Electricity Transmission

EIS 2024

SF_6 Whole Life Strategy

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Project consortium for Beta Phase

Funding – The project is funded by network users and consumers under the Strategic Innovation Fund (SIF), an Ofgem program managed in partnership with UKRI.

Project Lead nationalgrid

Project Partners

Scottish & Southern Electricity Networks TRANSMISSION

SP Energy Networks

MANCHESTER 1824 The University of Manchester

DNV

WIKA

DILO

Technical Advisory Board (in progress, contact prem.ranjan@nationalgrid.com)

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD

EPRI ELECTRIC POWER RESEARCH INSTITUTE

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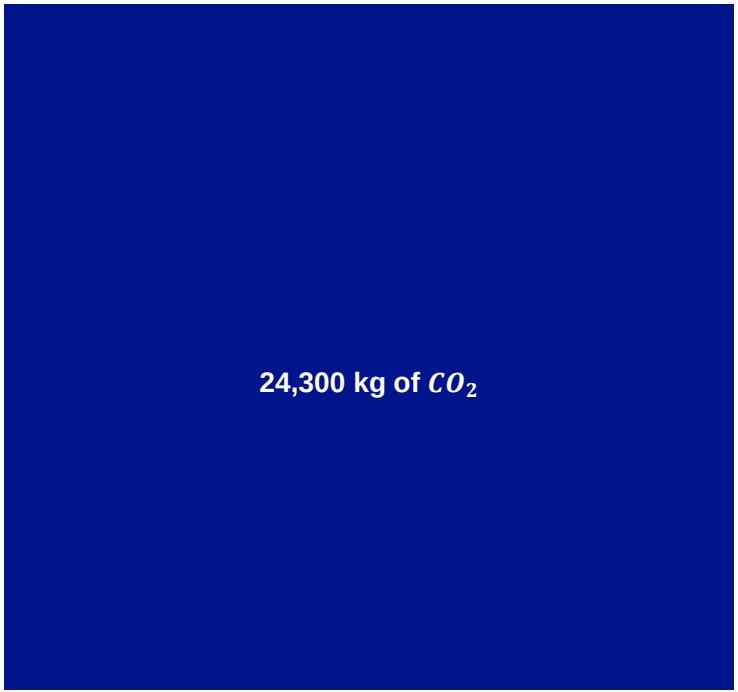
SF_6 in the GB Power Sector

1 kg of SF_6



Annual Emissions of SF_6 between 2012 and 2022 rose by

~47%

SF_6 inventory within GB transmission substations

1100 tonnes

% of National Grid's scope 1 emissions from SF_6 leakage (excluding losses)

92%

National Grid has the ambition to reduce SF_6 emissions by

50% by 2030

And committed to Net Zero by

2050

SF_6 Whole Life Related Challenges

Design → Build → Early Phase Operation → Late Phase Operation → Disposal and Replacement

Increasing the knowledge about practical challenges of operating the assets with SF_6 alternative gas mixtures

Increase knowledge about retrofilling newer assets with SF_6 alternatives

Considering strategies for old assets including leak repair, refurbishment and retrofill

End-of-life treatment of SF_6 removed from assets

Project Overview (Alpha)

Supporting the development of an economic, efficient and holistic replacement strategy for SF_6-free that will support GB's ambition to facilitate a net-zero and resilient energy system

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Key Activities

- **Develop and assess options available for replacing SF_6 use across all network assets**
- **Sampling of aged SF_6 alternative gas mixtures from live equipment to assess gas stability**
- **Laboratory scale testing of novel SF_6 disposal method**
- **Develop a model to forecast when leakages are likely to occur**
- **Undertake a techno-economic analysis of the interventions available for replacing SF_6 gas.**

Innovation Challenge

Challenge 3: Improving energy system resilience and robustness

- **Strengthening the UK's energy system robustness to support efficient roll out of new infrastructure**

Alpha Phase Approach

Data Analytical Approach of Leakage Rates

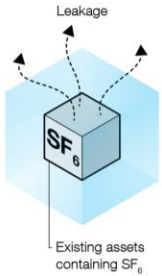
(WP4)

How do we make more informed decisions about interventions?

SF_6 Intervention FEED

(WP1)

Are retrofilling and leak repair a technically viable alternative to mass early replacement?



Decision-making about optimal interventions

Roadmap for Implementation of Interventions

(WP5)

What is the optimal timing of interventions?

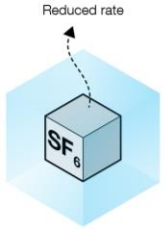
Techno-economic Analysis

(WP6)

Is there a business case for broadening the types of interventions?

1 Reduce Leakage

(refurbish, leak repair, prevention)



2 Use Alternative Gas

(retrofill)

3 Reduce Leakage and Use Alternative Gas

(early replacement or retrofill & refurbish)

Disposal of old SF_6

Handling guidance

Site Handling of Non-SF_6 Gas Mixtures

(WP2)

How does the handling of non-SF_6 gas mixtures differ from traditional practices?

Novel SF_6 Disposal Testing

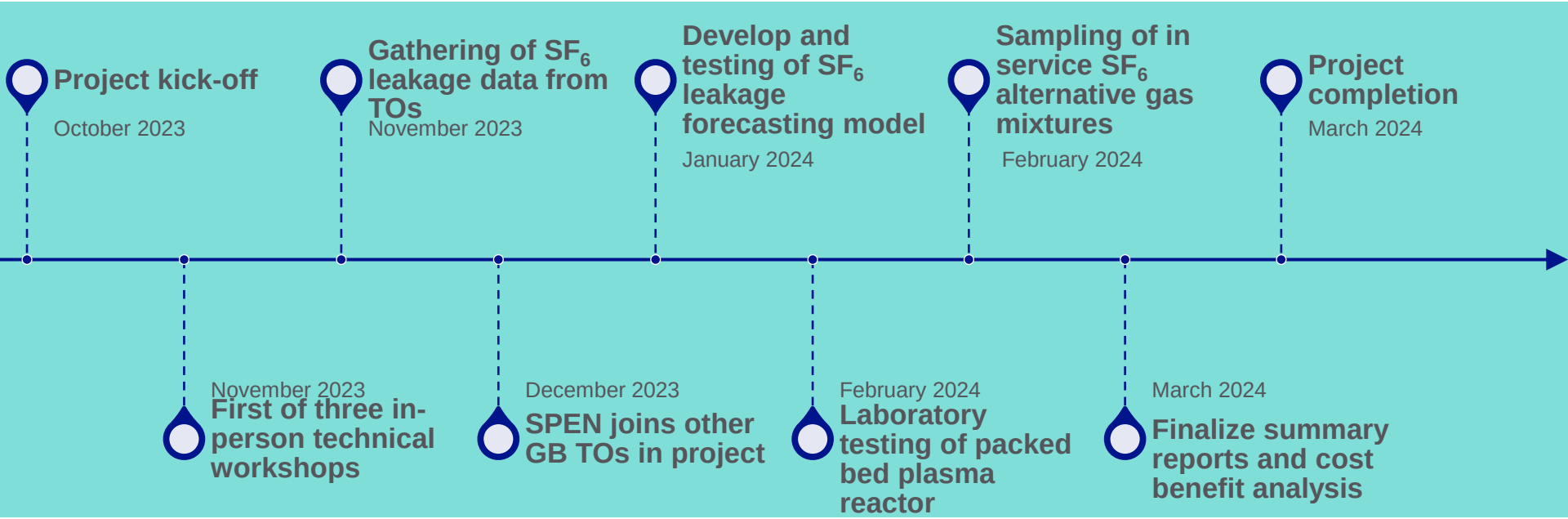
(WP3)

Are there better ways of disposing of SF_6 that is removed from assets?

Understanding of policy and regulatory environments

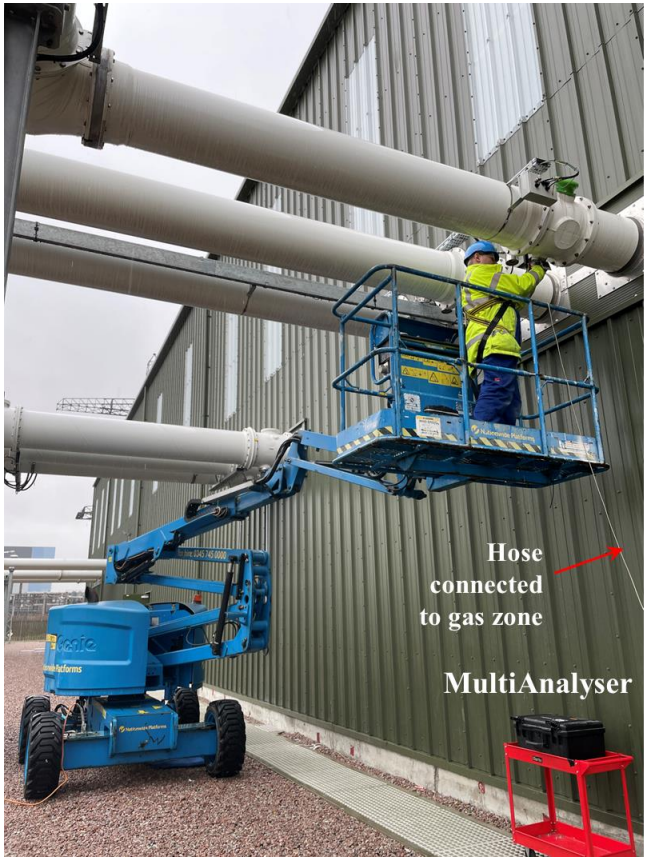
What we've been doing in Alpha?

Project Highlights

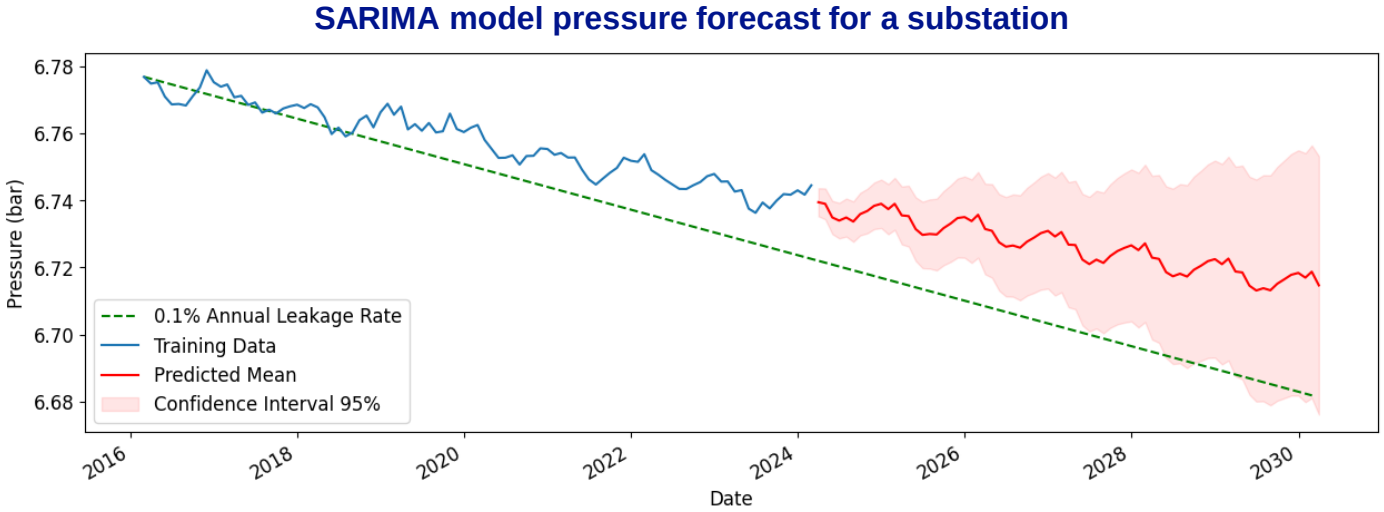


Key Insights and Benefits of Project

- **WP1** - there is limited user-experience for replacement intervention strategies such as retrofill therefore a high throughput and realistic failure mechanism analysis, would inform the development of innovative in-situ condition monitoring techniques/tools to evaluate in-situ performance of SF_6 alternatives.
- **WP2** - primary results show no formation of by-products, and sampled gas blends are stable within operational range
- **WP3** - laboratory scale testing of Packed Bed Plasma reactors demonstrated it as a viable alternative to conventional SF6 disposal methods with benefits around scaling up, energy efficiency and offering the opportunity for better chemical recycling of SF6



Key Insights and Benefits of Project



- **WP4** - forecasts with models developed in project show the meaningful general trends and the trend variance can be used to estimate the time for next possible top-up. However, more complex machine learning approaches may be required for large, labelled datasets. There is a need to acquire data from the assets that are in the middle of their lifetime to investigate the transitional patterns from normal operation to stages with increased leak rates.

Key Insights and Benefits of Project

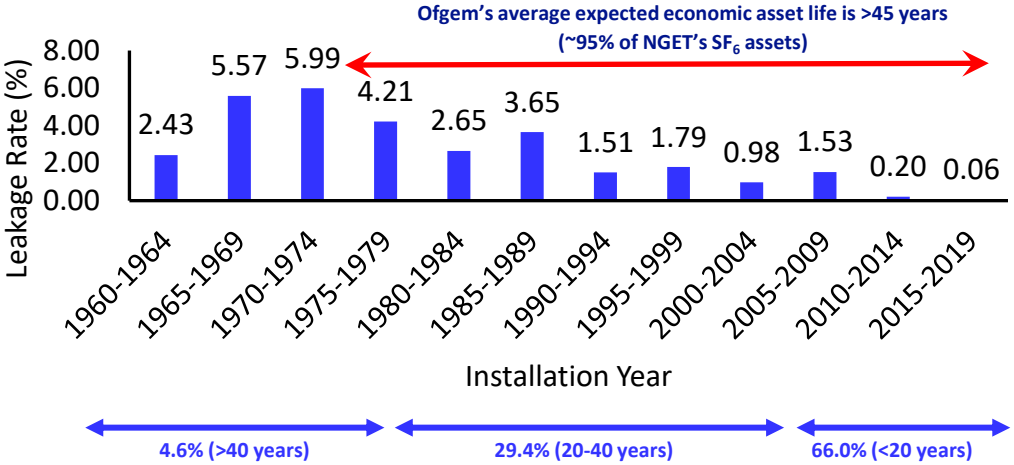


Figure 1. Leakage profile for NGET's SF_6 equipment inventory categorised by age and leak rate. Note that the leakage rate is a converted value from record of gas top-up operation

WP5 – while it is more beneficial to undertake SF6 interventions sooner rather than later however the need to undertake SF_6 driven works must be balanced with supply chain, outage and regulatory considerations in a staged and secure way

WP6 - in every instance it was always more advantageous both economically and environmentally to invest in an intervention. The cost of interventions are dwarfed by the benefits of lower emissions, calculated on the basis of societal cost of carbon and the cost of purchasing carbon credits

Looking Ahead - Implementation of Strategies

Discovery

Involvement in project from a multidisciplinary team of network owners, academia, consultancy,

Developed list of intervention strategies and carry out techno-economic analysis on example sites to better understand trade-offs.

Alpha

Explore opportunities and barriers to SF6 interventions defined in Discovery.

Topics include developing a machine learning approach to SF6 leakage assessment, site handling of gasses, laboratory testing of disposal methods and understanding system access implications.

Beta

Large scale demonstration of interventions effectiveness in-situ, followed by developing a holistic rollout strategy for other eligible sites, ensuring scalability and applicability across electricity networks.

Business-as-usual

Implementation of strategies refined in Beta phase across GB.

Updated site handlings procedures for SF_6 alternatives

Retrofill solutions for non-OEM supported assets

Lower cost/carbon disposal methods

Reliable leakage rate data for determining optimal intervention

Disseminate findings to increase adoption rates, inform commercial strategies and understand impact of regulatory changes

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