EnergisedFutures

Powered by centrica



White paper

DC Microgrids: Unlocking Grid-Constrained Growth for UK Businesses

November 2026

About Energised Futures

Energised Futures, powered by Centrica, is a research and innovation incubator launched to accelerate a new energy future and catalyse Centrica's purpose of energising a greener, fairer future.

Bringing together engineers, data scientists, behavioural scientists and developers across the UK and Belgium, we explore new ideas, test emerging technologies and turn challenges into breakthroughs through pioneering research and collaboration.

Executive Summary

UK businesses face a structural challenge: rising electricity demand, bottlenecks and high costs in securing grid connections, and mounting pressure to decarbonise. Direct current (DC) microgrids (MG) offer an effective way to tackle these pressures.

The UK microgrid market is forecast to grow from ~£3bn in 2025 to ~£12.8bn by 2033, a 20.5% compound annual growth rate.[1] DC Microgrids (DCMGs), and hybrid AC-DC configurations, represent an increasing share of that opportunity as the proportion of DC-native generation and load continues to rise.

Three structural forces are converging to make DCMGs commercially relevant now:

1. Grid constraints are the binding constraint on UK electrification.

Over 700 GW of projects are stuck in the connection queue and constraint costs are projected to rise from £2bn per year in 2022 to ~£8bn by 2030.[2] Behind-the-meter architectures that reduce peak grid demand cut costs whilst offering a faster route to connection approval.

2. Modern sites are increasingly DC by nature.

EV batteries, server racks, inverter-driven motors, LED lighting, solar PV and battery storage all operate natively on DC. Conventional AC distribution forces unnecessary conversion at every interface, creating avoidable losses, cost and complexity.

3. Decarbonisation obligations are intensifying.

Energy and carbon reporting, the UK Emissions Trading Scheme, the Zero-Emission Vehicle mandate, Future Homes and Buildings Standards, and ambitious NHS Net Zero goals are driving businesses to act on energy infrastructure, creating a demand pull for on-site solutions that work.

DCMGs simultaneously address all three. By integrating solar PV, battery storage and DC-native loads on a shared DC bus with a single controlled interface to the grid, DCMGs reduce peak import requirements, eliminate unnecessary conversion losses, and deliver measurable resilience for critical-load customers.

The evidence base has moved beyond theoretical with real deployments across the UK and Europe demonstrating significant reductions in annual energy costs, power losses and peak grid import. The opportunity is open now to the businesses ready to take it.



Why this matters now



Why this matters now

1. Grid constraints are a key barrier to UK electrification

Securing a grid connection has become slower, riskier, and more expensive at precisely the moment businesses need more electricity.

The UK grid connection queue has reached as high as 738 GW, around three times the clean energy generation capacity required to meet the UK Government's Clean Power 2030 target.[3] Major projects report multi-year delays beyond their original connection offer dates, with cost inflation of up to 200%.[4] The uncertainty is often worse than the delay itself, as NESO contractually moves connection dates when projects fail to progress, undermining investor confidence. For businesses, this creates four compounding problems:

1. Capital tied up before revenue
2. ESG commitments at risk
3. Energy costs that remain elevated (UK business electricity costs were 75% higher at the end of 2024 than in 2021)[5]
4. Competitive disadvantage in regions where grid access is tighter

The Sunak government's Connections Action Plan introduced the shift away from "first come, first served" to a "first ready, first connected" system.[6] Under this approach, smaller commercial systems requesting lower grid capacity are more likely to secure shorter connection times, and projects that cut peak import through behind-the-meter assets are well positioned to progress faster.

DCMGs turn grid constraints from a blocker into a competitive advantage. Sites that can electrify within their existing connection win.

2. Electrification is driving unprecedented demand growth

The UK's Clean Power 2030 target demands an estimated four-to-fivefold increase in demand flexibility, with battery storage rising from 5 GW to 23-27 GW by 2030.[7]

Industrial electricity demand could increase by 78% between 2024 and 2050.[8]

The Zero Emission Vehicle (ZEV) mandate requires 80% of new cars and 70% of new vans sold by 2030 to be zero-emission.[9] The transition will extend to HGVs, with all new vehicles up to 26 tonnes required to be zero-emission by 2035 and those over 26 tonnes by 2040."[10]

Each of these trends increases site electricity demand and raises the value of behind-the-meter architectures that reduce what must be imported from an increasingly constrained grid.

3. Decarbonisation obligations are becoming non-negotiable

The regulatory environment has moved from voluntary to mandatory.

- Streamlined Energy and Carbon Reporting (SECR) requires large businesses to disclose site-level emissions annually.
- UK Emissions Trading Scheme is tightening.[11]
- ZEV mandate is now law.
- Building Regulations Part S also mandates EV charging provision in new non-residential buildings.[12]
- PPN 06/21 requires carbon reduction plans for public-sector contracts over £5m.[13]

These obligations turn on-site energy infrastructure from a cost-saving option into a strategic requirement. DCMGs are an energy infrastructure solution that addresses efficiency, CO2 reduction and grid capacity simultaneously.



What are DC Microgrids?



What are DC Microgrids?

A DCMG is an on-site energy system that distributes power on a direct current bus, linking two or more of:

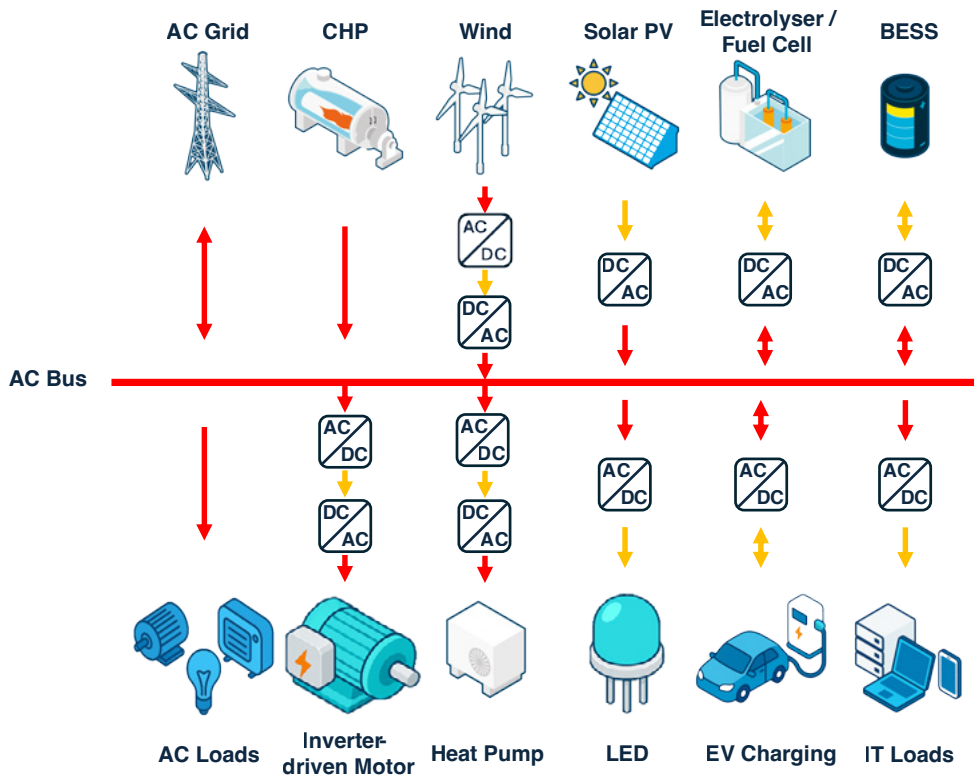
- DC-native generation (solar PV, fuel cells)
- DC-native storage (BESS)
- DC-native loads (EV chargers, servers, inverter-driven motors, LED lighting)
- Single controlled interface to the AC grid at the point of common coupling (PCC)

In practical terms, the concept is best thought of as replacing the series of individual AC-to-DC and DC-to-AC conversion steps performed at every device interface in today's AC-distributed site. Instead, a shared DC backbone removes most of those conversions entirely.

How AC and DC architectures work

AC Microgrid (ACMG) - the current default

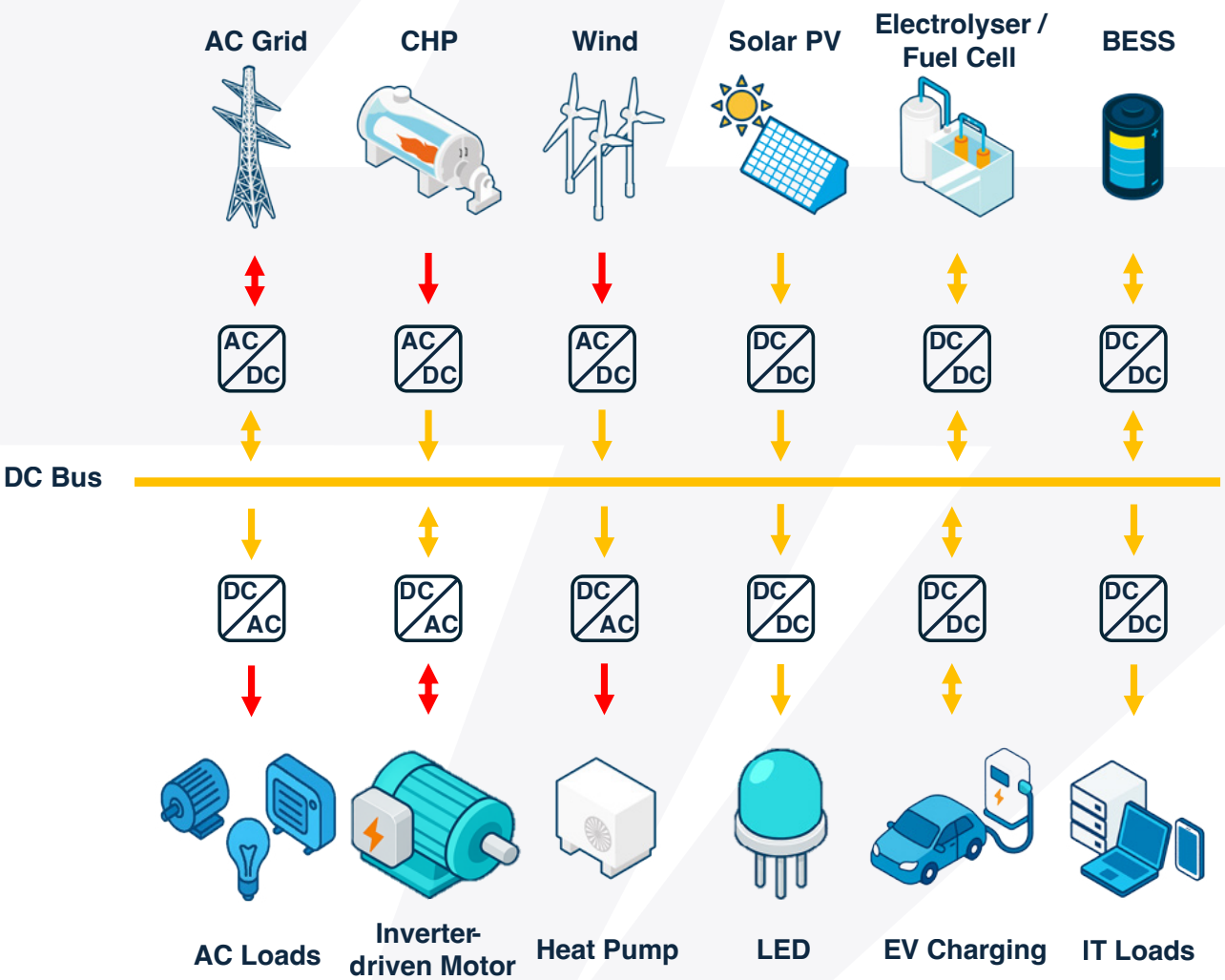
All assets connect to a shared AC bus. Each DC-native asset (PV, BESS, EV charger) requires its own AC-DC conversion stage. Multiple gridfacing inverters each contribute fault current and the grid import and export must be limited via G100 to avoid being disconnected.



DCMG

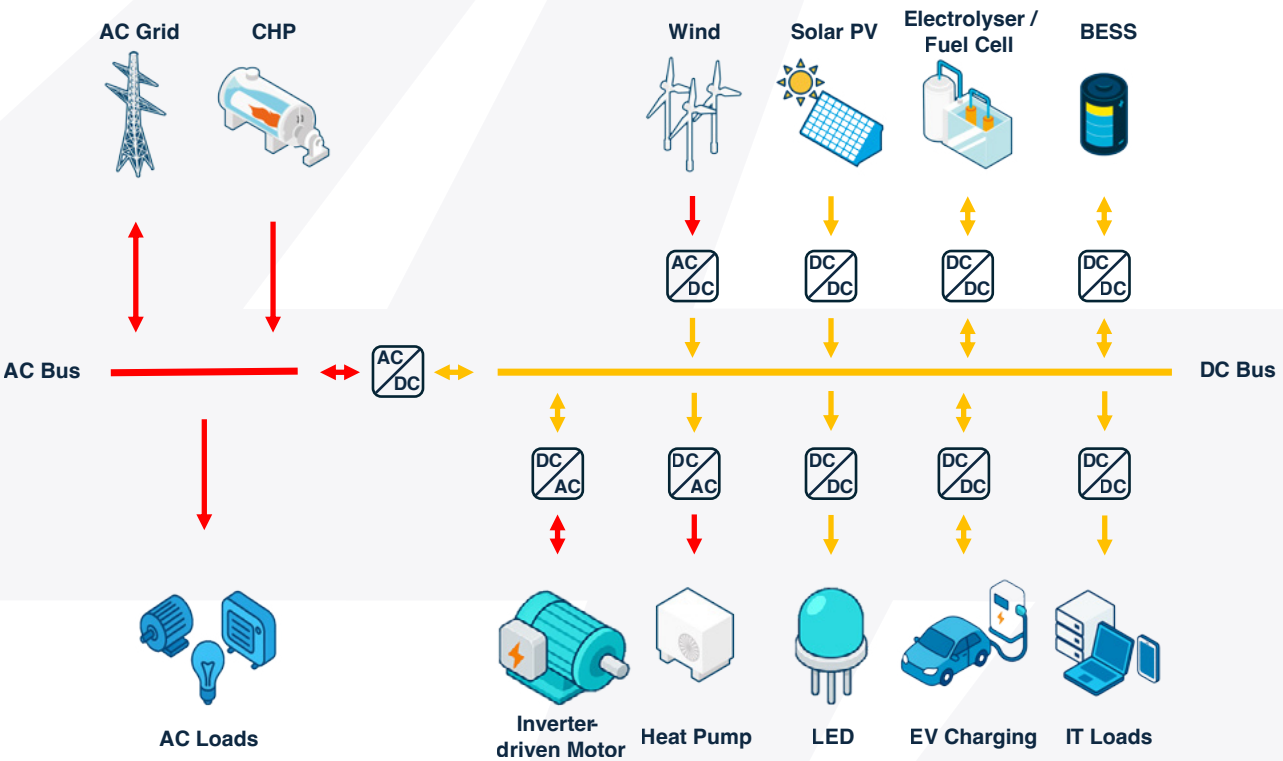
DC-native assets connect via DC-DC converters to a shared DC bus.

The grid interface is a single, controllable bidirectional converter at the PCC which can be programmed to never import or export more than the grid-imposed limits. This results in fewer conversion stages and simpler grid compliance.



Hybrid AC-DC

Retains an AC side for legacy equipment while adding a DC subsystem for new DC-native assets, linked by an interlink converter. This is the realistic near-term transition path for most sites with existing AC infrastructure.



The hybrid AC-DC approach is commercially significant. Most UK commercial and industrial sites cannot convert overnight. The hybrid path allows customers to capture the value of DC coupling, primarily for PV, BESS and EV charging, while maintaining compatibility with existing AC equipment.

AC vs DC Microgrid Comparison

Criteria	*ACMG*	*DCMG*
Efficiency	Higher conversion losses across multiple AC-DC stages	2-6% efficiency gain by eliminating multiple DC-AC-DC conversion[14]; up to 50% lower power loss in cabling compared to 3-phase AC[15]
Control Complexity	Requires frequency synchronisation, reactive power management and harmonic control	Voltage-based droop control; simpler, decentralised, no synchronisation needed
Grid Integration	Each asset needs individual inverter/ rectifier, greater fault level contribution, G100 is reactive and a lag could trigger a G99 trip	Single controllable interface at PCC, lower Total Harmonic Contribution
Compatibility with Distributed Energy Resources (DERs)	PV, BESS, EV chargers and other DC-native loads/generation/ storage all require AC-DC conversion steps	Direct DC bus connection for PV, BESS, EV and other DC-native loads/generation/ storage - fewer conversion stages
Protection & Faults	AC arcs self-extinguish at zero crossing so protection is simpler	DC arcs do not self-extinguish - requires dedicated DC protection devices
CAPEX/OPEX	Lower upfront cost; higher running losses	While DC components carry a premium today, a reduction in the number of AC-DC converters can mitigate this in terms of CAPEX. Similarly, as the technology matures and adoption increases the upfront cost may decrease. Lower OPEX over lifecycle.

Table 1: Comparison of AC and DC microgrid architectures across key commercial and technical dimensions

The key design insight is that the primary value of a DCMG in the UK context is not the efficiency gain alone. It is the ability to integrate more generation and storage behind a single, lower-rated grid interface, enabling electrification at sites where the grid connection would otherwise be a constraint.

Where the value comes from



Where the value comes from

There are four main sources of value in DCMGs. Their relative weight depends on the use case. In the UK context, grid constraint relief is the most commercially relevant near-term driver, but it stacks on top of efficiency, cost and control benefits that compound over the asset lifecycle.

1. Grid Constraint Relief

By integrating PV, BESS and other controllable DC devices behind a single controlled grid interface, DCMGs allow sites to reduce their peak import requirement dramatically and therefore operate within existing or lower-rated connections.

The PCC converter acts as a controlled gateway: regardless of what generation and loads are doing behind the meter, the grid sees a predictable, capped profile. In comparison, an AC microgrid can also coordinate a site as a controllable entity, but it typically does so by managing multiple AC-connected inverter interfaces rather than pooling DC-native assets behind one DC gateway (as described in How AC and DC architectures work.)

This makes sense commercially because:

1. Sites can electrify (adding on-site solar PV, BESS, EV chargers and DC loads) while reducing the likelihood of triggering grid reinforcement requirements.

2. Applications requesting lower-capacity connections are more likely to receive full Gate 2 connection offers under the government's 'first-ready, first-needed' reforms.

3. By capping the grid-facing export capacity at the PCC, the scheme may remain within the lower Type A G99 category (<1MW), reducing the step-up in studies, monitoring and DNO interface requirements associated with larger Type B projects (1-10MW).[16]

Grid constraint relief turns the DCMG from an energy efficiency investment into a growth enabler - the infrastructure that lets a business electrify faster than its competitors.

2. Conversion Efficiency Savings

Modern sites increasingly behave like DC systems even when power is distributed in AC.

- EV batteries, server racks and IT equipment are DC.
- Most high-efficiency motors and wind turbines use an internal DC link.
- Solar PV, batteries and maturing generation technologies, such as fuel cells, are natively DC.

In conventional AC architectures, each interface forces a conversion, DC to AC, then often AC back to DC, imposing switching losses, heat, and hardware cost at every step. DCMGs remove most of these conversion stages by linking DC assets directly on a shared bus, with documented energy savings ranging from 6% to over 28% across a variety of use cases.[17]

Higher efficiency lowers the cost of delivering the same energy to loads across the system's lifetime. The resulting OPEX savings offset the potential higher upfront CAPEX, due to the reduced maturity of DC systems, and reduce the size of on-site generation and storage needed to meet end-user demand.

3. CAPEX, OPEX and Footprint Reduction

Fewer conversion devices, simplified protection architecture and reduced copper use (DC cables carry equivalent power at lower current, with no skin effect losses, and utilise one fewer cable) mean that DC systems can deliver measurable materials and footprint savings versus AC alternatives as the market matures. Schaltbau's NExT Factory achieved 25% savings in materials, particularly copper, during construction.[18]

An important near-term caveat: DC-rated components and protection devices currently carry a cost premium due to lower supply chain maturity. Currently, this offsets space and material savings. The cost trajectory is downward as adoption scales, but projects being assessed today should model both scenarios.

OPEX from energy expenditure is shown to fall due to higher efficiencies associated with fewer conversion stages (see Table 3 for examples). Maintenance OPEX follows a similar pattern to CAPEX as fewer conversion stages means fewer serviceable assets. Although the effect is not that DC devices are more durable by default, since DC-DC and AC-DC stages share the same failure-prone semiconductors and capacitors. Early adopters also must budget for DC-specific items, arc management and the current shortage of DC-trained maintenance engineers among them, both of which are likely to ease as standards and supply chains mature.[19]

4. Control Simplicity and Resilience

DCMGs use voltage as an inherent signal of local power balance, a principle known as 'droop control'. When PV generation is high, the DC bus voltage rises, prompting loads and storage to absorb more energy automatically. No high-bandwidth communication network is required for basic stability.

However, communication to the converters can be included to provide continually updated setpoints to optimise the droop control across the system. This inherent self-regulating behaviour makes DC architectures more scalable, as new assets can be added without complex re-engineering of the control system, and more resilient due to fewer components that can trip or drift than in an AC-equivalent system. An American study of data centres concluded that 380V DC architectures achieve higher mean time between failures and lower mean time to repair than the equivalent 480V AC design.[20] An AC system can reach comparable uptime, but only by adding redundancy measures and therefore capital whereas DC delivers it architecturally.

Resilience is commercially significant for data centres, hospitals, and logistics operations where downtime has direct consequences. A native DC microgrid acts as a high-speed physical buffer that isolates the utility grid from the 'step-load' shocks of sudden high-power loads, such as EV charging or AI training in data centres, providing a more robust and trip-resistant solution for constrained sites than the software-governed limitations of a G100 AC architecture. DC architectures also more readily support ring or mesh distribution topologies, providing multiple power pathways and reducing single-point failure risks.

The relative importance of these value drivers varies by site. DCMGs are likely to offer the greatest potential where grid constraints coincide with a high share of DC-native generation,

Where DCMGs Could Add Most Value

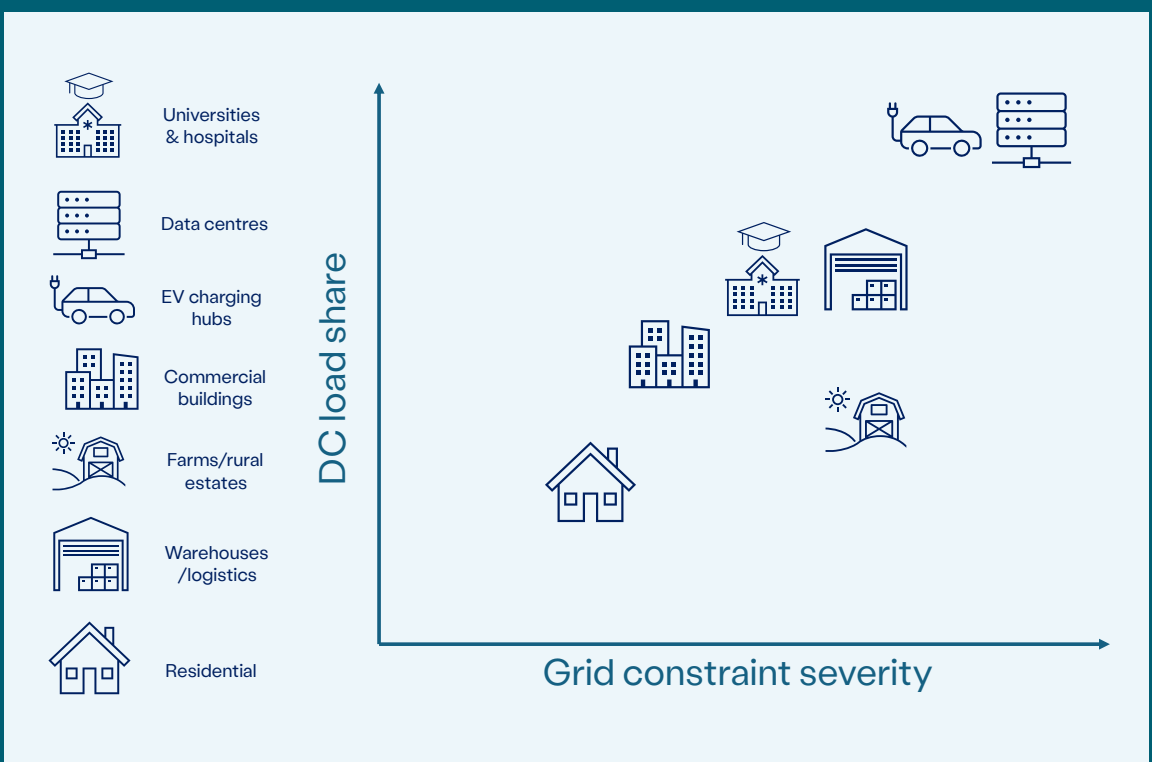


Figure 2: DCMG suitability by sector, using grid constraint severity on the x-axis and DC load share on the y-axis. Sectors facing severe grid constraints are likely to be attracted to DCMGs due to its ability to reduce grid import requirements and fault-level contributions and so too are businesses with high DC loads due to the efficiency benefits compared to ACMGs.

Sector	Primary Driver	DCMG Value Proposition	Evidence/Signal
Data Centres	Grid connection pressure + move to DC-distribution to racks due to AI power density surge	DC-native distribution reduces conversion losses; integrates BESS to buffer peak import. Higher power density in DC cables	125 GW in demand queue; 50 GW tied to data centres.[21] NVIDIA moving to 800 VDC racks by 2027.[22]
EV Charging Hubs	ZEV mandate + major expansion in charging hubs	DC bus removes rectification stage in chargers; PV/BESS buffer manages instantaneous peak demand on constrained connections. Higher power density	1,070 charging hubs across the UK as of September 2026,[23] 300,000 charge points target by 2030[24]; Innovate UK £10m funding for solutions for grid-constrained sites.[25]
Industrial & Logistics	Fleet electrification + motor regeneration value	Regenerative braking capture; direct DC link for drives; peak load reduction up to 85%.[26]	Industrial electricity demand up 78% by 2050; 42% of large sites face power constraints by 2030.[27]
Healthcare Estates	Resilience + funded solar/storage rollout	Critical-load resilience; integrates NHS-funded PV, BESS and EV fleets into a single DC architecture	£100m+ NHS solar and storage funding across 78 trusts.[28] £8m to electrify medical fleets across 200+ sites.[29]

Table 2: Priority sectors for near-term DCMG deployment, with primary commercial drivers and evidence signals

Where this works already



Where this works already

DCMG deployment has moved beyond academic prototypes into early commercial implementations, concentrated in Europe, particularly Germany and the Netherlands, where grid constraints began biting earlier. A small number of companies have consistently led development, while major industry players are increasingly active in DC distribution. Schneider Electric's acquisition of DC Systems in 2021, alongside existing activity from ABB, Eaton and Siemens, signals the technology's growing strategic importance.

The following case studies span the four priority sectors. They are all real-world commercial deployments rather than pilots, and illustrate the scale, sectors and results that are already achievable with DCMGs today.



Proven DC Microgrid Deployments — Key Results

Site	*Geography*	*Sector*	*System Scale*	*Headline Results*
Schaltbau NExT Factory (Germany, 2023)[30,31]	Germany	Industrial	1.3 MWp PV, 305 kWh BESS, 600-800V DC bus	35% reduction in annual energy costs, 8% efficiency gain on PV, 25% materials saving, 85% peak load reduction in logistics warehouse
TACC Data Centre (Texas, 2015–17)[32]	Texas, USA	Data Centre	380 VDC, 200 kW PV, Li-ion BESS	17% reduction in energy consumption vs. AC, 36% reduction in power losses, 74.8 tCO2 saved in demonstration period
Rosie Hospital HVAC[33]	Cambridge, UK	Healthcare	700 VDC bus, 80 kW PV, 160 kWh BESS	7% efficiency gain from DC-linked PV and HVAC, covers up to 90% of hospital heating, cooling and hot water needs
N470 Highway Lighting[34,35]	South Holland, Netherlands	Public	700 VDC, 100kWp Solar PV, 1MWh BESS	10% energy efficiency gain, 40-60% fewer converters, 35% copper reduction, 5 grid connections reduced to 1
a.s.r. EV Fleet[36]	Utrecht, The Netherlands	EV Charging	50 kW AFE, 48 kW Solar PV, 200 kWh BESS, 3× 10kW V2G chargers	15% energy reduction vs. AC, island mode capability and full autonomous operation achieved

Table 3: Real-world DCMG deployments demonstrating measurable commercial and energy outcomes across priority sectors.

What the evidence tells us

Across these five deployments, four findings are consistent:

1. The technology delivers against its promises

Efficiency gains of up to 17%, cost reductions of up to 35%, and significant materials savings are reproducible across different sectors and geographies.

2. The hybrid approach works in practice

Rosie Hospital, a UK site, demonstrates that a 700V DC bus can be integrated into an existing hospital estate, delivering 90% coverage of HVAC needs, highlighting that this is not a greenfield-only story.

3. EV charging is the most mature subsector

The Sortimo Innovation Park in Germany (144 chargers on a 1,000V DC bus) and Turbo Power Systems' Smart Fleet at Westminster Council demonstrate that DC-native EV charging at scale is operational today, including with V2G capability.[37,38] Eaton and ChargePoint will launch DC grid architecture which they claim can be deployed with 30% lower CAPEX in a 30% smaller footprint while delivering up to a 30% reduction in ongoing operational costs.[39]

4. Standards are in place

Most of the case studies mentioned were delivered under recognised standards (Current/OS, ODCA, IEC frameworks), demonstrating that sign-off and commissioning pathways exist for credible integrators.[40,41,42]

The road ahead



The road ahead

As the energy landscape shows strong signs of expanding into DC-native infrastructure, Centrica and our in-house research and innovation team, Energised Futures, are at the forefront of translating these technical advantages into commercial reality. We are currently focusing on three key pillars of development:

1. **Research and Development:** We are actively pursuing strategic pilot and demonstration opportunities to accelerate the deployment of DC-native solutions.
2. **In-House Capability:** Working to develop the engineering and operational expertise required to design, commission, and manage DC-coupled architectures, ensuring we can provide full-lifecycle assurance for complex sites.
3. **Strategic Partnerships:** By collaborating with leading OEMs and specialist technology providers, we are enhancing our delivery model to offer integrated, turnkey solutions that utilise the advantages of DC microgrids to overcome grid constraints.

In Conclusion

DCMGs have reached a commercial inflection point – they now go beyond a theoretical efficiency benefit and provide strategic advantage for businesses looking to bypass grid constraints and meet non-negotiable decarbonisation targets.

Energised Futures and Centrica remain committed to leading this transition, developing the tools and partnerships required to power the next generation of UK business infrastructure.



Contact Energised Futures

Innovation doesn't happen in isolation.

We work with partners across the energy system to explore ideas, test what's possible and turn promising thinking into real-world solutions.

Got an idea, challenge or opportunity to collaborate? Get in touch via: energisedfutures@centrica.com.

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