

Sustainability First
ED2 Business Plans - Ofgem Call for Evidence
8 February 2022

ANNEX 2 – DNO SF6 STRATEGIES

Introduction

Sustainability First is a think-tank and charity with a focus on social, environmental and economic issues in energy and water. We have significant experience of the RIIO price-control process through our involvement with the Ofgem RIIO2 Challenge Group, Consumer Engagement Groups and Ofgem stakeholder working groups. For many years Sustainability First has also led a significant work programme on how regulatory models must adapt to long-run future challenges.¹

This Annex forms one part of our Sustainability First response to Ofgem’s Call for Evidence on the DNO business plans for the ED2 price control period (2023-28)². Our main response takes a high-level look across DNO business plans from a consumer, citizen and net-zero standpoint – and can be found here - <https://www.sustainabilityfirst.org.uk/publications-consultation-submissions>

In producing our response to Ofgem, we undertook a detailed look at DNO environmental action plans (EAPs).³ Our focus was whether DNO EAPs sufficiently lay the ground for decarbonisation and net-zero while achieving a ‘right-balance’ for long-run affordability, whole-system efficiency and resilience. Two areas stand out as requiring considerably more attention in the next five-year period by both DNOs and Ofgem : the need for more ambition and sense of ownership in tackling the challenge of distribution losses; plus, the largely ‘unseen’ long-run business and consumer risk attaching to DNO SF6 equipment. We have produced stand-alone papers on each. We see these as priority areas in shaping the success or otherwise of critical EAP outcomes in the ED2 period and beyond.

- **Annex 1 – DNO Losses Strategies**
- **Annex 2 - DNO SF6 Strategies**

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¹ For example, our major three-year Fair for the Future Project - <https://www.sustainabilityfirst.org.uk/publications-fair-for-the-future>

² DNO final ED2 business plans were submitted to Ofgem on 1 December 2022
<https://www.ofgem.gov.uk/publications/call-evidence-electricity-distribution-business-plans-riio-2>

³ The DNO environmental action plans (EAPs) are required by Ofgem as a part of the business plan documentation

Annex 2 – DNO SF6 Strategies

Summary

This Annex examines the DNO SF6 Strategies as set out in their environmental action plans (EAPs).

Section I paints a general picture of the DNO SF6 challenge, making use of information in Ofgem’s own reports on DNO SF6 ‘banks’ and leakage. **Section II** takes a detailed look at DNO proposals for ED2 SF6 leakage targets plus looks across their wider SF6 Strategies to tackle their long-run SF6 challenge. **Section III** concludes with specific suggestions for Ofgem on regulatory approaches to the DNO SF6 strategies – both at draft determination stage and for financial incentives to drive a gear-change over the next-five years in DNO approaches to their SF6 risk.

The paper is organized as follows.

Section I – SF6 Overview

1. Headline conclusions
2. DNO SF6 context
 - Regulatory
 - DNO SF6 challenge – key features
 - Ofgem SF6 ED1 reports – SF6 banks and leakage

Section II – DNO ED2 SF6 Targets and Strategies

3. Stakeholder views on DNO approaches to SF6
4. DNO ED2 commitments and leakage targets against bank
5. SF6 Strategies
 - Overview
 - Core elements
 - Improved knowledge of SF6 bank
 - Reducing total SF6 bank
 - Procurement of SF6 alternatives and approach to supply-chain – including DNO collaboration
 - DNO innovation on SF6

Section III – Suggestions for Ofgem on SF6 Incentives in ED2

6. Ofgem draft determinations and regulatory incentives for SF6 in ED2
 - Incentives - headline conclusions
 - Draft determinations
 - Within-period financial incentives for SF6 strategies

Section I – SF6 Overview

1. Headline conclusions

DNO SF6 strategies vary considerably in quality. They range from the comprehensive to simply being on the ‘to-do’ list. The costs attaching to the strategies are not well-understood. With over 200,000 items of DNO equipment containing SF6⁴ – i.e a directly-controllable scope 1 emission - SF6 assets need far greater focus by DNOs in ED2. As a long-lived intense green-house gas⁵, a robust SF6 strategy must surely be a major input into development of DNO science-based targets. Given the immature state of several SF6 strategies in EAPs, Ofgem should provide a strong regulatory signal and opt to financially incentivise the ED2 SF6 strategy process, including collaboration. If left simply to reputational regulation as Ofgem presently propose, a concerted effort by DNOs in the next five years to address their long-run SF6 risk cannot be assumed – be that to support cost-efficient outcomes for SF6 asset-management or for net-zero delivery.

Leakage reduction targets – DNOs are required to adopt an ED2 SF6 leakage target. Individual targets sit against a complex backdrop of ageing equipment, variable but improving data on actual leakage, and SF6 banks still growing with new SF6 equipment being installed. In so far as it is possible to judge (given very variable baseline information presented in EAPs), the ambition-level of targets chosen by DNOs for overall rates of SF6 leakage-reduction against their total bank seem modest (and in some cases perhaps only level-pegging) – either against ED1 targets set six-years ago and / or against actual performance over the ED1 period. At draft determination, Ofgem should seek to better understand what a reasonable ‘stretch-target’ for SF6 leakage-reduction against bank and its associated cost could look like for each DNO. This is presently very hard to judge. In addition, within the total EAP BCF cost-envelope for ED2 it is hard to know in prioritising reductions in their scope 1 and scope 2 controllable emissions what short- and long-term trade-offs each DNO has made. For example, how has a DNO balanced relatively easy near-term steps to decarbonise (e.g. operational transport fleet) against SF6 measures? For example, was the trade-off made against SF6 measures which may be incremental and lower cost (e.g. leakage-detection, asset monitoring) instead of against more costly asset-based measures (i.e replacing items of leak-prone SF6 equipment).

Common reporting methodology - DNOs are also required to develop a common SF6 reporting methodology. Yet despite this being an Ofgem baseline expectation, not every DNO clearly commits in its EAP to making progress. Only two indicate an expected date. At draft determination, Ofgem should specify dates both for completion of the common reporting methodology and also the start-date for reporting. Otherwise, there will continue to be no comparable basis by which to understand progress against targets – be that for leakage or for reduction over time in DNO SF6 banks.

Reducing SF6 bank – in line with their science-based targets one or two DNOs reference a long-term vision of SF6 elimination from their operations. Under Ofgem’s current CBA methodology, SF6 asset-replacement invariably is justified only at end-of-life despite the value of avoided carbon emissions being factored into the assessment. While this equation may change in the future if a higher cost-of-

⁴ Total DNO SF6 Bank 2019-20 = 320,656 kg (7, 300, 000 tCO2e)

Total DNO SF6 Leakage 2019-20 = 865 kg (20,000 tCO2e)

⁵ 22,800 times the intensity of CO2

carbon is used in CBA assessments⁶, presently an asset must prove itself relatively leaky before it can be replaced early. Yet each DNO has many tens-of-thousands of SF6 equipment items right across their network – and growing. For the most part this equipment doesn't leak and / or is sealed. The strategies must therefore fully examine options, pathways and priorities for cost-efficient and considered steps on managing-down SF6 banks over time. This needs a far better grasp of the full long-run costs and benefits, including carbon impacts⁷, of asset replacement, the available viable commercial options and the sheer practicality of managing-down DNO SF6 banks to align with SBT time-frames. Some DNO strategies are already well-developed. For example, on inventory, data-collection, and long-run approaches to asset management. And some are barely off the starting blocks. Some also indicate a fuller understanding of available non-SF6 alternatives and perhaps have more active supply-chain engagement. On innovation in SF6 asset-management, the strategies indicated little new or ground-breaking. Several DNOs already make use of infra-red leakage detection and one DNO references exploring SF6 recycling. Going forward, we would like to see more effort devoted in strategies to how innovative approaches, including data-analytics, could help to tackle the many fundamental outstanding questions implicitly raised by the strategies on how best to manage-down SF6 banks over the long term.

2. DNO SF6 Context

Regulatory

Sulphur Hexafluoride (SF6) is a man-made green-house with a warming potential ~23,000 times that of carbon-dioxide. Long-lived and potent, it is widely used as an effective insulator in electricity substation switch-gear and circuit breakers. Equipment containing SF6 is found at every network voltage.

SF6 usage is controlled via the F-Gas regulations⁸. Broadly, the rules require reduced sales of all F-Gases, a ban on F-Gases in new equipment subject to alternatives being available, and leak prevention and record-keeping for existing equipment.

Until now, due to lack of viable equipment alternatives, electricity sector switch-gear and circuit breakers containing SF6 have been exempt on an EU-wide basis from phase-down of sales and for new-procurement. DEFRA is currently reviewing the F-Gas regulations for report by end-2022. DNOs expect new proposals by Spring 2023 and updated regulations in 2024. For electrical equipment containing SF6 where viable cost-efficient alternatives exist UK phase-out is increasingly on the cards. Any ban prior to end-of-life in the ED2 period would doubtless lead to discussion of a price-control re-opener. A far-reaching SF6 phase-out and ban looks more of a reality for ED3 and beyond.

⁶ Elsewhere in our ED2 response to Ofgem we have stressed that the new BEIS figure for the enduring cost-of-carbon – applicable to cost-benefit assessments in line with net-zero - is now three-times higher than the figure currently used by Ofgem in their CBA template. Ofgem will wish to revisit this. In using the higher BEIS figure for the cost-of-carbon in their CBA assessments DNOs may well find that certain proposed investments - where reducing carbon emissions is a main benefit (previously ruled-out on cost-benefit grounds) - may now have a higher benefit.

⁷ Including accounting for embodied carbon associated with early-replacement

⁸ <https://www.gov.uk/government/collections/fluorinated-gas-f-gas-guidance-for-users-producers-and-traders#full-publication-update-history>

Either way, active forward-planning by DNOs on their SF6 bank and supply-chain alternatives is clearly a very important element of risk management.

In ED2, regardless of new rules, the requirement by Ofgem for DNOs to adopt science based-targets for greenhouse gas reduction to limit warming to 1.5°, plus DNO plans to meet net-zero statutory targets, also mean that long-run DNO stewardship of their SF6 assets, including control of SF6 leakage, takes on new significance. For the first time Ofgem requires DNOs to have an SF6 Strategy⁹. This is very welcome.

The ED2 sector specific methodology¹⁰ noted that DNO strategies would to some extent mirror those for transmission IIG (insulation and interruption gases). In Section II we look in detail at the DNO SF6 strategies.

*The DNO SF6 challenge – key features*¹¹

High-voltage switchgear can contain hundreds of kilograms of SF₆, with rules on maintenance, leakage-checks and reporting (inventory, leaks). At medium voltage – assumed to be <50kV¹² – equipment containing <5kg of SF₆ is often sealed. So, in general terms more ‘fit-and-forget’.

In GB, most SF6 by mass sits in transmission equipment¹³. By volume, this represents ~85% of the full SF6 network inventory or ‘bank’. And almost all leakage recorded is from transmission - some 97%¹⁴. But, when we look across the voltages at the numbers of switchgear units which contain SF6 this picture reverses. There are over 200,000 of these in GB. Virtually all in distribution networks - some 97%. And most equipment items which contain SF6 sit at very low voltage – over two-thirds at 11 kV¹⁵.

⁹ RIIO-ED2 Business Plan Guidance. 30 September 2021. Appendix 3. Environmental Action Plans (EAP). Baseline Expectations. P 74
<https://www.ofgem.gov.uk/publications/riio-ed2-business-plan-guidance>

Sulphur Hexafluoride (SF6)

- Commit to implementing a strategy in RIIO-ED2 to manage SF6 on their network. This should include economic and efficient actions to reduce leakage rates and where appropriate, economic and efficient SF6 asset replacement.
- Adopt a target for SF6 leakage reduction.
- Commit to reporting on total SF6 bank and leakage reduction rates using a common DNO methodology.

¹⁰ RIIO-ED2 Methodology Decision: 17 December 2020
<https://www.ofgem.gov.uk/publications/riio-ed2-sector-specific-methodology-decision>
Annex 1 - Delivering value for money services for consumers. Appendix 4. Para A4.3

¹¹ Sustainability First. Expert Viewpoint. 18 November 2020.
<https://www.sustainabilityfirst.org.uk/publications-expert-viewpoints/149-sf6-time-to-get-serious>

¹² ENA Slide Set to ED2 Decarbonisation and Environment Working Group. 19 February 2020. **GB : SF6 ‘Bank’ – using EU boundary medium-voltage definitions for T & D >52kV and <52kV.**

¹³ Op cit. ENA indicate total GB bank estimated at ~1,300 tonnes. Of which Transmission holds 85% and Distribution around 15% (195 tonnes).

¹⁴ And leakage from Distribution equipment (i.e.. <52 kV) at 3% of total T&D leakage.

¹⁵ 70%

So, not to underplay the challenge of SF6 leakage for DNOs, but the practical reality is that distribution also faces a significant long-term and complex network asset-management challenge arising from such extensive holding of very many small equipment items containing SF6.

DNOs describe their SF6 leakage in EAPs as a share of their internal business carbon footprint (BCF) - ranging from 13% to 4% (in all cases as a share of their BCF minus losses)¹⁶. For some idea of how this sits within the total envelope of internal BCF emissions, one DNO indicates SF6 leakage to be equivalent to emissions from their operational transport - but substantially less than those from their business transport or their own buildings¹⁷. If emissions from losses are also included within BCF, then greenhouse emissions associated with SF6 leakage – together with all the other elements of scope 1 and 2 emissions – become a very small share indeed of total BCF. Adding contractor emissions (scope 3), smaller still. Nevertheless, none of this should detract from the fact that SF6 leakage is a scope 1 emission that arises directly from DNO business activity and is therefore ‘directly controllable’¹⁸.

DNOs have summarised their ED1 activity on SF6 at a high-level as follows¹⁹ :

- Investment and replacement of most significant contributors to SF6 losses on the network
- Innovation projects looking at alternatives to SF6 underway
- Investigation into more efficient repair options
- Use of FLIR (infra-red) camera to locate leaks
- Consideration of minimising emissions by de-gassing in situ
- Investigation into causes of SF6 leakages
- Installation of low leakage SF6 equipment
- Use of stringent high specifications at lower voltages to reduce SF6 leakage rates
- DNO collaboration via the ENA SF6 working group
- Understanding and compliance with FGas Regulations and contributing to the EU Consultation

In 2019-20, total leakage reported by DNOs to Ofgem amounted to 865 kg of SF6 (19,722 tCO₂e)²⁰. This is fourteen times less than leakage reported from transmission assets in the same year²¹. Even so, in terms of making progress towards DNO science based and net-zero targets, leakage prevention must be a first-order emissions reduction measure for DNOs.

¹⁶ For example, WPD – 13% (EAP p 26); Northern Powergrid – 11% (Chart on BCF Components. BP p 80. ‘Fugitive Emissions’ = 11% (ie without losses and emissions of external contractors); SPEN – 4% (EAP. SF6 Strategy. P 90); UKPN - 4% of scope 1& 2 emissions (excl losses).

¹⁷ NPG – Figure 1. Components of our Business Carbon Footprint. BP p 80. Buildings energy usage – 50%; Business transport – 28 %; Operational transport – 11%; SF6 leakage – 11%.

¹⁸ Described as ‘fugitive emissions’ in some plans – a technical term which in our view fails to adequately convey that these are controllable green-house gas emissions from leaking equipment.

¹⁹ SSEN & WPD slides to Ofgem Decarbonisation & Environment Working Group. 11 September 2020.

²⁰ <https://www.ofgem.gov.uk/publications/riio-1-electricity-distribution-annual-report-2019-20>

²¹ 12,441 Kg of SF6 leakage total for NGET, SPEN, SSET reported in 2019-20

<https://www.ofgem.gov.uk/publications/riio-electricity-transmission-annual-report-2019-20>

Without action, the risk of leakage will increase from older equipment deteriorating. This is currently assumed to be more problematic at higher distribution voltages, although current reporting requirements on leakage to Ofgem are not sufficiently granular to analyse this. Also, new load-related and other asset investment is still increasing the overall size of DNO SF6 banks. While not raising additional leakage prospects in the near term, it is hard to know if this will be the case in the long-term²².

The EAPs show that tackling leakage from deteriorating (most likely older) equipment at higher distribution voltages - either through repair or through limited asset replacement based on 'end-of-life' CBA assessments - to be the main focus for the DNO SF6 ED2 investment commitments.

For transmission in RII02 Ofgem addressed the leakage and asset management challenge for SF6 (and other interruption gases) with two incentives. First, via a stretch leakage-reduction target - specified against a very clearly defined baseline - with potential for a fine where targets are missed (and for some TOs, but not all, a potential to reward improvement beyond targets)²³. Second, an incentive for a specific programme of asset-intervention for National Grid (who have a particularly tough leakage problem) to help them manage-down some of their worst deteriorating SF6 assets. This programme to be targeted and carefully monitored²⁴. For ED2, Ofgem do not presently plan for any financial incentives to improve DNO management approaches to SF6 assets. We return in our conclusions to the question of sharper incentive signals for DNOs. It is also worth noting that there is also an anomaly on proposed RII02 SF6 incentive approaches between transmission and distribution - given that 132 kV is classed as a transmission voltage in Scotland and a distribution voltage in England & Wales.

Generally, in looking across individual EAPs it has proved hard in simple terms to :

- **Understand the main lessons learned by each DNO from their SF6 leakage performance in ED1** - how far targets were met and / or were in the end challenging, how problems were tackled and how far lessons on ED1 leakage have informed proposed actions and investment priorities for ED2.
- **Understand the basis for the ambition-level of each DNO SF6 leakage-reduction target relative to ED1** – in particular whether a DNO has simply adopted a straight-line trajectory from their ED1 target or performance, or their final 2019-20 outturn (or other date). Or, given SBTs, net-zero, and extensive stakeholder testing on environmental priorities²⁵, whether as a result the

²² ENWL RII02 Action Plan for SF6 : 'Our long-term vision is for our network assets to be 100% free of SF6 (or other greenhouse gases), but at present this is not technically or financially viable. We will continue to use SF6 switchgear until such time that the SF6-free solutions have been technically approved and are cost-effective over the whole asset life-cycle. While this market matures, our SF6 holding may increase, with the installation of new SF6 switchgear on the network; this switchgear will be highly unlikely to leak'.

²³ RII0-2 Final Determinations Electricity Transmission System Annex (Revised). 3 February 2021. Insulation and Interruption Gas (IIG) Leakage ODI-F. Pp 43-45 .
https://www.ofgem.gov.uk/sites/default/files/docs/2021/02/final_determinations_et_annex_revised.pdf

²⁴ RII0-2 Final Determinations. NGET Annex (Revised). 3 February 2021. Pp 33-36
https://www.ofgem.gov.uk/sites/default/files/docs/2021/02/final_determination_nget_annex_revised.pdf

²⁵ eg WPD

proposed ED2 trajectories for leakage reduction are more (or less) ambitious in ED2 when set against ED1.²⁶

- **Compare between DNOs on the relative ambition of their proposed reduction targets and investment commitments for SF6 leakage.**

Ofgem SF6 ED1 reports - SF6 banks and leakage

In taking a high-level view of commitments on SF6, and with limited resource, it has not been possible for Sustainability First to directly answer these important questions. In practice, given the great variability in the information provided by DNOs, we are not clear whether the EAP material in fact offers ready answers – in particular on questions around comparisons.

In attempting a better overview against which to judge DNO plans on SF6, we looked back at the information reported in Ofgem’s own annual distribution report for 2019-20 on SF6. In practice this information is also relatively limited.

Absent better information in business plans, Ofgem’s own ranking and RAG-rating perhaps offers a helpful start to any base-lining process. The tables are organised by licence area for each DNO - rather than by DNO name - so we have also added our own summary for 19-20 by DNO²⁷.

SF6 emissions as a percentage of the SF6 bank							
	DPCR5 - 2013/14	DPCR5 - 2014/15	2015/16	2016/17	2017/18	2018/19	2019/20
ENWL	0.42%	0.21%	0.10%	0.39%	0.37%	0.24%	0.48%
NPgN	0.17%	0.11%	0.16%	0.10%	0.22%	0.11%	0.09%
NPgY	0.57%	0.44%	0.46%	0.53%	0.32%	0.24%	0.25%
WMID	0.54%	0.32%	1.69%	0.88%	0.76%	0.65%	0.43%
EMID	0.28%	0.08%	0.41%	0.28%	0.25%	0.27%	0.42%
SWALES	0.27%	0.87%	0.56%	0.51%	0.57%	0.81%	0.38%
SWEST	1.39%	1.12%	0.90%	0.60%	0.91%	0.58%	0.59%
LPN	0.02%	0.05%	0.02%	0.04%	0.02%	0.06%	0.09%
SPN	0.08%	0.07%	0.08%	0.08%	0.17%	0.09%	0.06%
EPN	0.22%	0.19%	0.19%	0.27%	0.23%	0.10%	0.13%
SPD	0.49%	0.47%	0.01%	0.01%	0.24%	0.04%	0.05%
SPMW	0.55%	0.54%	0.18%	0.28%	0.38%	0.20%	0.16%
SSEH	0.18%	0.27%	0.11%	0.07%	0.03%	0.16%	0.21%
SSES	0.47%	0.46%	0.52%	0.55%	0.78%	0.88%	0.73%
Total	0.35%	0.32%	0.37%	0.32%	0.35%	0.30%	0.27%

Source : *Ofgem Annual Distribution Report. 2019-20*

²⁶ See section 4 below on proposed ED2 SF6 leakage targets.

²⁷ **ENWL** (Electricity North West) = ENWL; **NPG** (Northern Power Grid) = NPgN, NPgY; **WPD** (Western Power Distribution) = WMID, EMID, SWALES, SWEST; **UKPN** (UK Power Networks) = LPN, SPN, EPN; **SPEN** (Scottish Power Energy Networks) = SPD, SPMW; **SSEN** (Scottish & Southern Energy Networks) = SSEH, SSES.

SF6 emitted as % of bank - SNAPSHOT

Ranking	2015/16	2016/17	2017/18	2018/19	2019/20
ENWL	4	9	9	8	12
NPgN	6	5	4	5	3
NPgY	10	11	8	9	8
WMID	14	14	12	12	11
EMID	9	8	7	10	10
SWALES	12	10	11	13	9
SWEST	13	13	14	11	13
LPN	2	2	1	2	4
SPN	3	4	3	3	2
EPN	8	6	5	4	5
SPD	1	1	6	1	1
SPMW	7	7	10	7	6
SSEH	5	3	2	6	7
SSES	11	12	13	14	14

Source : Ofgem Annual Distribution Report. 2019-20

Below is our own summary of Ofgem’s SF6 information on SF6 leakage against bank for each DNO (for the most recent reporting year 19-20).

SF6 reporting to Ofgem by DNO – 2019-20	SF6 bank (Kgs) – 2019-20	SF6 kg emitted – 2019-20	SF6 kg emitted as percentage of each DNO bank – 2019-20 (rounded)
ENWL	16,098	78	0.48%
NPG	36,195	63	0.17%
SPEN	35,562	42	0.11%
SSEN	27,156	172	0.63%
UKPN	116,857	116	0.10%
WPD	88,788	395	0.44%
Total	320,656 kgs	866	0.27%

Source : Sustainability First from Ofgem Annual Distribution Report. 2019-20

From this Ofgem material, we conclude as follows.

SF6 banks in 2019-20

- Information on SF6 banks is submitted to Ofgem as ‘total SF6 installed’ (ie by volume (kgs)). This information should also be submitted in tCO2e to feed more transparently into SBT and net-zero calculations²⁸.
- Between DNOs, there are significant differences in the volume / size of SF6 banks (kg). UKPN and WPD each have a large share of the total DNO SF6 bank of 320,656 kg (taken together, approaching a 60% share).
- For some DNOs, there is a significant difference within their SF6 banks between their different licensed areas (i.e. SSEN, UKPN, WPD).
- In every DNO licence area except one (SSEN-Southern), the volume of the SF6 bank continued to grow in 2019-20 against the previous year. Several DNOs note in their EAPs that their overall SF6 asset holding is likely to increase due to the rate of new capital investment and the absence of suitable alternatives²⁹.

SF6 leakage in 2019-20

Against an overall DNO average of 0.27% leakage against the total SF6 bank (320,656 kg in 2019-20), our summary table indicates substantial differences on SF6 leakage at a DNO-level. Such differences will need a better understanding in future iterations of the SF6 strategies. For example in 2019-20 :

- UKPN with the largest SF6 bank by volume, had the smallest leakage-rate relative to its bank
- SSEN with the smallest SF6 bank volume, had the highest leakage-rate relative to its bank³⁰
- WPD and ENWL have similar percentage leakage rates reported relative to their banks – albeit WPD’s SF6 bank is five-times greater by volume than ENWL, so it is also perhaps important to understand the underlying asset picture.

Ofgem presently do not receive detailed information broken down by asset type - either in relation to the DNO SF6 bank or to SF6 leakage. For the longer-term such basic information will need to be recorded and reported to judge proposed DNO actions on SF6, including their adequacy or otherwise. EAPs (and detailed engineering justifications for ED2 which we have not looked at) offer some high-level insight into DNO priorities on tackling SF6 leakage-rates for their main deteriorating DNO assets. But more generally in terms of total SF6 bank, it is presently not feasible to judge either the practicality or the potential costs of possible SF6 phase-out or eventual removal. Nor indeed how far basic differences between DNO SF6 banks and leakage might also eventually impact individual DNO costs differently. This is the kind of detailed analysis that DNO SF6 strategies and plans will eventually need.

This over-view in Section I has drawn on available Ofgem and ENA/DNO material.

In Section II we now turn to the DNO ED2 environmental action plans and SF6 strategies.

²⁸ Ofgem guidance. 31 March 2021. ED2 Business Plan Template Data M23.Environmental Action Plan. pp 139-140.

²⁹ Eg. ENWL

³⁰ In their EAP, SSEN acknowledge this. They say that their ED2 focus on SF6 asset interventions are scheduled for SEPD (ie Southern). That SEPD leakage rates are significantly higher within SSEN and also comparatively high compared with other DNOs.

Section II – DNO ED2 SF6 Targets and Strategies

3. Stakeholder views on DNO approaches to SF6 management

From a stakeholder and consumer standpoint, and as our main response to Ofgem makes clear, ED2 is not in any sense business-as-usual in environmental terms for DNOs. Net-zero necessitates major new areas of business activity and new spend - plus a step-change across all activity. The requirement to adopt science-based targets and to meet the UK's statutory net-zero targets both in own-operations and wider business activity feeds directly into DNO EAP commitments and priorities - including for SF6.

DNOs thoroughly tested their EAPs through multiple stages of engagement. They received strong support from both customers and stakeholders for DNOs to be ambitious on decarbonisation and net-zero as well as in other environmental areas. Likewise, DNOs undertook extensive testing of customer and stakeholder views on cost trade-offs to inform high-level decisions about levels of EAP spend relative to other business areas, and also to inform more detailed decisions on specific EAP commitments and priorities. Generally, from a consumer standpoint, the EAP proposals have been generally well-considered. In the face of current energy bill pressures however the materiality of EAP costs clearly must be well-understood.

Specifically on SF6, one DNO said that stakeholder feedback was that SF6 was a 'key priority'. The same DNO tested five possible levels of reduction for SF6 leakage set against expected potential bill impacts. A clear majority of stakeholders favoured the maximum level of ambition that was put to them, and the DNO felt reassured that the options presented were in the correct range and 'sufficiently ambitious'³¹. Another DNO reports that when stakeholders were asked about implementing a new management approach for a potent green-house gas found in some equipment, 89% understood and 81% said 'yes' and only 2% said 'no'³². A third DNO said that some respondents were shocked at the figures shared on the potency and impact of SF6 and recognised that investment to reduce SF6 emissions would be costly but said that if investment was delayed, the real cost would be felt by future generations in terms of climate change. They wanted the DNO to be smarter with its equipment, replacing older kit with more environmentally friendly alternatives, as and when this technology becomes available while being mindful of the costs associated with replacement before end-of-life. They also wanted to see the DNO proactively managing its subcontractors, ensuring they understood the SF6 impact of the equipment that they supply³³.

At the other end of the engagement spectrum on SF6, one DNO simply notes under a short section on 'customer and stakeholder engagement' that the importance of the environment, and specifically achieving net-zero, is recognized by customers and stakeholders alike – but that 'we do not have any specific customer feedback on SF6 emissions'.³⁴ They also note in their business plan summary that

³¹ WPD – Supp Annex 2a – p 99 SF6 trade-offs. Against their present 17% SF6 reduction target, tested possible ED2 SF6 reduction targets of : 5% ↓ (= minus-£0.06p p.a.); 10% ↓ (= no bill impact); 15% ↓ (= £0.08p p.a); 20% ↓ (=£0.10p p.a); further ambition / an alternative (uncapped).

³² ENWL. EAP p 12

³³ NPG. Detailed Engagement Findings p 119. We did not locate a write-up where comparative bill impacts of different ambition levels for SF6 leakage and management were tested with stakeholders. The EAP p 13 discusses different costed options in light of stakeholder insights on 'delivery of an ambitious reduction level while remaining mindful of costs'.

³⁴ UKPN. EAP section on SF6 p 42.

they responded to feedback on their draft plan to make more ambitious commitments, inter al, ‘on our dependence on SF6 switchgear’³⁵

4. DNO ED2 commitments and SF6 leakage targets against bank

Ofgem’s ED2 baseline expectations on leakage targets and reporting are as follows³⁶ :

- **Adopt a target for SF6 leakage reduction.**
- **Commit to reporting on total SF6 bank and leakage reduction rates using a common DNO methodology.**

The table below attempts to collate information from DNO EAPs relevant to their ED2 commitments and targets adopted for SF6 leakage reduction against their SF6 bank.

As noted, the considerable variability in DNO SF6 asset condition, and also the fact that DNO banks may increase at varying rates over ED2, mean that for each DNO the main ED2 ‘benchmark’ on ambition-level on SF6 leakage reduction, must, for the time-being, be their own ED1 target. Or, alternatively their performance (however specified) against that target. At present, this is the only practical way to give context to ambition-levels for ED2 targets. Adoption of science-based targets should in the end drive a better understanding of the ambition level of DNO commitments to tackle leakage and also for reducing their SF6 bank.

Meaningful cross-company comparison on targets on the basis of information in the EAPs is hard. Even so, our table below of DNO SF6 leak-reduction targets might at least prompt some useful questions. In itself it doesn’t offer conclusions on the relative ambition of DNOs in their ED2 proposals on SF6 leakage reduction.

Pulling this table together has not been straightforward. The EAPs do not necessarily set out clear information on initial ED1 SF6 leakage reduction targets - nor on ED1 out-turn performance against those targets in a standard or readily accessible way - so there may well be errors of interpretation in our table. Several EAPs also don’t set out in a single place their ED2 leakage reduction targets alongside the specific investments proposed to deliver the targets, nor the expected cost. On balance, ENWL and NPG probably offer clearest context for their selected targets. NPG in particular has a clear and helpful graphic³⁷.

SSEN provide a very full account of their approach on SF6, but their leakage reduction target is baselined against 2019-20, so it is hard to understand the chosen ‘ambition-level’ relative to their ED1 target or their historic ED1 performance (plus their cost-information is redacted in their EAP). UKPN has also placed its proposed investments in the context of its science-based targets. Only one DNO, ENWL, openly recognises the uncertainty of target-setting against ageing assets. They commit

³⁵ UKPN. BP – p 9

³⁶ RIIO-ED2 Business Plan Guidance. 30 September 2021. Appendix 3. Environmental Action Plans (EAP). Baseline Expectations. Page 74 - <https://www.ofgem.gov.uk/publications/riio-ed2-business-plan-guidance>
Sulphur Hexafluoride (SF6)

- Commit to implementing a strategy in RIIO-ED2 to manage SF6 on their network. This should include economic and efficient actions to reduce leakage rates and where appropriate, economic and efficient SF6 asset replacement.
- Adopt a target for SF6 leakage reduction.
- Commit to reporting on total SF6 bank and leakage reduction rates using a common DNO methodology.

³⁷ NPG. Annex 4.6. EAP. Fig 4 p15.

to review their target ‘at the end of the first two years of RII0-ED2 and look to impose a stretch target if we are on track to meet our initial goal’³⁸. This seems a good approach.

In their baseline expectation, Ofgem simply require a target to be set for leakage reduction, but do not suggest how this should be formulated relative to ED1 or in terms of ‘stretch’. To support a more universally ambitious approach to SF6 leakage reduction across all DNOs, Ofgem may therefore wish to consider whether every DNO should similarly undertake a two-year review of the ambition of the targets currently proposed in their EAPs.

DNO	SF6 ED2 commitment / target for leakage against bank	What is the ED2 target is baselined against ?	Ambition level of proposed ED2 target ?	Cost attributed to meeting ED2 target for SF6 leakage
ENWL	<p>Maintain an SF6 leakage rate of below 0.30 % of total SF6 bank</p> <p>Reduce carbon emissions by ~340 tCO2e p.a.</p> <p>Commit to review leakage rate after 2 years – and look to impose a stretch target if on track to meet initial goal (EAP p 30)</p>	<p>EAP Appendix F – sets out clearly</p> <p>ED1 <i>average leakage rate</i> to date = 0.33% relative to bank ED1 forecast = 0.35% ED2 target = 0.30%</p> <p><i>ED1 goal</i> was to reduce leakage against bank by > 20% -from a rate of 0.38% in 2013 to 0.30% by 2023.</p> <p>In first six years of ED1, average SF6 leakage is 0.33% of total bank (i.e 48kg p.a).</p> <p><i>NB – Ofgem Table - 19-20 leakage rate was 0.48% of bank</i></p>	<p>EAP says : (1) we will <i>replicate our ED1 target</i> to maintain a leakage rate of 0.3 %</p> <p>Also : 0.3% would be an improvement of ~10% on <i>ED1 performance to date</i></p>	£9.6m
NPG	<p>Reduce SF6 losses by 15%.</p> <p>Report annually on progress</p>	<p>Yes – a clear graphic on kg leakage agst bank from 2011. (Fig 4 Annex 4.6. EAP p15). Sets out ED1 ‘stretch target’, actual emissions against ED1 target, end-ED1 forecast and trajectory of ED2 target</p> <p>Since start of ED1, SF6 losses 23% lower.</p>	<p>Yes Graphic suggests a reducing trajectory by against both ED1 out-turn and ED1 ‘stretch target’ by end-ED2</p>	£0.3m p.a = £1.5m total Targeted asset replacement over four-years. Seven leak-prone assets with >5kg SF6

³⁸ ENWL. EAP p 30

SPEN	<p>BP Commitment 75 : Reduce our SF6 leakage by 10% over the RIIO-ED2 period, compared to RIIO-ED1.</p> <p>‘Leakage needs to be signif reduced to achieve 2030 & 2050 CO2 redn targets’ – despite ongoing higher SF6 deployment in SPEN network.</p>	<p>ED2 target is base-lined against ED1 out-turn (ie not against ED1 target)</p> <p>Time-line back to 2013, indicates ‘annual leakage at 0.75% of total SF6 mass against a target of 0.85%’</p>	<p>Unclear</p> <p>EAP SF6 strategy notes due to better data-collection that leakage increased by 9% in 20-21 from 19-20 – with Manweb up 53%.</p>	<p>£5.159m (EAP p 99)</p>
SSEN	<p>Aim to reduce BCF impact from SF6 leakages by a minimum of 35% by 2028 from 2019/20 levels.</p> <p>Also, begin reducing our holdings</p>	<p>Target is baselined against 2019-20.</p> <p>EAP p 25 SBT (1.5 degrees) for delivery in 2033 agst 19-20 base-year means must reduce SF6 emissions 35% by 2028 and 55% by 2033</p> <p>EAP p 25 ‘We had an ambitious ED1 target on both our networks to reduce SF6 by 15% and although we are currently behind, we are seeing benefits from the strategy and expect continued improvement of our performance in the final years of this price control’.</p>	<p>SSEN EAP p 43 Fig 9 on BCF notes the following SF6 emissions reductions 2016 - 3,165 mtCO2e 2017 – 3,105 mtCO2e 2018 – 4,281 mtCO2e 2019 – 4,568 mtCO2e 2020 – 3928 mtCO2e</p> <p>Ambition level not clear. 2019 had a high emissions level (so may mask true ambition level against ED1 ?)</p>	<p>£5.6m Aim to replace 45 units – but do not specify voltage etc</p> <p>(Also, all EAP costs, incl for SF6, redacted)</p>
UKPN	<p>EAP 11.6</p> <p>Reduce leakage to 0.1% of the installed bank by end-RIIO2.</p> <p>A reduction of 9% against current performance.</p> <p>0.1% leakage by end RIIO2 ‘which is a 1% contribution towards our carbon reduction target at the current bank’</p>	<p>Baselined against ED1 target of 0.2% - ‘have consistently managed SF6 leaks below that target’</p> <p>EAP App 16 – p 41) ED1 baseline 2014-15 was 0.1% - (but target was ‘up to 0.2%’ in 18-19)</p> <p>Current leak-rate is 0.11% of bank.</p>	<p>Ambition level set against ED1 outturn</p> <p>Will tighten <i>target</i> to 0.15% of the quantity of SF6 on our network for the beginning of ED2 period – and then tighten <i>target</i> annually to reach our <i>goal of reducing leakage to no more than 0.1% by the end of ED2 – a 9% improvement on current performance</i></p> <p>‘As we move toward this goal by the end of the</p>	<p>EAP Appdx 16 – p 42</p> <p>£6m ex ante baseline: 12 schemes / 108 items of equipment ‘to slow down rate of increase in SF6 bank (EPN - £1.26 m; LEB - £4.37m; £0.36m SPN)</p> <p>Commitment to install no</p>

			period, we will ramp our target down from 0.15% which will maintain our industry leading performance’.	new 132kV or EHV (>20kV) SF6 equipment in ED2. (In ED1 replacement of 14 x 132kV units in hand)
WPD	Commitment 12 - Significantly reduce our impact on climate change by delivering a 20% reduction in SF6 losses and drive industry partners to develop technological alternatives to reduce overall volumes of SF6 on the system.	<p>EAP p 35 & Supp Annex2a. p99</p> <p>Initial ED1 target was to achieve a leakage rate of 0.37% against bank by end ED1. This was expected to reduce losses by 17% over 8 years.</p> <p>By 2021, had achieved a 0.11% leakage rate (but see below for note on outturn against initial ED1 target due to a changed basis for leak recording).</p> <p>EAP p 35 Fig 16. In 2015-16 adopted a new basis for leakage recording (top-ups <i>plus</i> estimates of actual leakage). As a result, ED1 annual leakage target seems not to have yet been met revised reporting in any ED1 year so far - but perhaps may do so by end ED1.</p>	<p>Annex2b p 99: states that ‘leakage rates are now so low there are diminishing returns and therefore a limit on the scale of further improvement that can be delivered’.</p> <p>Following stakeholder testing, WPD propose to deliver a 20% reduction in SF6 losses over the 5-years of ED2 at a bill impact of £0.10 / customer p.a.</p> <p>EAP p 35 ‘Whilst a 20% reduction may appear a conservative target for RIIO-ED2 it does represent an increase on our RIIO-ED1 commitment’</p> <p>By end-ED2 aim to reduce SF6 leak-rate by 37% against current ED1 commitment.</p>	<p>No numbers or costs in EAP</p> <p>Asset replacement: 11 kV – ‘leak & replace’ >11kV ‘two leaks & replace’</p> <p>Customer bill impact of £0.10 / customer p.a.</p>

Source : Sustainability First. ED2 commitments and leakage targets pulled together from DNO ED2 SF6 Strategies

5. DNO SF6 Strategies

Overview

Ofgem's baseline expectation on SF6 strategies is³⁹ :

- **Commit to implementing a strategy in RIIO-ED2 to manage SF6 on their network. This should include economic and efficient actions to reduce leakage rates and where appropriate, economic and efficient SF6 asset replacement.**

The ED2 sector specific methodology⁴⁰ noted that DNO strategies would to some extent mirror strategies for transmission IIG (insulation and interruption gases). Namely :

- **Proposed approach to reducing emissions**
- **Leak repair**
- **Asset management**
- **Procurement**
- **Innovation**
- **Collaboration for alternatives**

Ofgem decided against a DNO 'asset management target' as a baseline expectation for SF6. Rather, they expect this to reflect in the DNO SF6 strategies and also in associated reporting via the AER (annual environmental report).

In practice there is very considerable variability among the SF6 strategies. Some DNOs produce at best a couple of pages in their EAPS, indicating that a strategy remains a work in progress. Others set out a full strategy document either in their EAP or in a separate Annex. The most comprehensive are SPEN (within their EAP) and SSEN (EAP plus an SF6 Appendix). Possibly they are each ahead of the game being already required by Ofgem to have an SF6 transmission strategy, plus an incentivised approach to leakage. NPG also sets out a clear account of their EAP approach to SF6. Several DNOs also indicate a long-run SF6-free vision in the context of their commitment to science-based targets, but at the same time may not yet have developed a comprehensive strategy⁴¹. One DNO proposes collaboration on a strategy through the ENA⁴².

³⁹ RIIO-ED2 Business Plan Guidance. 30 September 2021. Appendix 3. Environmental Action Plans (EAP). Baseline Expectations. Page 74
<https://www.ofgem.gov.uk/publications/riio-ed2-business-plan-guidance>

⁴⁰ RIIO-ED2 Methodology Decision: 17 December 2020
<https://www.ofgem.gov.uk/publications/riio-ed2-sector-specific-methodology-decision>
 Annex 1 - Delivering value for money services for consumers. Appendix 4. Para A4.3
 'We therefore consider it is right for SF6 to be included within the baseline expectations **and have strengthened the expectation by outlining that DNOs should have an SF6 strategy.** We note that in RIIO-ET2, the **transmission operators' Insulation and Interruption Gas (IIG) strategies set out their proposed approach to reducing emissions, leak repair, asset management, procurement, innovation and collaboration for alternative IIGs. We consider a similar breadth of coverage from the DNOs' strategies would be welcome.** We also note that some respondents questioned whether an asset management target was an appropriate inclusion within the baseline expectations. At Consultation we included this as an 'and/or' requirement, however have removed this addition for the final Decision. We consider the SF6 strategy expectation and associated reporting within the AER to sufficiently cover this.

⁴¹ UKPN, ENWL

⁴² ENWL

Company	DNO SF6 Strategy – how far does strategy in EAP cover the ground suggested by Ofgem in ED2 sector specific methodology ?
ENWL	2-pages. Clear approach. Recognise more to do. Propose collaboration on a strategy via ENA
NPG	4-pages. Clear approach.
SPEN	10-pages. Comprehensive approach.
SSEN	4-pages plus 13-page Annex. Comprehensive approach.
UKPN	2-pages. More to do
WPD	1-page. More to do

Source : Sustainability First

Core elements of strategies

Although some strategies are clearer or more comprehensive, there is a set of common elements across DNO approaches.

SPEN has a strong asset-focus with a stress on the need for actions to be cost-efficient reflecting an approach which embodies ‘reduce, replace where economic and to identify feasible alternatives’. In particular they give a full account of their different assets that contain SF6, and, also helpfully discuss state of play on available asset-alternatives, summarized in a good table – see below.

SSEN is the lead DNO on SF6 for the ENA and also for the DEFRA review of the F-Gas regulations. Although SSEN give no costed information, they set out a considered and detailed *process* for SF6 management – from basic inventory, to monitoring, measuring, leak-detection, replacement (incl supply chain involvement). This includes the following elements :

- Commit to efficient and economic actions to reduce leakage rates and improve management of SF6 assets
- Adopt target(s) for SF6 leakage and/or SF6 asset management
- Develop a reporting system to report on total SF6 bank , leakage reduction rates and where possible using a common DNO methodology.
- Develop and implement an ‘alternative first approach’ for replacement of all of our SF6 assets due for replacement. Our strategic aim is to work internally and externally to develop economic and efficient alternatives to SF6 to enable the long-term removal of this greenhouse gas from our system.
- Deliver on our Science Based Targets to reduce emissions as a result of SF6 leakage by 35% by 2028 and 55% by 2033 from a 2020 base.
- In SSEN, targets will be measured against output performance measures (KPIs) governed through the Asset Management System. To review & adapt as needed for the most economic and efficient outcomes for consumers.
- Be compliance-ready for GB legislation developments
- Enhance equipment handling procedures and processes;
- Record usage at all life-cycle stages (from purchase to disposal);
- Quantify and minimise emissions during testing, manufacturing, installation, operation and maintenance and reclaim gas at the equipment's end of life;
- Review the processes and training related to SF6⁴³.

⁴³ SSEN EAP. p 25

Improved knowledge of SF6 bank

Several DNOs note the important role for data analytics (NPG, SPEN) in obtaining a better understanding of their SF6 assets. Indeed, SPEN indicate that their reported leakage increased by 9% overall in 20-21 from 19-20 (in Manweb up by 53%), due largely to improvement in completeness of data collected⁴⁴.

SSEN say : ‘Our strategy to minimise SF6 leakage from our switchgear, implemented in 2019/20, focuses on using updated data to improve our understanding of our SF6 assets’⁴⁵ As noted, SSEN show a relatively poor ED1 performance on leakage against bank in Ofgem’s RAG-rating, but they now also seem to point the way on transparent disclosure about their SF6 assets⁴⁶.

Both SPEN and SSEN describe a detailed approach to their SF6 inventories. For example, as of May 2021, SSEN know that they have almost 11,000 SF6 assets in service, three-quarters of which are 10-30 years old. They describe the asset-classes most prone to leakage and at which voltage (over half = 6.6/11kV). For their total asset bank, they have identified the five asset-types which account for two-thirds of the total bank. And for equipment most prone to leakage, they know which asset models and manufacturers.

This more detailed understanding of SF6 assets also suggests that there is a potential for leakage to become problematic not just at higher distribution voltages (which contain most SF6) but also on medium-voltage equipment.

Reducing total SF6 bank

In line with their science-based targets at least three DNOs reference a long-term vision of SF6 elimination from their operations. Total DNO SF6 bank amounted to 320,656 kg in 2019-20 (7,310,956 tCO2e) and grew in every year of ED1. While as noted the total DNO SF6 mass is far less than that for transmission, each DNO has many tens-of-thousands of smaller SF6 equipment items right across their network. It should also be stressed that for most part this equipment doesn’t leak and / or is sealed.

At the same time, new SF6 equipment will still be installed during the ED2 period.

SPEN say⁴⁷: ‘where modern SF6-free equipment is now available, we have considered whether otherwise healthy legacy SF6 filled plant should be replaced before its anticipated end of life. Currently, our cost assessments – which include evaluating the cost of carbon- suggest that it is not viable to replace good condition SF6 assets with like-for-like non-SF6 solutions. However, this will be kept under review.

SSEN spells out the case for an ‘alternative first’ approach⁴⁸: ‘Change will not happen unless we all push for it and that is why we are adopting an alternative first approach to all SF6 replacements, whereby investment decisions will have to justify why an alternative to SF6 is not suitable for any

⁴⁴ SPEN. A4c.3 – 6.12.2 p 98

⁴⁵ SSSN EAP p25

⁴⁶ SSEN EAP. Appendix B. Pages 106-118

https://ssenfuture.co.uk/wp-content/uploads/2021/12/A_13.1_EAP_CLEANFINAL_REDACTED.pdf

⁴⁷ SPEN EAP p 93

⁴⁸ SSEN EAP Appendix B. p 115

particular project. Project teams will have to demonstrate the business case for SF6 for every case put forward in ED2’.

WPD say they have a ‘leak and replace’ regime on 11kV distribution assets and a ‘two leaks and replace’ regime on larger or higher voltage assets but do not spell out their underlying CBA approach.

To meet their science-based targets, both NPG and UKPN each indicate an aim to reduce the total size of their SF6 banks. NPG notes⁴⁹ : ‘our investment decisions are based on economic viability, but we recognise we have a responsibility to take proactive action where we can to minimise our environmental impact, as doing nothing would undermine our long term goals to achieve net zero operations by 2040.’

We did not have the resource to look at any of the accompanying Engineering Justifications nor the CBA material. And in any case, much of that material is unavailable to third-parties such as ourselves.

Under Ofgem’s CBA methodology however, SF6 asset-replacement is invariably justified only at end-of-life despite the value of avoided carbon being factored into the assessment⁵⁰. Elsewhere in our ED2 response to Ofgem we have stressed that the new BEIS figure for the enduring cost-of-carbon - applied in cost-benefit assessments and aligned to net-zero - is now three-times higher than the figure currently used by Ofgem in their CBA template. Ofgem will wish to revisit this. If applying the higher BEIS cost-of-carbon figure in their CBA assessments DNOs may perhaps now find - for those assets where reducing carbon emissions was a main benefit but previously ruled-out on cost-benefit grounds – that these may now show a higher benefit. One added complication is that at least two DNOs note how removing healthy SF6 switchgear also has a high embodied carbon cost, likely to reduce the total carbon benefit of early SF6 asset replacement⁵¹. The point remains however that in using Ofgem’s current cost-of-carbon in CBA evaluations, an SF6 asset must presently prove fairly leaky before it will be considered for replacement.

It is therefore all the more important for the SF6 strategies to explore options, pathways and priorities for cost-efficient and considered steps on managing-down DNO SF6 banks over time. This will need a far clearer grasp of the full long-run costs and benefits, including carbon benefits, of asset replacement, viable options available and the sheer practicality of managing-down DNO SF6 assets to align with SBT time-frames. As noted, some DNO strategies are already some way down the track, while others on the face of it seem barely off the ground.

Procurement of SF6 alternatives and approach to supply-chain – including DNO collaboration

In the RII02 period, at both distribution and transmission voltages, engagement with manufacturers and the supply chain on cost-efficient procurement of non-SF6 and non-greenhouse gas alternatives has a new urgency. Not least, some current alternatives are understood also to contain at least some green-house gases. Given that those alternatives will also have long-asset lives the implications of their use also needs to be well-understood in terms of meeting company science-based and net-zero targets.

⁴⁹ NPG – EAP Annex 4.6. p 14

⁵⁰ Also accounting for an embodied carbon value associated with early-replacement

⁵¹ WPD - EAP p 35. ENWL

Broadly speaking, on a life-cycle cost-analysis basis, the cost-effectiveness of replacement of SF6 assets with non-SF6 switch-gear decreases with decreasing voltage level. So, in general, 132 kV switchgear replacements are the most cost-effective options; replacement of 33 kV switchgear is significantly less cost-effective than 132 kV, and replacement of 11 kV switch-gear is the least-cost effective.⁵²

DNO strategies reflect the differing availability and differing cost-profiles at the different distribution voltages of suitable alternative equipment. DNOs also seem to have differing degrees of engagement with the supply-chain. Subject to competition rules, procurement of SF6 alternatives is a clear area for significantly more sector-wide collaboration and push.

UKPN say⁵³: ‘there is currently no reliable, safe alternative to SF6 insulated equipment for the lower voltages we operate on our network that is available at scale’

NPG say⁵⁴: ‘to reduce the volume of SF6 on our network we need to replace our circuits with non-SF₆ alternatives. While alternatives to SF6 are being explored by manufacturers they currently have limited viability to be rolled out across the network. The feasibility of SF6-free solutions depends on the voltage level. NPG also notes it is the first DNO to trial indoor non-SF6 switchgear equipment at distribution voltage level⁵⁵.

- **Low voltage (LV) <1kV:** No solutions have been found to address assets at this level.
- **Medium voltage (MV) 1kV-52kV:** There are a limited number of products available in both primary and secondary distribution. Typically these cost 5 to 30 per cent more than SF6 equipment, require additional maintenance and widespread production capabilities have not yet been developed.
- **High voltage (HV) and extra high voltage (EHV), >52kV>150 kV:** SF6 free gas blends for gas insulated switchgear up to 145kV have been demonstrated with wide-spread commercialisation expected from 2025.

NPG indicate SF6 alternatives at both 132kV and 66kV currently to be ~30% higher-cost. Both SPEN and SSEN are likely to have practical experience to share with other DNO colleagues on 132kV alternatives.

SPEN devote a substantial part of their SF6 strategy to describe their active pursuit of alternative equipment supply⁵⁶: ‘we will drive the development and adoption of SF6-free technologies, collaborating with supply chain and industry peers and piloting new technologies where technically viable’. As well as cost-efficiency, SPEN describe the physical and efficiency benefits that SF6 insulating characteristics bring – in particular enabling a smaller footprint at both indoor and outdoor sites – making substitution more of a challenge, especially at very low voltage. The SPEN summary table below gives a helpful snapshot on state-of-play.

⁵² ENA Slides to Ofgem ED2 Decarbonisation & Environment Working Group. 19 February 2020. Impact assessment – alternatives to SF6 switchgear. Life-cycle cost-analysis – slide 16.

⁵³ UKPN - EAP App 16 – p 42

⁵⁴ NPG – EAP Annex 4.6. p 14

⁵⁵ ABB equipment

⁵⁶ SPEN EAP. A4C.3 p 93 section 6.12.1

Switchgear/ System Level	Legacy Technology	Current Technology Interruption	Current Technology Insulation	SF6 alternatives available ?	Market Ready Date	Cost Change in RIIO-ED2
132kV	Oil /Air Blast	SF6/Alt gas	SF6/Alt gas	Yes [Vac/Alt gas]	Now	↑
EHV (33kV)	Oil/SF6	SF6/Vacuum	Solid/SF6	No	3yrs-plus	N/A
HV Primary (6.6/11kV)	Oil/SF6	Vacuum	Solid/Air	Yes	Now	↔
Secondary HV (6.6/11kV)	Oil	SF6/Vacuum	SF6	No	5-8 yr	↑
Overhead Line Switchgear	Oil	SF6/Vacuum	SF6/Solid	Auto- reclosers (Yes) PM Switches (No)	Now – 3 years	↔
Source : SPEN EAP. Table 18: 'Switchgear and SF6 alternative development'. P.93 A4C.3 p 93 section 6.12.1						

In sum, the DNO strategies as set out in their EAPs leave a great many unanswered questions for future procurement approaches. In light of company science-based and net-zero targets these questions require very active consideration in the ED2 period, including via strong collaboration effort (competition rules permitting). For example :

- For how long should new SF6 switch-gear continue to be installed in DNO networks – either as a replacement unit or for new load-related assets ? And at what voltages ?
- Do alternatives also contain greenhouse gases ? If so, in light of long asset-lives, for how long will it be prudent on grounds of either cost or carbon-reduction to install these alternatives ?
- Should DNOs agree priorities for their supply-chain engagement to better focus asset development ? e.g. higher / lower voltages ? indoor / outdoor switchgear ?
- Should there be more common DNO approaches to replacing leaking assets at different voltages pre-end-of-life ?
- What do DNO visions 'to eliminate SF6 banks' mean in practice ? How does this play out for small sealed SF6 units at the lowest distribution voltages which are not leaking ? i.e. is there a general consensus to leave these in place on a life-cycle cost-basis (followed by safe-disposal) ? How far might imperatives on green-house gas removal drive uneconomic early-replacement ? If so, are the operational and cost-impacts well-understood from both an affordability and resilience standpoint ?

DNO Innovation on SF6

Generally, the strategies do not emphasise DNO innovation as a focus for helping to tackle SF6 leakage, nor for tackling the potentially bigger long-term logistics, including the operational challenge and costs, of eventual elimination of SF6 banks.

There would seem to be two key areas for SF6 where innovation can be expected to make an important contribution in ED2.

Innovation for leakage detection, leakage reduction and overall improvement in asset monitoring and management : Several DNOs introduced infra-red SF6 leak-detection in ED1 and some DNOs

mention plans to introduce or increase this capability in ED2. Indeed, it is not clear why this is not referenced as standard practice for all DNOs in ED2. There are also several references to the use of improved data-analytics in SF6 asset-management, but other than SSEN these are not expanded on. There is one brief reference to exploring potential opportunities with asset recovery contractors and manufacturers on the recycling of used SF6 gas.

DNO collaboration and greater engagement with manufacturers and the supply chain in developing SF6 alternatives – especially at lower distribution voltages. As discussed above, this area is rightly a main focus for DNO innovation on SF6 and the strategies outline how several new investments are planned on this basis in ED2.⁵⁷

Given the many uncertainties above, we would wish to see DNOs commit to innovation actions in both of these major areas with regular progress reports via their Annual Environmental Reports.

Section III – Suggestions for Ofgem on SF6 Incentives

6. Ofgem draft determinations and regulatory incentives for SF6 in ED2

Incentives - headline conclusion

From both a decarbonisation and consumer standpoint, DNOs have a particular SF6 asset-management challenge. There are long-run risks – logistical and operational – and potentially high-cost. Even with adequate leak management, SF6 assets need life-long containment and safe-disposal. Critically, suitable equipment alternatives are not yet cost efficient or even commercially available at every distribution voltage.

Some core elements for addressing the SF6 challenge are certainly reflected in DNO EAPs and SF6 strategies. Nevertheless, we still see a need for concerted effort and clear incentives to drive progress in this relatively ‘unseen’ and unglamorous asset-management area.

Our specific suggestions for Ofgem on the DNO SF6 strategies are two-fold.

- At draft determination stage to clarify key elements in Ofgem’s SF6 baseline expectations – and also very important -
- To introduce financial regulatory incentives for the SF6 strategies to drive a gear-change in DNO outputs and outcomes on SF6 by the end of the ED2 period. These incentives need to shape a better grasp of what ‘good-looks-like’ for SF6 asset management equipment items large and small in the long-run. The incentives also must actively motivate joint-working among DNOs and the supply chain, so that viable and cost-efficient solutions can be identified capable of addressing the long-run SF6 distribution company business risk.

Ofgem’s ED2 baseline expectations on SF6 - for a leakage reduction target and for a common reporting methodology – are best described as ‘minimal’. Even so, we much welcomed the introduction, for the first time, of the need to adopt and implement an SF6 Strategy which brought DNOs in line with transmission. Unlike for transmission however, we regret that Ofgem saw

⁵⁷ E.g. NPG, SPEN

reputational regulation as the way forward for SF6 in ED2⁵⁸ – through the SF6 Strategies and the Annual Environmental Report – whether for establishing new leakage targets, for addressing actual leakage performance, for delivering a common reporting methodology, or, longer-term for reducing the SF6 bank through improved approaches to asset management.

In the meantime, DNOs have begun to take on board the practical reality of science-based targets and statutory net-zero targets. This fundamental change in the external drivers to decarbonize DNO operations – against clear deadlines - must surely now also knock-through into DNO and Ofgem thinking on the nature of SF6-equipment as a future business risk. Over time, science based targets and net-zero will entail near-elimination of DNO SF6 assets.

Against this wider context, our review of the DNO SF6 strategies reinforces our initial thinking⁵⁹ that SF6 presently remains a neglected area of DNO asset management. In general terms, neither the business plans nor the Environmental Action Plans suggest that this area is a priority for either the companies or for Ofgem. Yet from both a consumer and environmental standpoint clear long-run risks attach to a business-as-usual / ‘do-little-or-nothing’ approach – logistically, operationally and in cost-terms.

We see a strong case for Ofgem to recognise the need to do more in ED2 to drive concerted action by DNOs to avoid unnecessary longer-term costs and risks being picked up by future consumers, possibly in a disproportionate way if everybody gets this wrong.

Draft determinations

At draft determination Ofgem should therefore look to :

- **Common reporting methodology** - set a date for completion of the methodology plus the start-date for common reporting into Ofgem.
- **ED2 Leakage Targets** – request each DNO (1) to express their proposed ED2 leakage target against a common agreed ED1 baseline so that the relative ambition-level of the ED2 targets are clear and (2) to describe why the target represents a ‘stretch’ against the newly-agreed common ED1 baseline. There is already a clear precedent in transmission for just such a well-defined Ofgem approach to target-setting⁶⁰.
- **SF6 Strategies** – consider whether each SF6 strategy as set out in company EAPs sufficiently meets the Ofgem baseline expectation. As noted, we consider two may still have ‘more to do’.

⁵⁸ ED2. Ofgem Common Methodology Decision. December 2020.

Unlike transmission, Ofgem decided against a leakage penalty – and also wished to avoid incentivising needless asset replacement.

⁵⁹ https://www.sustainabilityfirst.org.uk/images/publications/other/Working_Paper_-_Greening_electricity_distribution_networks.pdf

⁶⁰ RII0-2 Final Determinations Electricity Transmission System Annex (Revised). 3 February 2021. **Insulation and Interruption Gas (IIG) Leakage ODI-F. Pp 43-45 .**

https://www.ofgem.gov.uk/sites/default/files/docs/2021/02/final_determinations_et_annex_revised.pdf
Initial baseline calculated, using the average leak-rate from 2013-20, with separate levels of improvement applied (0-15%) for each TO. Initial leakage rate is multiplied by the IIG Inventory at the end of RIIOT-1 to prove a target baseline in tonnes of CO₂e.

Within-period financial incentives for SF6 strategies

Ofgem has proposed a financially-incentivised balanced score-card for the environment in the ED2 period. In their EAPs, DNOs set out their own proposals for which elements of their EAP performance should be financially incentivized. No DNO has suggested that SF6 should be financially incentivised under the score-card, notwithstanding that this is a controllable scope 1 BCF emission.

Thus the companies and Ofgem both favour a reputational approach to regulation of SF6 in ED2. For the reasons set out in the preceding paragraphs and reflected throughout this paper we disagree. SF6 demands a stronger regulatory signal in ED2. A reputational incentive is inadequate to the task of driving the change-of-gear necessary for DNO approaches to their SF6 risk over the next five years – albeit annual reporting to Ofgem via a common methodology - and also reporting more widely on their SF6 strategies via the AERs – is at least an improvement.

We would therefore strongly encourage Ofgem to consider a ‘within-period’ SF6 financial incentive along the following lines.

- **A financial incentive for SF6 leakage against target** – while we agree that at distribution voltages SF6 leakage is comparatively low by volume, a financial incentive would send a far sharper signal for better outcomes - across DNO leakage performance and reporting, gas-handling, leakage monitoring, leakage management and equipment repair. A well-defined leakage target would offer a readily quantified output suited to a financial incentive. One option would be to include this incentive as a part of the environmental balanced score-card. Also, if desired, (as per transmission), it may be feasible to acknowledge genuine difference in the underlying reasons among DNOs for their SF6 leakage position by switching-on the penalty / reward elements of the incentive differently. It would also be possible, as one DNO already proposes, to revisit the ambition of a target after two years.
- **A financial incentive for the SF6 strategies** – development of DNO SF6 strategies and acting on these over the next five years ranks highly in addressing the considerable business risk which SF6 represents. Given the significant variability in the SF6 strategies presented in the EAPs, we conclude that some form of financial incentive for the strategies, as well as one for the leakage-reduction target as proposed, would send an important signal from Ofgem to DNOs about the need for pro-active management of their SF6 business risk in ED2. The incentive would reward overall quality of the SF6 strategies against the Ofgem criteria, including approaches to inventory, reporting on asset-management and bank, integrated data-analytics, innovation, and, important, active DNO collaboration on developing viable alternatives at all voltages through the supply chain. Because of the long-run nature of the DNO SF6 asset management challenge, and the potential scale of uncertainty, any financial incentive on SF6 is likely to be a mix of quantitative and qualitative elements (for example, like the per DSO strategy output delivery incentive). One possible model for Ofgem to consider might be the ED1 Distribution Losses Discretionary Reward. This was put in place at the start of ED1 to make progress on DNO losses strategies and to spur innovative approaches⁶¹. A financial incentive for SF6 strategies could also be introduced via the balanced score-card. Or, via a separate incentive. Because the desired outcomes here are both long-run and complex, perhaps a separate incentive may be

⁶¹ The Losses Discretionary Reward (LDR) was introduced in the RIIO-ED1 price control to encourage and incentivise DNOS to undertake additional actions to better understand and manage electricity losses <https://www.ofgem.gov.uk/publications/riio-ed1-losses-discretionary-reward-submissions-tranche-three>

appropriate. Either way, Ofgem should not reject the idea of a financial incentive out-of-hand on the basis that the SF6 strategies do not lend themselves to a simple quantifiable metric set. Rather, Ofgem should view a financial incentive as a suitable means to drive progress in an environmental area in need of far more active attention both by themselves and by the companies.

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