

RAF048/2425: Pathways to SF6 free GB distribution networks

Potential impacts and policy
recommendations for a phase-out of SF6 in
new electrical switchgear used in Great
Britain's electricity distribution networks

Views expressed in this report are those of the researcher and not necessarily those of the UK government.



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Contents

Executive summary	5
Readiness varies significantly by voltage level	5
GB lacks a clear regulatory and financing framework for phase-out.....	5
Cost is a barrier for network operators, but not for consumers	5
Report recommendations	6
Introduction	7
Background	9
SF6 as a key component in electricity transmission and distribution	9
Significance of SF6 from an emissions perspective	9
SF6 timelines in a European vs GB energy context	9
Economic drivers for SF6 phase-out	12
Scope of the study	12
Delimitations	13
Data collection and data sources.....	13
Overview of general market, technology and supply readiness across voltage levels	16
Assessment by voltage level	16
GB regulatory preparedness and EU trajectory	25
Approvals and standards	28
Economic and cost recovery uncertainty	29
Deliverability constraints	32
Model design and outputs	34
Introduction to the model	34
DNM model description	34
Model assumptions.....	35
Model methodology	36
Model results	38
Conclusion.....	42
Identified barriers and mitigation measures.....	43
1) Lack of regulatory clarity for a SF6 phase-out	43
2) Finance framework (RIIO-ED) delays investment decisions.....	45
3) GB-specific requirements and industry standards	46

4) Lack of a clear stance on transition technologies	46
5) Like-for-like replacement of retired SF6 equipment	47
6) Grid expansion and connection workload reduces transition capacity	48
7) Low operational maturity of SF6-free technologies	49
Recommendations for a phase-out timeline	51
Principles for an effective GB phase-out approach	51
Recommendations for DESNZ	52
Indicative sequencing	56
Limitations and areas where further evidence would be useful	58
Recommendations not supported by the current evidence	58
Case studies: SF6-free alternatives in non-regulated industries	59
SF6-free switchgear in data centres	59
SF6-free switchgear solutions in offshore wind	61
Appendix	64
Bibliography	68

Executive summary

Sulphur hexafluoride (SF6) is widely used in electricity networks but is also one of the most potent greenhouse gases in the world. As electricity networks in Great Britain (GB) expand rapidly, the continued installation of SF6-based switchgear risks locking in long-term emissions that are fundamentally incompatible with the UK government's net-zero commitments. The case for action is not only environmental. The absence of binding UK government legislation is creating uncertainty that inhibits investment by both manufacturers and network operators. Meanwhile, the EU's clear regulatory direction has aligned the European supply chain behind SF6-free alternatives, leaving GB at risk of falling behind, facing potential cost increases as the pool of SF6 suppliers shrinks and losing the opportunity to build a competitive, future-proof supply chain ahead of an inevitable global transition. This study assesses the feasibility, impacts and policy implications of phasing out SF6 in electrical switchgear in GB electricity networks, drawing on extensive engagement with network operators, manufacturers, regulators and industry experts.

Readiness varies significantly by voltage level

SF6-free technologies are technically mature and commercially available at 11 kilovolts (11kV) and across parts of the 66kV to 132kV range. In contrast, 33kV secondary distribution remains the most constrained segment, reflecting limited GB-approved product diversity and higher delivery uncertainty. At the highest transmission voltages, SF6-free solutions exist but remain supply-constrained and in some cases rely on transitional gas mixtures.

GB lacks a clear regulatory and financing framework for phase-out

Unlike the EU's binding, voltage-specific bans, GB relies on retained fluorinated gas (F-gas) rules and RIIO-based incentives that, while allowing for the procurement of SF6-free alternatives, do not provide a definitive direction for phase-out. Clearer long-term policy, aligned with cost-recovery arrangements under RIIO-ED and with GB-specific exceptions where justified, would accelerate investment in SF6-free alternatives and strengthen GB's position in the SF6-free supply chain.

Cost is a barrier for network operators, but not for consumers

While SF6-free switchgear carries higher upfront costs, capital expenditure (CAPEX) modelling shows the average annual consumer bill impact is small. The primary constraint is therefore regulatory financeability and investment incentives for network operators, not consumer affordability.

Report recommendations

The report recommends a broad industry collaboration led by the Department for Energy Security and Net Zero (DESNZ) to establish a GB framework to phase out SF6 from electrical switchgear in electricity networks, differentiated by voltage level and broadly aligned with the EU timetable, with GB-specific adjustments where justified (notably at 33kV and 275kV). To enable delivery, DESNZ should:

- engage with Ofgem to confirm a credible cost recovery route for efficient SF6-free procurement, so early adopters are not penalised
- provide a clear policy stance on transitional technologies, clarifying where and for how long gas-based alternatives are acceptable and ensuring alignment of SF6 and per- and polyfluoroalkyl substances (PFAS) policy signals
- support market readiness through coordinated demand signalling and transparency on supply gaps

Overall, the evidence supports a sequenced transition suggesting early action at 11kV and parts of the 66kV to 132kV range where SF6-free technology is mature, while linking later decisions at 33kV, 275kV and the highest transmission voltages to explicit readiness tests reflecting product availability, approvals and supply-chain conditions.

Introduction

Sulphur hexafluoride (SF6) presents a particular climate challenge. With a 100-year global warming potential (GWP) of approximately 24,300 times that of carbon dioxide (CO2), even small leaks have significant, long-lasting impacts.¹ Its widespread use in sealed transmission and distribution assets can also make SF6 emissions a material part of network operators' direct emissions (Scope 1), making continued growth difficult to reconcile with long-term climate targets.

A growing number of electricity network operators on both distribution (DNOs) and transmission (TOs) level are beginning to explore SF6-free solutions. As climate ambitions intensify across Europe and GB, network owners increasingly recognise that reducing reliance on high GWP fluorinated gases is a core element of their environmental and social responsibility strategies.

In GB, Ofgem's regulatory framework provides several routes for DNOs and TOs to support reductions in SF6 use. For electricity distribution, the current RIIO-ED2 price control runs from April 2023 to March 2028 and includes environmental action planning, monitoring and reporting obligations, alongside access to investment and innovation funding. Looking ahead, Ofgem published its Sector Specific Methodology Decision for the subsequent ED3 price control in May 2026, establishing the regulatory methodology that will apply from April 2028 to March 2033. For transmission, RIIO-ET3, which began on 1 April 2026 and runs to March 2031, strengthens the framework for SF6 management and innovation, building on mechanisms established under RIIO-ET2.

While this arrangement support ongoing innovation and asset management activities, the adoption of SF6-free technologies within baseline projects generally needs to be considered at project inception. Nevertheless, some progress in the deployment of SF6-free technologies is beginning to emerge, particularly among transmission operators.

Looking towards the European Union, the regulatory direction in the European Union is now setting a clear transition pathway. Under the EU F-gas Regulation (EU) 2024/573, restrictions on the use of F-gases in new electrical switchgear tighten in stages by voltage class, including a prohibition on F-gases in new switchgear up to and including 24kV from January 2026, followed by additional restrictions at higher voltage levels in later years. While the UK government is not bound by EU legislation, GB operators and suppliers are nonetheless exposed to the consequences through procurement markets, supply chain prioritisation, and evolving expectations from stakeholders and investors. (Northern Ireland operates within a distinct regulatory and market context, so the impacts and potential actions may be shaped differently than for GB actors).

¹ IPCC AR6 – updated by GHG Protocol in 2024 as the latest IPCC value for corporate reporting

At the same time, SF6-free alternatives are increasingly available, enabling a realistic transition in parts of the system, but not necessarily at the same pace across all voltages and applications. This matters because without a managed transition, uncertainty through the supply chain and procurement of SF6-free switchgear will persist.

The aim of this report is to provide evidence-based policy recommendations that enable policy makers and sector stakeholders in GB to plan and implement an affordable and secure transition away from SF6 in electrical switchgear, balancing climate ambitions with engineering feasibility, deliverability constraints, and consumer impacts.

Background

SF6 as a key component in electricity transmission and distribution

SF6 is widely used in electrical equipment across electricity transmission and distribution networks, because of its unique technical properties. The scale and function of SF6-filled equipment vary significantly by voltage level; however, equipment is on a large-scale at substations where distribution and transmission lines interconnect or voltage levels are transformed. In this equipment, SF6 serves 2 essential purposes: it acts as an interrupting gas in switching components and circuit breakers extinguishing dangerous electrical arcs during switching and it provides high-performance insulation in components such as busbars and gas-insulated lines, which are large conduits housing conductors and insulating gas.

Significance of SF6 from an emissions perspective

SF6 represents a severe environmental risk within the GB electricity system due to its extremely high global warming potential and its atmospheric lifetime of approximately 3,200 years. The current total SF6 inventory in the GB electricity sector is estimated at approximately 2 to 2.45 kilotonnes (kt), with the majority held in regulated transmission and distribution assets.

Reported leakage rates are relatively low in percentage terms, typically below 1% of installed inventory. Looking forward, without a managed phase-out, the total SF6 inventory in GB electricity networks is expected to grow substantially as the network expands to meet electrification demand, locking in long-term emissions that would persist well beyond the decarbonisation of electricity generation itself. Leakage reduction alone is therefore insufficient to manage the climate impact of SF6 and that a phase-out of new SF6-containing equipment is required to avoid long-term lock-in of high-GWP emissions within the GB electricity network.

SF6 timelines in a European vs GB energy context

The EU has taken a prescriptive approach so far. Regulation (EU) 2024/573, introduced in March 2024, sets a clear phased timeline for banning SF6 (and other F-gases with global warming potential) in new switchgear at successive voltage levels with the key milestones being:²

Medium voltage distribution level:

- **January 2026:** SF6 prohibited in new switchgear up to and including 24kV
- **January 2030:** SF6 prohibited in new switchgear above 24kV up to and including 52kV

² European Commission, Regulation (EU) 2024/573 on fluorinated greenhouse gases, March 2024. Full reference provided in the bibliography.

High voltage transmission level:

- **January 2028:** SF6 prohibited in new switchgear from 52 to 145kV (up to and including 50 kiloamperes (kA)) (for gases with GWP greater or equal 1)
- **January 2032:** SF6 prohibited in all new switchgear above 145kV or up to 50kA

All voltage levels:

- **January 2035:** SF6 prohibited for use in maintenance and repairs, except when the gas is recycled or in technical/emergency situations

Existing SF6 equipment does not need to be immediately replaced, allowing the industry to adapt without major disruption. However, operators must prevent leaks and comply with leak-checking and record-keeping rules, with switchgear only exempt from periodic leak checks if it meets strict conditions such as a tested leakage rate below 0.1% per year. Member states are required to establish penalties for infringements by January 2026, with public documentation on finalised structures still in preparation to be integrated in national legislation as soon as possible.

The Regulation allows limited flexibility where compliant switchgear is demonstrably unavailable for a specific procurement. The restrictions may be disapplied where a tender process shows that:

- compliant solutions cannot be sourced, for example where no compliant bid is received
- where procurement yields only one compliant bid, or compliant bids from only one manufacturer (for up to 2 years after the relevant prohibition start date)

Where such non-availability is evidenced, a cascaded derogation applies. First, switchgear using an insulating and/or interrupting medium with a GWP below 1,000 may be used. If procurement evidence indicates that even this option cannot be obtained for the specific application, then other technologies, including SF6, may be used as a last resort. Tender specifications are expected to be non-prescriptive (that is, not mandating a specific gas) and should avoid unnecessary technical criteria that would effectively exclude compliant solutions.

An additional complication is the interaction with the proposed EU PFAS restriction. Some of the leading synthetic gas alternatives to SF6, such as fluoronitrile (C4F7N), could themselves face a ban several years after any PFAS restriction comes into force.³ This creates regulatory uncertainty for manufacturers and operators who have invested in these alternatives.

GB: retained framework, no binding phase-out dates yet

The UK retained the EU's 2014 F-gas Regulation (517/2014) but has not adopted the EU's revised 2024 regulation with its binding switchgear phase-out dates.

³ C4-FN (fluoronitrile) is a PFAS substance. When used in mixtures with CO2 or N2 as is standard practice, the GWP of the complete mixture is typically in the range of 300 to 500.

The UK government plans to consult on revising UK F-gas rules. The Department for Environment, Food and Rural Affairs (Defra) consultation that has taken place so far has focused primarily on hydrofluorocarbon (HFC) phasedown reform (synthetic gases widely used in refrigeration, air conditioning, foams, aerosols and fire-suppression systems) rather than SF6 in switchgear specifically. That consultation acknowledged that further work on other fluorinated gases, including SF6, could follow.

In the absence of binding phase-out legislation, GB relies on Ofgem's control framework (RIIO) to drive SF6 management.⁴ However, the strength of this mechanism differs significantly between network levels.

For Distribution Network Operators, RIIO-ED2 runs until 31 March 2028, under which SF6 obligations remain reputational only, companies must report and set internal targets but face no financial consequences for underperformance. Work on the subsequent price control ED3 is already underway, presenting an opportunity to strengthen SF6 incentives for distribution operators.

For Transmission Operators under RIIO-ET3, SF6 leakage is subject to the Insulation and Interruption Gas (IIG) Emissions financial output delivery incentive (ODI), which applies both monetary rewards for outperformance and financial penalties for exceeding leakage targets. ET3 also introduces additional mechanisms to further incentivise the transition to SF6-free alternatives, including pre-approved funding for specific asset interventions and an Advanced Procurement Mechanism to address supply chain lead time pressures.

A key structural difference between the 2 frameworks is how funding is allocated. Under ED2, distribution operators receive their entire total expenditure (TOTEX) allowance upfront and allocate it at their own discretion, meaning SF6-free procurement must compete with other network priorities within a fixed budget. Under ET3, transmission operators can also access additional targeted funding mechanisms as projects mature, enabling more direct investment in SF6-free alternatives (partly explaining why progress has been more visible at transmission level).

Key contrasts

- **regulatory certainty:** the EU provides hard, date-certain bans tied to voltage levels. The UK government's position for GB currently offers voluntary targets and financial incentives but no statutory prohibition on installing new SF6 equipment (currently)
- **scope:** the EU regulation covers the entire market, from data centres and renewables installations to distribution and transmission. GB's RIIO framework primarily governs the regulated network companies, leaving other sectors (industrial, commercial) without equivalent drivers
- **PFAS risk:** both jurisdictions face the same underlying challenge around 'forever chemicals' in alternative gases, though the EU has more explicitly linked its F-gas and PFAS regulatory tracks

⁴ Ofgem, RIIO-ED2 and RIIO-T3 regulatory frameworks. Full references provided in the bibliography.

Economic drivers for SF6 phase-out

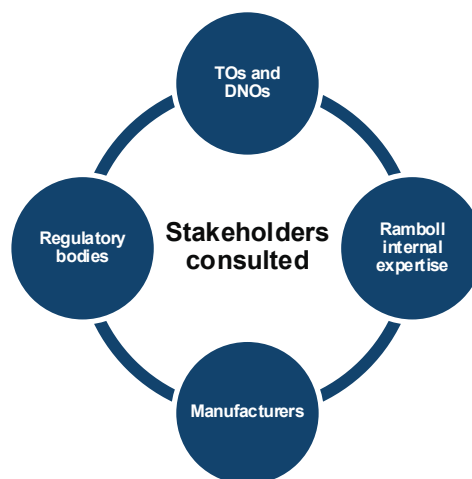
The case for phasing out SF6 in GB electricity networks is not solely environmental. There is a distinct and growing economic rationale that warrants equal weight in policy design.

In a worst-case scenario, manufacturers may defer investment in GB-specific SF6-free product development without confidence that sufficient demand will materialise, while network operators may in turn delay procurement of higher-cost alternatives in the absence of a clear cost-recovery route or compliance obligation (see the ‘Economic and cost recovery uncertainty’ section).

This dynamic is significantly underlined by EU's clear and time-bound regulatory framework, which has given its supply chain the certainty needed to invest at scale in SF6-free alternatives. In the absence of an equivalent policy signal, GB industry is less able to participate fully in the SF6-free transition, limiting domestic deployment at scale and reducing its competitiveness compared to EU markets where demand is increasingly shaped by binding regulation.

The longer this persists, the greater the risk of having an underdeveloped GB SF6-free supply chain relative to European peers and a growing dependency on a shrinking pool of SF6 suppliers as European demand declines, which over time carries real risk of supply chain constraints and upward pressure on costs for GB consumers.⁵

Scope of the study



The study's core scope is the assessment of electricity distribution network impacts arising from the phase-out of SF6 in electrical switchgear and the transition to SF6-free alternatives. The report also draws on evidence from high voltage transmission networks to provide broader context, though transmission is not included in the quantitative modelling.

⁵ Grid operators consulted for this study noted that some SF6 switchgear configurations are no longer being manufactured, indicating that this dependency risk is beginning to materialise at product level.

The emphasis is on understanding what is standing in the way of adopting SF6-free alternatives, with the objectives being:

- assess the deliverability impacts of a GB-specific SF6 phase-out timeline, with focus on maturity and implications by voltage level
- assess implications for equipment choices, including the identification of the key significant barriers and potential mitigations
- propose a phased approach to transition, supported by stakeholder evidence and scenario analysis
- provide a high-level assessment of potential socio-economic cost pass-throughs to end consumers via electricity bills, reflecting key cost drivers such as procurement and (where relevant) additional land or space requirements

Delimitations

The study is designed as a maturity and impact assessment. Based on the defined approach, key delimitations include:

- the assessment focuses on policy, market readiness and deliverability, rather than detailed engineering design or product-level validation
- focus for the assessment is on new installations in the distribution grid (with high voltage transmission addressed at a high level only) rather than mandatory replacement of all existing SF6 assets
- the assessment is exploring potential options and implications of a GB-specific phase-out plan rather than defining a specific GB transition timeline
- high-level cost analysis only, with consumer impacts presented as ranges rather than precise forecasts

Where evidence is incomplete or commercially sensitive, the approach explicitly anticipates the need to use estimates with clearly stated uncertainty.

Data collection and data sources

This report is based on a combination of qualitative and quantitative evidence. Qualitative insights have been gathered through extensive stakeholder engagement, including questionnaires and targeted interviews with manufacturers, distribution and transmission network operators, industry experts, and regulators, complemented by structured desk research. This approach ensured coverage of equipment choices, costs, barriers and delivery constraints across the value chain. Quantitative analysis draws primarily on manufacturer inputs, which were used to develop best-, average- and worst-case scenarios underpinning the assessment.

Questionnaires and interviews

Based on the identification of relevant stakeholders, Ramboll distributed more than 20 semi-structured questionnaires to stakeholders relevant for the assessment. A total of 14 responses were received in the period from January to March 2026, providing a representative base of qualitative insights.

To complement and deepen the findings from the questionnaires, 8 semi-structured interviews were subsequently conducted with various stakeholders.

A semi-structured format was applied to both the questionnaires and interviews, allowing discussions to follow a defined topic guide while retaining flexibility for follow-up questions and exploration of emerging themes.

The organisations that responded to the questionnaires and those interviewed are presented below.

Table 1: List of organisations consulted

Number	Organisation	Type	Country focus
1	Northern PowerGrid	DNO	GB
2	UK Power Networks	DNO	GB
3	SP ENW	DNO	GB
4	SPEN	DNO - TO	GB
5	National Grid (NGED - GET)	DNO - TO	GB
6	SSE	DNO - TO	GB
7	ABB	Manufacturer	Global
8	Bowers Electricals	Manufacturer	GB
9	Eaton	Manufacturer	Global
10	Lucy Electrics	Manufacturer	GB/Global
11	Mitsubishi	Manufacturer	Global
12	Nuventura	Manufacturer	EU
13	Ormazabal	Manufacturer	EU
14	Schneider Electric	Manufacturer	EU/Global
15	Siemens	Manufacturer	EU/Global

Number	Organisation	Type	Country focus
16	Siemens Energy	Manufacturer	EU/Global
17	Ramboll	Industry experts	EU/GB
18	Ofgem	Regulator	GB
19	BEAMA and ENA	Industry Bodies	GB

Assessment of the data used

This report combines qualitative stakeholder engagement, desk research and quantitative data to provide a robust evidence base, while recognising inherent data limitations. Stakeholder engagement was weighted towards medium-voltage distribution networks, with more limited direct input from high voltage transmission operators.

Transmission level findings are therefore supported primarily by desk research and expert input. While most respondents were GB based, some operate across European markets, which may introduce perspectives not fully aligned with the GB market and regulatory context. As with all qualitative research, stakeholder views reflect organisational roles and experiences, with distribution network operators in particular tending to express more cautious assessments, likely reflecting their specific operational and regulatory constraints.

Overview of general market, technology and supply readiness across voltage levels

This chapter assesses the feasibility of implementing a phase-out of SF6 in new electrical switchgear. It examines the maturity and availability of SF6-free technologies across voltage levels and considers the key barriers that influence deliverability, including regulatory and policy conditions, economic and cost-recovery considerations, and practical implementation constraints. Together, these factors provide an evidence-based view of where a phase-out is currently viable and where additional enabling measures are required.

Assessment by voltage level

Overall, the SF6-free switchgear market is defined by a surge in technological maturity, but this maturity has not yet fully transferred to the GB market, where solutions still require adjustment to GB-specific operational standards and approval processes (see the 'Approvals and standards' section for more details here).

At 11kV, which forms the backbone of the distribution network, primary distribution switchgear is considered highly mature, with F-gas free technologies already operational. However, the secondary distribution segment remains slightly less mature, not because of technological limitations but due to a limited number of GB-approved product variants and suppliers, particularly for configurations commonly required by DNOs such as outdoor single tank multi-switch devices and extensible ring main units (RMUs).

The 24kV segment, widely used across Europe, is highly mature, with a fully developed supply chain driven by EU F-gas regulations that prohibit SF6 in new switchgear up to this voltage from January 2026.

Moving to 33kV, which connects the 132kV transmission-distribution interface to the 11kV network, the market shows medium technical maturity with a growing pipeline of F-gas free solutions rated for up to 36kV to 40.5kV equipment classes. However, GB deployment remains constrained by utility approval processes and GB-specific design preferences. The 33kV secondary distribution segment, particularly RMUs, is currently the least mature, reflecting both the technical challenge of achieving high performance in compact designs and a development lag caused by manufacturers prioritising the 24kV class required by European regulation.

Table 2: Summary assessment of maturity of switchgear equipment across medium voltage level

Voltage level	11kV primary distribution	11kV secondary distribution	24kV distribution (EU standard)	33kV primary distribution	33kV secondary distribution
General assessment	Highly mature	Mature	Highly mature	Medium maturity	Low maturity

Understanding of GB power system to grasp diversity of switchgear equipment

Switchgear control, protect and isolate various types of electrical equipment for example by avoiding current overload. Many different types of switchgear exist. They can be distinguished based on their application on voltage level, electricity network level or their used insulation medium and switching device mechanism.

In practice, the electricity network level is defined by the voltage level required to fulfil the network function. Hence, talking about the different voltage levels below inherently carries the differentiation between transmission and distribution network level. This report broadly distinguishes in the following way:

Table 3: Voltage classification and distinction between DNO and TO level used in this report

Switchgear type	Voltage level
Extra high and high voltage	66kV, ⁶ 132kV, 275kV, 400kV, 525kV ⁷
Medium voltage	11kV, 33kV

The transmission network operated by Transmission Owners (TOs) moves large volumes of electricity across long distances from major generation sources to regional demand centres. In Scotland, transmission begins at 132kV, while in England and Wales it operates at 275kV and above. Below these thresholds sits the distribution network, operated by Distribution Network Operators (DNOs), which steps electricity down through progressively lower voltages to deliver power to businesses and households.

Within this structure, electricity flows through a hierarchy of voltage levels. At the top sits the 400kV extra high voltage network, which forms the backbone of the national transmission system and carries bulk electricity over long distances. Alongside this, 275kV lines perform a

⁶ 66kV is a GB-specific legacy voltage. In GB operational terms, transmission is defined as 132kV and above, with 66kV falling within distribution network operator territory. However, under IEC standards and the EU F-gas Regulation, which uses 52kV as the dividing line, 66kV is classified as high voltage.

⁷ 525kV is increasingly adopted for offshore HVDC (high voltage direct current) bootstraps and interconnectors. As this report's analysis centres on the onshore GB network, this voltage level is not examined in detail here.

similar transmission role, particularly in Scotland. The 132kV network then acts as the interface between transmission and distribution in England and Wales, distributing power regionally before it enters the lower voltage system. Complementing this layer is the 66kV level, which serves as a high-voltage interface predominantly utilised in outdoor substations where footprint constraints are less pressing. From there, voltage is reduced through 33kV and 11kV, which form the upper and mid tiers of the distribution network. The 33kV network supplies larger industrial or commercial users and feeds into the 11kV system. The 11kV system forms the primary distribution backbone reaching most towns, villages, and suburbs and connects to the largest number of substations and customers. Finally, electricity is stepped down to 230V (single phase) or 400V (three phase) through local transformers for direct supply to homes and small businesses.

While the above describes the operational distinction between DNOs and TOs in the GB context, this report distinguishes between distribution and transmission level equipment based on the International Electrotechnical Commission (IEC) and EU F-gas Regulation voltage classification (using 52kV as the boundary between medium and high voltage) for consistency with the European regulatory and product framework referenced throughout.

The network levels of primary and secondary distribution and transmission

Zooming into the electricity distribution network, the network is divided into primary and secondary distribution, which requires specific switchgear. Primary switchgear consists commonly of metal-enclosed switchgear located in major substations (typically 33kV to 11kV) at the interface with the transmission network that distribute power to multiple feeders or large industrial sites. It can also encompass outdoor open-terminal equipment. In contrast, secondary switchgear refers to compact equipment, most notably Ring Main Units (RMUs), used at local step-down points to deliver power for homes or within renewable collector networks for wind and solar farms. At the transmission level, this equipment distinction does not exist since serving as bulk power transfer points is the purpose of switchgear rather than tiered local distribution.

An in-depth analysis of SF6-free solutions

The availability and maturity of SF6-free solutions differ by application and voltage level and are best understood by separating 2 fundamental functions of switchgear being electrical insulation and current interruption. These functions are delivered through different design choices, which remain relevant regardless of whether SF6 or alternative technologies are used.

Enclosure and insulation

At primary distribution and transmission level, switchgear is commonly categorised according to its enclosure and insulation concept, most notably as Air-Insulated Switchgear (AIS) or Gas-Insulated Switchgear (GIS). This distinction describes how insulation is achieved and is independent of the operational role of the switchgear within the network.

Air-Insulated Switchgear (AIS) uses air as the external insulating medium between live components. In indoor AIS, air insulation is provided within a grounded enclosure, while in outdoor AIS (such as live-tank or dead-tank equipment), clearances are achieved through physical separation in open air. Because air has lower dielectric strength than gas, AIS generally requires larger clearances and, depending on configuration, larger overall spatial envelopes. AIS is widely used where space constraints are less acute, but its application is driven not only by footprint, but also by whole-substation economics, including building size, civil works, land take, and long-term maintenance costs.

Gas-Insulated Switchgear (GIS) encloses live components within sealed metallic compartments filled with an insulating gas. This allows significantly more compact designs and controlled environmental conditions, making GIS the preferred solution where space is constrained (for example urban substations, indoor installations, offshore platforms) or where environmental exposure must be tightly managed.

The transition away from SF6 does not alter this basic AIS/GIS distinction. Instead, SF6-free solutions replace the insulating and interrupting functions within AIS and GIS designs using alternative technologies.

Interruption technologies and panel design

Across both AIS and GIS, vacuum interruption has become the dominant SF6-free switching technology at medium voltage and is increasingly applied at higher voltages. Vacuum interrupters may be integrated into different panel and enclosure designs.

In indoor metal-enclosed switchgear, designs typically fall into 2 categories:

- fully withdrawable (racked) switchgear, where the circuit breaker can be physically withdrawn from the panel for maintenance while keeping busbars energised
- fixed pattern switchgear, where the circuit breaker is permanently installed, and isolation is achieved via disconnectors or by taking the panel out of service

While withdrawable designs offer operational flexibility, fixed pattern switchgear is generally more compact, mechanically simpler, and widely used across GB DNOs licence areas, reflecting lower maintenance complexity and reduced spatial requirements. Fixed pattern designs may use vacuum circuit breakers or, in some configurations, fused disconnectors, particularly at lower ratings.

Solutions by voltage level

In primary distribution (at 11kV and 33kV), SF6-free solutions predominantly rely on vacuum interruption, combined with either air-based or gas-based insulation. Where space allows, AIS based configurations are commonly used. These may include metal-enclosed AIS panels with vacuum circuit breakers or fused disconnectors, using air as the insulating medium. In locations where a more compact footprint is required, GIS solutions are adopted that similarly use vacuum interrupters for current interruption but rely on dry air or clean air (N2/O2 mixtures) as the insulating medium within a sealed metallic enclosure.

In secondary distribution (at 11kV and 33kV, with 33kV not commonly used by DNOs), the dominant solution pathway consists of sealed-tank RMUs combining vacuum interruption with F-gas-free air insulation. As an alternative, particularly where a fully gas-free design is preferred, RMUs are also available that combine vacuum interruption with solid dielectric insulation.

At transmission levels (66kV to 400kV), SF6-free pathways follow the same fundamental separation between interruption and insulation but exhibit greater technical differentiation due to higher dielectric stresses and short-circuit requirements.

AIS can refer both to metal-enclosed indoor switchgear using air as the insulating medium and to outdoor switchgear installed in open air, such as live-tank and dead-tank configurations. In the context of SF6-free transmission solutions, AIS therefore primarily describes equipment where external insulation is achieved through air clearances, regardless of whether the installation is indoor or outdoor. Two principal SF6-free technology pathways are observed. One pathway combines vacuum interrupters with pressurised clean air (N₂/O₂ mixtures), with air providing the external insulation. A second pathway retains a gas circuit breaker (GCB) architecture similar to conventional SF6 designs, replacing SF6 with CO₂/O₂ mixtures or fluoronitrile-based gas mixtures (for example C₄F₇N mixed with CO₂ and O₂). In these designs, the gas fulfils both the interruption and insulation functions within sealed chambers, while the overall installation remains air-insulated.

For GIS, the insulating medium fills the entire sealed enclosure, including busbars, disconnectors, earthing switches and the circuit breaker chamber. Two SF6-free approaches are available. The first combines vacuum interruption with clean air (N₂/O₂ mixtures) as the insulating medium throughout the assembly. The second uses fluoronitrile-based gas mixtures (C₄F₇N with CO₂/O₂) to provide both insulation and interruption.

Below assessment shows the maturity across voltage levels and equipment using the described equipment distinction of primary versus secondary equipment for the distribution level voltages and AIS versus GIS for the transmission level voltages. The output is focussing in more detail on the distribution level based on the stakeholder outreach. It is not an exhaustive listing of alternatives.

11kV distribution

The 11kV voltage level forms the backbone of the GB distribution network, connecting the largest number of substations and end users. The maturity assessment for the phase out of SF6 switchgear reveals a divide within this voltage class. 11kV primary distribution switchgear is generally considered mature with several F gas free technologies having been in operation for multiple years. In contrast, the market for 11kV secondary distribution equipment is more constrained in GB due to a limited number of approved product variants and suppliers. While global manufacturers often regard this segment as technically mature and ready for large scale deployment with various suppliers and solutions, driven in part by regulatory deadlines in Europe, DNOs characterise the GB-specific market as being in its early stages. The main constraint is not the underlying technology but the lack of GB-approved configurations,

particularly for equipment types such as outdoor single tank multi switch devices and extensible block designs, which are commonly required within GB distribution networks.

Table 4: Overview 11kV level

Voltage level	11kV primary distribution (33 > 11kV)	11kV secondary distribution (11kV > 433/230V)
Technology category	Switchboard (AIS or GIS)	Ring Main Unit (RMU)
Solution types	This category utilises metal-enclosed switchboards (AIS or GIS) for major substations feeding multiple feeders. The primary technological pathways include vacuum interruption combined with dry air or clean air insulation, as well as vacuum switching integrated with solid dielectric or air-insulated (AIS) metal-clad designs.	This category focuses on Ring Main Units (RMUs) used for local step-down from 11kV to 400V. Solutions are dominated by vacuum interruption paired with pressurised dry/clean air insulation or solid dielectric insulation.
Suppliers	Key suppliers offering active solutions include Schneider Electric (SM AirSeT GIS, GenieEvo, MCSeT, and Pix AIS ranges), Siemens Energy (NXAIR AIS and 8DAB 24 GIS), Eaton (Xiria NGX, PowerXpert FMX/UX), Bowers, and Ormazabal (sbp.zero24).	Leading suppliers include Schneider Electric (Ringmaster and RM AirSeT), ABB (SafePlus), Siemens Energy (8DJH 12), Eaton (Xiria 630A), LUCY Electric (AegisEcoTec and SabreEco Tec), and Ormazabal (cgm.zero24).
Time needed for implementation⁸	>= 0 years	1 to 2 years
General assessment of maturity	This segment is characterised by high maturity with sufficient options currently available. 11kV primary distribution in GB is already a well-established AIS market, and SF6-free equipment has been successfully installed for several years. A flagged shortcoming in this segment are options for extensions of existing SF6 apparatus.	Maturity is ranked as high with the segment considered commercially established. Driven by European regulatory deadlines, the supply chain is ready for mass deployment, and new pilot installations for GB-specific needs emerged as of Q3 2025. A limiting factor is not technological maturity, but rather GB specific requirements and approval times to reach a diverse supply offer.

⁸ 'Time needed for implementation' refers to the estimated time before SF6-free solutions at this voltage level are sufficiently available in the GB market for procurement at scale.

24kV distribution (EU standard)

For completeness, the 24kV voltage level is mentioned despite it being the standard EU distribution voltage level. Looking at primary and secondary GIS, AIS and RMUs, the equipment segment is considered technically highly mature with the supply chain considered fully ready for mass deployment. This high level of readiness is fundamentally driven by the EU F-gas regulation, which prohibits SF6 in new switchgear up to 24kV starting 1 January 2026, having forced major manufacturers to establish complete commercial portfolios.

Table 5: Overview 24kV level

Voltage level	24kV distribution (EU standard for completeness)
Technology category	Primary and Secondary GIS/AIS/RMU
Solution types	This range covers primary and secondary GIS/AIS and RMUs designed for the standard European 24kV grid. Technological solutions parallel those at 11kV, utilising vacuum switching with natural origin gas (dry air) mixtures or solid insulation.
Suppliers	Active suppliers include Nuventura (Nu1 and Nu2 family), Schneider Electric (RM, SM, and GM AirSeT), ABB (SafePlus), Siemens Energy (8DJH 24 and 8DAB 24), Eaton, LUCY Electric, and Ormazabal.
Time needed for implementation	0 years
General assessment of maturity	This is a highly mature product line, as major manufacturers have prioritised development to meet the EU ban on SF6 in new medium voltage (MV) switchgear up to 24kV, which activates on 1 January 2026. Solutions are commercially ready and already being procured at scale by European utilities.

33kV distribution

The 33kV voltage level acts as a vital link in GB distribution network, serving as the bridge between major 132/33kV substations and the 11kV network, while also providing critical collector rings for onshore wind and solar farms. For 33kV primary distribution, the segment is in a state of medium technical maturity, with a robust pipeline of F-gas-free solutions. Manufacturers have or are about to launch products that diversify the market. Once more the critical view comes from DNOs, which see less options available for GB needs due to approvals as well as GB specificities for example the more commonly used dead tank circuit breaker versus live tank circuit breaker. In this segment, products are available that are designed to operate at voltage levels ranging from 36kV to 40.5kV.

The 33kV secondary distribution segment, particularly for compact Ring Main Units (RMUs), is identified by manufacturers as the "most challenging product area" in the medium-voltage sector, with the fewest solutions currently offered for immediate deployment. This segment is

challenged since it requires high performance in compact footprints from a technical perspective and is equally impacted by the development lag from manufacturers prioritising 24kV.

Table 6: Overview 33kV level

Voltage level	33kV primary distribution (sometimes referred to as 36kV to 40.5kV distribution)	33kV secondary distribution
Technology category	Switchboards (AIS or GIS)	Ring Main Unit (RMU)
Solution types	This category utilises metal-enclosed switchgear (AIS or GIS) for major step-down substations (typically 132 to 33kV). Solutions include vacuum switching combined with dry/clean air or solid dielectric insulation.	This category focuses on compact Ring Main Units (RMUs) or compact GIS used for local distribution and as collector rings for onshore wind and solar farms. Technical solutions rely on vacuum interruption and pressurised dry air insulation.
Suppliers	Nuventura (Nu1 GIS; Nu2 GIS), Siemens Energy (NXAIR H AIS and 8DAB 40 GIS), and Eaton (Xiria NGX and PowerXpert). Schneider Electric has scheduled GB product launches for the GM AirSeT range in 2027 and 2028.	ABB currently offers the SafePlus 36; Lucy Electric has a product in development for release over the next 18 months.
Time needed for implementation	1 to 2 years	2 to 3 years
General assessment of maturity	Maturity is currently described as medium or emerging. While products are launch-ready, progress in primary GIS is slower than at lower voltages, with limitations still existing on available panel variants and ratings compared to legacy SF6 designs.	This is currently the most challenging product area for MV switchgear. Solutions must remain compact enough while managing higher dielectric stress without SF6, leading to a recognised lack of diverse options in the current market.

Transmission level

Table 7: Summary assessment of maturity of switchgear equipment across high voltage level

Voltage level	66kV	132kV	275kV	400kV
General assessment of maturity	Mature	Mature	Low maturity	Medium maturity

High-level overview of maturity across the transmission level voltages

The 66kV class is a GB-specific legacy voltage, with the IEC standard sitting at 72.5kV.⁹

As is common practice in voltage adaptation, SF6-free products designed and manufactured to the 72.5kV IEC rating are applied to GB's 66kV network, with no significant cost implication at this modest voltage differential. This means that the mature 72.5kV supply chain, with established products from multiple major manufacturers, is directly accessible for GB applications at this level. As for the distribution level, specific assets like 66kV outdoor dead-tank circuit breakers are being described as being in their "infancy", as there is currently a lack of Energy Networks Association (ENA) Switchgear Assessment Panel (SAP) approved SF6-free options for these configurations, forcing operators to continue using SF6 in certain outdoor applications.

The 132kV level follows the same reasoning, with products designed and manufactured to the IEC 145kV rating and applied to GB's 132kV network. Products from all major manufacturers are commercially available. Active installations by some DNOs are already underway in GB, though rating limitations have been noted in certain configurations. The near-term outlook for both voltage classes is one of competitive broadening, with procurement volumes expected to accelerate significantly ahead of the EU's January 2028 deadline for switchgear up to 145kV, and further market entrants anticipated as the ban drives procurement across the industry.

The 275kV tier is a niche voltage level within GB and is not used elsewhere in Europe. While GB transmission operators are upgrading parts of this legacy network to 400kV, a large proportion of the 275kV network is expected to remain in place for the foreseeable future. At present, no dedicated SF6-free product appears to be commercially available for this voltage class within the European market, and the only available alternative is to apply 400kV-rated equipment.¹⁰ The expectation is therefore that new developments will deploy 400kV-rated equipment in the short to medium term. Manufacturers may place greater development focus on this voltage level once further progress has been achieved at 400kV and where sufficiently strong market demand emerges.

⁹ Solution availability assessments draw additionally on manufacturer product documentation and technical specifications; full references are provided in the bibliography.

¹⁰ Applying 400kV-rated equipment to 275kV applications carries an associated cost premium, reflecting the higher specification of the equipment.

At 400kV, the SF6-free market is the most challenging and attracting the greatest development focus, with significant market evolution expected in the near term. Multiple SF6-free GIS and one AIS solution are commercially available, with C4-FN-based gas mixtures representing the most widely adopted alternatives at higher voltages, although their longer-term regulatory position remains subject to ongoing discussion in relation to evolving PFAS policy, sometimes regarded as part of a transitional regulatory pathway away from SF6 (see the ‘GB regulatory preparedness and EU trajectory’ section).¹¹ Operational examples include 400kV GIS installations using low-GWP gas mixtures at substations including Littlebrook and Middleton and Harker. Further research and development is underway, with vacuum and clean air solutions currently at pilot stage, indicating that the technology gap is narrowing. The trajectory of the market at this voltage level is therefore heavily contingent on the pace at which these alternatives reach commercial readiness.

Supply chain strain has become the primary constraint at this voltage level, with lead times for SF6-free components now reported to stretch to nearly 3 years, driven by the concentration of global procurement demand at this tier.

A detailed breakdown of SF6-free solution types, suppliers, and maturity assessments by voltage level is provided in the technology overview tables in the appendix.

GB regulatory preparedness and EU trajectory

The EU’s revised F-gas Regulation (2024/573), adopted in February 2024, establishes binding prohibitions on putting new fluorinated-gas switchgear into operation (including SF6), differentiated by voltage level (see Table 8). Time-limited derogations are available where competitive supply is insufficient, though these narrow progressively.

Table 8: EU timeline per voltage level

Date	Voltage / rating	GWP threshold	What is prohibited
1 January 2026	MV ≤ 24kV (primary and secondary distribution)	All F-gases prohibited (any GWP)	Putting into operation of any new MV switchgear up to 24kV that uses or relies upon fluorinated greenhouse gases.

¹¹ For the purposes of this report, the term ‘transitional’ is used in the context of the evolving European regulatory framework relating to fluorinated gases and PFAS policy, rather than to imply short operational asset life or technical unsuitability. Certain fluoronitrile-based alternatives (such as C4-FN mixtures) currently play an important role in enabling reductions in SF6 emissions at higher voltage levels, but their longer-term regulatory position within the EU remains subject to ongoing policy discussion. The report does not suggest that such technologies are unsuitable for long-term network deployment, nor that the UK is necessarily expected to adopt the same regulatory approach as the EU. However, given the scale and influence of the European market on manufacturer product development and supply chains, the EU regulatory trajectory is considered relevant to the GB market context assessed in this report.

Date	Voltage / rating	GWP threshold	What is prohibited
1 January 2028	HV 52kV to 145kV, ≤50kA short-circuit current	GWP ≥ 1	Putting into operation of new HV switchgear in this range with insulating/breaking medium with GWP of 1 or more.
1 January 2030	MV > 24kV to ≤ 52kV (primary and secondary distribution)	All F-gases prohibited (any GWP)	Putting into operation of any new MV switchgear in this range that uses or relies upon fluorinated greenhouse gases.
1 January 2032	HV > 145kV or > 50kA short-circuit current	GWP ≥ 1	Putting into operation of new HV switchgear above 145kV or above 50kA with insulating/breaking medium with GWP of 1 or more.
1 January 2035	All voltage levels (servicing)	Virgin SF6 prohibited	Use of newly produced (non-reclaimed, non-recycled) SF6 for maintenance or servicing of any existing electrical switchgear.

The UK does not currently have equivalent binding phase-out dates for GB electricity networks in domestic law. The retained EU F-gas Regulation (517/2014) provides the statutory baseline, covering containment, leak checking, personnel certification, and end-of-life recovery, but does not restrict the placing of new SF6 switchgear on the market. Ofgem's RIIO-ED2 price control requires DNOs to set SF6 management strategies and report on leakage, with performance incentivised through reputational mechanisms, but there is no financial reward or penalty at the distribution level for changing to SF6-free equipment as long as it continues to be more expensive than the SF6 equivalents (see more on the economical dynamics in the 'Economic and cost recovery uncertainty' section).

The revised National Policy Statement EN-5 (2025) introduces a presumption against SF6 in nationally significant infrastructure projects, whereby applicants should at the design phase of the process consider carefully whether the proposed development could be reconceived to avoid the use of SF6-reliant assets and where this is not possible, provide evidence of their reasoning on this point – including cost differences.

In addition to this, the DESNZ Clean Energy Industries Sector Plan (August 2025) identifies SF6 phase-out as a policy priority linked to both decarbonisation and industrial strategy. These represent policy signals and planning-level expectations rather than statutory prohibitions with fixed compliance dates.

Drivers behind the EU regulation and GB readiness to adapt

The EU's approach is supported by a detailed evidence base developed over several years. The Commission's 2022 impact assessment included results from a market readiness study in 2020, that assessed the commercial readiness of SF6-free MV solutions and noted advancing pilot deployments at HV, informing the voltage-differentiated timelines. See the table below for a summary of their assessment in 2020.

Table 9: Overview of availability

Voltage level	Assessment of alternative availability (as of 2020)
≤ 24kV	Commercial SF6-free alternatives were already available for certain applications. Technical characteristics (dimensions, technical life, reliability) were found to be identical to equivalent SF6 solutions from the same manufacturers. However, the full product range across all configurations would require 2 to 5 years to mature, and manufacturing capacity would need to scale. This informed the 2026 date, giving approximately 4 years from the 2022 proposal.
> 24kV to ≤ 52kV	More time (4 to 5 years) was judged necessary to satisfy the diversity of client needs, as the product portfolio would need to grow incrementally. For commercially available solutions, further time was needed to scale manufacturing capacity. This informed the later 2030 date.
52kV to 145kV	Pilot installations had been successfully implemented and operated. According to manufacturers, several hundred bays had been ordered. Implementation of different technology approaches was expected within the next 2 years (that is, by 2022). The report also noted that HV switchgear manufacturing was component-based and individually specified, allowing faster industrialisation than mass-market MV products. This informed the 2028 date.
> 145kV / > 50kA	SF6-free switchgear for 245kV and 420kV was still under active development, with scheduled development periods of 2 to 5 years depending on voltage and functionality. Manufacturers indicated a cost factor of up to 200% for alternative HV GIS being piloted compared to SF6, though learning curves were expected to reduce costs. This informed the latest date of 2032.

A further regulatory dimension is emerging through the European Chemicals Agency's (ECHA) proposed restriction on per- and polyfluoroalkyl substances (PFAS) under the EU REACH Regulation, which may affect fluoronitrile-based transitional alternatives independently of the F-gas Regulation. The restriction proposal covers more than 10,000 PFAS substances, including C4-FN gases used in some SF6-free switchgear, and a European Commission decision is anticipated in 2027. The current draft proposal suggests a complete ban on C4-FN in new products 6.5 years after the regulation enters into force, with shorter deadlines for equipment rated at 145kV and below.

GB's direction of travel is broadly consistent with the EU's objectives, though the regulatory framework is at an earlier stage of development. Defra's late-2025 F-gas consultation on HFCs indicated an intention to consider further SF6 regulation, but a formal UK government response and any legislative proposals have not yet been published. Manufacturers confirmed in interviews that they had assumed GB would follow the EU trajectory and have invested accordingly.

Approvals and standards

In GB, switchgear products cannot be deployed on distribution networks solely on the basis of IEC type test certification, as is the case in most European countries. Before a product is eligible for installation, it must also obtain a Notice of Conformity (NOC) from the ENA's SAP, which assesses compliance against ENA Technical Specification (ENATS) 41-36 for equipment rated at 36kV and below, or ENATS 41-37 for higher voltage classes. The SAP is composed of specialist engineers drawn from ENA member companies, principally the Distribution Network Operators (DNOs), and assessments are carried out by nominated groups under the process set out in ENA Technical Recommendation G79. In several areas, the ENATS requirements exceed the corresponding IEC standards; notably, the ENA's internal arc fault test mandates a one-second duration, compared with 200 milliseconds under IEC 62271. Once a product has received its NOC, individual DNOs may then apply their own additional assessment before approving the equipment for use on their specific network.

This layered approval structure means that, beyond IEC certification, additional GB-specific assessment and approval stages are required before products can be deployed on GB networks. The assessment process requires at least 2 DNO sponsors to put a product forward to the SAP, and panel scheduling depends on the availability of volunteer engineers with competing operational responsibilities. Timelines vary, but the case of GE Vernova's F35g 145kV SF6-free gas-insulated switchgear (GIS) is illustrative. The product was submitted for ENA assessment in 2018 and did not receive its NOC until October 2021, a period of approximately 3 years. While lower voltage products may clear the process more quickly, the structural overhead of the SAP assessment, followed by individual DNO policy team reviews, means that even a straightforward submission is likely to add a minimum of 6 to 12 months to a product's route to market, on top of any time already spent on IEC type testing and certification.

The impact of these approval timelines is felt most acutely at the 33kV voltage class. At 11kV (rated 12kV), SF6-free switchgear based on vacuum circuit breaker technology has been commercially available for many years, and a substantial range of products already holds NOCs and DNO approvals. At 33kV, however, SF6-free alternatives are a more recent development, and the number of products that have completed the full GB approval pathway remains limited. Original equipment manufacturers (OEMs) such as Nuventura and Eaton now offer IEC-certified SF6-free GIS at this voltage level, but these products must still clear the SAP process and subsequent DNO assessments before they can be installed on GB networks. Given that 33kV is the primary distribution voltage across much of England and Wales (and a voltage class experiencing significant demand growth from offshore wind connections, data

centres, and electrification infrastructure) the mismatch between the pace of product approval and the pace of deployment need represents a material constraint on GB's ability to transition away from SF6 in its distribution networks.

Economic and cost recovery uncertainty

The economic impacts (CAPEX and operating expenditure (OPEX)) of SF6-free alternatives vary according to voltage level, which are elaborated on in the paragraphs below.

The 11kV level is the most mature market for SF6-free switchgear. Multiple manufacturers offer commercially proven alternatives using clean air, dry air, solid insulation, and vacuum switching, and several GB DNOs have already approved 11kV SF6-free configurations. There is no reported premium for solid insulation or vacuum at this level, which are seen as well-established technologies. Gas-insulated alternatives (clean air, dry air) cluster around 15% to 30% CAPEX premium, with interview evidence suggesting this will narrow to 5% to 10% as production volumes scale. The CAPEX barrier at 11kV is therefore negligible for solid insulation and vacuum and modest for gas-insulated SF6-free alternatives.

At 33kV, the picture is materially more challenging. No manufacturer currently offers a commercially mature 36kV SF6-free secondary RMU (36kV being the nearest IEC standard to GB 33kV), with manufacturers estimating 18 to 24 months to commercial readiness, targeting the EU 2030 deadline. The CAPEX premium is driven by higher tank pressure requirements, different disconnecter designs, and more demanding internal arc testing. Manufacturer estimates ranged from 25% to 40% or more, with the premium varying by voltage, current, and fault level rating. Industry experts noted that new market entrants may exert downward pressure over time. Given the absence of a mature product, the indicative range of 25% to 40% should be treated as provisional.

DNO evidence provides the most specific cost data at 66kV to 132kV. One DNO reported CAPEX premiums of 76% to 91% for 132kV GIS using C4-FN-based gas mixtures, with clean air technologies more expensive still. Interview evidence placed transmission-level premiums broadly at 70% to 90%. Alternatives at this voltage level rely primarily on C4-FN-based gas mixtures, with clean air technology available up to 145kV. DNOs noted that natural origin gas technologies may require building extensions or new sites to accommodate larger equipment footprints, adding to the total installed cost.

Above 132kV, one DNO reported premiums of 74% to 202% for 275/400kV GIS using C4-FN-based gas mixtures, and approximately 90% for live tank breakers using natural origin gas.

Interview evidence indicated that 275kV is transitional, while at 400kV two mature SF6-free solutions exist and a third major OEM is preparing a clean-air design expected in the second half of 2026.

Table 10: CAPEX premiums for SF6-free switchgear by voltage level, based on manufacturer and DNO engagement

Voltage	CAPEX premium	Primary technologies	Maturity	Confidence
11kV	0% to 15% (solid/vacuum) 15% to 30% (clean/dry air)	Clean air, solid insulation, vacuum	High	Strong
33kV	25% to 40% (provisional)	Clean air, vacuum (no mature 36kV RMU)	Low	Moderate
66kV to 132kV	76% to 91%	Clean air, vacuum, C4-FN-based gas mixtures	Moderate	Strong
>132kV	74% to 202%	Clean air, vacuum, C4-FN-based gas mixtures	Transitional	Limited

OPEX uncertainty

Manufacturers present a broadly favourable OPEX picture. The consensus is that sealed-for-life products (whether SF6 or clean air) have equivalent OPEX, and that where gas handling is eliminated, SF6-free equipment offers a 15% to 20% OPEX reduction over a 25-year lifecycle. This advantage increases when end-of-life disposal costs are included, since clean air requires no gas recovery. Several manufacturers noted that newer SF6-free products include embedded internet of things (IoT) sensors for condition monitoring, and that some designs have been tested to a 40-year life with rated switching operations doubled from 5,000 to 10,000.

DNOs are more cautious. All respondents identified gas handling as the primary cost driver, citing the higher cost of SF6-free gas handling equipment (reported at up to 5 times the equivalent SF6 equipment), the complexity of working with gas mixtures rather than a single gas, and the safety precautions required for gases that can produce toxic by-products and/or at high pressure. For C4-FN-based gas mixtures specifically, one DNO estimated an OPEX premium of up to 20%. A further concern is that each variant of SF6-free apparatus uses a different gas ratio, requiring separate handling kits, cylinders, pipework, and personal protective equipment (PPE) for each variant. No GB facility currently exists for the disposal of C4/C5 gases, and limited continental capacity creates a logistical barrier. One DNO estimated an overall lifecycle cost increase of approximately 30% relative to SF6, though this was expected to reduce after 5 to 10 years as familiarity grows. A specific operational concern was raised about clean air leak detection, which requires spray application and a potential outage, unlike SF6 which can be detected by dedicated monitors.

At 11kV, the OPEX picture is most favourable. Solid insulation and vacuum involve no gas handling, and sealed-for-life clean air products eliminate routine gas management. The DNO concerns about gas handling complexity are largely inapplicable to gas-free technologies at this voltage.

At 33kV and above, the OPEX picture is more complex. Where C4-FN is required, the DNO evidence on gas handling costs, the absence of GB disposal infrastructure, and the proliferation of variant-specific procedures is material. Higher voltages face additional challenges related to thermal management and forced cooling. The net OPEX impact at these levels will depend on whether gas-free technologies can displace gas-based alternatives, and on the pace at which transitional costs are absorbed.

The divergence between manufacturer and DNO perspectives reflects a fundamental tension between the lifecycle benefits of the individual asset and the operational realities of the wider network. Manufacturers focus on the efficiency gains provided by IoT-driven predictive monitoring and the total elimination of SF6 recovery liabilities over a 40-year life. Conversely, DNOs are constrained by the operational reality of the implementation of transition, which requires the duplication of kit and competencies, the procurement of significantly more costly gas-handling equipment, and the management of unproven assets in their technological infancy. Ultimately, the manufacturer's optimistic Total Cost of Ownership is a vision of a mature future state, whereas the DNO's pessimism is a reflection of the early-stage industrialisation risks.

Table 11: Manufacturer and DNO perspectives on OPEX for SF6-free switchgear

Factor	Manufacturer view	DNO view
25-year OPEX	15% to 20% lower than SF6; equivalent for sealed-for-life units	Up to 20% higher (C4-FN-based gas); about 30% higher lifecycle cost initially, reducing over time
Gas handling	Eliminated for clean air. IoT monitoring reduces interventions	Main cost driver. Variant-specific kits. No GB C4/C5 disposal facility
End-of-life	Lower: No gas recovery for clean air; SF6 disposal costs rising	Uncertain: Continental export may be required for C4/C5

Limitations of RIIO-ED mechanisms for cost recovery

The regulatory framework under RIIO-ED2 lacks explicit financial incentives or dedicated funding mechanisms for the procurement of SF6-free switchgear, as Distribution Network Operator (DNO) capital allowances remain benchmarked against legacy SF6-insulated technology. While the TOTEX framework does not constitute a formal legal prohibition on SF6-free assets, it introduces a structural impediment to adoption. Because DNOs operate within fixed capital expenditure (CAPEX) limits, the price premium associated with SF6-free alternatives necessitates the displacement of funding originally designated for other critical

network infrastructure requirements. This inherent budgetary trade-off effectively reduces the total capital available for wider network reinforcements. Consequently, DNOs maintain that the transition to green technology is only financially viable if these incremental unit costs are fully integrated into regulatory capital allowances, ensuring that the adoption of environmentally superior technology does not result in a net reduction of investment capacity for the remainder of the network.

Deliverability constraints

Installation footprint

SF6-free switchgear is generally larger than its SF6 equivalent, but the scale of the increase is not uniform across voltage levels and is highly dependent on product type and configuration. Notably, vendors across the supply chain are actively designing SF6-free products to match or closely approximate the footprint of existing SF6 equipment, reflecting a deliberate commercial focus on enabling both new installations and asset replacement. At 11kV secondary distribution, where compact ring main units (RMUs) are standard, the footprint penalty is most pronounced with manufacturers reporting a volume increase of approximately 20% to 30% for SF6-free RMU replacements.

At 24kV to 33kV primary distribution, the picture is considerably more favourable. Multiple vendors report footprint increases in the range of 0% to 10%, with some claiming near-parity or no difference at all. Typical deltas include modest increases in panel width (for example, approximately 50mm on a 33kV panel) with height and depth remaining broadly similar. The relative size of different SF6-free alternatives also varies depending on the specific substation layout and electrical configuration, meaning no single technology is consistently the most compact option.

At 66kV and 132kV, SF6-free GIS deployment in GB largely leverages mature IEC-rated products (72.5kV and 145kV respectively), enabling access to established multi-vendor supply chains. Fluoronitrile-based blends (C4-FN with CO₂ or N₂) offer dielectric performance closer to SF6 and are expected to deliver smaller footprint penalties at these voltages than clean air alternatives, though project-specific data remains sparse.

Substation space and planning

For new-build substations, the footprint implications of SF6-free equipment must be factored into site selection and civil design from the outset. The practical significance of size increases depends on the context. At 11kV secondary level, where the percentage increase is largest, substations are numerous, distributed, and relatively small, so the absolute space impact per site may be manageable even where the proportional increase is notable. At 33kV primary level, the near-parity reported by vendors means that new substations can in most cases be designed around SF6-free equipment without significant additional land take. At higher voltages, where substations are fewer and more strategically significant, any footprint increase requires more careful spatial planning. In urban areas, where land availability is constrained and planning consent can be difficult to obtain, even modest increases in equipment

dimensions may limit site options or require design adjustments. DNOs are simultaneously facing pressure to accommodate load growth from the electrification of heat and transport, meaning that provision for switchgear competes with the need for additional transformer capacity, battery storage, or flexibility assets.

Workforce training and competency

The introduction of SF6-free switchgear into new installations creates new training requirements for DNO workforces. Fluoronitrile blends have distinct handling properties, including different decomposition by-products and temperature-dependent behaviour, that require updated safety protocols and gas handling procedures. Vacuum and clean air systems involve different maintenance philosophies, failure modes, and condition monitoring approaches compared to SF6 GIS. Staff accustomed to using SF6 gas density as a primary diagnostic indicator will need retraining on alternative methods. These demands arise in a labour market where experienced high-voltage engineers are already in short supply across the GB energy sector. For new installations, the training requirement is best addressed at the design and procurement stage, ensuring that operational teams are familiar with the selected technology before commissioning.

Mixed fleet management

Even where new installations adopt SF6-free technology, DNOs will operate mixed fleets for a prolonged transition period, likely spanning 15 to 25 years given typical asset lifecycles. This introduces operational complexity across spare parts and inventory management, maintenance scheduling and procedures, and gas inventory tracking and regulatory reporting. The vendor evidence that size impacts and technology characteristics vary between SF6-free alternatives, and are configuration-dependent, reinforces this challenge. DNOs may find themselves managing not just a split between SF6 and non-SF6 equipment, but a range of different SF6-free platforms with distinct operational requirements. At 11kV and 33kV, mixed fleets are already common, as vacuum and air-insulated units have coexisted with SF6 equipment for some time. At 66kV and 132kV, where SF6 GIS has been more dominant, the introduction of alternative technologies into the fleet represents a more substantive change. Procurement processes must also adapt to accommodate multiple OEM platforms with differing service and warranty arrangements.

Retrofit considerations

Retrofit of existing substations with SF6-free switchgear is generally feasible but conditional on site-specific factors rather than universally straightforward. Key variables include whether minimum internal arc clearances can be maintained within existing enclosures, whether cable entry positions are compatible or require reconfiguration, and the overall layout and spatial constraints of the site. Vendor experience to date indicates that some installations permit near direct replacement, while others require varying degrees of civil or electrical adjustment. Several manufacturers have designed their SF6-free product ranges explicitly with asset replacement in mind. Retrofit complexity increases at higher voltages, particularly at 33kV, at which level it needs high performance in compact footprint.

Model design and outputs

This chapter sets out the financial implications of transitioning to SF6-free switchgear across GB's electricity distribution network. By integrating the DESNZ Distribution Network Model with cost evidence gathered from manufacturers and network operators, the model provides a consistent framework for quantifying the incremental capital cost of SF6-free equipment and translating this into an indicative impact on the end-consumer.

The results demonstrate that while SF6-free switchgear is associated with higher upfront capital costs, particularly at higher voltage levels and in less mature segments such as 33kV, the overall impact on consumers is small when these costs are annualised and spread across the GB customer base. Even under conservative, worst-case assumptions, the estimated bill impact remains modest, reinforcing the conclusion that consumer affordability is unlikely to be a binding constraint on the transition. Instead, the model highlights that total system costs are driven primarily by asset volumes and voltage-level deployment patterns, rather than by unit cost differentials alone.

Introduction to the model

The model described in this chapter has been developed to realise the financial impacts of the transition to SF6-free equipment. It integrates the DESNZ Distribution Network Model (DNM) data with inputs gathered from relevant stakeholders to evaluate the financial implications of adopting SF6-free equipment on an individual solution basis. By grounding the assessment in real network data and stakeholder intelligence, the model provides a consistent and repeatable framework for comparing the cost of SF6-free equipment against conventional alternatives across the range of solutions under consideration. The model's outputs quantify the incremental cost impact of SF6-free equipment selection for each solution type and identify the extent to which any additional financial burden is passed through to the end consumer.

DNM model description

DESNZ's Distribution Networks Model (DNM) consists of various decarbonisation pathways, which analyse the flow of electric power and calculate reinforcement requirement projections based on future power demand, generation and flexibility scenarios, including heat pump and electric vehicle (EV) adoption. The model quantifies the scale, timing and network topology (rural, urban, Manweb and London) within which different solutions would be applied.

These 4 heat decarbonisation pathways are reviewed under both the baseline and low voltage (LV) network capacity cases within the DNM:

- Baseline Headroom case: assumes current LV network spare capacity remains constant, with reactive investment based on 5-year foresight
- Low Headroom case: tests the impact of having less spare capacity, which results in the need for earlier and more frequent infrastructure upgrades to accommodate demand

For the modelling conducted in this project, only the Baseline Headroom case is considered. This baseline scenario reflects a pathway where heat is electrified.

Model assumptions

Table 12: Model assumptions

Assumption	Description
DESNZ Distribution Network Model (DNM) data	The model assumes that the DESNZ DNM dataset accurately represents the network across the assessment period. Solution volumes derived from the DNM are taken as the basis for quantifying SF6-free equipment deployment across each solution type.
One switchgear for every transformer	The DESNZ DNM dataset is used to determine the volume of equipment requiring replacement across the assessment period. The total quantity and make-up of infrastructure required for each solution is required. This is achieved by linking each solution in the DNM to its corresponding component breakdown. The output of each solution is used to scale the associated assets (for example kilometres of cable, number of transformers, switchgear units), thereby establishing a consistent and comparable quantity baseline for further analysis. However, as the DNM does not explicitly state the quantity of switchgear required, the model assumes a one-to-one ratio between transformers and switchgear units for each solution type.
Scenario scope limited to the 'Baseline Headroom' category	This model assesses only the 'Baseline' category to provide a view of the current implementation requirements for switchgear
Incremental CAPEX	The cost differential between SF6-free and conventional SF6 equipment is the sole driver of incremental CAPEX, with no additional costs included. Unit cost assumptions from stakeholder engagement are: 33kV switchgear at £55,000 to £57,500 (SF6), with a 28% to 32.5% SF6-free premium (average 30%); and 11kV switchgear at £15,400 to £32,300 (SF6), with a 24% to 30% SF6-free premium (average 27%).
Annualisation of CAPEX	Incremental CAPEX is annualised using regulatory financial assumptions appropriate to the ED2 price control period. The model assumes these financial parameters remain constant across the assessment period.
DUoS revenue requirement	The model assumes that the full incremental annualised CAPEX is passed through to the distribution use of system (DUoS) revenue requirement, with no offsetting efficiencies or savings assumed elsewhere in the cost stack.

Assumption	Description
Consumer bill impact	The total DUoS revenue impact is allocated across customers by dividing it by the number of electricity meter points in Great Britain (32.2 million). This figure is taken from DESNZ, 'Smart Meters Statistics in Great Britain', quarterly report to end December 2025 (2025 data), Table 5c, and includes large and small suppliers, and both smart and non-smart meters.
Switchgear lifespan	The assumed lifespan for the switchgear required to calculate the annualised CAPEX is 40 years, consistent with Ofgem's ED2 methodology.
WACC is 3.9%	A weighted average cost of capital (WACC) of about 3.9% (CPIH-real, where CPIH is the Consumer Prices Index including owner occupiers' housing costs) is consistent with regulatory allowances set by Ofgem under the RII price controls, where the WACC for network operators typically falls in the range of about 3.7% to 4.0%. This reflects a cost of equity of about 4.5% to 4.75%, a low cost of debt, and about 60% notional gearing.

Model methodology

The model has been developed to assess the financial implications of transitioning to SF6-free switchgear on a solution-by-solution basis, drawing on inputs gathered from manufacturers and DNOs. The methodology progresses through a series of defined stages, each building on the outputs of the previous, to ultimately derive an estimate of the cost impact passed through to the end consumer.

Stage 1: Establishing cost benchmarks

The first stage of the model consolidates cost data gathered from manufacturers and DNOs to establish a set of cost benchmarks for switchgear at both 11kV and 33kV voltage levels. For each voltage level, best, worst, and average case unit costs are derived for both conventional SF6 and SF6-free equipment. In addition, the average percentage cost increase associated with SF6-free equipment relative to its SF6 equivalent is calculated at each voltage level. These benchmarks form the foundational inputs against which all subsequent analysis is conducted.

Stage 2: Extracting solution volumes from the DESNZ DNM

In the second stage, the DESNZ DNM dataset is expanded to identify the volume of switchgear required across each solution type. The DNM data is disaggregated by solution and voltage level, separating 11kV and 33kV requirements, to ensure that the appropriate cost benchmarks established in Stage 1 are subsequently applied to the correct equipment category. As the DNM does not explicitly state switchgear quantities, a one-to-one ratio between transformers and switchgear units is assumed for each solution type.

Stage 3: Applying cost benchmarks to DNM solutions

With solution volumes and voltage levels established, the cost benchmarks derived in Stage 1 are applied to each DNM solution. This produces 3 cost scenarios for every solution: best, worst, and average case, representing the range of potential incremental CAPEX associated with transitioning from SF6 to SF6-free equipment. This staged approach ensures that the cost impact can be assessed with transparency across the full range of market uncertainty, rather than relying on a single point estimate.

Step 4: Annualising the incremental CAPEX

To reflect how capital expenditure is treated within the regulatory framework, the total incremental CAPEX is converted into an annualised cost using the regulatory financial assumptions applicable to the ED2 price control period. This annualisation process applies the Weighted Average Cost of Capital (WACC) and asset life assumption of 40 years, converting the one-off capital cost into an annual equivalent that can be compared against revenue recovery mechanisms.

$$\text{Annual recovery} \approx \text{Depreciation} + (\text{WACC} \times \text{Extra cost})$$

Step 5: Estimating the increase in DUoS revenue requirement

The annual recovery derived in Step 4 is used to estimate the corresponding increase in the DUoS charges. DNOs typically recover asset costs through one of 2 mechanisms either directly from the connecting customer where expenditure is covered by specific connecting customer(s), or through Distribution Use of System (DUoS) charges where expenditure relates to general network reinforcement or replacement. For the purposes of this assessment, recovery via DUoS charges is assumed, reflecting the network-wide nature of the SF6-free transition. It is further assumed that the full incremental annualised cost is passed through to the DUoS revenue requirement, with no offsetting efficiencies or savings, providing a conservative estimate of the revenue uplift required.

Step 6: Deriving consumer bill impact

The estimated increase in annual DUoS revenue requirement is divided by the number of energy meters in GB (32.2 million) to derive a range of potential annual bill impacts per customer.¹² This produces a per-customer annual cost range for each DNM solution and cost scenario, providing an accessible and meaningful metric for stakeholder engagement and regulatory reporting. To account for the uncertainty inherent in both the cost benchmarks and the regulatory assumptions, the consumer bill impact is presented across the best, worst, and average cost scenarios derived in Step 3. This range of outcomes enables decision-makers to understand the full spectrum of potential financial impacts on consumers, from the most optimistic to the most challenging deployment scenario and supports a more informed and transparent assessment of the transition to SF6-free equipment.

¹² Number of energy meters in the UK. This figure is taken from DESNZ data: [‘Smart meters in Great Britain, quarterly update December 2025’](#)

Model results

Figure 1 shows that the most expensive DNM solution is TX-UGC-HV Urban HV Baseline. This outcome is primarily volume-driven: it requires the largest quantity of switchgear (577.6 units in the model), so even a modest SF6-free unit-cost premium translates into a materially higher total incremental cost than other solutions. The ‘urban HV’ context is also typically associated with more complex, space-constrained installations and higher specification requirements, which can further amplify cost sensitivity when alternative technology options are priced at the upper end of the range.

Across these solutions, the difference between the best-case and worst-case scenarios is on average 91.4%, indicating that results are sensitive to the assumed range of SF6-free procurement costs. This spread should be interpreted as an uncertainty band rather than a change in the underlying network need.

Finally, the distribution of outcomes is notably skewed: the 10 least-cost solutions each result in a lower incremental cost than the single most expensive solution. This highlights that a relatively small subset of high-volume solutions drives a disproportionate share of total cost exposure.

Figure 1: Cost implications of adopting SF6-free equipment for each solution

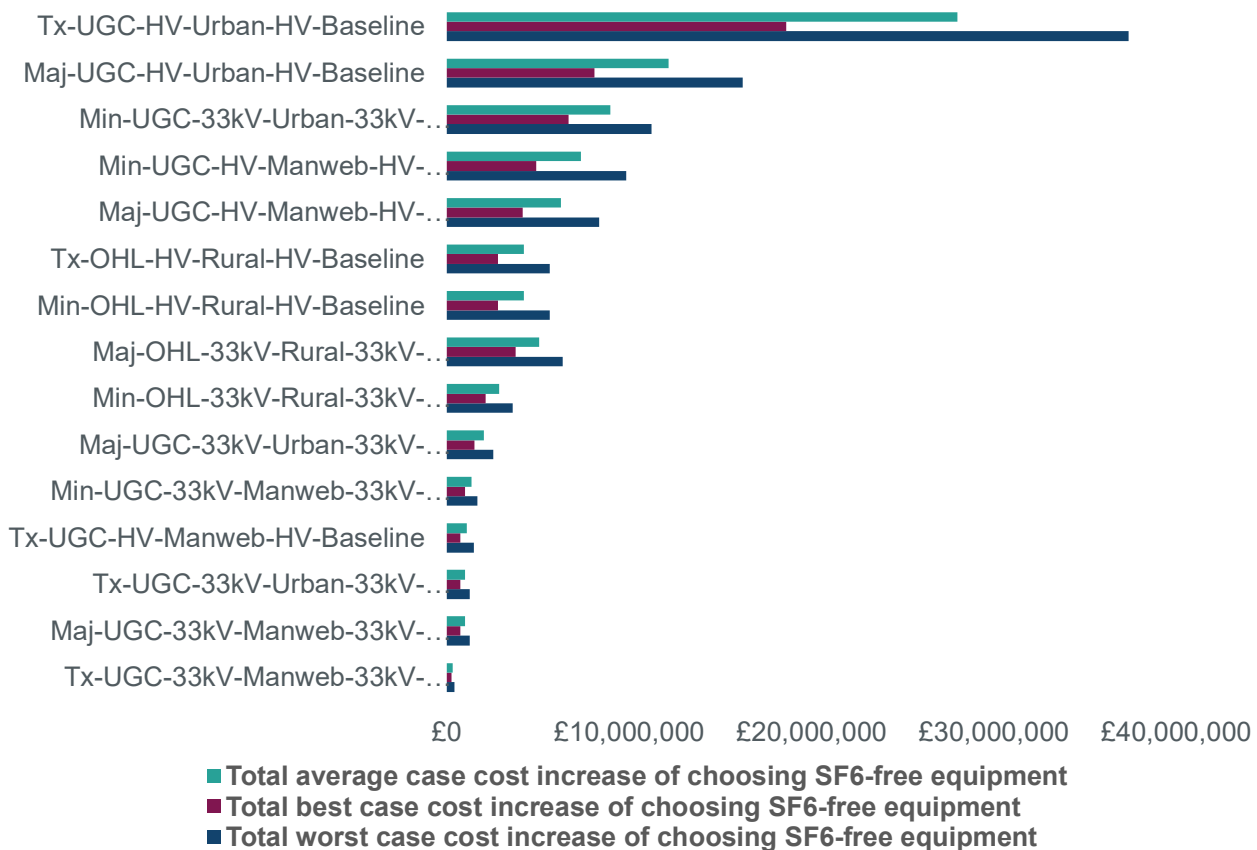


Figure 2 shows the total cost increase per voltage level. Based on the gathered data, the average SF6-free cost increase for 33kV Solutions is £2,717,863.83 lower than for 11kV Solutions. However, a single 33kV switchgear results in a 3% higher cost increase than an HV switchgear. The key driver is the volume effect. HV solutions require substantially more switchgear overall, on average, 229 units per HV solution, whereas the 33kV solutions require around 89 units. As a result, even where the percentage premium at 33kV is higher, the total incremental cost impact is dominated by the number of assets needing to be procured and installed at HV.

Figure 2: Difference in total cost increase for adopting SF6-free switchgear depending on DNM solution voltage

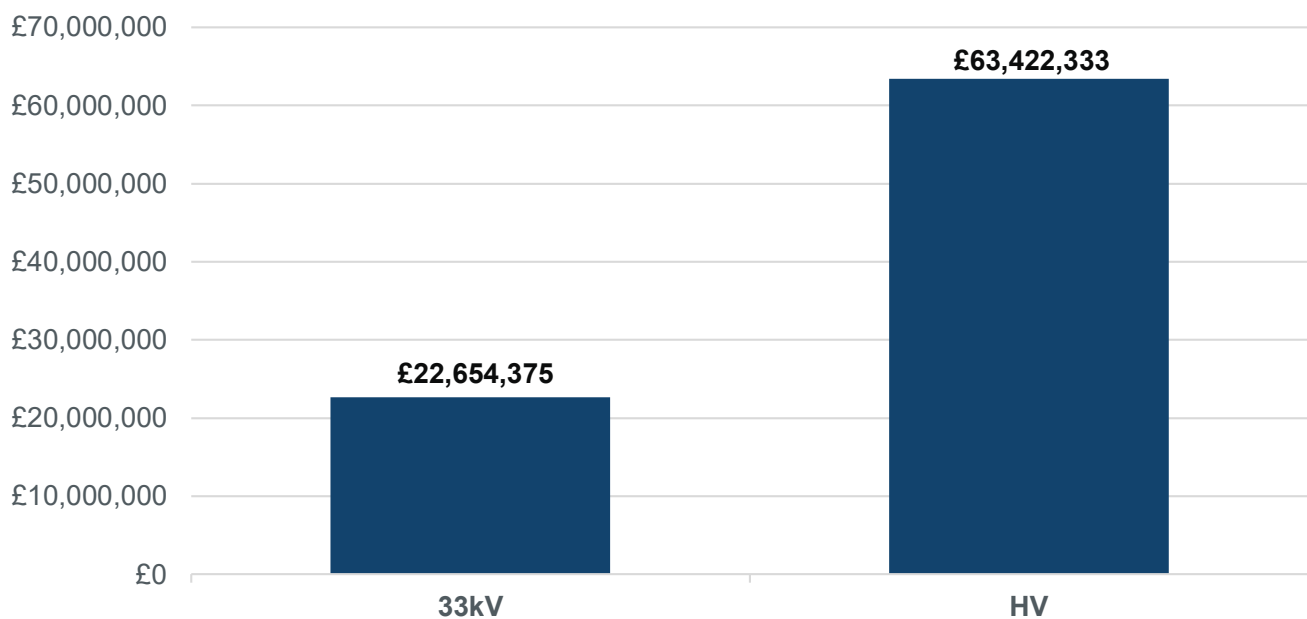


Figure 3 shows that on average, the Urban topology has the largest financial implications for adopting SF6-free switchgear. This is mainly volume-driven: Urban solutions require the highest number of switchgear units, so the same (or similar) SF6-free unit-cost premium adds up to a higher total cost. The model also shows a broadly similar split of 33kV and HV switchgear across topologies, so the higher urban cost is not due to a different voltage mix, but simply more assets being installed overall.

Figure 3: Difference in total cost increase for adopting SF6-free switchgear depending on DNM solution topology

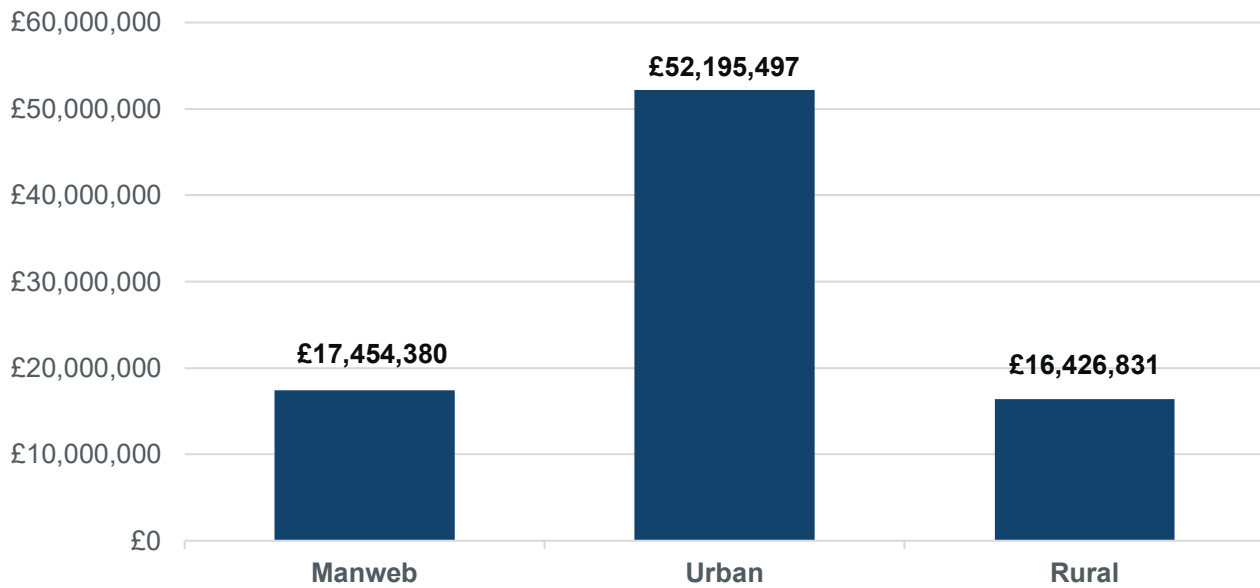
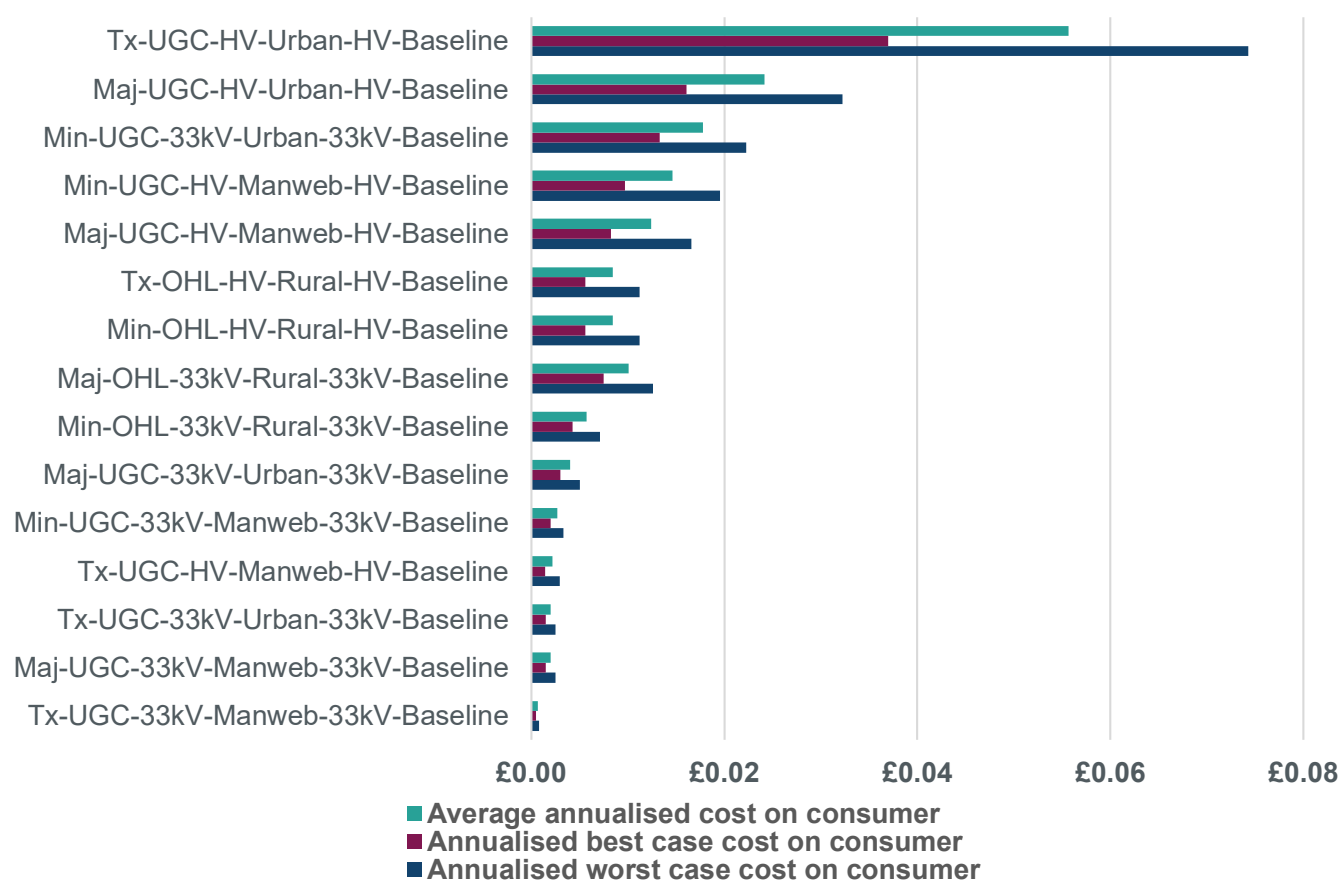


Figure 4 shows the estimated impact of choosing SF6-free switchgear for each DNM solution on end consumers (homes and businesses) through electricity bills. The main takeaway is that the bill impact is small: even if all DNM solutions adopt SF6-free switchgear and the worst-case cost assumptions apply, the average annual bill increase is around £0.22 per customer. This relatively low value is explained by the incremental cost being spread across a large customer base. In practice, this indicates that the consumer affordability impact is likely to be a secondary constraint compared to deliverability factors (for example, approvals, product availability at specific voltage classes, and programme capacity), with the main sensitivities driven by total switchgear volumes and the assumed SF6-free unit-cost premium rather than the pass-through mechanism itself. This estimate reflects only the incremental equipment cost of SF6-free switchgear versus SF6 switchgear and does not include any additional costs for removal or installation of existing SF6 equipment, nor potential differences in OPEX (for example, gas handling, training, spares, and end-of-life treatment), so it should be treated as a conservative, equipment-only view of bill impact. Additionally, this cost estimate covers new network expansion or load related expenditure only, not the replacement of existing assets.

Figure 4: Cost implications on the end consumer of adopting SF6-free equipment for each solution



Conclusion

The model has shown how the incremental capital cost of adopting SF6-free switchgear can be estimated by combining the DESNZ DNM data with stakeholder cost evidence. The model calculates incremental CAPEX by solution type and voltage level and then converts this into an indicative consumer impact by annualising costs and assuming recovery through DUoS. Overall, the results show that total incremental cost is driven mainly by the volume of switchgear required in each solution, while the spread between best- and worst-case outcomes is driven by uncertainty in procurement costs.

Even under conservative assumptions, the estimated bill impact remains modest when spread across the GB customer base. This suggests that consumer affordability is unlikely to be the binding constraint for a transition in new equipment. Instead, the key challenges relate to deliverability and financeability, ensuring timely approvals and sufficient supplier capacity in constrained segments (notably 33kV), and providing a credible and predictable route for efficient cost recovery within the regulatory framework.

The modelling is limited to equipment costs and focuses on network expansion. It therefore excludes installation and commissioning constraints, outage planning, training, tools, spares and new procedures, gas handling and disposal, end-of-life treatment, and potential differences in operating expenditure (OPEX). There is also significant uncertainty in the level of headroom available in the LV network. If the headroom is lower than assumed, additional network reinforcement would be required, increasing the overall costs of adopting SF6-free equipment. These factors should be considered alongside the results when designing and sequencing a GB phase-out approach.

Identified barriers and mitigation measures

This chapter provides an overview of the key barriers affecting GB's transition away from SF6-based electrical equipment. The barriers have been identified through literature review and structured interviews with network operators, manufacturers, regulators, and other sector stakeholders. Together, they illustrate the technical, regulatory, financial, and operational challenges that shape the feasibility and pace of a national SF6 phaseout.

To support effective decision making, each barrier is presented with a description of its underlying drivers, its expected impact on the transition timeline, and the potential measures that can mitigate its impact.

The barriers are ranked according to their relative significance and their expected effect on GB's ability to deliver a timely, secure, and cost efficient phaseout pathway.

Table 13: Overview of identified barriers

Number	Barrier	Significance
1	Lack of regulatory clarity for a SF6 phase-out in GB creates uncertainty among market actors and delays investment in (GB-ready) alternatives from manufacturers	High
2	The current finance framework (RIIO ED, applicable to distribution networks) delays investment decisions in SF6-free technology	High
3	GB-specific requirements and industry standards are limiting product offerings (and potentially affecting costs and lead time)	Medium
4	Lack of a clear stance on transition technologies	Medium
5	Like-for-like replacement of retired SF6 equipment with SF6-free options often requires site-specific adaptations	Medium
6	Existing plans for grid expansion and grid connection of projects put pressure on resources and priorities hence affecting SF6 timelines	Low
7	Low operational maturity of implementing new technologies like SF6-free switchgear potentially creates higher OPEX	Low

1) Lack of regulatory clarity for a SF6 phase-out

The UK has no binding, statutory SF6 phaseout dates for GB electricity networks or a unified regulatory roadmap. While voluntary industry commitments and incentives exist, they are still limited and lack long-term visibility. Market actors, for example, DNOs and manufacturers therefore face uncertainty about what technologies to invest in, what standards will apply, and when future compliance obligations will take effect in GB.

In addition, switchgear assets typically operate for several decades, which means that decisions to continue the installation of SF6-containing equipment lock in SF6 dependency well beyond 2050. Continued installation of SF6-based technology commits DNOs to ongoing access to SF6 gas, specialist handling services, spare parts, and manufacturer-specific expertise over several decades. As European demand for SF6 declines, the overall market for SF6 equipment will likely change. For GB operators, this potentially means a shrinking pool of SF6 suppliers, reduced competition, and growing reliance on international supply chains outside Europe, potentially including higher-risk or non-preferred trading countries. This increases future exposure to supply disruption, price volatility, and geopolitical risk, and may leave DNOs dependent on suppliers or regions they would otherwise seek to avoid.

Potential impact

- manufacturers deprioritise the GB market, focusing instead on regions (for example, EU) with clear timelines, resulting in a lack of GB-ready SF6-free alternatives or continued premiums for these
- DNOs postpone or minimise investment in SF6-free technologies
- slower diffusion of innovation and reduced competition in GB supply chain
- can increase long-term supply chain dependency and procurement risk if critical SF6 components or services need to be sourced from suppliers outside Europe

Potential measure

Identified measure	What needs to be done	Effect on transition	Time to impact
Set a national phase-out schedule aligned with EU timelines but tailored to GB needs	Initiate regulatory process, including consulting key stakeholders to implement unified policy signal (and potential exemptions) giving DNOs/manufacturers certainty on deadlines, clarity for technology readiness, and procurement planning.	High	Medium
Introduce mandatory transition milestones (for example, bans by voltage class)	Ensure structured transition (MV first, HV later) and publish binding backstop dates per voltage level.	High	Medium
Provide a clear regulatory governance structure with periodic reviews	Establish a 'review board' to build credibility and adaptability into the transition by reviewing progress regularly and adjust parameters as needed.	Medium	Short

2) Finance framework (RIIO-ED) delays investment decisions

The current RIIO-ED framework, applicable to DNOs, is built around a TOTEX approach and efficiency incentives that prioritise delivery of core outputs at least cost. In practice, this can discourage early adoption of SF6-free switchgear where the upfront cost premium is higher and whole life benefits (for example, avoided emissions, reduced SF6 handling) are not consistently monetised or rewarded in allowances and incentives.

With increasing pressure on network investment programmes (including grid connections and reinforcement), DNOs face a trade-off within fixed regulatory allowances. In this context, higher-cost SF6-free equipment directly competes with 'must-deliver' network projects, meaning that adoption of newer, more expensive technologies displaces other regulated investment. The need for explicit unit-cost uplift or allowance adjustments for SF6-free equipment has been raised consistently by all DNOs.

As a result, DNOs typically do not invest in more expensive SF6-free alternatives and manufacturers do not see the demand for GB-specific SF6-free products.

Potential impact

- DNOs default to lower-cost SF6 solutions to remain cost-efficient within the regulatory framework
- lower investment confidence slows down market scaling and industrialisation
- risk of 'wait-and-see' behaviour across the entire sector

Potential measure

Identified measure	What needs to be done	Effect on transition	Time to impact
Introduce financial incentives and dedicated allowances for SF6-free procurement and pilot projects	Co-design with Ofgem and DNOs; provide cost recovery and ring-fenced allowances for SF6-free options, potentially as trials and whole volume procurement (including data reporting and learning requirements) so early movers are not penalised for higher upfront costs.	High	Medium
Allow DNOs to direct TOTEX underspend towards SF6-free procurement	Provide clear regulatory guidance confirming that DNOs may use TOTEX underspend to finance the incremental cost difference between SF6 and SF6-free alternatives.	Medium	Short

3) GB-specific requirements and industry standards

Although SF6-free technologies are increasingly mature and widely available at lower voltage levels (for example, 11kV and 24kV), GB distribution networks rely heavily on 33/36kV switchgear, which is a niche voltage class compared to EU. Many EU and international manufacturers therefore scale SF6-free product platforms around 24kV because this segment has far larger global demand. The resulting mismatch means fewer qualified 33/36kV SF6-free models are available to GB buyers, with longer development, testing/approval and delivery lead times (and, in some cases, weaker spares and service support due to low production volumes).

In addition, GB-specific approval requirements (ENA, ENATS, SAP) differ to international IEC certifications. This potentially leads to duplicated testing, documentation demands, and extended approval timelines.

Potential impact

- products available and proven in the EU may not be deployable in GB
- manufacturers prioritise larger markets, and face higher market entry costs, delaying GB-specific development
- DNOs experience procurement bottlenecks due to lack of available options and single supplier dependency

Potential measure

Identified measure	What needs to be done	Effect on transition	Time to impact
Policy certainty for DNOs to commit to long-term framework agreements and higher industry order volumes	Signal expected volumes and timelines for SF6-free procurement at a national or sector level to give manufacturers confidence to scale production and expand supply capacity	High	Medium

4) Lack of a clear stance on transition technologies

While SF6 free alternatives are increasingly available, particularly at higher voltages, many rely on fluorinated gas mixtures that may themselves face future regulatory restrictions. The absence of a clear GB policy position on whether such technologies are acceptable as transitional solutions creates uncertainty for manufacturers, DNOs and TOs when making long-lived investment decisions.

Potential impact

- risk of over-investment in transitional technologies that may face future restrictions or early retirement
- hesitation or delay in procurement decisions
- risk of fragmented technology pathways, increasing mixed-fleet complexity and OPEX over time

Potential measure

Identified measure	What needs to be done	Effect on transition	Time to impact
Acceptance of transitional technologies	Define criteria for when transitional gas-based technologies are acceptable (for example by voltage level, time-bound use, or where no gas-free alternative exists).	Medium	Medium
Alignment of SF6 and PFAS policies	Align SF6 phase-out policy with emerging PFAS policy to provide a credible long-term signal to the market.	Medium	Medium

5) Like-for-like replacement of retired SF6 equipment

Like-for-like replacement of retired out-of-life SF6 equipment with SF6-free options is not always straightforward, particularly at constrained sites.

Differences in implementation largely relate to footprint and site conditions when out-of-life SF6 equipment is replaced. In some space-constrained indoor substations, SF6-free replacements may require a larger footprint or modest civil modifications, while in other cases replacement should be feasible. In addition, SF6-free designs may face practical constraints (for example around heat dissipation), which can limit like-for-like replacement options depending on manufacturer and configuration.

In outdoor or less constrained sites, replacement is often simpler, provided existing layouts, earthing, protection interfaces and outage requirements can be accommodated. In practice, technical feasibility is rarely the primary issue, often poorly performing or unreliable assets tend to be the main candidates for intervention.

Where space constraints, foundation changes, or wider site modifications would make a like-for-like retrofit disproportionately complex or costly, a more effective solution may be to construct a new substation. In such cases, this approach can deliver broader system benefits without materially impacting customers.

Potential impact

- leads to unbalanced needs and challenges across DNOs
- requires bespoke engineering solutions, increasing project durations
- national transition pace is limited by the slowest or most complex regional cases

Potential measure

Identified measure	What needs to be done	Effect on transition	Time to impact
SF6-free by default 'buy-first' with defined exceptions	Make SF6-free the procurement default for new and replacement switchgear in regulated networks, however allow for other options when no compliant SF6-free option is available within defined constraints (for example, footprint, outage window, safety, required ratings, delivery time and so on) like EU practice.	High	Medium
National demand aggregation and forward volume signalling (led by market actors)	Facilitate DNOs to publish a joint forward view of expected 33/36kV volumes and indicative delivery windows and use joint frameworks to give manufacturers confidence to allocate production capacity and spares support for GB-relevant variants.	Medium	Medium
Build transparency around derogations	Require annual reporting of total SF6 purchases (by voltage level)	Low	Short

6) Grid expansion and connection workload reduces transition capacity

GB faces an increase in demand for network growth, driven by for example grid reinforcements and connection of renewable projects. Delivering this growth while simultaneously reducing SF6 emissions places additional pressure on system access, engineering, installation and project management capacity.

In addition, avoiding SF6-containing infrastructure depends according to manufacturers on a swift and well-managed adoption of SF6-free technologies, supported by regulatory and legislative certainty and early, credible demand signals to manufacturers.

Potential impact

- SF6 phaseout competes with legally binding connection targets and net-zero delivery
- risk that SF6-containing assets continue to be installed because they are quicker and easier to deploy
- bottlenecks in labour, design engineers, and construction resources slow down planned replacements

Potential measure

Identified measure	What needs to be done	Effect on transition	Time to impact
Longer term integrated investment planning	DESNZ should (in coordination with Ofgem) ensure that SF6 reduction objectives are explicitly integrated into long-term network investment planning frameworks, rather than treated as a parallel or secondary objective. This requires clear policy sequencing on when SF6-free solutions should become the default by voltage level, coordination with Ofgem to ensure price control mechanisms do not force trade-offs between network delivery and SF6-free adoption, and alignment of delivery expectations so connection targets and decarbonisation objectives do not conflict.	Medium	Medium

7) Low operational maturity of SF6-free technologies

DNOs still have limited data foundation and hands-on experience with the operation, maintenance and failure modes of SF6-free alternatives.

During the transition, the operational challenge is compounded by the need to run a mixed fleet in parallel. Legacy SF6 assets remain in service for decades while multiple SF6-free technology families are introduced across sites and voltage levels. This increases complexity in day-to-day operations, as procedures, training and authorisations must cover different maintenance regimes, gas handling requirements (where relevant), condition monitoring approaches and troubleshooting methods. It also affects logistics and resilience, since DNOs and contractors may need different tools and test equipment, larger and more fragmented spares holdings (with less interchangeability), and clear decision trees for faults and emergency repairs when experience is limited. Until a sufficiently large SF6-free installed base is established and reliability data accumulates, operating both SF6 and SF6-free equipment can therefore increase cost, extend restoration times in some cases, and raise perceived operational risk.

Potential impact

- higher operating costs for DNOs early in the transition operating different technologies and equipment (training, new tools, safety processes)
- increased perceived technology risk may limit adoption
- inconsistent operational capability across DNOs can lead to uneven rollout

Potential measure

Identified measure	What needs to be done	Effect on transition	Time to impact
Align public and regulatory guidance where it reduces operational friction	Where alternative gases or new designs introduce uncertainty, provide clear cross-government guidance on handling, end of life, and compliance expectations.	Low	Short
Joint SF6 collaboration across TOs and DNOs.	Facilitate/sponsor multi-DNO national demonstration sites and structured knowledge-sharing forums to collect and mature standard operating/maintenance guidance	Low	Short
In depth assessment of OPEX changes for the different technologies	Define OPEX cost categories per technology and voltage level and develop an asset-life cost framework	Low	Short

Recommendations for a phase-out timeline

This chapter sets out recommendations for DESNZ on how to support a transition away from SF6 in new electrical switchgear in GB electricity networks. The recommendations have been developed from the evidence presented in this report, including the assessment of maturity by voltage level, the comparison between GB and EU regulatory contexts, the discussion of approvals and standards, the evidence on capital and operating costs, the deliverability assessment, the modelled consumer bill impacts, and the case studies.

Principles for an effective GB phase-out approach

An effective GB phase-out framework should follow 5 design principles:

1) Differentiate voltage levels and application

The evidence points to relatively mature SF6-free options at 11kV and in parts of the 66 to 145kV range, but more limited maturity and approval depth at 33kV secondary distribution, at certain 33kV primary configurations, and at the highest transmission voltages. A uniform deadline across all segments would therefore risk either being unnecessarily slow in mature areas or undeliverable in less mature ones.

2) Prioritise system security and deliverability alongside environmental objectives

Stakeholder engagement indicated that TOs, DNOs, manufacturers, and industry bodies are already actively progressing trial deployments, product development, and operational experience with SF6-free technologies within the GB context. The report nevertheless finds that the pace and scale of broader deployment continue to be shaped by factors including product availability, GB approval processes, delivery lead times, site-specific constraints, and the regulatory treatment of higher upfront costs. Policy design should therefore avoid creating incentives that would compromise network delivery programmes or force adoption where suitable equipment is not yet approved or available in sufficient quantity.

3) Provide policy certainty while retaining flexibility

The comparison with the EU indicates that clear forward signals can accelerate manufacturer investment and support portfolio development. At the same time, the report also shows that GB network characteristics, especially the importance of 33kV equipment and the remaining 275kV, justify some adaptation rather than simple replication of the EU timetable.

4) Treat affordability for consumers and financeability as distinct issues

The consumer bill impact modelling suggests that the incremental equipment cost of SF6-free switchgear, when spread across consumers, is likely to be modest in the modelled scenarios. However, that does not remove the financing barrier faced by DNOs and, to a lesser extent, the different incentive structure applying to transmission. Regulatory treatment of cost

recovery, budget allowances and evidence requirements remains material to deployment behaviour even where aggregate consumer impacts are limited. This is likely to require continued involvement from Ofgem and consideration of SF6-free deployment costs within future ED3 and ET3 regulatory frameworks.

5) Avoid market lock in to a narrow set of solutions

At higher voltages, some currently available alternatives rely on fluorinated gas mixtures that appear to be a practical route to near-term deployment but may face future uncertainty if PFAS restrictions tighten. The report does not support delaying action until all such uncertainty is resolved, but it does support designing the transition in a way that preserves optionality and avoids unnecessary dependence on a single technological pathway.

Recommendations for DESNZ

Establish a phased statutory framework for new equipment, differentiated by market segment

DESNZ should continue to work with Defra (with regulatory responsibility for F-gas legislation) to bring forward a statutory phase-out framework for the use of SF6 in new switchgear installations, with differentiated requirements by voltage level and by the maturity of available solutions.

The evidence supports earlier action in market segments where the technology is already commercially mature or close to mature, particularly at 11kV and for parts of the 66 to 145kV range. In contrast, greater caution is warranted for 33kV secondary distribution, certain 33kV primary configurations still requiring GB-specific approvals, and the highest voltage classes where supply chain strain and technology uncertainty remain more significant.

The main value of a statutory framework would be to replace the present policy ambiguity with a clearer investment signal for manufacturers, network operators and other relevant market actors. The current GB position, which relies largely on retained F-gas rules and RIIO-based incentives rather than binding installation restrictions, does not provide enough incentive for a phase out of SF6 equipment and is unclear on how this is expected to happen. A phased framework would be expected to improve procurement planning and reduce the risk that GB remains a secondary market for GB-specific product variants.

The framework should apply to new installations and material new procurements rather than to the existing installed base and existing procurement contracts. The evidence does not support recommending systematic early replacement of operational assets, however, include limited and clearly defined exceptions where compliant alternatives are not yet available for a specific application.

In designing the framework, DESNZ should also consider PFAS uncertainty. Aligning with the EU's anticipated 2027 decision on PFAS restrictions would reduce regulatory risk for both operators and policymakers. In the interim, fluoronitrile-based alternatives should be recognised as transitional technologies, with their long-term role in the GB phase-out framework remaining subject to review as the regulatory and market picture develops.

Align with the EU where the evidence indicates practical benefits, but retain GB-specific adjustments where justified

For DESNZ and Defra to establish a GB specific phase-out timeline, the EU trajectory should be used as the reference point for policy design, while making targeted GB-specific adjustments where the evidence indicates that the structure of the British network or the state of product readiness differs materially from the continental market. Alignment appears most feasible for lower-voltage segments and for parts of the higher-voltage market where internationally standardised products are already available or expected to become available on broadly similar timescales. Alignment would reduce the risk that GB buyers face thinner supplier competition or delayed access to EU-driven product development and would support supply-chain alignment by anchoring GB demand to larger, standardised European production and logistics flows.

However, GB should not assume equal readiness across all segments. The strongest case for adjustment concerns 33kV, especially secondary distribution equipment, because this segment is both especially important to GB and less developed than the 24kV class that has driven much of the EU product response. A second case concerns 275kV, which is a niche GB voltage with no dedicated European SF6-free product class and where the immediate pathway may involve use of 400kV-rated equipment at materially higher cost. In these areas flexibility should be retained to set later backstop dates or narrower initial scope while requiring regular review.

Work with Ofgem to confirm a credible route for cost recovery and efficient early procurement

DESNZ should work jointly with Ofgem to confirm how efficient additional costs associated with compliant SF6-free procurement will be treated within the regulatory framework. While RIIO-ET3 has introduced mechanisms that begin to address this for transmission operators, the position for distribution remains unresolved. Capital allowances for DNOs remain anchored to legacy equipment costs and operators face competing demands on finite network budgets. The modelled bill impacts suggest that affordability at the whole-system level is unlikely to be the primary constraint, but this does not remove the need for an investable mechanism at company level.

The immediate priority should be to ensure that the transition to SF6-free equipment in new installations does not depend solely on ad hoc business cases. DESNZ should therefore support the development of an approach under which efficient additional expenditure on eligible SF6-free assets can be recognised transparently in price control decisions or relevant reopeners. This is likely to be most important in distribution, where the current incentives are

weaker than in transmission. Any such mechanism should be limited to new assets within the scope of the phase-out pathway and should avoid encouraging premature replacement of serviceable equipment.

The evidence on operating expenditure is mixed and does not justify strong assumptions in either direction across all technologies. DESNZ should therefore ask Ofgem to develop a more robust evidence base on operating and end-of-life costs by technology type and voltage level. This would improve future regulatory decisions and reduce the risk that unsupported assumptions about OPEX either delay deployment or lead to over-compensation.

Reduce approval bottlenecks by reforming the route from international certification to GB deployment

DESNZ should convene ENA, network operators, manufacturers and Ofgem to assess whether the current GB approval pathway for SF6-free switchgear is proportionate to the risks it is intended to manage, or whether aspects of the process may be unnecessarily complex or acting as a barrier to manufacturers and deployment. In particular, this assessment should consider whether the sequencing of IEC certification, the ENA Notice of Conformity process, and subsequent operator-level approvals contributes to avoidable delays to market entry at 33kV and other segments, and whether this may be slowing the transition to SF6-free equipment more broadly. The evidence suggests that deployment timelines for SF6-free technologies at higher voltage levels remain influenced by the maturity and availability of fully type-tested products across all required configurations and ratings, particularly within the GB operational context. While several SF6-free technologies are already progressing through deployment and approval pathways, broader market readiness continues to depend on the expansion of approved product portfolios and operational experience across different applications.

The aim should not be to remove GB-specific technical requirements where they are justified for network safety or operability. Rather, it should be to identify where the present process creates avoidable duplication, unnecessary sequencing or insufficient resourcing.

This recommendation applies most strongly to distribution and especially to 33kV, where the report identifies a combination of limited approved variants and rising network demand. The main trade-off is that faster approval should not come at the expense of confidence in operational performance. For that reason, any reform should be paired with stronger post-installation learning and shared performance reporting.

Support market readiness through coordinated demand signalling and transparency on gaps

DESNZ should work with ENA, DNOs, TOs and manufacturers to improve visibility of likely future demand for SF6-free switchgear by voltage level and application. Suppliers respond most strongly where there is clear, durable demand backed by regulation or credible procurement pipelines. In GB, fragmented visibility of future requirements risks reinforcing limited product variety, especially in 33kV applications and in segments where GB-specific variants are needed.

A practical step would be to establish a structured market-readiness forum, through which operators can share forward views of expected procurement needs and manufacturers can identify where approval, testing or component availability is likely to constrain supply. Such a forum should not attempt to direct commercial choices, but it could reduce information failures and help identify where UK government or regulatory action is justified. Output could include a periodic demand forecast by voltage class, a shared pipeline of planned procurements, and/or a register of known supply constraints. The report also supports greater transparency on where compliant alternatives are genuinely unavailable, so that any exceptions to phase-out requirements can be evidenced rather than assumed.

This recommendation is relevant across distribution and transmission, but the rationale differs by segment. At lower voltages the issue is breadth of approved product availability, while at 400kV the evidence points more to lead times and supply chain strain than to complete technological absence. In both cases, the policy objective is to reduce avoidable delay without hard-wiring the system to one supplier or one transitional gas solution.

Sequence implementation so that mature segments move first and constrained segments are reviewed against explicit readiness tests

DESNZ should set out an implementation approach in which the earliest requirements apply where the evidence base is strongest, while later decisions for constrained segments are linked to explicit readiness tests. The report provides a basis for this sequencing. It indicates that 11kV primary switchgear SF6-free applications at this voltage level is the most mature area for broad deployment in GB networks, that 33kV requires a more cautious approach because product diversity and approvals remain constrained, and that higher voltages divide between relatively mature 66 to 145kV solutions and more uncertain pathways for 275kV and some 400kV applications.

The sequencing should therefore distinguish between market segments that are ready for policy certainty now and those where the better course is to state direction, define evidence requirements and review against objective milestones. Readiness tests could include the number of approved suppliers, evidence of successful deployment in relevant applications, delivery lead times, and the status of cost recovery and operational guidance. This would give DESNZ a more defensible basis for finalising backstop dates and reduce the risk of either locking in delays or creating obligations that cannot be met in practice.

Clarify governance roles across DESNZ, Defra, Ofgem, ENA and industry

DESNZ should define a clearer governance structure for the transition, including how responsibilities will be shared across UK government, regulators, industry bodies and network operators. The report shows that barriers are not confined to a single institution. Where regulatory responsibility for F-gas legislation and related environmental policy, including PFAS restrictions and associated training and certification requirements, sits with Defra. Cost recovery and incentives fall largely within Ofgem's remit. Approvals and technical acceptance involve ENA and network operators. Manufacturers control product development and supply capacity.

Without a more explicit governance arrangement, there is a risk that each part of the system will wait on another. DESNZ should therefore establish a formal cross-institution working structure with a limited remit: to monitor readiness by voltage level, coordinate policy and regulatory changes, and review evidence on exceptions and technology risks. This would not replace existing institutional responsibilities, but it would provide a focal point for implementation and reduce the risk of misalignment between statutory requirements, approvals and price control treatment.

Indicative sequencing

The evidence in the report supports a sequenced approach rather than a single uniform transition date. A high priority should be to establish the policy framework itself including a clear statement of scope, the intended application to new equipment only, the broad direction of travel by voltage level, and the governance arrangements needed to support implementation. In parallel, DESNZ should initiate work with Ofgem and ENA on the 2 enabling conditions that appear most material in the evidence being treatment of efficient additional costs and reform of the approval pathway.

The next phase should focus on segments where there is existing strong readiness. That means creating early certainty for 11kV and for those higher-voltage applications where products are already commercially available. During this phase, DESNZ should also require structured evidence gathering on 33kV, on constrained transmission applications, and on the operational and disposal implications of different alternative gases.

A later phase should address the more constrained segments once evidence shows that product diversity, approvals and supply conditions are sufficient. For 33kV, this is likely to depend less on fundamental invention than on GB-specific approvals and a broader set of approved configurations. For 275kV and some of the highest-voltage applications, the need for additional time is more likely to reflect a combination of niche market characteristics, supply chain strain and uncertainty over the long-term role of certain transitional gases. The sequencing should therefore be dynamic rather than fixed in all respects, but it should still be anchored in announced review points so that uncertainty does not become open-ended delay.

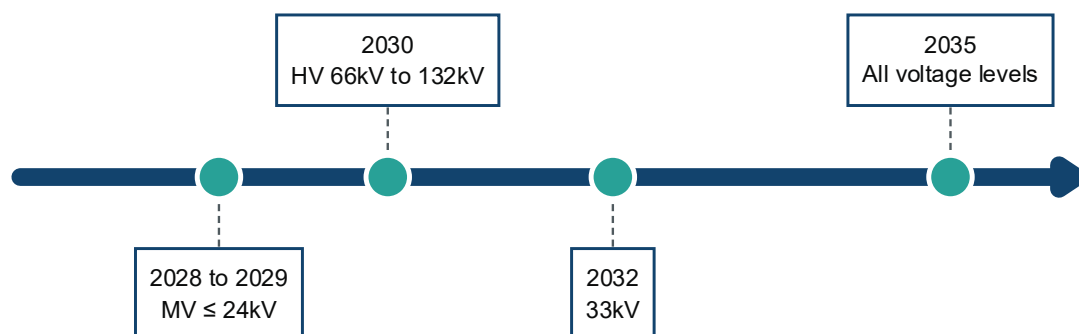
An indicative phase-out timeline for GB has been developed that sets out the earliest plausible points at which SF6 could be phased out in new switchgear by voltage level, based on the report's maturity assessment and implemented EU trajectory.

Table 14: Indicative SF6 phase-out timeline – EU vs GB

Date	EU voltage / rating	GB voltage / rating	Note
1 January 2026	MV ≤ 24kV (primary and secondary distribution)	-	N/A

Date	EU voltage / rating	GB voltage / rating	Note
1 January 2028	HV 52kV to 145kV, $\leq 50\text{kA}$ short-circuit current	MV $\leq 24\text{kV}$ (primary and secondary distribution)	Dependent on the regulatory process and ability to implement a phased timeline for GB.
1 January 2030	MV $> 24\text{kV}$ to $\leq 52\text{kV}$ (primary and secondary distribution)	HV 66kV to 132kV (EU equivalent of HV 52kV to 145kV)	Alignment with the EU's January 2028 date for 52kV to 145kV should be considered given the maturity of SF6-free solutions at these voltages. The GB product approval process (ENA SAP) may require additional lead time.
1 January 2032	HV $> 145\text{kV}$ or $> 50\text{kA}$ short-circuit current	MV $> 24\text{kV}$ to $\leq 52\text{kV}$	The GB product approval process (ENA SAP) may require additional lead time.
1 January 2035	All voltage levels (servicing)	All voltage levels, including HV $> 132\text{kV}$ (and servicing)	Including use of newly produced (non-reclaimed, non-recycled) SF6 for maintenance or servicing of any existing electrical switchgear. The GB product approval process (ENA SAP) may require additional lead time.

Figure 5: Indicative GB phase-out roadmap



Limitations and areas where further evidence would be useful

Several issues remain insufficiently resolved for DESNZ to fix detailed deadlines across all segments without further work.

1. The evidence base is stronger for medium-voltage distribution than for some parts of the high-voltage and transmission market. That does not prevent action, but it does support greater caution when setting detailed requirements for the highest voltage classes.
2. The cost evidence is more robust for incremental capital costs than for operating costs over time. The report presents divergent stakeholder views on OPEX, especially where alternative gas mixtures, specialist handling arrangements and end-of-life pathways are concerned. A more detailed evidence base would improve future regulatory design and help distinguish between transitional costs and enduring cost differences.
3. The future regulatory position of some fluorinated alternatives remains uncertain. These technologies may play a material role in near-term deployment at higher voltages, but also that their long-term status could be affected by PFAS regulation. DESNZ should take this uncertainty into account when designing any long-dated pathway.
4. The report identifies approval processes as a material bottleneck, but it does not quantify in detail how far those processes can be shortened without changing technical requirements. That question should be addressed directly before DESNZ relies on rapid approval reform as a central delivery assumption.

Recommendations not supported by the current evidence

The report does not support recommending a programme of early replacement of existing SF6 assets across the network. Its scope is focused on new installations, and the evidence does not show that the consumer, operational or carbon case for systematic premature retirement has been established.

The report also does not support a single undifferentiated phase-out date across all voltage levels. The evidence points too clearly to differences in maturity, approvals and supply readiness between segments for that approach to be well founded.

Finally, the report does not support committing GB exclusively to one higher-voltage technology pathway at this stage. While some transitional gas-based alternatives are already enabling deployment, the evidence also points to ongoing uncertainty regarding longer-term regulatory treatment and to continuing development of vacuum and clean-air solutions. A policy approach that preserves flexibility is therefore better supported than one that backs a single end-state technology now.

Case studies: SF6-free alternatives in non-regulated industries

SF6-free switchgear in data centres

Data centres are scaling rapidly and are increasingly material drivers of electricity demand growth.¹³ The International Energy Agency estimates that electricity consumption from data centres, artificial intelligence (AI) and cryptocurrencies was around 460 terawatt hours (TWh) globally in 2022 and could exceed 1,000TWh by 2026. As capacity expands, high-availability electrical design (redundancy, sectionalisation, maintainability) multiplies the quantity of primary distribution plant required per site, making MV switchgear a repeat, high-volume procurement item across data-centre portfolios. Data-centre electrical architectures typically span 3 voltage classes, each with distinct switchgear requirements:

Table 15: SF6 free relevance per voltage class

Voltage class	Typical function	SF6-free relevance
LV ($\leq 1\text{kV}$)	In-building distribution from transformer secondaries to backup power systems, power distribution units and IT equipment	Low. LV distribution is SF6-free in standard practice.
MV ($>1\text{kV}$ to 52kV)	Utility intake (often 10/11kV or 33kV) and site primary/secondary distribution to MV/LV transformers	High. MV is the primary decision point for SF6-free adoption and EU regulatory compliance.
HV ($>52\text{kV}$)	Campus grid-interface substations (66kV to 132kV) stepping down to internal MV	Moderate to high, where HV/MV step-down falls within the data-centre project boundary.
HV ($>132\text{kV}$)	Direct transmission-level connection for hyperscale campuses (typically 400kV), stepping down to internal MV distribution via an on-site grid supply point	Moderate and growing. Hyperscale data centres are the fastest-growing segment of the market. SF6-free products are increasingly being procured for new transmission substations.

For most data centres, the MV switchgear decision is most important. The utility supply arrives at MV and is routed through MV switchgear to distribute feeders to MV/LV transformers, generators and inter-building links. For large campuses with HV points of connection, an on-site HV/MV substation is required, after which the internal network still operates at MV.

¹³ Project-level evidence in this section draws on publicly available developer and operator announcements, company websites, and press releases; full references are provided in the bibliography.

Project examples

SIN01, Start Campus – Portugal

Start Campus's SIN01 is the first operational facility at the SINES Data Campus, a planned 1.2 gigawatt (GW) development on Portugal's southwest coast specifically engineered for AI and cloud computing workloads. SIN01 became operational in Q4 2024.

The facility has an IT capacity of 26 megawatts (MW) (about 2% of total planned capacity). The building is constructed on repurposed industrial land adjacent to a decommissioned coal-fired power station, runs on renewable energy and uses seawater drawn through the former plant's existing inlet infrastructure for cooling.

Schneider Electric partnered with Start Campus to deliver and operate SIN01's electrical infrastructure, supplying SF6-free MV switchgear alongside LV distribution systems. Siemens Energy supplied HV power transformer equipment for the grid connection. The specific HV and MV voltage levels and redundancy configuration are not publicly disclosed.

At MV, the SF6-free implementation would likely draw one of Schneider Electric's established platforms, given their active portfolio at this voltage level: the GM AirSeT or RM AirSeT families (clean-air insulated GIS/RMU with vacuum interruption) or the SM AirSeT (air-insulated switchgear). Given the EU F-gas Regulation (2024/573) timeline and Schneider Electric's stated commitment to phasing out SF6 across its product range, the SIN01 deployment is consistent with the direction of travel for new European data centre builds.

PDC2, Previder – Netherlands

PDC2 is an operating example of a data centre that has used SF6-free MV switchgear since 2010, demonstrating that the technology predates the current regulatory phase-out trajectory by over a decade. Previder's PDC2 is a high-availability data centre with extensive power redundancy in Hengelo, the Netherlands. The facility has a total floor area of approximately 2,500m², with electrical infrastructure sized to scale to 6MW. The site receives a 10kV utility supply from network operator Enexis, stepped down to 400V via 2 independent 2,500 kilovolt-ampere (kVA) dry-type transformers.

Eaton supplied the complete electrical infrastructure as a single turnkey package, including MV switchgear, LV distribution, Uninterruptible Power Supply (UPS) systems and busbars. At MV, 2 Eaton Xiria Ring Main Units (RMUs) provide intake and distribution. The Xiria is an SF6-free platform using vacuum interruption with solid and air insulation in a sealed enclosure, first introduced in 2002. Previder did not select the Xiria specifically for its SF6-free properties; rather, it was Eaton's standard MV product for this application in the European market. The SF6-free characteristic was incidental to a procurement decision driven by reliability, single-supplier integration and energy efficiency.

PDC2 demonstrates that SF6-free MV switchgear has operated in a mission-critical data centre environment for over 15 years. The fact that it was deployed as a routine commercial product — without requiring any special environmental specification from the operator — illustrates the maturity of SF6-free technology at certain voltage levels in the European secondary distribution market well before the current regulatory phase-out trajectory.

Supplier landscape

Multiple manufacturers offer SF6-free MV switchgear products targeting the data-centre market, each mapping onto one or more of the technology routes described above:

- Schneider Electric: the GM AirSeT and RM AirSeT families use clean-air (shielded, dry air) insulation with vacuum interruption for primary and secondary MV distribution up to 24kV. Schneider positions these products for lower maintenance cost and total cost of ownership
- Eaton: the Xiria platform provides solid-insulated (gasless) MV switchgear with vacuum interruption, available since 2002 with large installed volumes globally
- ABB: the AirPlus portfolio uses a fluoroketone-based gas mixture with very low GWP (<1) for compact MV GIS/RMU. Despite the low GWP, these mixtures contain fluorinated compounds and face regulatory scrutiny under EU F-gas rules
- Siemens Energy: offers clean-air and vacuum-based MV switchgear for indoor and outdoor applications, including the 8DJH Blue GIS range

SF6-free switchgear solutions in offshore wind

Offshore wind has now demonstrated repeatable, large-scale deployment of SF6-free switchgear at 66kV and 72.5kV using vacuum interruption plus clean-air insulation.¹⁴ Hornsea 3 is the clearest recent scale example. Beyond Siemens Energy's Blue GIS pathway, alternative suppliers exist, including GE Vernova's g³ (a C4-FN-based proprietary gas mixture) portfolio and Hitachi Energy's EconiQ GIS. The practical question for project teams concerns which technology pathway best fits each voltage class and installation constraints.

Offshore wind electrical architecture switchgear choice

Offshore wind farms require compact, high-reliability switchgear for turbine protection, inter-array collection networks, and offshore and onshore substations. Historically, gas-insulated switchgear (GIS) has been preferred offshore because it offers a smaller footprint and better environmental sealing than air-insulated alternatives, which is valuable in space- and weight-constrained platforms and corrosive marine conditions.

¹⁴ Project-level evidence in this section draws on publicly available manufacturer and developer documentation, press releases, and technical specifications; full references are provided in the bibliography.

SF6-free solutions in offshore wind broadly follow 2 technical routes: (i) vacuum interruption combined with ‘clean air’ (natural-origin gases) as the insulating medium, and (ii) low-GWP gas mixtures (typically fluoronitrile-based) designed to retain GIS compactness at higher voltages. Supplier portfolios map differently onto these routes.

At higher voltages (offshore substations and export systems, typically about 145kV and above), SF6 is still widely used. Fully SF6-free GIS at these voltage levels is less mature and less widely deployed. Some alternatives exist (for example, using fluoronitrile gas mixtures), but these are not yet universal and can involve trade-offs in size, weight, or regulatory uncertainty. As a result, most offshore substations commissioned to date still contain significant quantities of SF6.

At medium voltage (below about 66kV), there is a mixed picture. SF6-free technologies exist and are increasingly used, but many existing assets and some new installations still use SF6, depending on supplier choice, specifications, and the timing of procurement.

Project examples: Siemens Energy

Hornsea 3 (UK, Ørsted, 2.9GW) is procuring Siemens Energy’s 8VM1 Blue GIS™ for turbine-level protection at a standard connection voltage of 66kV. The design uses vacuum circuit-breaker technology for arc interruption and ‘clean air’ (nitrogen and oxygen) for insulation, eliminating fluorinated gases from the switchgear compartment.

Scale and timing: Siemens Energy delivered about 200 units of SF6-free 8VM1 Blue GIS for Hornsea 3. First deliveries began January 2025, with final delivery scheduled for April 2026. The wind farm is expected to be fully operational by end of 2027.

Environmental claim: Siemens Energy reports approximately 900 tCO2e avoided per unit compared with an SF6-filled equivalent.

System architecture: operation at 66kV supports reduced cable requirements and lower losses relative to older 33kV array concepts.

Siemens has also supplied SF6-free 8VM1 high-voltage switchgear for offshore wind turbines in the East Anglia ONE project and Nissum Bredning Vind in Denmark East Anglia ONE (UK): Siemens stated supplied 102 SF6-free, gas-insulated 8VM1 high voltage (66kV) switchgear units for the offshore wind farm, operating with vacuum circuit-breaker technology and clean air insulation. The wind farm was commissioned in July 2020 and has been fully operational since.

Nissum Bredning Vind (Denmark): Siemens reported 4 bays of 8VM1 SF6-free GIS (72.5kV) deployed in offshore wind turbines, using vacuum circuit-breaker technology and clean air as the insulating medium. Fully operational since early 2018.

Alternative suppliers and technology pathways

GE Vernova Grid Solutions: offshore substations plus the g³ SF6-free pathway

GE Vernova's Grid Solutions business is an established supplier of offshore substation electrical systems. GE also offers the g³ technology pathway for SF6-free GIS at high voltages, designed to maintain GIS compactness with a low-GWP gas mixture.

Offshore substations: GE Vernova reported offshore electrical platforms for the Neart na Gaoithe (Scotland, fully operational July 2025) and Saint-Brieuc (France, fully commissioned May 2024) wind farms, housing high-voltage substation equipment including GIS at multiple voltage levels.

Onshore high-voltage SF6-free deployment (evidence of g³ maturity): SSEN Transmission contracted GE Vernova in December 2020 to install 420kV g³ gas-insulated switchgear at Kintore substation in Scotland, alongside a separate 145kV g³ GIS installation at the same site, with construction scheduled through to 2026.

Hitachi Energy: EconiQ GIS and deployments linked to wind integration

Hitachi Energy positions EconiQ as its eco-efficient portfolio for SF6-free (or SF6-reduced) high-voltage products. Internal project material used in this programme describes EconiQ GIS offerings including ELK-04 up to 145kV and ELK-3 up to 420kV, using a C4-FN-based gas mixtures.

Offshore wind integration (UK): Hitachi announced it will provide onshore and offshore grid connection equipment to ScottishPower Renewables for the East Anglia TWO offshore wind farm, and trade reporting noted this includes onshore grid connection equipment using an EconiQ gas-insulated switchgear. Construction is expected to begin in 2027, with operations scheduled for 2028.

Practical procurement implications (non-regulatory)

For offshore wind project teams, the supplier landscape implies 3 practical decision points. First, 66kV turbine and inter-array applications can already be procured at scale using clean-air plus vacuum GIS solutions, with multiple reference projects. Second, as voltage increases towards transmission-class GIS, supplier options shift towards low-GWP gas mixtures to retain compactness, but reference deployments tend to be fewer and more recent. Third, because offshore platforms are space- and weight-constrained, technology choices that increase bay size, auxiliary systems, or handling complexity can drive knock-on impacts in platform design, installation vessel requirements, and ultimately project costs.

Appendix

Table 16: Voltage level 66kV

Technology category	AIS	GIS
Solution types	Vacuum interrupter + air insulation medium (clean air) Gas circuit breaker with CO ₂ /O ₂ or fluorinated gas mixtures (C ₄ -FN + CO ₂ /O ₂)	Vacuum interrupter + air insulation medium (clean air) Fluorinated gas mixtures (C ₄ -FN + CO ₂ /O ₂)
Suppliers	Siemens Energy: 3AV1 Blue LTB / DTB 72.5kV Hitachi Energy: EconiQ LTA, 72.5kV GE Vernova: GL309g / GL310g, 72.5kV Mitsubishi: MEPPI, 72kV	Siemens Energy: 8VM1 / 8VM3 Blue GIS, 72.5kV Hitachi Energy: EconiQ GIS 72.5kV GE Vernova: F35g GIS 72.5kV HD Hyundai Electric: GREENTRIC 72.5kV Toshiba: AEROXIA 72.5kV (availability in the European market is still emerging rather than fully established) Mitsubishi: MEPPI, 72kV
Time needed for implementation	0 years	0 years
General assessment of maturity	Commercially mature: multiple suppliers offer SF ₆ -free AIS solutions at 72.5kV, with proven technology across both clean air vacuum and fluoronitrile-based gas circuit breaker approaches. The step-down application to the GB's 66kV network presents no meaningful barrier and supply chain readiness is strong. The near-term outlook is one of competitive broadening, with new market entrants expected.	Commercially mature: the technology is proven, multiple suppliers are in the market, thousands of units are in operation globally, supply chain is established and the step-down from 72.5kV to 66kV presents no meaningful barrier. Competitive broadening is already underway, with new market entrants beginning to secure European orders.

Table 17: Voltage level 132kV

Technology category	AIS	GIS
Solution types	Vacuum interrupter + air insulation medium (clean air) Gas circuit breaker with CO ₂ /O ₂ or fluorinated gas mixtures (C ₄ -FN + CO ₂ /O ₂)	Vacuum interrupter + air insulation medium (clean air) Fluorinated gas mixtures (C ₄ -FN + CO ₂ /O ₂)
Suppliers	Siemens Energy: 3AV1 Blue LTB / DTB 145kV GE Vernova: GL312g 145kV Hitachi Energy: EconiQ LTA 145kV Hitachi Energy: EconiQ DTB 145kV	Siemens Energy: 8VN1 Blue GIS 145kV GE Vernova: F35g / F35 Dual Gas 145kV Hitachi Energy: EconiQ GIS ELK-04 145kV HD Hyundai Electric: GREENTRIC 145kV
Time needed for implementation	0 years	1 to 2 years
General assessment of maturity	Commercially mature: multiple suppliers offer SF ₆ -free AIS solutions at 145kV, with both clean air vacuum and fluoronitrile-based gas approaches proven in service. The step-down application to the GB's 132kV network presents no meaningful barrier. Supply chain readiness is strong, with procurement volumes expected to accelerate ahead of the EU's January 2028 deadline.	Commercially mature: products from all major manufacturers are commercially available, with thousands of units in operation. The step-down application to the GB's 132kV network presents no meaningful barrier. Lead times of 1 to 2 years reflect growing procurement demand. Near-term outlook is one of competitive broadening, with new market entrants expected as the ban drives procurement across the industry.

Table 18: Voltage level 275kV

Technology category	AIS	GIS
Solution types	N/A	N/A
Suppliers	N/A	N/A
Time needed for implementation	N/A	N/A
General assessment of maturity	No SF6-free AIS product exists at this voltage class in the European market. No manufacturer has announced development activity at 275kV AIS for Europe.	The 275kV tier has no commercially available SF6-free product developed specifically for this voltage class in the European market. The only available option is to apply 400kV-rated equipment at a significant cost premium, meaning the transition pathway exists, but is not economically attractive in the current context. However, solutions are deployed in non-European markets where 275kV remains an active part of the network. In GB, this voltage class is being progressively phased out through NGET's network upgrade programme.

Table 19: Voltage level 400kV

Technology category	AIS	GIS
Solution types	Gas Circuit Breaker with fluorinated gas mixtures (C4-FN + CO2/O2) Clean air + vacuum (pilot)	Fluorinated gas mixtures (C4-FN + CO2/O2) Clean air + vacuum (pilot)
Suppliers	Hitachi Energy: EconiQ DTB 420kV Siemens Energy: 3AV2FI 420kV live-tank (pilot stage)	Hitachi Energy: EconiQ GIS ELK-3 ≥ 420kV GE Vernova: T155g / T155 Dual Gas 420kV Siemens Energy: LIFE Blue 420kV GIS Pilot only
Time needed for implementation	2 to 3 years	2 to 3 years (diversity in suppliers is expected to develop in 2 years)
General assessment of maturity	Limited commercial availability, with one supplier commercially active additional solutions progressing through development and approval pathways. GIS remains the dominant technology at 400kV in practice due to large footprint requirements of AIS.	The 400kV tier is technically the most challenging, but also the most actively targeted for development. Solutions are commercially available and being deployed and whilst the market is not yet fully mature, significant development activity is underway driven by both regulatory pressure and strong procurement demand.

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