Reduction of SF_6 emissions in high-voltage switchgear equipment

In response to global warming, GE's Grid Solutions developed g^3 insulating and switching gas as an alternative to SF_6, which has a very high global warming potential and extended duration in the atmosphere, for use in high-voltage electrical transmission equipment.

Starting date of the project	July 1st 2019
Project Localisation Places of implementation of the project at this stage and targeted geography if replicable.	Circuit-breaker development: Villeurbanne, France Bay development: Aix les Bains, France First implementation on a high voltage network: Kintore substation, Scotland
Project objectives Type of climate innovation of the project with a description of the problem/issue addressed	Propose an alternative solution to the use of SF_6 for the insulation and switching of high voltage equipment. The circuit breaker development project called LifeGRID is supported by the European Union, through its LIFE Programme (https://webgate.ec.europa.eu/life/publicWebsite/project/details/5056).
Detailed project description	**Since the late 1960s, because of its remarkable insulating properties, sulfur hexafluoride (SF_6) was the most widely used gas in switchgear and metering equipment in high-voltage electrical substations, the "strategic nodes" of power grids. The electricity transmission industrý accounts for about 80% of the world's SF_6 use.** **Nevertheless, it has been listed as a greenhouse gas. SF_6 is estimated to contribute 23,500 times more emissions than CO_2, if leaked, and can remain in the atmosphere for up to 3,200 years.** GE's alternative to SF_6 gas, which is used as an insulating and switching gas, is the g^3 gas. It is the result of ten years of research and development by its teams in France, Germany and Switzerland, in collaboration with the 3M group. The g^3 gas mixture consists of carbon dioxide, oxygen, and 3M™'s Novec™ 4710 dielectric fluid from the fluoronitrile range. Fluoronitrile was identified by GE R&D experts as the most suitable additive to CO_2 and O_2 to achieve the targeted environmental benefits of an alternative to SF_6 without compromising on technical performance and equipment footprint. The global warming potential (GWP) of the g^3 gas used in GE's equipment is more than 99% lower than that of SF_6. In terms of technical performance, high voltage equipment insulated with g^3 gas offers the same level of performance as products insulated with SF_6. They have the same physical size and operate in the same environmental conditions (down to -30°C). A recent European Commission report concluded that switchgear using fluoronitriles may be the only alternative to SF_6 when space is a constraint (e.g. in urban areas). Tests on a 420 kV, 63 kA gas-insulated g^3 substation circuit-breaker are underway and will demonstrate that g^3 technology can be applied to all other high-voltage levels of European power grids. Eventually, when all g^3 products are available, 10,000 tons of SF_6 will no longer be added to the electrical networks each year. In addition, the g^3 gas can be used to replace SF_6 in particle accelerators.
Main project's drivers for reducing the greenhouse gas emissions Enter the information in the appropriate boxes	

Reduction levers	Details on the aspects of the project
☐ Energy and resource efficiency (including behaviour)	
☐ Energy Decarbonisation	
☐ Energy efficiency improvements	
☐ Improving efficiency in non-energy resources	
☐ Emissions absorption: creation of carbon sinks, negative emissions (BECCS, CCU/S, ...)	
☐ Financing low-carbon producers or disinvestment from carbon assets	
☒ Reduction of other greenhouse gases emission	Replacement of SF_6 (GWP 23,500) by g^3 gas (GWP 408) in high voltage equipment.

<table>
<tr>
<td>Emission scope(s) on which the project has a significant impact and quantification of GHG emission reductions per emission scope

Indicate the aspects of the project that contribute to the reduction of emissions per category of emissions considered (left-hand column) and the quantification of associated emissions.

Indicate the main hypotheses and calculation steps in the intended section (below the table)

For further details, please refer to the methodology guidelines.</td>
<td>
<table>
<tr><th></th><th>Aspects of the project contributing to the reduction of emissions by emission category</th><th>Quantification of associated GHG emissions by emission category

Please follow the quantification methodology used in the Afep guidelines.</th></tr>
<tr><td colspan="3">Reduction of the company's carbon dependency</td></tr>
<tr><td>Scope 1
Direct emissions generated by the company's activity.</td><td></td><td></td></tr>
<tr><td>Scope 2
Indirect emissions associated with the company's electricity and heat consumption.</td><td></td><td></td></tr>
<tr><td>Scope 3
Emissions induced (upstream or downstream) by the company's activities, products and/or services in its value chain.</td><td></td><td></td></tr>
<tr><td colspan="3">Increase of carbon sinks</td></tr>
<tr><td>Emissions Absorption
Carbon sinks creation, (BECCS, CCU/S, …)</td><td></td><td></td></tr>
<tr><td colspan="3">GHG emissions avoided by the company at third parties</td></tr>
<tr><td>Avoided Emissions
Emissions avoided by the activities, products and/or services in charge of the project, or by the financing of emission reduction projects.</td><td>Replacement of SF_6 (GWP 23,500) by g^3 insulating and switching gas (GWP 408) in high voltage equipment.</td><td>825 tCO2eq/year over the 40 years of the equipment's operation</td></tr>
</table>

Clarification on the calculation or other remarks: Calculation is based on the life cycle analysis of the equipment.
For an average 420 kV GIS substation (10 circuit breaker bays and 100 m of gas insulated line) the gain will be in the order of 33,000 tons of CO2eq over the 40 years of operation of the unit, or 825 tCO2eq/year over the 40 years of operation of the substation
</td>
</tr>
<tr>
<td>Modality of verification of the quantification.</td>
<td>Calculation standard used (base ADEME, GHG protocol, …): Method SIMAPRO IPCC 2013
Verification of the calculation (internal or external): internal verification</td>
</tr>
<tr>
<td>Other environmental and social benefits of the project

If possible, list the impacts and Sustainable Development Objectives concerned</td>
<td>By replacing SF_6 with g^3 insulating and switching gas in high voltage equipment, the project limits the risk of leakage, which can generate 23,500 times more emissions than CO_2 and can remain in the atmosphere for up to 3,200 years. In this sense, this project contributes to the Sustainable Development Objective #13 "Measures to Combat Climate Change".</td>
</tr>
<tr>
<td>Project maturity level</td>
<td>☒ Prototype laboratory test (TRL 7)
☐ Real life testing (TRL 7-8)
☐ Pre-commercial prototype (TRL 9)
☐ Small-scale implementation
☒ Medium to large scale implementation

Notes: The 420 kV circuit-breaker development project is still in the laboratory testing stage, other equipment using g^3 technology are now in the medium scale implementation stage.</td>
</tr>
<tr>
<td>Capacity and conditions of the project reproducibility, with associated climate impact mitigation potential</td>
<td>The demonstration of the ability to replace SF_6 with g^3 insulating and switching gas on the highest performance level of networks in Europe (420 kV, 63 kA), allows the deployment of this technology for all high voltage applications using SF_6 today.
To facilitate the deployment of this technology, GE has also signed a non-exclusive, cross-licensing agreement with Hitachi - ABB Power Grids that will allow Hitachi-ABB Power Grids to develop equipment using the same technology:
https://www.gegridsolutions.com/press/gepress/ge-and-hitachi-abb-power-grids-sign-landmark-agreement.htm</td>
</tr>
<tr>
<td>Amount of investment made (in €)</td>
<td>For the development of the g^3 420 kV gas-insulated circuit-breaker project the amount is €4M of which €2.2M comes from the contribution of the European Union via their LIFE programme.</td>
</tr>
<tr>
<td>Economic profitability of the project (ROI)</td>
<td>☐ ST (0-3 years)
☒ MT (4-10 years)
☐ LT (> 10 years)</td>
</tr>
</table>

	Remarques : Cliquez ou appuyez ici pour entrer du texte.
Engaged partnerships	As part of the LIFE project, partnerships have been established with European universities and research centers such as the Leibniz Institute for Plasma Science and technology (Germany) and the Universitý of Technology in Brno (Czech Republic).
Open comments from the project owner	/
Pour en savoir plus sur le projet	
Contact the company carrying the project	bertrand.portal@ge.com
Project URL links	https://www.lifegrid.eu/ https://www.gegridsolutions.com/hvmv_equipment/catalog/g3/
Illustrations of the project	LifeGRID Introduction - YouTube  


PROJET : LIFE 2018 CCM/FR/001096
Une ambition au service du climat
lifeGRID
Cleaner energy · Safer future
Une première mondiale g³ : développement du premier disjoncteur haute tension (420 kV/63 kA) sans gaz SF6 qui, grâce à notre innovation g³, Green Gas for Grid, sera le composant principal du réseau électrique Européen 420 kV à faible impact environnemental.
Web : www.lifegrid.eu
Début : 01/07/2019
Fin : 31/01/2022
Budget total : 4,045 M€
Financement par l'Union Européenne : 2,225 M€ (soit 55%)
LifeGRID contribue aux programmes majeurs visant à atténuer les changements climatiques
- Réglementations sur les gaz fluorés (UE) N°517/204
- Les résolutions de l'UE pour atteindre la neutralité carbone en 2050
- Accord de Paris (Nations Unies UNFCCC COP 21)
Chef de projet :
Yannick Kieffel
yannick.kieffel@ge.com