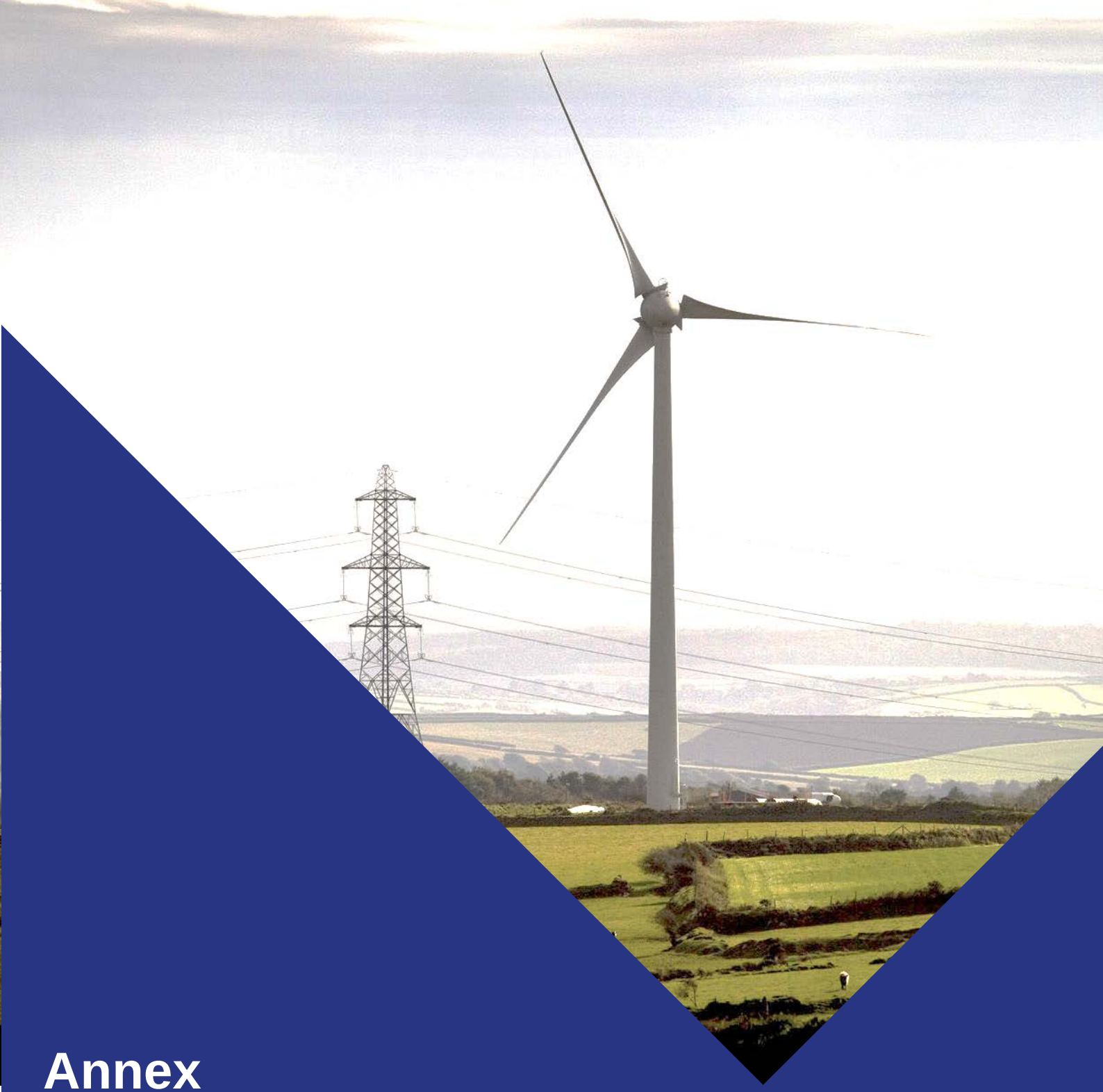


Annex

NGET_A11.09_SF6 Uncertainty Mechanism

December 2019

As a part of the NGET Business Plan Submission

nationalgrid

SF_6 Emissions Reduction Uncertainty Mechanism, to achieve a key milestone, towards a Science Based Target and a Net Zero Pathway

SF_6 Net Zero Pathway			
Asset Family	Various		
Primary Investment Driver	Environmental		
Reference	Annex A11.09		
Output Asset Types	N/A Output is an absolute SF_6 leakage reduction or prevention		
Cost	**Level 1** and **Level 2** = £/kg.yr to be developed through collaboration and engagement		
Delivery Year(s)	2021 – 2026		
Reporting Table	A6.5_IIGs_SF6 and A4.3BCF		
Outputs included in RIIO T1 Business Plan	This work is additional to that delivered in RIIO-T1.		
Spend Apportionment	**T1**	**T2**	**T3**
	N/A	Dependant on programme	Dependant on programme

Contents

Executive Summary

The UK's net zero by 2050 ambition became law in the UK in June 2019, which we fully support. As NGET, SF_6 is our largest controllable greenhouse gas contributor and we recognise that achieving Net Zero needs a step change to how we manage our SF_6 equipment. In this paper, we outline the principles for an uncertainty mechanism, developed from the initial draft investment programme outlined in our October submission[1]. We have further developed the October proposal to allow 1) the flexibility to respond to changing leaks within T2, 2) the flexibility to assess the best intervention for the asset and leak and 3) the ability to stretch beyond the Science Based Target (SBT) Net Zero pathway. This uncertainty mechanism will fund us to make reductions in SF_6 emissions with the long-term aim for continued and permanent reduction that our stakeholders expect to see from us.

Our stakeholders are clear that they want us to be carbon neutral faster than the 2050 target. During our consumer research testing 60% of consumers wanted us to be a Net Zero business by 2030 or 2040 (instead of 2050). In line with our stakeholders, we believe it is the right thing to do, whilst ensuring the right levels of speed and cost are fully acceptable to consumers . Ofgem asked that we provide information on what is needed to remove SF_6 from our system and where the carbon price is sensitive. **These investments are carbon price sensitive and the cost of carbon doesn't currently cover the investments required for within this mechanism that focuses on longer-term benefit.** There are two proposed treatments within this mechanism which we have named level 1 and level 2**.**

Level 1 – For reductions in SF_6 emissions up to our SBT Net Zero pathway in the T2 period, we propose an approach built from the SF_6 replacement proposal we submitted in October[1]. This will build a value of SF_6 leakage reduction (or prevented) in £/kg.yr. Our October proposal outlined a value of £150m to replace some of the worst leaking and simple gas insulated busbar (GIB) assets on the system. Our principles would use a portfolio of solutions (repairs and replacement) using an annualised equivalent costing (AEC) which assesses the remaining life of the leaking assets to make the best decision for the installation, for example a repair to align with substation replacement. For level 1, the uncertainty mechanism funding in £/kg.year would be based on the value delivered and expected period of effectiveness (life of the intervention). This rate will need to be defined through engagement with Ofgem ahead of T2.

Level 2 – For reductions in SF_6 emissions beyond the SBT Net Zero pathway in the T2 period, we propose an extension to the level 1 approach. The level 2 part of the uncertainty mechanism recognises the step change in performance required to respond to evolving environmental ambitions and allows us to go beyond the SBT Net Zero pathway for this period (-34% emissions by 2026). We propose level 2 would use the same mechanism but it requires a different calibration for the funding rate in £/kg.yr because in level 1 the simplest assets with the highest leak rate will have already been targeted. Thus, the remaining assets will be more complex and the volumes of leaks will be smaller, requiring us to spend more to get the same benefit. We expect increments within level 2 meaning a non-linear approach would be required.

The assets we are targeting with this uncertainty mechanism in both levels aren't prioritised by existing processes, so there is limited overlap with our existing NARMs plans but they are complementary to each other. We will engage with Ofgem and consumers to fully develop this approach over the coming months, aiming to have both parts of the mechanism in place for the start of the T2 period in 2021.

[1] The material submitted in October is included in Appendix 1

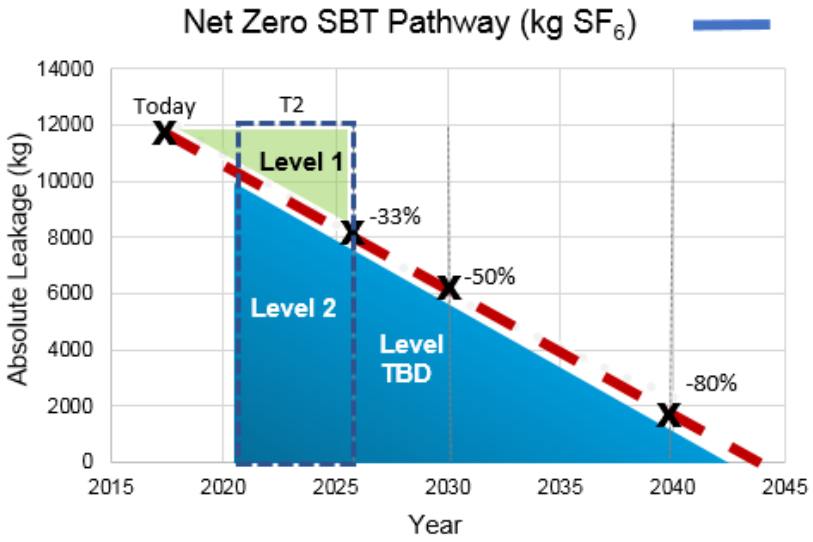


Figure 1 - SBT Net Zero pathway shown for illustrative purposes only

Background and Key Drivers

Our stakeholders have been clear that they want us to focus on decarbonisation of our own business as the highest priority in our T2 plan's environmental topic. As well as the increased awareness of society around the impacts of GHG emissions, the government has now legislated for net-zero greenhouse gas emissions by 2050, which we fully support.

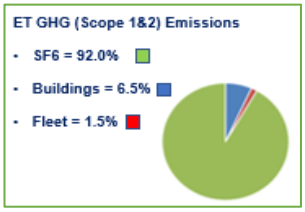


Figure 2 - England and Wales ET GHG emissions

It is important to us and our stakeholders that we take appropriate action now which will have a meaningful impact towards preventing further climate change. Inaction could cost more to future consumers and risks escalating climate events.

The three largest controllable contributors to our emissions are as below, and these are the elements measured in a Science Based Target[2] (SBT) approach:

1) leakage of interruption & insulation gases that we use in our equipment, primarily SF_6 – scope 1
2) transport – the fuel emissions from our operational fleet vehicles – scope 1
3) energy use from our buildings – scope 2

We have now verified, with the Science Based Target Institute (SBTI), what scope 1 and scope 2 reductions we must achieve for a credible pathway that limits global warming to within 1.5 degrees Celsius. Both our scope 1 and scope 2 emissions must reduce by 50% by the year 2030, and by 80% by 2040. Taking a linear trajectory, our 2026 T2 milestone is calculated at 34% from a 2018/19 baseline. Scope 1 is primarily made up of our operational fleet and SF_6, whilst scope 2 is the carbon associated with our buildings energy use. Given our operational fleet initiatives will account for the reduction in scope 1 emissions by circa 1% in the T2 period, our SF_6 emissions reduction must be at least 33% in the T2 period.

Sulphur Hexafluoride (SF_6) is a gas that has two distinct uses within electrical apparatus – electrical insulation and arc interruption. Its other characteristics include taking over 1000 years to degrade in the atmosphere and having a GWP of 23,500 times that of CO_2. It is the most potent greenhouse gas on Earth. For context, an emission of 10 grams of SF_6 broadly has the equivalent of driving a typical family diesel car over 1,500km. That's equivalent to driving from London to Dundee and back again. On the National Grid network, we have just under 900,000 kilograms of SF_6 installed, which is currently leaking at around 1.33% annually. SF_6 is the standard for insulation and arc interruption gas for electricity networks across the globe and has been for the last 30 years as it outperforms all other technologies.

[2] The Science Based Target Institute are an external organisation which calculates the requirements of a business to achieve net-zero emissions and will assign a 2030 and 2040 interim milestone which is called a Science Based Target (SBT).

Strong stakeholder support

On 17th September 2019 we held two international engagement webinars where over a dozen SF_6 experts joined us to discuss the proposed options at the time, which included the focus on GIB replacement. In our results, 85% (11/13) of the industry experts supported adopting a non- SF_6 early replacement strategy, although transmission owners from the far east favoured a leak detection and repair approach. As well as engagement with experts, we also performed acceptability testing with consumers to assess the appetite for funding an investment of up to £150m to achieve a 33% reduction. Against an estimated investment value of £150m to reduce the carbon emissions from our operations, using a nationally representative sample of consumers, resulted in 68% acceptability amongst the population. Finally, during our last round of consumer testing before this December plan finalisation, we asked respondents to indicate when they would expect National Grid to be a carbon neutral business and 60% of consumers said they would like us to be carbon neutral by 2030 or 2040. This highlights the need for emissions reduction which is faster than the SBT Net Zero pathway.

We are proposing an Uncertainty Mechanism to enable us to minimise our emissions in a manner that delivers good consumer value. The £150m we consulted on in Autumn 2019 was based on complete removal of SF_6 gas by replacement of relatively simple assets (Gas Insulated Busbar – GIB) that were the highest leaking assets. Subsequently, we used this stakeholder support to build a methodology that would encourage us to go above and beyond the requirements of Science Based Targets, whilst providing adequate levels of funding to effectively deal with the increasingly complex asset base. The methodology allows us to compare different repair options with replacements as well as using pro-actively prevention techniques.

Level 1 – For reductions in SF6 emissions up to our SBT Net Zero pathway in the T2 period, we propose an approach built from the SF6 replacement proposal we submitted in October1. This will build a value of SF6 leakage reduction (or prevented) in £/kg.yr. Our October proposal outlined a value of £150m to replace some of the worst leaking and simple gas insulated busbar (GIB) assets on the system. Our principles would use a portfolio of solutions (repairs and replacement) using an annualised equivalent costing (AEC) which assesses the remaining life of the leaking assets to make the best decision for the installation, for example a repair to align with substation replacement. For level 1, the uncertainty mechanism funding in £/kg.year would be based on the value delivered and expected period of effectiveness (life of the intervention). This rate will need to be defined through engagement with Ofgem ahead of T2.

Level 2 – For reductions in SF6 emissions beyond the SBT Net Zero pathway in the T2 period, we propose an extension to the level 1 approach. The level 2 part of the uncertainty mechanism recognises the step change in performance required to respond to evolving environmental ambitions and allows us to go beyond the SBT Net Zero pathway for this period (-34% emissions by 2026). We propose level 2 would use the same mechanism but it requires a different calibration for the funding rate in £/kg.yr because in level 1 the simplest assets with the highest leak rate will have already been targeted. Thus, the remaining assets will be more complex and the volumes of leaks will be smaller, requiring us to spend more to get the same benefit. We expect increments within level 2 meaning a non-linear approach would be required.

The assets we are targeting with this uncertainty mechanism in both levels aren't prioritised by existing processes, so there is limited overlap with our existing NARMs plans but they are complementary to each other. We will engage with Ofgem and consumers to fully develop this approach over the coming months, aiming to have both parts of the mechanism in place for the start of the T2 period in 2021.

This mechanism will allow us to continue using current risk methodology on lead assets to manage the network risk in the most optimal way, meaning it will drive us to focus aggressively on reducing emissions and with the lowest equivalent annual cost.

This methodology will also select a group of assets that is different to those selected in the Reliability section of the submission. These assets are currently within their expected asset life and will be assessed for their long-term benefit.

Conclusions

This mechanism uses a £/kg.yr system which has an increasing value after the simple (GIB) phase 1 assets have been completed, with an absolute target against our SBT Net Zero pathway. Adopting this flexible approach offers the ability to respond to changing conditions to support the existing network risk methodology, and to change focus if location and severity of leaks change within the period. This will drive the focus on absolute emissions whilst remaining in-line with stakeholder support. Along with this proposal we are developing, for a sharp focus on long-term emissions reduction, we are also taking bold steps to prevent our SF_6 footprint increasing. We are evaluating our policy and processes to ensure that we can be ready to deliver the steps below:

- Stop using 132kV SF_6 assets in new build substations by 2021.
- Stop using 275/400kV SF_6 assets in new builds by 2024 (or once 2 solutions are viable), sending clear market signals to support this (in 2020).
- Continue to use collaboration and innovation to develop alternative technologies so that we no longer need to buy equipment that uses SF_6 as an interruption and insulating gas.

Appendix 1 – SF6 Replacement Proposal Submitted in October 2019 T2 Business Plan

SF_6 Emissions Reduction Programme, to achieve a key milestone, towards a 2030 Science Based Target and a Net-zero

SF_6 Emissions Reduction			
Asset Family	SF_6 Gas Based GIB on T-155 and YG2 Designs		
Primary Investment Driver	Asset Health (Non-Lead Assets)		
Reference	Annex A11.11		
Output Asset Types	GIS Busbar Systems SF_6 Equipment Bushings		
Cost	£149m (including non-funded T1 cost of £0.224m to facilitate T2 Works)		
Delivery Year(s)	2020 – 2026		
Reporting Table	C0.7, C2.2, C2.5, C2.5A and C2.7		
Outputs included in RIIO T1 Business Plan	This work is additional to that delivered in RIIO-T1.		
Spend Apportionment	**T1**	**T2**	**T3**
	£224,000 (18-19 prices)	£148,752,000 (18-19 prices)	£25,000 (18-19 prices)

Executive Summary – The paper justifies a total spend of £149m for the targeted replacement of leaking SF_6 asset (specifically outdoor gas insulated busbar) during the T2 period. This will deliver the step change in SF_6-leak performance required to deliver our milestone of 34% emissions reduction by 2026, on the SBT Net Zero pathway to a Science Based Target (SBT) of 50% reduction by 2030. The worst leaking asset families will be targeted for replacement with SF_6- free alternatives. This option has been identified as delivering the optimum balance between cost, risk and performance and as delivering the best value for consumers.

We are passionate about making the right investment to meet a key net-zero milestone, however, deliverability of some of the proposed interventions is still under review and we are unable to conclude with full confidence ahead of the T2 submission deadlines that all the proposed solutions at these sites can be delivered before 2026. Therefore, we propose an in-period reopener that will allow us to fully assess the challenges and deliverability with a view to proposing the final solution to meet a 34% emissions reduction before 31 January 2020.

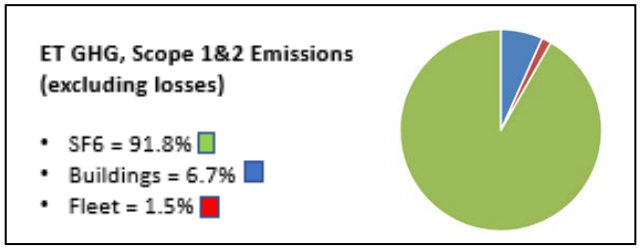
We have calculated a total 1,224,620 tCO_2e saved through this investment (on a total carbon impact basis). This equates to a societal **saving of ~£160m** (using the BEIS estimated non-traded cost of carbon forecast). Therefore, **this investment can be fully justified on an environmental (carbon) benefit basis only.**

Background Information - our stakeholders have been clear that they want us to focus on decarbonisation of our own business as the **highest priority** in our T2 plan's environmental topic. As well as the increased awareness of society around the **impacts of GHG emissions**, the government has now legislated **net-zero** which we fully support. We have now verified, with the Science Based Target Institute (SBTI), what reductions we must achieve for a credible pathway that limits global warming to within 1.5 degrees Centigrade. Our emissions must reduce by 50% by the year 2030, and taking a linear trajectory, our 2026 T2 milestone is calculated at 34% from an 18-19 baseline.

Sulphur Hexafluoride (SF_6) is a gas that has two distinct uses within electrical apparatus – electrical insulation and arc interruption. Its other characteristics include taking over 1000 years to degrade in the atmosphere and having a GWP of 22,800 times that of CO_2. It is the most potent greenhouse gas on Earth. For context, an emission of 10 grams of

SF_6 broadly has the equivalent of driving a typical family diesel car over 1500km. That's equivalent to driving from London to Dundee and back again. On the National Grid Network, we have just under 900,000 kilograms of SF_6 installed, which is currently leaking at around 1.33% annually. It has been however been the de-facto standard for insulation and arc interruption gas for electricity networks across the globe for the last 30 years as it out performs all other current rivals on every count except global warming potential.

Key drivers – it is really important to us and our stakeholders that we make investments now which will have a meaningful impact towards preventing further climate change. Inaction could cost more to future consumers and risks escalating disastrous climate events. To meet a science based target we must achieve a 34% GHG reduction (by 2026) within the category of each scope 1 and scope 2 target independently.



The three largest direct contributors to our emissions are:
- leakage of insulation gases that we use in our equipment, primarily SF_6 – scope 1
- transport – the fuel emissions from our operational fleet vehicles – scope 1
- energy use from our buildings – scope 2

Figure 1 - England and Wales ET GHG emissions

Given that SF_6 makes up ~98% of our scope 1 emissions, and fleet at only ~2%, is virtually negligible in achieving the overall reduction. Therefore, our key focus must be on SF_6.

Strong stakeholder support - On 17th September we held two international engagement webinars where over a dozen SF_6 experts joined us to discuss the proposed options. Our polling results offered opportunity to review the options presented as well as to propose new options. In our results, **85% (11/13) of the industry experts supported adopting a non- SF_6 early replacement strategy** and no alternate suggestions were made. We also tested the approach to calculating the carbon benefit and 64% (9/14) preferred a "**total carbon impact**" approach i.e. reduce SF_6 emissions only where there is a total carbon reduction across Scopes 1, 2 & 3, rather than an investment based solely on scope1. Most the stakeholders also agreed with our assumption that SF_6 alternatives for 400kv are **forecast to be available ~2030**. As well as engagement with experts, we also performed acceptability testing with consumers to assess the appetite for funding an investment of this magnitude. Against an estimated investment value of £150m to reduce the carbon emissions from our operations, using a nationally representative sample of consumers, resulted in excellent levels (68%) of acceptability amongst the population.

Options considered – we have considered a range of interventions to reduce SF_6 emissions during T2. These range from continuing solely with the leak repair activities established and delivered during T1 to wholesale substation replacement of sites exhibiting the worst leakage.

Option 1 (minimum) - Continuing solely with a leak repair approach, however aggressively pursued, is insufficient to deliver our SBTs (see Figure 2). During T1 we have developed leak repair strategies, both temporary and permanent. Temporary repair provides only short-term mitigation and makes no long-term contribution to achieving SBTs. Long terms repairs, typically developed and delivered in conjunction with original equipment manufacturers, have been effective to fix major leaks that are detected. However, these techniques require outages and major intrusive works i.e. outages and system access leaks and leaks can worsen significantly between detection and intervention. Long term leak repair also retains SF_6 filled equipment with a proven poor performance in service with the associated risk of re-occurrence of problems in the long term.

Leak repair still plays a part in our recommended option to address cases where early replacement of leaking assets is not proven to be the best option and for emergency cases.

Option 2 - Wholesale substation replacement would involve replacing large quantities of well-performing assets, particularly those installed indoors, earlier than otherwise planned. This would make minimal additional contribution to achieving our SBTs compared to the recommended option and would not deliver value for consumers. Additionally, due to lack of availability of fully SF_6-free technology, asset replacements during T2 at 275kV and 400kV would require us to deploy new SF_6-filled equipment thereby perpetuating our long-term reliance upon SF_6 to a greater degree than absolutely necessary.

Option 3 (recommended) - The recommended option is to use our asset knowledge to target and replace our worst leaking assets, in conjunction with our ongoing programme of leak management, to deliver a step change in performance towards achieving our SBTs in T2. In conjunction with a replacement programme, we propose to adopt a more aggressive and focussed leak detection.

We have clearly identified two specific families of outdoor gas insulated busbar to be major sources of SF_6 emissions which, if replaced with SF_6-free alternative solutions, would deliver the necessary step change in SF_6 leak performance in an enduring manner during T2.

On this basis, during RIIO-T2, we are proposing to replace specific family types of 400kV Gas Insulated Busbar (GIB) with non-SF_6 technology to meet the UK emissions target as well as the additional SF_6 leakage repairs defined within A9.03 – Circuit Breakers and Bay Assets. GIB replacement is the most technically effective and cost-efficient option we have currently and can be considered as achievable with the lowest risk to the security of the National Transmission System.

GIB replacement will provide a solution designed to last for at least 40 years and avoid additional spend on short-term solutions. To meet our challenge, we propose to replace sections of outdoor Gas Insulated Busbar (GIB) on 17 substations with non-SF_6 alternatives in the RIIO-T2 period. This ensures that the risk of SF_6 leakage is removed entirely and we are suitably positioned to meet the 2050 emissions target, and the greenhouse gas emissions reductions requested by our regulator by 2026.

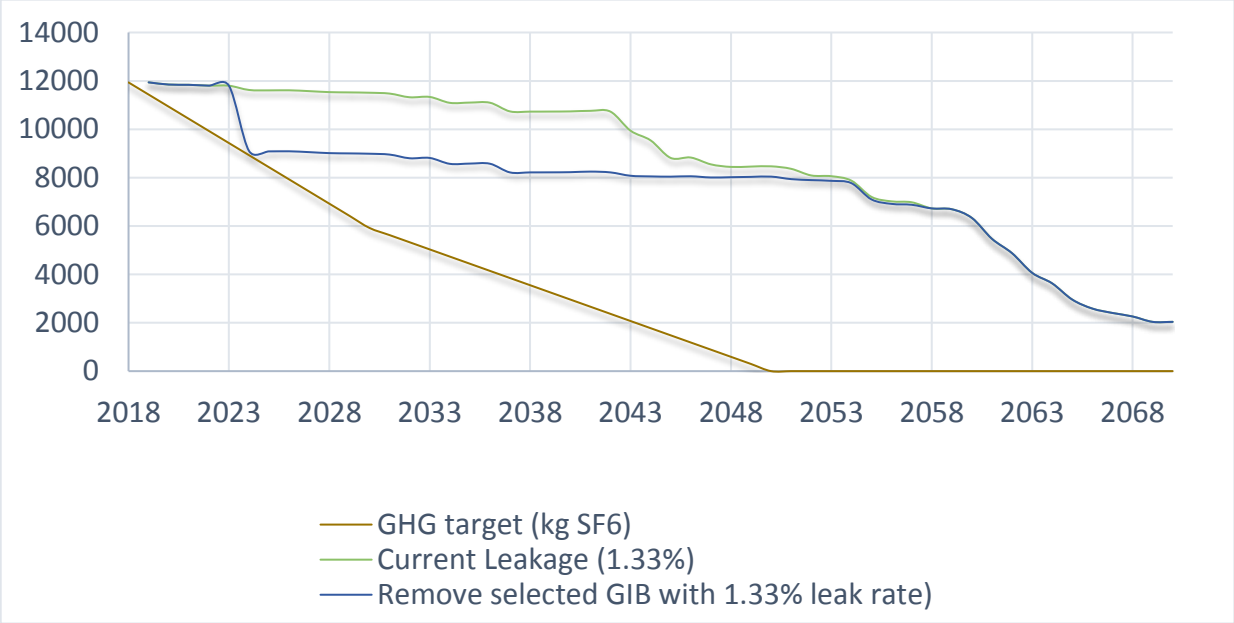


Figure 2 – Science based targets and outlook for SF_6 emissions

The proposed solution will achieve a proposed trajectory shown by the blue line in the Figure 2. This outlines that the intervention would get us to a SBT for T2 and there would need to be similar levels of intervention within T3 to continue the SBT trajectory.

We propose this work will be conducted over the period of 2021-2026 and will be delivered using a mixture of cable and SF_6-free GIB solutions to suit site-specific needs and constraints.

Table 1 - Sites proposed to have the 400kV GIB (including Gas-to-Air Bushing) replaced:

Substation	Count of Bushings Replaced	T1 Leakage (Substation Level)	Intervention Proposed	Confidence in deliverability
Norton	15	3934.65	Replace with Cable	Medium
Lackenby	9	2410.3	Replace with non—SF_6 GIB	Medium
Rassau	12	2550.31	Replace with non—SF_6 GIB	High
Seabank	15	1840.16	Replace with non—SF_6 GIB	Low
Barking	12	1812.66	Hybrid – Cable and non-SF_6 GIB	Low
Hams Hall	6	276.48	Replace with Cable	High
Harker	6	2047.33	Hybrid – Cable and non-SF_6 GIB	Low
Barking	15	1812.66	Hybrid – Cable and non-SF_6 GIB	Low
Eaton Socon	12	793.765	Replace with Cable	Medium
Harker	21	2047.33	Hybrid – Cable and non-SF_6 GIB	Low
Killingholme	GIB only	329.96	Hybrid – Cable and non-SF_6 GIB	High
Northfleet East	12	1403.8	Replace with Cable	High
Ryehouse	9	538.86	Replace with Cable	High
Sizewell	16	3248.44	Replace with Cable	Medium
St Johns Wood	63	23.38	Hybrid – Cable and non-SF_6 GIB	Low
Stocksbridge	GIB only	1507.6	Replace with Cable	High
Wimbledon	GIB only	1099.17	Replace with Cable	Low

We have proposed a mixed approach to the interventions chosen for the substations above. This allows us to cater for the constraints already in place in the substation. In some cases, the configuration of the substation allows for direct replacement with cable. In others, the GIB was installed because there is no other viable technology, so we must replace it with non-SF_6 based GIB. In other cases, a mixed approach on site is required.

As indicated in Table 1 there are a variety of deliverability risk levels associated with delivering this work due to currently planned work and outages already planned in this period. We require several months to fully assess the deliverability of the proposed solutions at the sites. To-date we have been able to conclude that six of the proposed sites are high confidence, four are assessed as medium confidence and seven are designated low confidence with respect to their deliverability given the complexity in nature and planned works already at the sites

As we are unable to conclude with confidence that all the sites can be delivered, ahead of the T2 submission deadlines, we propose a reopener. This will allow us to fully assess the challenges and deliverability with a view to proposing the final solution to meet a 34% emissions reduction before January 2020.

Cost of the investment – we estimate this work will cost £148.75m over the five-year period, plus £224k in T1 to enable the work to be delivered and £25k in T3 to close out the project.

Benefit - the overall carbon impact of this work results in a decrease of 1,255,619 tCO_2e, which if calculated as a financial benefit would equate to approximately **£163m** using the forecast non-traded cost of carbon within the year for the duration of the emissions.

To calculate the saving on a total cost of carbon basis, as requested by stakeholders, carbon transferred to scope 3 as a result of this investment, we could assume 207tCO_2e per £1m of expenditure giving a total of 207tCO_2e x £150m = ~31,000tCO_2e. The overall net benefit of this work would be 1,255,619 tCO_2e – 31,000 tCO_2e = 1,224,620 tCO_2e. Therefore, the new calculated carbon savings would be **~£160m**. This value is based on previous legacy schemes which have been measured through their design and delivery.

This work is additional to the existing plan and there is no duplication across other investments.