Energy Networks Innovation Process

Project Closedown Report Document

Date of Submission: 05/07/2021

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Project Title (*This cannot be changed once registered*)	Project Reference
Feasibility of Compressed Dry Air 33kV Insulated Switch gear	NIA_SSEN_0042
Funding Licensee(s)	**Project Start Date**
Southern Electric Power Distribution	December 2019
Project Duration	**Year**
6 months	2021

Nominated Project Contact(s)
SSEN NIA Programme Delivery Manager – Colin Mathieson

1. Scope

The scope of this project is to undertake a desktop study which will include as a minimum;

· Literature review on compressed dry air as an alternative to SF6, identifying any associated risks and unforeseen challenges;
· Contact with supply chain to ascertain their progress in developing compressed dry air as an insulation medium;
· Identification of the likely parameters of the compressed dry air switchgear, associated operating functionality/performance, operational and maintenance requirement and risk assessments;
-Cost Benefit Analysis for potential field trials;

Understand the parameters where compressed dry air can be utilised;
· Produce an implementation plan detailing the requirements if we were to transition compressed dry air 33kV switchgear into business as usual;

Recommend potential for further work if initial timings are positive.

2. Objective(s)

The project's objectives are as follows;
1. Production of a desktop study which details switchgear manufacturers progress into investigating compressed dry air as an alternative to SF6 for 33kV products.
2. Detail an implementation plan required to transition compressed dry air 33kV switchgear into business as usual.

3. Success Criteria

A report with a clear recommendation on the potential benefits and likely time frames, on the use of compressed dry air as an alternative to SF6, incorporating previously stated project scope and objectives.

4. Performance compared to the original project aims, objectives and success criteria

Details of how the Project is investigating/solving the issue described in the NIA Project Registration Pro-forma.
Details of how the Project is performing/performed relative to its aims, objectives and success criteria.

Project background

The environmental impact of Sulphur Hexafluoride (SF6) means that its use in the electrical distribution industry is becoming increasingly regulated and restricted, therefore it is important that alternatives to SF6 are investigated.

SF6 is used as an insulating medium and on the distribution systems it is mainly found in switchgear. This project was initiated to investigate the progress switchgear manufacturers were making into alternatives. More specifically to determine the viability of utilising compressed dry air as a SF6 alternative across 33kV switchgear.

Project Progress

The projects objectives were successfully completed, and a report investigating switchgear manufacturers progress into utilising compressed dry air as a SF6 alternative across the 33kV switchgear was delivered.

1. Production of a desktop study which details switchgear manufacturers progress into investigating compressed dry air as an alternative to SF6 for 33kV products.

Threepwood Consultancy approached 28 switchgear manufacturers, world-wide, as part of the desktop study and received replies from 12 Manufacturers. Presently, there is only one Research and Development company, Nuventura in Germany, who are working on designing a compressed dry air alternative solution to SF6 for 33kV products. The Nuventura 33kV compressed dry air solutions still requires two type-tests associated with its operational safety to be undertaken, only when these are satisfactorily passed will the equipment be considered for a live trial on a network. As Nuventura are a Research and Development company, they have the additional challenge of finding a switchgear manufacturer that will produce the equipment. Threepwood have assumed that the Nuventura compressed dry air 33kV solution could take 2 years to pass the necessary type-testing operational safety requirements and negotiate the associated product license with a manufacture. It is envisaged that it will take the manufacture a further 6 months to set up the compressed dry air production line.

The 12 replies provided 26 examples of 33 kV switchgear equipment that did not rely on SF6 as insulating medium. Examples of alternatives for SF6 ranged from using;

- naturally occurring gasses - like air, nitrogen, carbon dioxide and their mixtures;
- man-made gasses - like fluroroketone or Hydrochloroflouroolefin;
- or a combination of vacuum interrupter, solid insulation and a gas to provide a dielectric within the disconnector chamber.

Threepwood within the report also outlined the pros / cons for switchgear insulation mediums other then SF6 and project implementation time frames for these other novel solutions.

2. Detail an implementation plan required to transition compressed dry air 33kV switchgear into business as usual.

Threepwood, in their summary report, included an implementation plan to facilitate new technologies onto a network, this is applicable to all alternatives to SF6 and is as follows;

- 33kV switchgear specification – either amend an existing specification or produce a new specification for a device intended for use on the electrical system. This document pulls together all the information about how the new switchgear is to fit and operate within the existing system;
- Type-testing – demonstration that the new 33kV equipment can withstand the network conditions to which it will be exposed (it often takes a minimum of 9 months from the launch of new type of switchgear to the completion of the type-testing stage);
- Operation acceptance - a period when the actual end product can be put through its paces and more can be learnt about how it is installed, run and maintained. In the UK, this investigation period will often assess if additional physical safety features need to be applied to meet the UK Distribution Network Operators' operational safety requirements. This phase will depend on the number of modifications or changes the new switchgear incorporates from the present functional design that is used on the system, for instance if the enhancement is only the insulation medium then 4-8 months might be sufficient for the operation acceptance; alternatively if it's a new manufacturer to the market with an innovative solution, 12-18 months might be required.
- Commissioning – determining whether existing commissioning procedures are adequate. If there are changes to the conventional operational practices, new commissioning procedures might need to be developed and implemented. It may be possible to undertake this activity concurrently with the operational acceptance phase.

- Prospective numbers of 33kV switchgear required - this has an impact on the unit price of the new model, the manufacturing timescales and the scale of necessary equipment spare parts.

- Maintenance and repair – key part of the selection and purchase decision process is research to establish whether any special apparatus or tools are required for maintenance or repair, procurement of consumables and their storage or shelf life, also into who the equipment can be serviced by.

Looking specifically at a 33kV compressed dry air switchgear solution, the only present design is approximately two and half years away from starting on a UK implementation programme for business as usual (BaU). It is estimated that a further eighteen months would be required, as a minimum, to address the implementation challenges and achieve a BaU compressed dry air switchgear solution for the UK.

5. Required modifications to the planned approach during the course of the project

The Network Licensee should state any changes to its planned methodology and describe why the planned approach proved to be inappropriate. Please confirm if no changes were required

No modifications required.

6. Lessons learnt for future projects

Describe how the project (methodology, stakeholder engagement etc.) changed, or provided opportunities, from your expectation at the start of the project and therefore could be useful for a future project. In addition, please discuss the effectiveness of the research development or demonstration undertaken.

As a result of this investigative project we have developed a snapshot of the level of development of 33kV switchgear alternatives to SF6 at the current time. This document could be used positively by other Distribution Network Owners to select a preference in emerging insulation technology, which best matches their network parameters and supports their future 33kV switchgear procurement programmes. This snapshot of 33kV switchgear alternatives for SF6 also could be used as a baseline to measure the onward development within the market.

All approached manufacturers supply the 33kV switchgear market world-wide. It is important to note that electrical products have to be made specifically or adapted for the UK market, so they are housed and maintained in a way that aligns with present UK Operational Safety Requirements, this incurs additional costs. The UK 33kV switchgear is a relatively small market comparing to the world-wide one, therefore there are greater world-wide influential factors that will stimulate changes in insulation mediums away from SF6. As it is more likely that a new switchgear product will come from the world-wide market the operational acceptability and commission phases of the implementation plan will take longer to ensure inclusion of appropriate UK system safety de-risking measures.

This project was a desk-based study, further research is required once an alternative solution to SF6 switchgear is ready for the operational acceptance phase of the implementation plan. This will develop the functional understanding and the technical documentation suitable for SF6 free 33kV switchgear to move towards BaU.

7. The outcomes of the project

When available, comprehensive details of the Project's outcomes are to be reported. Where quantitative data is available to describe these outcomes it should be included in the report. Wherever possible, the performance improvement attributable to the Project should be described. If the TRL of the Method has changed as a result of the Project this should be reported. The Network Licensee should highlight any opportunities for future Projects to develop learning further.

The Threepwood report conclusions are summarised below;

- A 33kV compressed dry air switchgear solution has not been presented to the ENA panel for consideration and approval due to the technology not being ready;
- Alternative insulation mediums are available, but they have a larger footprint than the SF6 33kV switchgear; a substantial remodelling and substation expansion would be required to replace existing SF6 equipment;
- Modelling demonstrates no cost benefit to introduce compressed dry air;

- Positively, there are no major technical barriers to compressed dry air as an alternative to SF6 but it's still at the design stage;
- Currently, there is only one company - Nuventura developing a compressed dry air solution. This technology still must undergo and achieve two remaining type-tests, which will prove the electrical safety and suitability of the design;
- DNOs should develop a strategy to move away from their reliance on SF6 as an insulation medium and outline an implementation plan. This will help determine the timescales and allow SF6 insulation alternatives to be selected for investment. This will then allow elements of the implementation plan to be addressed such as SF6 free switchgear specification development;
- New switchgear products that no longer use SF6 as an insulation medium but have the same footprint are more likely to be produced first for the world-wide market before coming into the UK. As the products will be designed for the world-wide market, the operational acceptance phase of the implementation plan will need to focus on what modifications or additions are required to comply with UK Operational Safety Requirements.

There has been no change to the technical readiness level of 33kV compress dry air switchgear, as it was a desk-top study.

8. Data Access & Quality Details

A description of how any network or consumption data (anonymised where necessary) gathered in the course of the Project can be requested by interested parties. Please include a link to the publicly available data policy.

For information on how to request the data gathered as part of this project see Network Innovation Competition (NIC) and Network Innovation Allowance (NIA) Data Sharing Procedure at https://www.ssen.co.uk/InnovationLibrary/Distribution/

9. Foreground IPR

A description of any foreground IPR that have been developed by the project and how this will be owned.

This project did not produce any foreground IPR.

10. Planned implementation, recommendations or next steps

Please describe the next steps to implement this innovation project. What policies and standards need to be updated or created as part of this implementation.

As part of the SSEN data gathered to support the Threepwood report, the volumes and types of 33kV switchgear across the network were accumulated. This is the basis upon which a phasing out of SF6 switchgear strategy can be developed. Using the Threepwood report and SF6 alternative switchgear strategy, it will be possible to identify further implementation plans for specific types of new switchgear. With further NIA funding development opportunities, new equipment 'live' trials as well as the implementation and commissioning procedures can be developed, which would lead onto commercially available products.

11. Other comments

N/A

12. Standards Documents

Identify any industry standards that may require updating due to the outcomes or understanding developed from this innovation project. If no standards will need to be updated, please state - not applicable

Information including the Threepwood report can be requested through the SSEN Future Network email address:
futurenetworks@sse.com