide high reliability and operational flexibility.

In terms of power delivery technologies, the results of our modelling exercise emphasise the advantages of the modularity of medium speed internal combustion engines (ICE) which can be optimised more easily for varying load requirements. The larger unit sizes of combined cycle gas turbines (CCGTs) require greater investment in both battery energy storage systems (BESS) and additional maintenance reserve units to ensure reliability.

The most cost-effective model (Model 4) generates emissions, but these fall well below the current aggregated northern European grid level, with the potential to reduce emissions further as new fuels become available. The medium-speed Wärtsilä engines that AVK work with are also compatible with a wide range of sustainable fuels, making them a future-ready investment.

More importantly, the dispatchable power provided by these microgrids is a crucial ingredient in enabling the stable growth of renewables. There are significant cost and environmental benefits to integrating renewable energy with balancing power plants and battery energy storage. When given the option, as in Model 4, the model consistently favours significant deployment of renewable capacity.

Time and flexibility are also key considerations. While designed for data centre needs, these microgrids should be regarded as energy centres rather than being tied exclusively to data centres for their full lifecycle. Microgrid power can support the larger grid in parallel to powering a data centre or separately when the data centre no longer needs the microgrid. At the outset, power can be made available to the grid as soon as sufficient excess capacity has been installed. Then, at a future date, if the data centre transitions to a grid-connected model, the installed generation assets can serve as valuable grid resources — exporting electricity and providing balancing and reserve services.

Section 3

# Putting theory into practice: opportunities and challenges

# The size of the opportunity

The exact scale of potential applications for our modelling is hard to define. However, it is clearly massive. Gartner estimates the power required globally for data centres to run incremental AI-optimised servers will reach 500 terawatt-hours (TWh) per year in 2027, which is 2.6 times the level in 2023. As mentioned in the introduction, European data centre power demand is forecast to grow 18-fold by 2040.

If just a fraction of this power is generated independently, the impact of the industry on overall generation requirements will be significant. In Europe, considering grid constraints in major hubs, that fraction may need to be larger, with an even greater proportional impact. Total European power consumption is currently around 2,500 TWh per year, around half of this coming from renewables. To align with the global energy mix recommended above in the Wärtsilä paper Crossroads to net zero: Choosing the optimal path to a renewable energy future, balancing power requirements would initially be around 23% (2025), reducing to 3% by 2050.

As an industry we have already gone a long way to supporting the growth of renewables. Perhaps we can now be leading supporters of the evolution of the grid itself. The industry and its power solutions providers will clearly need to develop new best practice models which include microgrid research, design and deployment.

# Benefits of backing up the grid

## In addition to longer-term environmental benefits, grid supporting microgrids create practical and immediate benefits for all participants.

It makes little sense for a data centre and a local utility to invest separately in flexible backup power. The data-centre owner may want local backup to be sure it can ride through grid outages; the utility may want central backup to ride through periods of low wind or solar provision, or may need to add capacity to meet increasing demand.

### Operator benefits

Going 'behind the meter' is smart as well as socially and environmentally responsible. Operators can reduce emissions while contributing to national decarbonisation targets, at the same time as increasing resilience (in case of power cuts), reducing costs, earning money and improving their maintenance regime. Microgrids also reduce the geographical constraints for data centre locations. Bypassing the national grid unlocks new sites and allows for faster construction and operation.

### Government benefits

Leveraging data centre investment to add grid-balancing engines would take a significant investment load off the government's shoulders. It would reduce their obligation to invest in some renewables which, as the Wärtsilä model shows, are not strictly necessary to achieve net zero.

It would allow governments and grids to focus their investments on transmission, where it is really needed. This is critical, as without new transmission the expansion of renewables gets delayed.

### Price reductions

Today, less than 30% of European power is tradable. While it is an indirect effect, freeing up capital for improved transmission at scale would speed delivery of new capacity, and it would also improve power tradability, expanding and stimulating the market and driving prices down for other consumers.

### Public perception

Data centres are far from being the largest consumers of electricity in Europe, and they have an excellent track record in improving efficiency and promoting renewables. However, because data centre power consumption is increasing so fast, and because facilities are concentrated in a few key hubs (i.e. Frankfurt, London, Amsterdam, Paris and Dublin) they have been widely criticised, regulated against, and even been accused of being power 'thieves'. Providing dispatchable power to the grid in support of resilience and climate goals could turn this perception around at a critical time for industry expansion.

# New ways of working

Contributing data centre dispatchable power to the grid may require some new approaches to planning, finance, and operations, in order to maximise cost-effectiveness and positive environmental impact. It also holds promise for policymakers, but will require their support.

## Specialist power solution providers

Currently, data centre operators own their assets and are more comfortable (and differently regulated) in their role as data centre companies as opposed to energy trading companies. However, owning the assets their power generation comes from would place any emissions firmly under Scope 1 for reporting, which would undermine their ability to reach their sustainability targets.

These and other issues may encourage the growth of a new breed of specialist power solutions providers, who can both build the power generation asset, then own and run it on behalf of operators. AVK, for instance, offers this service. This would mean that data centre operators get the power they need when they need it, but when they don't need it, the power provider could trade it. This could lead to reduced energy costs for operators and reduced management and reporting responsibilities. Maintenance, emissions, and management would also be taken off their hands. These are potentially significant benefits considering the huge demand levels operators are currently dealing with.

### A long-term energy asset

New ways of working together could create a long-term win-win situation for both grid and operator.

For instance, if a microgrid is built as an interim "bridge" to a grid connection, the data centre operator could sign a long-term Power Purchase Agreement (PPA) with a specialist power solutions provider who manages both maintenance and electricity trading on their behalf. Surplus power could be traded throughout the agreement - both as the IT power load of the data centre is stepped up, and once the delayed grid connection has been achieved.

Once the facility is grid-connected, the full output of the microgrid could be made available to the grid. Throughout the agreement, all the operator sees is the upside of having a cleaner energy supply, fewer management headaches, and more cost-effective power.

# Microgrids in action

The practice of power exchange between data centres and utilities is not new. In 2016, Microsoft struck a deal with Black Hills Energy who gave them cheaper power in exchange for using Microsoft's backup generators as a power resource for the grid as needed, eliminating the need for Black Hills Energy to build an additional plant.

Tencent has deployed a large-scale 10 MW solar plant at one of its data centres in Tianjin. Amazon recently acquired a data centre behind the meter at a nuclear power station in Pennsylvania. Many microgrid projects in Dublin, Ireland, have filed for gas connections to generate power on site, to circumvent the moratorium on new data centre grid connections.

Operators are already moving in this direction across Europe. In the State of European Data Centres Report 2025, the EUDCA states that 22% of survey respondents are currently participating in programmes for grid stabilisation/energy trading, and 59% expect to be doing so in the next two years.

## Microgrids from AVK

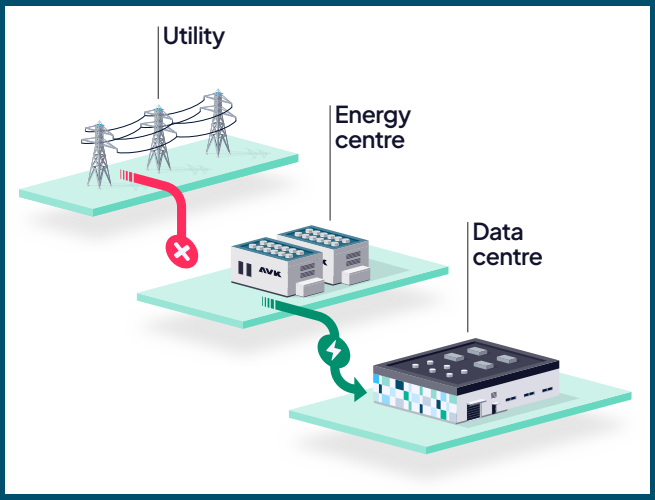
Over the last five years AVK has designed and built large microgrids with more than 250 MW of dispatchable power capability in the data centre market. We also have the in-house expertise to own and operate these microgrids for our clients´ benefit.

We typically integrate flexible assets into our microgrids, allowing for a number of sources including renewables for power generation and hydrogen-ready systems that can run on HVO fuel. We also design, implement and maintain a wide range of cutting-edge battery storage solutions for all kinds of client applications.

By coupling critical applications using reciprocating gas engines, and HVO engines with innovative energy storage systems, our microgrids can deliver a great deal of flexibility and competitive grid-scale storage.

Because they are stand-alone power grids, microgrids require constant attention and expert care to ensure optimal performance. Through our partnership with Wärtsilä, we can take full responsibility for the operation and maintenance of a microgrid.

Our comprehensive lifecycle solutions integrate advanced technology, sophisticated software, and expert service to protect your investment, drive efficiency and guarantee safe and reliable operations.



# Key market considerations

## The following chart based on data from the EUDCA/Pb7 Research gives a fairly conservative estimate of data centre power capacity growth in the top 5 European markets over the coming 5 years.

Overall, the current top five leading (and most power constrained) markets are expected to grow capacity from 8 GW in 2025 to 13 GW in 2030.

According to this study, around €110 billion will be invested across Europe over this period, generating around € 208 billion in revenue. Capacity will grow from 12 GW in 2025 to 23 GW in 2030. This is based on a fairly conservative overall growth rate of 14%.

### Colocation (MW)

| | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|
| France | 813 | 874 | 970 | 1082 | 1197 | 1308 |
| Germany | 1799 | 2124 | 2522 | 2909 | 3275 | 3572 |
| Ireland | 543 | 569 | 617 | 695 | 795 | 903 |
| Netherlands | 991 | 1125 | 1273 | 1388 | 1521 | 1630 |
| United Kingdom | 1771 | 1930 | 2107 | 2292 | 2523 | 2770 |
| **Total** | **5918** | **6622** | **7488** | **8366** | **9311** | **10182** |

### Hyperscale (MW)

| | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|
| France | 0 | 0 | 50 | 120 | 200 | 280 |
| Germany | 20 | 20 | 42 | 42 | 64 | 85 |
| Ireland | 1189 | 1213 | 1274 | 1363 | 1486 | 1616 |
| Netherlands | 460 | 495 | 525 | 582 | 612 | 664 |
| United Kingdom | 88 | 160 | 242 | 325 | 400 | 435 |
| **Total** | **1757** | **1888** | **2133** | **2432** | **2762** | **3081** |

Source: EUDCA/Pb7 Research, 2025

## UK: a sizeable opportunity

The UK is the largest potential microgrid market in Europe, with over 1.4 GW of power currently deployed in data centres and up to 400 GW of outstanding grid connection requests around London alone, according to Cushman and Wakefield.

The UK transition timeframe is also extremely tight, as the Secretary of State for Energy, Security and Net Zero's ambition is to achieve clean power by 2030. Encouragingly, the government wants to work with data centre developers and energy solutions firms to establish an AI infrastructure cluster of at least 500 MW by 2030. Speed and incisiveness will be key in these discussions, and microgrids should form a significant part of any solution.

## Germany: path to hydrogen

As the forecasts above show, Germany is on-track to have over 3.5 GW of colocation capacity by 2030, the largest in Europe. Currently, with a preponderance of coal-fired generation, Germany is emitting up to 392 grams of $CO_2$/kWh. In the medium-term the market seems likely to move to a slightly different clean energy model, with an ambitious target of at least 10 gigawatts (GW) of green hydrogen production capacity by 2030, as part of its National Hydrogen Strategy. While there is no obligation on private investors to use hydrogen currently, the CHP incentive scheme will require that plants can be converted to hydrogen further down the road, once an adequate delivery network is in place.

## Ireland: the microgrid pioneer

By 2023, 21% of metered power in Ireland was being used for data centres, most of it in the Dublin area. This has put such strain on the grid that new data centre developments which require grid power have been halted. This potentially makes Ireland Europe's pilot microgrid market. Recently, there have been over 20 applications from data centre operators to connect to the gas network, and the government is fast-tracking new legislation promoting private power generation and supply.

AVK will be publishing a series of updates on each of these markets which will go into more detail on grid strategy, funding, energy and storage mixes and potential hot spots.

# Conclusion: grasping the grid opportunity

European data centre power demand is rising steeply, creating anxiety and regulatory and supply chain delays for new facilities as power becomes harder to find and climate targets loom. Power grid upgrades in Europe are underfunded and new fuel solutions are not yet ready.

Microgrids are an answer to this challenge. Generating dispatchable power for data centre and grid consumption makes a virtue of necessity, with the potential to accelerate speed to market for AI, reduce cost and management headaches and speed the European transition to net zero, while reducing the overall cost of the transition to clean power.

As demonstrated above, the energy mix of the microgrid is the key both to speeding the transition to net zero and to optimising cost/ROI for operators. If just a fraction of new data centres were to follow some variation on the optimal model set out in this paper, they could create a significant bank of dispatchable capacity for balancing the European grid during the energy transition, enabling a huge amount of new renewable energy.

Grasping this opportunity will require a change in mindset for all stakeholders, and increased cooperation. Key to this is a change in the perception of energy. Data centres are also (and increasingly) energy centres, and operators need to stop looking at their assets as stand by or prime. Instead they should look at them as dispatchable assets that could be used for decarbonisation and resilience. Power solution providers may need to expand their portfolios to include load balancing services and trading. Politicians and others in the public sector need to understand and facilitate this shift in the market as it is crucial to financing and achieving European and national climate goals. To secure the major advances microgrids offer, power utilities need to work with politicians and regulators to open up access and work at the same speed as the data centre industry.

Data centre microgrids are clearly key to accelerating both the energy and the digital transition.

# Glossary of power terms

There is significant overlap/repetition in power generation terms, and new terms and acronyms are being created all the time. For readers without a background in electrical engineering, this may help. It includes terms in common use in the industry that are not necessarily included in this paper.

| Term | Definition |
|---|---|
| balancing plant / grid-balancing engines | Power generators that are adaptable and can suit the fluctuations in renewable generation at the push of a button. |
| base load | The minimum amount of power needed to supply continuous demand around the clock (as opposed to peak load, see below). |
| BtM | Behind the Meter: energy and energy systems located on the user (rather than provider) side of the power meter. |
| BESS | Battery Energy Storage Systems which can be powered using surplus electricity from sources including wind or solar farms. When designing a Battery Energy Storage System (BESS), the most important parameter is are the power capacity, measured in MW or kW—which determines the rate at which energy can be stored or delivered |
| CCGT | Combined Cycle Gas Turbines: A CCGT passes the waste heat from the exhaust gases through a Heat Recovery Steam Generator (HRSG), which converts the heat into steam, which drives a steam turbine, generating additional electricity. CCGTs are generally more efficient and economical than OCGTs (see below) for large-scale, baseload power generation |
| CHP | Combined Heat and Power: technology that generates electricity and useful heat simultaneously from a single source. More efficient than separate power generation and heating, as it uses heat that would otherwise be wasted. Also known as cogeneration. |

| Term | Definition |
|---|---|
| CO2eq | Carbon dioxide equivalent: a metric measure used to compare the emissions from various greenhouse gases on the basis of their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential. |
| curtailment | The reduction or temporary shutdown of energy production, typically from renewable sources like wind and solar, due to excess supply or grid constraints |
| DER | Dispatchable Energy Resource: a power source that can be easily turned on or off, and its output adjusted as needed. As opposed to non-dispatchable sources like wind and solar, which are inherently intermittent. |
| dispatchable power / dispatchable generation | Dispatchable power refers to electricity generation that can be turned on or off, or adjusted, on demand by the grid operator or data centre facility manager. It is the opposite of (and therefore complements) intermittent sources like wind or solar. |
| flexible engine power plants | Flexible engine power plants use internal combustion engines to generate electricity, offering rapid startup and shutdown and the ability to adjust output quickly to balance grid demand. |
| GW | Gigawatt: 1000 megawatts: a measure of power capacity equivalent to the output of about 1.8 million photovoltaic solar panels, 300 utility-scale wind turbines, or 0.5 Hoover Dams. |
| HVO | Hydrotreated Vegetable Oil: a second-generation biofuel that reduces net $CO_2$ emissions by up to 90% when compared with the fossil diesel it can be substituted for. |
| ICE | Internal Combustion Engine: in this study ICEs referred to are medium-speed gas engines. ICEs are typically powered by hydrocarbon-based fuels like natural gas, gasoline, diesel fuel, or ethanol. |
| LCOE | Levelised Cost of Electricity: a measure of the average net cost of electricity generation for a generator or grid. |
| legacy baseload plants | Older power plants that do not change their power output quickly, such as some large coal or nuclear plants. |
| microgrid | Small-scale power grids that operate independently to generate electricity for a localised area |
| OCGT | Open Cycle Gas Turbines: Gas turbines which do not reuse exhaust gases for heat (unlike CCGTs, see above). OCGTs are better suited for peak power, quick startup, or smaller applications. |

| Term | Definition |
|---|---|
| peak load | The highest demand for energy or capacity during a specific time period, usually a day, over the base load (see above) |
| peak shaving | Peak shaving reduces electricity costs by decreasing power consumption during peak demand periods, often referred to as "load shedding". It involves either temporarily scaling down production, using on-site power generation, or relying on stored energy to avoid a spike in energy use. |
| PPA | Power Purchase Agreement: a long-term contract between an energy buyer and a seller (often a renewable energy generator) that defines the price, quantity, and delivery schedule of electricity. PPAs can be Physical (for direct supply) or Virtual (credits or offsets for the renewable energy generated where the energy supplier sells the electricity to the grid, not the buyer). |
| RES | Renewable Energy Source, e.g. solar, wind or geothermal. |
| ramp rates | The speeds at which a generator or other power source can increase (ramp up) or decrease (ramp down) its power output. Usually measured in MW/min or the percentage of nameplate capacity that can be reached in a minute. |
| smart grid | A smart grid is an advanced electrical power system that integrates digital communication and control systems with traditional power infrastructure to enable real-time monitoring and management of energy flows. |
| TWh | Terawatt-hour: a unit of energy representing one trillion watt-hours (1,000,000,000,000 Wh). This is a large unit of energy used to measure electricity production and consumption on a large scale,for instance for entire countries or regions. |
| VRE | Variable Renewable Energy: renewable energy sources like wind and solar whose output fluctuates based on weather conditions. |

# Sources & further reading

## Long-term energy planning/overviews

Crossroads to net zero - choosing the optimal path to a renewable energy future (Wärtsilä Energy *date*)

Generative AI – The Power and the Glory (Michael Liebreich, Bloomberg NEF, Dec 2024)

EU Energy Outlook; How will the European electricity market develop over the next 30 years? (Matt Schmitt, April 2022)

Live Carbon-intensity Map: This app provides a live overview of carbon intensity by country, including energy mix and cross-border trading

Global Smart Energy Federation

## Power demand

AI to drive 165% increase in d ata center power demand by 2030 (Goldman Sachs, Feb 2025)

The role of power in unlocking the European AI revolution (McKinsey & Co, Oct 2024)

EU Power trading levels (Clean Energy Wire, April 2025)

EU Electricity Market Report (Europa, Oct 2024)

## Microgrids/behind the meter solutions

Greening Europe's AI data centre hotspots using renewable microgrid independent power (AVK overview of Loughborough University paper, Feb 2025). The paper addresses the optimal configurations with wind and solar generation, backed up by battery storage and onsite gas generation for a 50 MW constant load hyperscale data centre with an expected operational life of 35 years in Frankfurt, London, Amsterdam, Paris, and Dublin. Full paper, Jan 2025, here.

Energy Industry Ramps Up Efforts to Solve the Data Center Power Shortage (Data Center Knowledge, Feb 2025)

Europa Lag: Why Microgrid Adoption is Slower Across the Pond (Microgrid Knowledge, June 2024)

Grid capacity demands vs renewable targets: uneasy bedfellows? (Data Centre Dynamics, Oct 2040)

Local Energy Communities (EU; with details of regulatory support)

DCFlex Initiative (EPRI, USA) initiative to explore how data centers can support and stabilize the grid.

How data centers and the energy sector can sate AI's hunger for power (McKinsey, Sept 2024)

Microgrids Take Major Role for Reliability, Resiliency (Power, June 2024)

## Key market considerations

Cushman & Wakefield report reveals 400GW of grid requests around London (The Tech Capital, Feb 2024)

UK Plots 500 MW AI Cluster – But Can the Grid Keep Up? (Data Center Knowledge, April 2025)

Energy experts appointed to deliver clean power 2030 mission (UK Government, Oct 2024)

Smart Grid Ireland (public-private 'cluster' targeting decarbonised electricity grid by 2030)

New pro-microgrid legislation Ireland (Data Centre Dynamics, June 2025)

Ireland data centre emissions growth and rise of gas applications (The Journal, Nov 2024)

State of European Data Centres 2025 (EUDCA, April 2025)

## Data sources

Embodied Emissions

Land Use GIS (Google Earth)-based area calculation

Thermal CAPEX Aurecon, 2021 Costs and Technical Parameter Review

Total Electricity Generation by Source by Country (2024)

Electricity Generation Emissions by Country (2024)

Generation capacity by country (2023) EMBER

## AVK Thinking

AVK is renowned for employing the best expertise and technology on the market to provide the most advanced, efficient and sustainable power solutions for data centres and leading organisations. We pride ourselves on our technical ability and practical expertise, and we constantly invest in research and development. This short paper is designed to give our customers the latest and most reliable insights into designing, operating, maintaining and upgrading their power systems to support their own customer needs while meeting and exceeding the most stringent climate legislation and supporting their sustainability goals.

## Find out more about Microgrids

AVK experts have been building microgrids for data centre customers for over a decade. We bring a unique set of skills and experience to the challenges of sustainable on-site power provision for data centres at scale, and we can also draw on the deep expertise of specialist partners like Wärtsilä.

From feasibility to design, commissioning to operations management and maintenance, with AVK's help developers, hyperscale operators, and colocation providers can start to build for the future of data centre sustainable energy through grid-independent on-site power.

**Contact** avk-seg.com/contact-us

## About AVK

AVK is the largest and fastest-growing supplier of innovative power solutions for data centres and leading organisations in the UK and Europe. We specialise in all aspects of design, planning, implementation, and continuing maintenance. At AVK, we power tomorrow's data. We are transforming the way the data industry connects to and consumes energy by developing innovative and sustainable solutions.

We deploy leading-edge solutions for our clients, helping them to meet their power demands alongside their sustainability goals. With offices and hubs across the UK and Europe, AVK is in a unique position, in terms of operational scale and delivery capabilities to tackle complex, large-scale, and ground-breaking engineering and energy projects.

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