SF_6: The Hidden Giant of Super Pollutants

INVESTIGATING CARBON MARKET AND POLICY DEVELOPMENTS IN CRITICAL NON-CO_2 GREENHOUSE GASES

REPORT SERIES I BY

Planet2050 AlliedOffsets

UP NEXT: METHANE REFRIGERANTS

SUPER POLLUTANTS, WHY DO THEY MATTER?

As described by the Climate & Clean Air Coalition, Super Pollutants are "warming agents that are far more potent than carbon dioxide per ton. They include methane, tropospheric ozone, fluorinated gases (F-gases; such as HFCs), nitrous oxide" - all are part of the seven main greenhouse gases covered by the Paris Agreement.

Super pollutants are either Greenhouse Gases (GHGs) that trap Earth's heat in the climate, or have an effect on other GHG through effect on atmospheric chemistry. According to IPCC (2021), **emissions of super pollutants to date have caused half of today's warming.**

Because some of these pollutants are relatively short-lived, acting on their mitigation can have an almost immediate effect on global warming and reducing climate risks. Slashing emissions of all climate super pollutants is one of the only emergency breaks the world has available today. Yet, the carbon markets have somewhat overlooked these critical areas.

Studies suggest that we could avoid global warming by more than a degree by the end of our century by slashing emissions of all climate super pollutants[1]. In addition, super pollutants also have an impact on public health or food security.

Progress has been made globally to address the issues, especially since the Montreal Protocol and Kigali amendment, the launch of the Global Methane Pledge, and the introduction of F-Gas regulation in some regions. Much remains to be done, however, and in the absence of real policy and public budget support, the carbon market can provide real incentives to act now.

Various carbon methodologies have been developed under the Clean Development Mechanism (CDM) - UN-run carbon market introduced by the Kyoto Protocol - or voluntary standards over the years to tackle Super Pollutants in industrial, agricultural or waste management sectors. The decisions from the Integrity Council from the Voluntary Carbon Market (ICVCM) in 2024 to attribute the first Core Carbon Principle (CCP) labels to methane and F-Gas projects have sparked renewed interest from market participants.

Newly adopted instruments from the Paris Agreement with Article 6 Crediting Mechanism (PACM) open new opportunities to tackle Super Pollutants as governments are setting targets for Methane and F-Gas reduction as part of the Methane Pledge or their Nationally Determined Contributions (NDCs).

REPORT SERIES BY ALLIEDOFFSETS & PLANET2050

The series of reports will highlight key carbon market and policy development in the area of Super Pollutants. For our first Report in the Super Pollutant series, we focus on the lesser known **SF_6 gas : the Hidden Giant of Super Pollutants**.

[1] Shoemaker et al. 2013; Xu et al. 2013; Ocko et al. 2021

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Planet2050

PLANET2050

Planet2050 is a climate solutions company dedicated to accelerating the global transition to net zero through high-integrity emission reductions and removal projects. Through project finance and development, digital innovation, transparency and collaboration, Planet2050 is shaping a sustainable future for businesses and ecosystems worldwide.

AlliedOffsets

ALLIEDOFFSETS

AlliedOffsets is the world's largest database and market intelligence provider for the voluntary carbon market. We aggregate and analyze data to present the most comprehensive dataset on carbon offsetting activity globally. Our dashboard includes data and analysis of over 30,000 projects, including information on pricing, buyers, transactions, brokers, and more.

SULFUR HEXAFLUORIDE (SF_6)

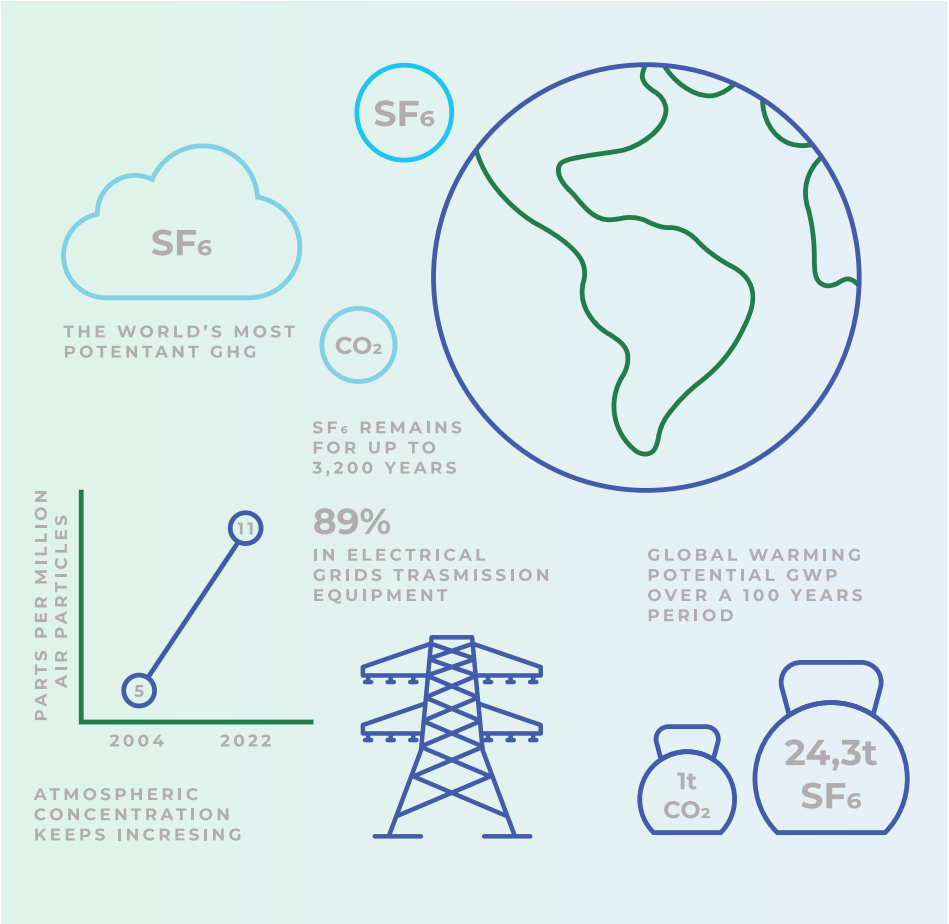
SF_6 ENVIRONMENTAL IMPACTS

Sulfur hexafluoride (SF_6) is a colorless, odorless, and non-flammable gas. It is man-made, typically produced by reacting sulfur with fluorine gas.

Out of the seven GHGs tracked by IPCC3[2], SF_6 has the highest Global Warming Potential (GWP), 24,300 times more potent than one ton of CO2. This is due to the fact that it absorbs and transfers a large amount of energy for a wide range of radiation source energies and frequencies.

Besides, SF_6 can stay in the atmosphere for up to 3,200 years and there is no removal possibility.

SF_6 Climate Impact infographics



GAS INSULATED SWITCHGEAR

Around 80% of SF_6 emissions are estimated to come from Gas Insulated Switchgears (GIS), as seen on the left picture, which serve key transmission equipment in the power grids around the world.

SF_6 has great insulation properties, but can be mishandled, not properly recovered, and present leakage risks in aging equipment due to high pressure.

Other applications of SF_6 include the magnesium industry, semiconductors, particle accelerators, and in the medical field.

And in case you didn't know, even Nike used sulfur hexafluoride to create a strong cushion in the air bubbles of its Air shoes, before it switched to nitrogen in 2006.

[2] IPCC GHG: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF3).

SF_6 METHODOLOGIES FROM THE CDM

There are a handful of carbon crediting methodologies supporting SF_6 reduction projects. While the methodologies originated in the UN's Clean Development Mechanism (CDM), some of them are also available on the carbon standards ACR (previously known as American Carbon Registry) or Verra. The most active methodology is **AM0065**, which credits projects for replacing SF_6 with alternative gas in the magnesium industry.

In 2024, Verra submitted AM0065 for ICVCM's Core Carbon Principle. It was rejected due to unmet additionality criteria. This suggests that entities looking to promote SF_6 will need to take a step back and rework the way the CO2 is quantified for these projects, before they can gain trust in the broader Voluntary Carbon Market (VCM) landscape. In the magnesium industry, producers have mainly transitioned away from SF_6 which can explain the lack of additionality. Verra therefore subsequently invalidated this methodology in September 2024.

TABLE 1: OVERVIEW OF THE SF_6 METHODOLOGIES UNDER THE CDM

Project Methodologies	Type of Mitigation Action	Clean Development Mechanism	Verra*	ACR*
AM0035 SF_6 emission reductions in electrical grids	GHG emission reduction	8		
AM0065 Replacement of SF_6 with alternate cover gas in the magnesium industry	GHG emission reduction	3	2	1
AM0078 Point of Use Abatement Device to Reduce SF_6 emissions in LCD Manufacturing Operations	GHG destruction	4		
AM0079 Recovery of SF_6 from Gas insulated electrical equipment in testing facilities	GHG formation avoidance	1		

**These standards have adopted CDM Methodologies*

SF_6 PROJECTS

Out of over 33,000 projects that AlliedOffsets tracks, there are only 19 projects in the voluntary carbon market (VCM) that focus on reducing, replacing, or recovering SF_6 gas.

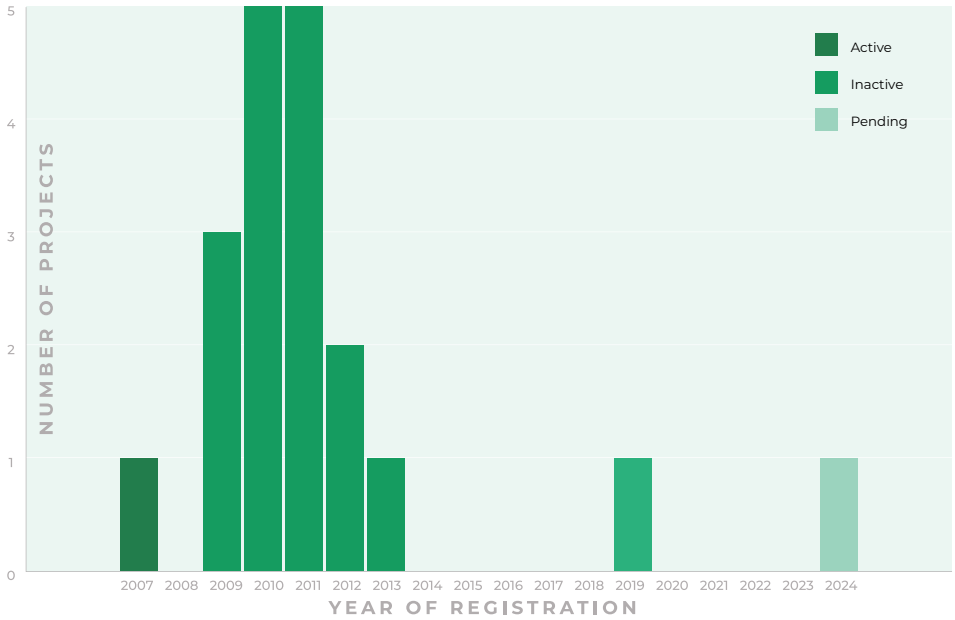
AlliedOffsets is the world's largest database of VCM projects and activity, covering projects from 29 registries, transactions, buyers of credits, and more. This aggregated view of the market allows unparalleled data insights into all aspects of the VCM.

Most of the projects were launched in 2010/11, with only one project on the Verra registry still active with last issuance in 2022 and last retirements in early 2025. This is the VCS project 618, located at the US facility Meridian Magnesium Products, which used SF_6 in the casting process of magnesium alloys into automotive parts. The gas is used as protection to prevent the ignition of molten magnesium in the presence of air, but is partly released in the air in the process.

The project justified its additionality at the time of registration by the fact that *"there is no requirement, either local or federal, that requires the limitation or elimination of SF_6. The choice to utilize a replacement gas for SF_6 is not the result of any legal or regulatory mandate, nor are the Meridian Magnesium facilities regulated entities under any emissions trading schemes in Michigan"*.

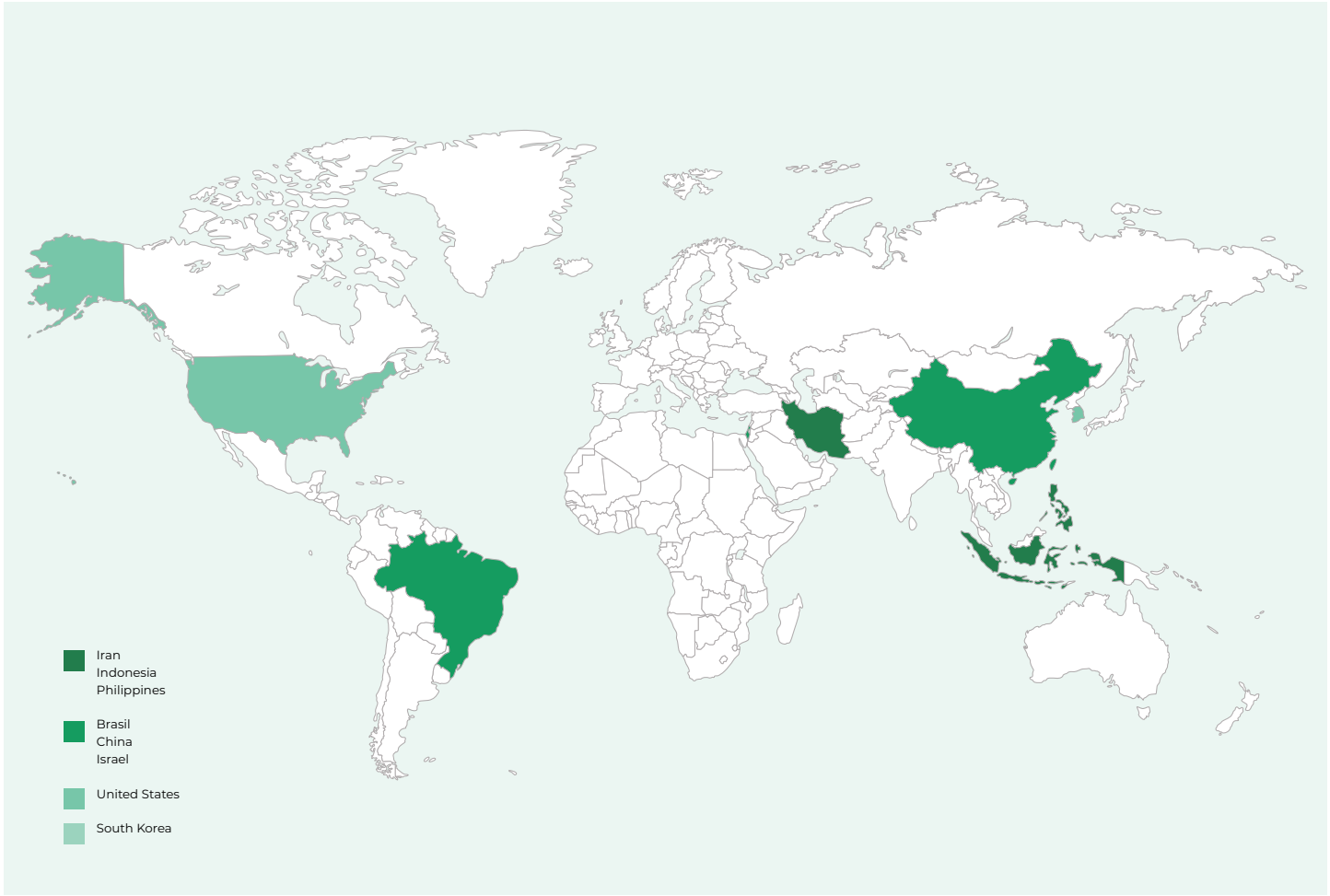
Having said that, there is one more American project that is in the process of requesting registration, launching just last year. The future of the project is unclear due to the decision of Verra to invalidate the methodology.

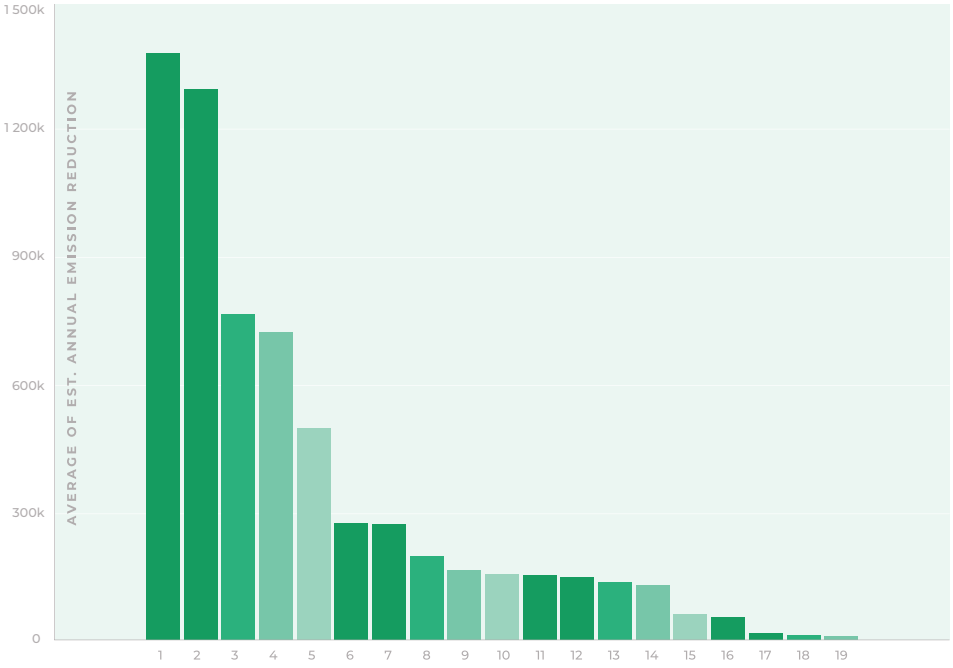
The majority of other SF_6 projects are inactive ones developed for the Clean Development Mechanism (CDM) registry:



PROJECT MAP

When more projects were registering, they were global in nature, with activity happening in the Americas, Middle East, and Asia.





1. Recovery and recycling of SF_6 in electric facility of Korea Electric Power Corporation
2. Point of Use Abatement Device to Reduce SF_6 emissions in LCD Manufacturing Operations in the Republic of Korea (South Korea)
3. Samsung Electronics SF_6 abatement project
4. SF_6 Emission Reduction in LCD Manufacturing Operation in Tangjung, South Korea
5. SF_6 Emission Reduction in LCD Manufacturing Operation in Cheonan, South Korea
6. Conversion of SF_6 to the alternative cover gas SO2 at RIMA magnesium production
7. SF_6 Switch at Dead Sea Magnesium
8. Conversion of SF_6 To An Alternative Cover Gas In Magnesium Production In Eaton Rapids, MI and Strathroy, ON
9. SF_6 recovery and reclamation project, South Korea
10. SF_6 recycling project of North China Grid
11. Replacement of SF_6 as a Cover Gas at US Magnesium
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15. Reductions in SF6 Emissions from the Electricity Grid in the Greater Jakarta region, Indonesia
16. SF_6 emission reduction in transmission sector of Iran electric power industry
17. SF_6 Emission Reduction in High-Voltage Transmission Systems in the Philippines
18. SF_6 Switch at Ortal Diecasting 1993 Ltd.
19. SF_6 Emissions Reduction Program at AES Eletropaulo

PROJECTS BY ESTIMATED ANNUAL ISSUANCES

The projects can cater to activities of all sizes, with the largest projects estimating to reduce or avoid over 1 million tCO2e per year, while the smallest project aimed to reduce under 10,000 tCO2e per year.

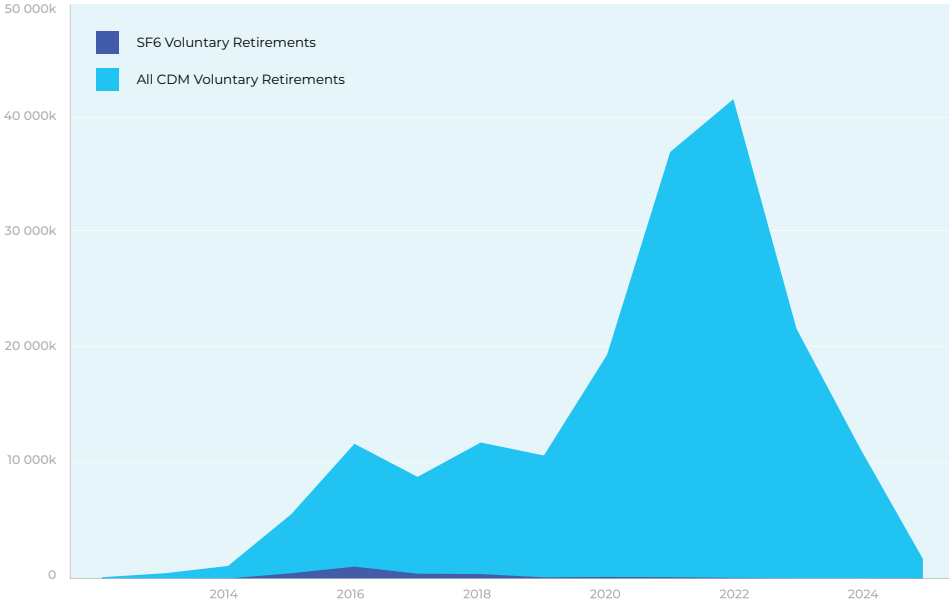
This variance in project scale suggests that projects of all sizes can tap into carbon finance – it's not just for those who can capture economies of scale.

CREDIT STATUS

Overall, less than 50% of the credits that have been issued to SF_6 projects have been retired, meaning there are over 6.5m tCO2e available for buyers to purchase – though this is primarily from CDM projects that are no longer active.

SHARE OF SF6 IN CDM

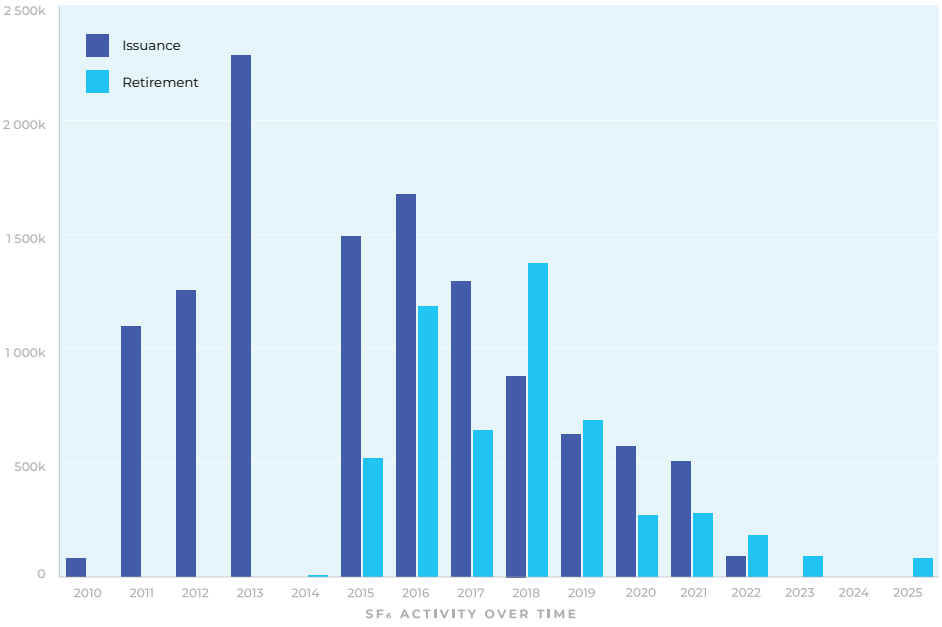
In total, CDM SF_6 projects have retired 2.8m credits (2.8m tons of CO2 equivalent) for voluntary purposes, out of about 180m tons retired in CDM overall – representing just over 1.5% of all of the credits retired in the registry.



SF_6 CREDIT ACTIVITY

The decline of industrial projects and of the CDM overall in the 2010s, together with real concerns over perverse effects related to F-Gases projects including SF_6[3] can explain the drop of interest in new SF_6 projects in recent years.

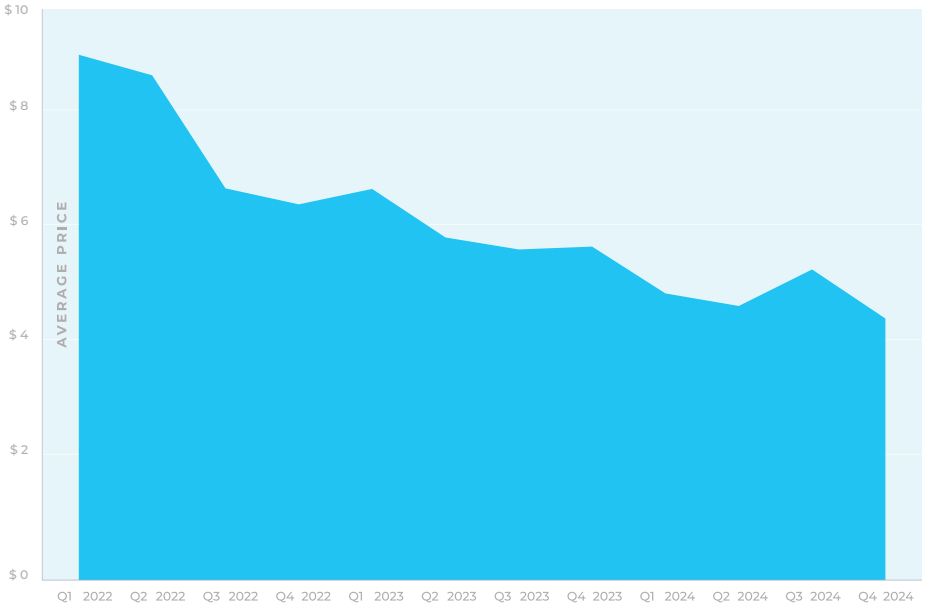
The number of retirements has decreased consistently since 2018, with only about 1,000 retirements matched to these projects in 2024. 2025 has seen increased retirement activity, however, with over 80,000 tCO2e of SF_6 credits retired in the first quarter alone.



CREDIT PRICING

One thing that may drive buyers back to these credits is their decreasing price: it's the cheapest it's been in three years to purchase this offset type.

Pricing are estimates based on data collected by AlliedOffsets.



[3] https://www.nature.com/articles/nclimate2772

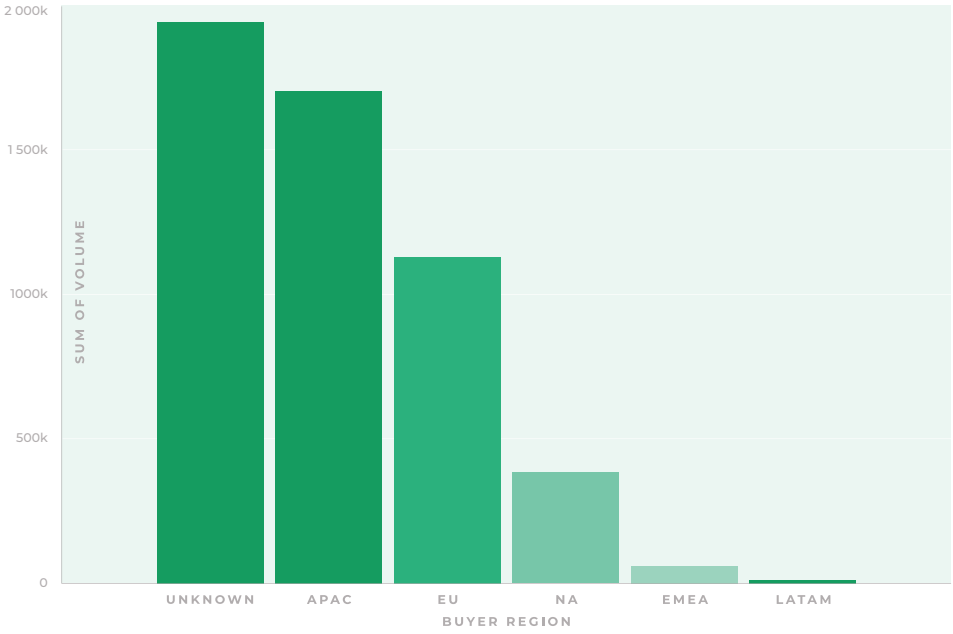
SF6 CREDIT BUYERS PER REGION

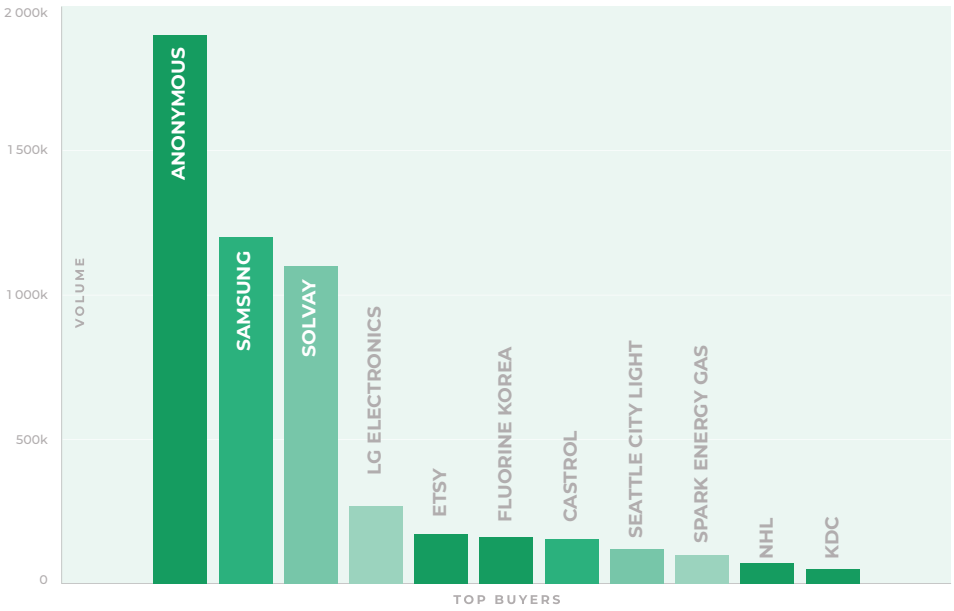
Projects and brokers looking to sell SF_6 credits can look to Asia as a source of demand: buyers in the region had more interest in these credits than those in EU, North America, (ex-EU) EMEA, and Latin America combined.

This can be explained partly due to the Korean Emissions Trading Scheme (ETS), which encouraged the use of SF_6 credits related to collection of SF_6 from testing of gas insulated electrical equipment, and re-use at an SF_6 manufacturing facility.

In one recent project, terminated in 2021 and done in partnership with Solvay Energy Services, the Korea Electrotechnology Research Institute (KERI) aimed to reduce emissions of SF_6 from its testing facility of electrotechnical equipment in South Korea. In a business-as-usual scenario, SF_6 that would have been vented.

In the past, this project had cancelled Certified Emission Reductions (CERs) from the CDM to convert them to Korean Offset Credits (KOCs) which companies could use for ETS compliance when converted further into Korean Carbon Units (KCUs).





TOP SF6 CREDIT BUYERS

The top buyers track with the above, with Asian companies such as Samsung and LG in the top 3 of known buyers in the VCM.

Among the other Top buyers are:

Solvay, Etsy, Fluorine Korea, Castrol, Seattle City Light, Spark Energy Gas, NHL (NHL Enterprises - National Hockey League), KDC/One.

DRIVING SF_6 EMISSION REDUCTIONS

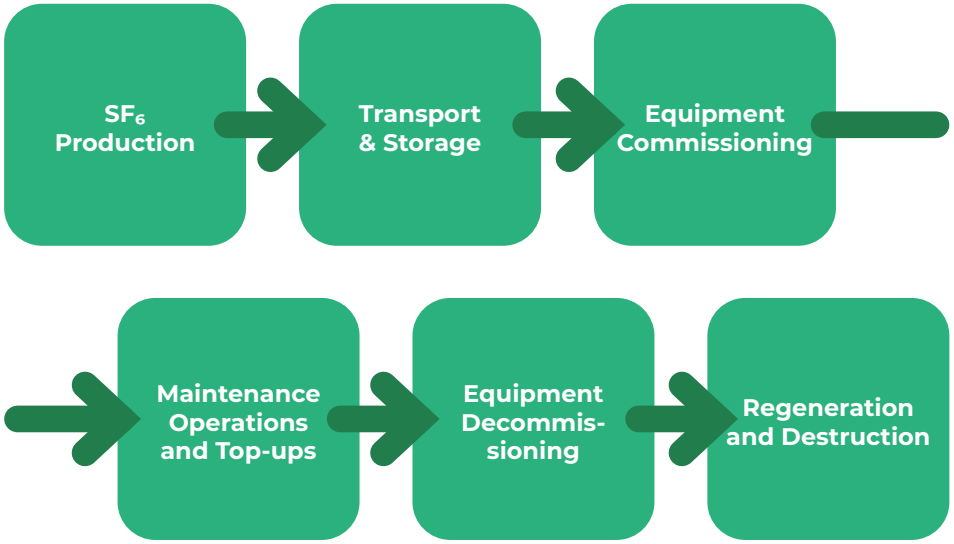
FOCUSING ON HOTSPOTS

It is estimated that **89%[6] of SF_6 is in electrical infrastructure for transmission and distribution,** with high-voltage switchgears concentrating most volume of SF_6.

According to estimates[4] about 15 million medium voltage switchgear units are in operation in Europe, out of which a significant quantum (10 million) rely on SF_6 which leads to high carbon emissions. But those typically contain small quantities of SF_6 per system, between 50 grams to 5 kg, compared to the several tons contained in high-voltage switchgear gas compartments.

SF_6 VALUE CHAIN APPROACH

When looking at SF_6 emission reductions the entire SF_6 value chain, its risks and hotspots for emissions along its lifecycle which we can simplify in the following way:



[4] Fraunhofer Institute, Impact assessment of F-gas free medium voltage switchgear, 2020 , https://www.iee.fraunhofer.de/en/presse-infothek/press-media/overview/2020/Impact-assessment-of-F-gas-free-medium-voltage-switchgear.html

SOLUTIONS EXIST TO CURVE DOWN SF_6 EMISSIONS:

- Early prevention, detection, and monitoring systems
- Conventional repairs or of SF_6 leakage sealing
- Reducing SF_6 mishandling in operations through training
- Regeneration and recycling of SF_6 gases
- Retro-filling or retrofitting with SF_6-free gases and equipment
- Installing SF_6-free GIS equipment in new-builts

NEW TECHNOLOGIES SUPPORTING SF_6 MITIGATION:

While SF_6 projects under the CDM focused mainly on traditional repair and replacement or changes in industrial processes, new technologies are now available to support the transition to an SF_6-free world especially for power grid applications:

- Solutions to detect and address leakages such as permanent sealing devices
- New Gas Insulated Switchgear equipment running with SF_6 gas alternatives
- IoT sensors for real-time SF_6 gas density monitoring
- Data platforms supporting predictive maintenance and smart modelling.

SOLUTIONS EXIST TO CURVE DOWN SF_6 EMISSIONS:

MASTERGRID

Leakage detection and sealing with the Sleakbox solution

NUVENTURA

Berlin startup producing 24kV & 36kV switchgears, Made in Europe

SIEMENS

“Blue GIS” line with “Clean Air” replacing SF6 (GWP < 1)

WIKA

Digital SF6 density sensors with IoT data connectivity options for real-time monitoring

GE

145kV GIS based on g3 (GWP 98% lower than SF6), co-eveloped with 3M

HITACHI

EconiQ 420 kV GIS based on a mixture of Fluoronitriles (C4-FN), CO2 and O2

ABB

SafePlus 24kV switchgear with dry-air as insulation medium

SIEMENS

145 kV Blue voltage transformer using synthetic air as insulation medium

SF_6 GAS ALTERNATIVES:

Pushed by regulations planning the phase-out of SF_6, industrial equipment providers are introducing new technologies and switchgears models using alternative gases to SF_6.

It is not that easy, because SF_6 has been used for decades and has been recognized for its excellent dielectric strength and arc-quenching properties. It provides great insulation at high-voltage, absorbs the heat and cools down rapidly after electrical arcs.

Current technology maturity reveals that SF_6-free solutions for use at higher-voltages are more challenging, although pilot installations do exist at 145kV or above.

Existing SF_6 alternatives offer various levels of performance and environmental benefits, with fluoroketones and fluoronitriles standing out for higher-voltage systems, while vacuum and air are more suitable for lower-voltage setups:

- **CO2 (Carbon Dioxide)**: CO2 is already being used for outdoor circuit breakers. It has low GWP, is readily available and cost-effective but not highly performant at higher voltages.
- **Fluoroketones** (e.g., C5 Ketones): these are synthetic gases mixed with CO2 and air. They have similar insulating properties to SF_6 but poorer circuit-breaking capabilities.
- **Fluoronitriles** (e.g., g^3 – Green Gas for Grid): these have similar properties to SF_6 but are more potent GHG (about 2,000 GWP).
- **Vacuum and Air** (Mixture of Nitrogen and Oxygen): this is a good solution for medium-voltage GIS, with zero environmental impact, and already in use for vacuum circuit breakers.

SF_6 ABATMENT COSTS

There is little data available on the exact cost for different SF_6 mitigation options, especially as technologies are still being developed.

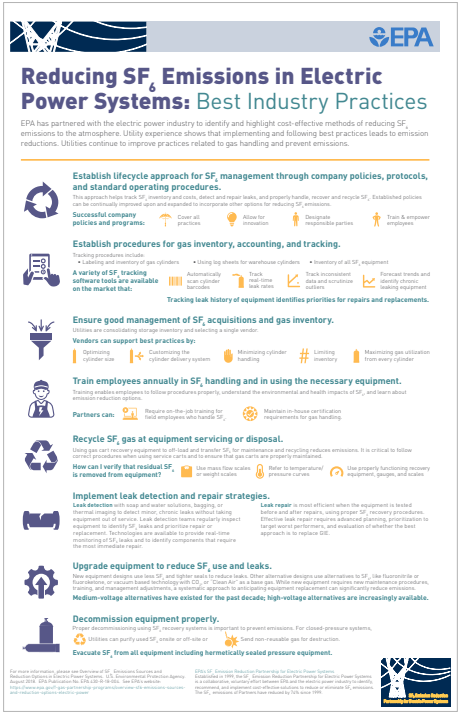
The following table presented by GIZ and Perspectives Climate at COP29 is derived from US EPA analyses from 2019.

This table shows that several options are available at a feasible abatement cost level for carbon finance. However this assessment is not taking innovations and costing improvements. More research should be carried out to provide reliable, up-to-data data points. Costs are highly variable depending on regional context, quality of grid infrastructure and maintenance, external environmental conditions, equipment age, etc.

TABLE 2: SF6 ABATMENT COSTS ESTIMATION (US EPA)

MEASURE	SPECIFIC ABATEMENT COST RANGE	ACHIEVABLE MARGINAL EMISSION REDUCTION CUMULATIVE (% OF TOTAL EMISSIONS)
Improving SF_6 handling	< 0-10 USD/ tCO2e	± 35%
SF_6 recycling, recovery from assets at the end of their life	30-100 USD/ tCO2e	± 10%
Equipment refurbishment	150-300/ tCO2e	± 10%
Alternative gas mixtures with lower GWP	250-700/ tCO2e	± 10%
Leak detection and repair	300-700/ tCO2e	<5%

Derived from: "Global non-CO2 GHG Emission Projections and Mitigation 2015-2050, USEPA, 2019



The EPA also published its "*Best Industry Practices*" for Reducing SF6 Emissions in Electric Power Systems.

1. Establish lifecycle approach for SF6 management through company policies, protocols, and standard operating procedures.
2. Establish procedures for gas inventory, accounting, and tracking.
3. Ensure good management of SF6 acquisitions and gas inventory.
4. Train employees annually in SF6 handling and in using the necessary equipment.
5. Recycle SF6 gas at equipment servicing or disposal.
6. Implement leak detection and repair strategies
7. Upgrade equipment to reduce SF6 use and leaks.
8. Decommission equipment properly.

POLICY LANDSCAPE: SF_6 IN FOCUS

Recognizing the significant environmental impact of SF_6, particularly due to its high global warming potential (GWP), various regulatory frameworks and initiatives have been developed to control and reduce SF_6 emissions.

These actions encompass both regulatory compliance and voluntary carbon market participation, demonstrating an increasing dedication to reducing the environmental impact of this powerful greenhouse gas.

INTERNATIONAL FRAMEWORKS & UN-LED INITIATIVES

- **Vienna Convention (1985):** this convention laid the groundwork for international cooperation on scientific research, monitoring, and information exchange on Ozone Depleting Substances (ODS). It drew significant attention to the atmospheric effects of substances like chlorofluorocarbons (CFCs).
- **Montreal Protocol (1987):** Legally binding international treaty which inspired a "step-based" phasedown of ODS. CFCs have then been gradually replaced by man-made gases (F-Gases).
- **Kyoto Protocol (1997):** SF_6 (a category of F-gas) was identified as one of six GHGs targeted for reduction. The protocol obligated industrialized countries to reduce emissions of SF_6 alongside other major GHGs. As part of Protocol, the Clean Development Mechanism (CDM) facilitated more than four approved methodologies, enabling emission reductions via project-based mechanisms (See Table 1).
- **Paris Agreement (2015):** unlike the Kyoto Protocol, the Paris Agreement (which replaced Kyoto post-2020) does not list specific gases but instead covers all greenhouse gases (GHGs) under nationally determined contributions (NDCs). SF_6 emissions remain covered, but reduction commitments are country-specific under NDCs rather than a top-down protocol like Kyoto. Many nations continue monitoring and reporting SF_6 as part of GHG inventories submitted to the UNFCCC, but the majority of countries still lack proper SF_6 accounting. See details about SF6 in NDCs in the next section (Table 3).
- **Kigali Amendment (2016)** to the Montreal Protocol focused on phasing down hydrofluorocarbons (HFCs) with a high global warming potential (GWP). The amendment imposed binding emission caps for HFCs, and included provisions to support developing countries in transitioning away from HFCs
- **UN Environment's OzonAction Compliance Assistance Programme (CAP)** Supports developing countries in meeting Montreal Protocol obligations. It indirectly aids SF_6 mitigation via policy support, capacity building, and technology transfer.

- **COP28:** SF_6 Transparency and Phase-Out Dialogue (2023) Event co-hosted by UN Climate Technology Centre and Network (CTCN) in collaboration with CTCN National Designated Entity (NDE) Germany and the German Federal Ministry of Economic Development and Climate Action (BMWK). The three-day learning exchange highlighted the urgent need for SF_6 disclosure, policy harmonization, and investment in climate-neutral technologies across grid infrastructure.

- **Kenya CTCN** workshop in 2024 was part of a UN-led technical assistance project to develop an SF6 Phase-out roadmap, implement safe management practices and prepare pilot projects to reduce SF6 use and emissions. The Roadmap and Pilot Projects is part of the IICT programme funded by the European Commission, with a grant of EUR 2 million

- **International initiative to mitigate SF_6 in the power sector:** Led by the Federal Ministry for Economic Affairs and Climate Action (BMWK) with GIZ and Perspectives Climate Research, the initiative begins with analyzing technology and financing options. It aims to develop regulatory, monitoring, and incentive mechanisms, and also looks at the role of climate finance and carbon markets.

- **G7 Climate & Energy Ministers' Meeting (2024):** G7 ministers formally recognized the climate impact of SF_6 and committed to work towards its phase-out in new switchgear applications by 2035, conditional on viable alternatives and technology diffusion.

SF_6 IN PARIS AGREEMENT'S NDCS

Central to the Paris Agreement are Nationally Determined Contributions (NDCs), serving as each country's commitment to addressing climate change through emission reductions and adaptation measures.

As outlined in Article 4, paragraph 2 of the Agreement, all Parties are required to formulate, submit, and update their NDCs, which are recorded in a public registry managed by the UNFCCC Secretariat.

In this context, assessments have also noted that certain countries explicitly include sulfur hexafluoride (SF_6) among their targeted greenhouse gases. 77 countries with active NDCs mention SF6 as a targeted GHG within their NDCs. The following is a Snapshot of a few selected countries used as examples..

TABLE 3: SNAPSHOT OF SF6 STATUS IN NATIONALLY DETERMINED CONTRIBUTIONS (NDCs)

Country	Flag	NDC Version[1]	SF_6 Status	Inventory Document (NID) / NDCs
Thailand		Thailand 2nd Updated NDC	SF_6 is included within the targeted greenhouse gases for 2021 – 2030, though no specific reduction target found outlined. The overall aim is an absolute, economy-wide (excluding land use, land-use change, and forestry) emissions reduction set as a single-year target.	The NDC Action Plan outlines GHG reduction measures and 2030 targets across sectors; however, it does not include SF_6 among its targeted gases, despite national GHG emissions from SF_6 in the Industrial Processes and Product Use category being estimated at 756.09 $ktCO_2e$ in 2022 (BTR, 2024).
European Union[2]		EU NDC 2023 Update	In 2023, as part of the "Fit for 55" package, the EU formally adopted key legislation, including a review of the F-gas Regulation to strengthen climate ambition which noe includes SF6 Phaseout by 2032.	SF_6 emissions—covering production and consumption—were reviewed in 2006 and 2008 as part of fluorinated gases. The 2012 EU Effort Sharing Decision (ESD) further improved data accuracy, using 2005 EU ETS plant data to validate and align estimates in national inventories.
Tunisia		Tunisia First NDC (Updated submission)	SF_6 is included within the targeted greenhouse gases for 2021-2030, though no specific reduction target found outlined.	SF_6 use in electrical equipment is tracked over the full time series, using data from the Tunisian Electricity and Gas Company (STEG) for 2010–2022 and extrapolated averages for earlier years. Verification is planned to assess if all consumed SF_6 is emitted, to be supported by comparisons with customs import data.
Chile		Chile First NDC (Updated submission)	The economy-wide emission reduction target for the period 2020-2030 recognizes SF6 as a target GHG.	In 2022, SF_6 emissions were estimated at 156 kt CO_2e, primarily from the manufacturing sector and use of electrical equipment. SF_6, mainly used in gas-insulated switchgear (GIS), substations, and circuit breakers, emits across all life cycle stages—manufacturing, installation, operation, maintenance, and disposal.
United Arab Emirates		Third Nationally Determined Contribution (NDC 3.0)	SF_6 is covered for the first time in the national NDC to enhance the comprehensiveness and robustness of reporting; however, specific reduction targets are not outlined.	SF_6 emissions are only partially included in the inventory due to limited data availability, particularly from the electric power transmission sector. These emissions have not been fully incorporated into the report and are considered negligible to national totals pending further data acquisition.
Republic of Korea		Korea First NDC (Updated submission)	SF_6 is included within the targeted greenhouse gases for 2021-2030, though no specific reduction target found outlined.	In Korea, SF_6 emissions rose to 8.4 $MtCO_2e$ in 2018 (1.2% of total emissions), with notable year-on-year fluctuations. Emissions are tracked under industrial consumption, mainly from semiconductors and heavy electric equipment, with K-ETS identified to support reduction goals.
China		China First NDC (Updated submission)	SF6 is recognized as a potent GHG. However, the current NDCs do not specifically mention inclusion / exclusion or reduction targets.	According to the 2020 National GHG Inventory, SF_6 emissions totalled 93 $MtCO_2e$, with 97.5% from other product manufacture and use, and 2.5% from the chemical industry, all reported under the IPPU sector.
Peru		Peru First NDC (Updated submission)	SF_6 is included within the targeted greenhouse gases, though no specific reduction target found outlined in the NDC for implementation period 2021-2030	Between 2000 and 2021, Peru's national GHG inventory reported 18.72 kt CO_2e of SF_6 emissions from electrical utilities. Combined emissions from fluorinated gases—HFCs and SF_6—accounted for less than 0.3% of total emissions between 2010 and 2021

Note: This table provides a brief overview of SF_6 commitments and reasons for exclusions, aiming to support positive action towards its abatement, mitigation, and reduction

NDC Version[1] refers to the latest NDCs submitted by the countries as accessed from the registry on the cutoff date: 26th March 2025.

European Union[2] The EU and its 27 member states submitted a joint NDC under the Paris Agreement, counted as one NDC representing 28 Parties with shared information from all.

INDUSTRY-LED INITIATIVES & TECHNICAL COALITIONS

CIGRE (International Council on Large Electric Systems)
CIGRE, a key body in power system engineering, continues to expand its contributions toward SF_6 reduction. In addition to earlier mitigation guidance on SF_6 recycling, tightness, ways to minimise the use or loss of SF_6 during routine testing of electrical equipment and SF_6 measurement guide, it has launched several new working groups to explore sustainable alternatives like vacuum and eco-friendly gases for switchgear systems:

- WG D1.51 – Studies insulation performance of low-impact gas-insulated systems
- WG D1.67 – Evaluates dielectric strength of non-SF_6 gases
- WG A3.41 – Examines switching performance of SF_6-free equipment
- WG B3.45 – Tests use of alternative gases in MV/HV switchgear applications.

NEMA SF_6 & Alternatives Coalition – Industry Coordination on Insulation Technologies: the SF_6 & Alternatives Coalition, led by the National Electrical Manufacturers Association (NEMA), serves as a key platform for industry dialogue on SF_6 and its substitutes inelectric transmission and distribution. It also facilitates engagement with regulators on emissions reporting and reduction strategies.

Key contributions include:

- 2020 – Planning for an SF_6 Phase-Out: Strategic guidance for policymakers on transitioning away from SF_6 at a system or market level.
- 2019 – Overview of Alternative Technologies: Comparative review of emerging insulating gases versus SF_6 on performance metrics.
- 2019 – Dry Air in Gas-Insulated Equipment: Best practices for OEMs to reduce costs and improve emission tracking through dry air shipment.
- 2016 – Reporting Challenges: Analysis of how relying solely on nameplate data can distort SF_6 emission figures.
- 2016 – Nameplate Adjustments: Recommendations for improving the accuracy of SF_6 reporting through data correction processes.

MISSION: SF_6-Free Future Horizon Europe (2024–2028) Project MISSION under Horizon Europe, allocated €11 million in co-funding to support the research, development, and deployment of alternatives to SF_6 in medium- and high-voltage grids.

The project kicked off with a strong consortium of 12 partners across 9 countries, coordinated by SINTEF, one of Europe's largest independent research organization which has worked since the 1990s on SF_6 issues in Norway as part of a dedicated user group.

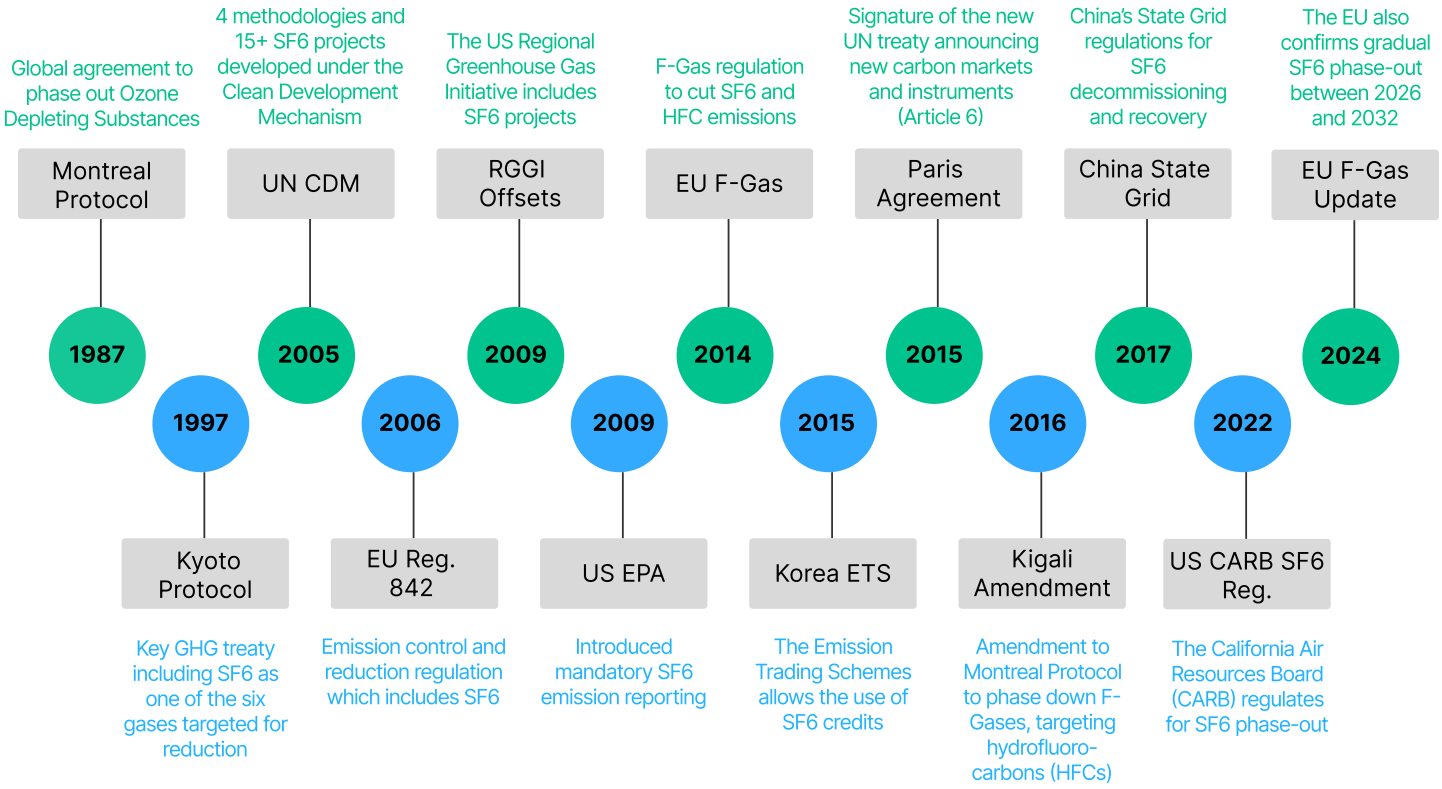
Between 2024 and 2028, MISSION will focus on developing three next-generation switchgear components for both AC and DC appli cations, all with a Global Warming Potential (GWP) of less than 1. These components will close key technological gaps across medi um-voltage (MV) and high-voltage (HV) networks.

Among the pioneering developments, Siemens Energy will lead the creation of a high-voltage AC (HVAC) live-tank air-insulated vacuum circuit breaker (VCB) and a high-voltage DC (HVDC) GIS using pressurized air—an environmentally friendly alternative to SF_6.

SF_6 Whole Life Strategy: this project has been granted by Ofgem, Britain's independent energy regulator, as part of its Strategic Innovation Fund (SIF) round 2 which aims to help transform gas and electricity networks for a low-carbon future. The project will aim to develop novel methods for SF_6 leakage monitoring and prediction, retrofilling, understanding of non-SF_6 gas blend behaviour and disposal of SF_6 using energy efficient methods.

SECO2ND LIFE GIS (Solution for ECO-friendly and ECOnomically viable Deletion of SF_6 in operating GIS) is a program as part of EU LIFE, EU's funding instrument for the environment and climate action. It has awarded three GE g3 gas product development to be co-funded by the EU Commission within four years. While the previous LifeGrid project focused on g3 technology for new-built, the SECO2ND LIFE GIS aims to develop and deploy an alternative gas to SF6 for GE's existing installed base of 420kV gas-insulated substation (GIS).

SF6 REGIONAL AND GOVERNMENT POLICIES



EUROPEAN UNION

The Article 19 of the 2014 EU F-gases Regulation 517/2014 (FGR) required entities producing, importing, exporting or destroying F-gases, or those using F-gases as feedstock, as well as companies importing products or equipments containing F-gases, must disclose information relating to the respective amounts of gases or gas mixtures. Additionally, wherever applicable, the intended purposes of gases supplied to the EU market or incorporated into various products or equipment must be documented and reported.

In 2021, F-gases, in general, amounted to 2.2 % of total greenhouse gas emissions in the EU-27.

In 2022, total supply of F-gases[5] to the EU was 13% higher than in 2021. This increased F-gases supply in the EU-27[6] was observed to be approximately at the same level as observed in 2019-2020.

Notably, SF_6 contributed to approximately 66% of this increase, amounting to 20% of 2022 EU F-gases supply, almost all of which is reported to be used mainly in electrical equipment.

As of March 11, 2024, a more stringent revised EU F-gas Regulation (2024/573) has come into effect. The updated framework mandates a significant reduction in HFC usage, targeting a nearly 95% decrease by 2030 compared to 2015 levels, with a complete phase-out by 2050. This reduction in F-gas emissions will further contribute to Member States' commitments under the Effort Sharing Regulation.

[5] Measured in CO^2 equivalents
[6] Including the United Kingdom

ELECTRICAL SWITCHGEARS	PLANNED SF6 PHASE-OUT IN UPDATED EU F-GAS REGULATION
Up to 24 kV (Medium voltage)	PHASE OUT IN 2026
From 52 kV up to 145 kV and up to 50 kA, short circuit current, with F-gases GWP 1+ (High voltage)	PHASE OUT IN 2028
Above 24 kV and up to 52 kV (Medium voltage)	PHASE OUT IN 2026
More than 145 kV/more than 50 kA short circuit current, with F-gases GWP1+ (High voltage)	PHASE OUT IN 2032

Specifically, this new F-Gas Regulation coming into effect in 2026 establishes a gradual phasing-out of the use of SF_6 gas in electrical equipment. Already in 2026, connecting new SF6-insulated devices up to 24 kV will be prohibited. By 2030, this prohibition will expand to include all devices with an insulation voltage of up to 52 kV. By 2032, the ban will also concern equipment above 145 kV.

From January 1, 2035, the use of newly produced SF_6 for maintenance or servicing of electrical switchgear is prohibited, including the refilling of systems with SF_6. Reclaimed or recycled SF_6 is exempt from this ban.

UNITED STATES

Voluntary Environmental Protection Agency (EPA) Initiatives: The EPA established the SF_6 Emission Reduction Partnership for Electric Power Systems in 1999, a collaborative effort with the electric utility industry to identify and implement cost-effective solutions to reduce SF_6 emissions.

Reporting Requirements-EPA's Greenhouse Gas Reporting Program (GHGRP) Subpart DD outlines mandatory reporting requirements for SF_6 and perfluorocarbon (PFC) emissions from electrical transmission and distribution systems.

State Regulations:

- The California Air Resources Board (CARB) implemented regulations in 2011 to reduce SF_6 emissions from gas-insulated switchgear,as part of the same regulatory subchapter that includes California's mandatory GHG reporting and cap-and-trade program. This regulation covers all owners of SF_6-insulated equipment. In 2022, CARB finalized amendments to phase out the use of SF_6 in gas-insulated equipment starting in 2025, with a voltage-based phase-out schedule and updated emission limits, with planned phase-out for larger equipment by 2033.

Regional Greenhouse Gas Initiative (RGGI) started in 2009 as a cooperative cap-and-invest program focused on reducing carbon dioxide (CO_2) emissions from the power sector across 12 participating states. Under this program, Connecticut offers CO_2 offset allowances for approved projects that reduce sulfur hexafluoride (SF_6) emissions. To qualify, SF_6 projects had to:

- Implement new emissions reduction actions beyond those taken in the baseline year.
- Show that the utility's emissions rate is below regional performance standards, based on 2004 averages from the EPA SF_6 Partnership.
- Utilities with urban constraints or unique system limitations may be eligible for exemptions.

ASIA

JAPAN

Japan pioneered a voluntary action plan in the late 1990s to cut SF_6 and other F-gas emissions. 19 industrial associations (covering 10 sectors) in April 1998, agreed on action plans to limit HFC, PFC, and SF_6 emissions, following guidelines from Japan's Ministry of International Trade and Industry (MITI).

Later, in March 2002, Japan introduced the Guideline for Measures to Prevent Global Warming, setting sector-specific goals to meet its Kyoto Protocol target of a 6% reduction. It aimed to limit emissions of SF_6, HFCs, and PFCs—p—to about 73 $MtCO_2e$ through planned reductions of 34 $MtCO_2e$.

In 2009, the Ministry of Environment issued a set of recommendations aimed at minimizing emissions of greenhouse gases from electrical equipment that uses liquid PFCs and SF_6.

CHINA

Recent research found that SF_6 emissions in China almost doubled from 2.6 gigagrams (Gg) per year in 2011, when they accounted for 34 percent of global SF6 emissions, to 5.1 Gg per year in 2021, when they accounted for 57 percent of global total SF_6 emissions. Regulations have played a critical role in shaping the use and monitoring of SF_6. The gas has long been regulated under frameworks such as the State Council's Hazardous Chemicals Management system and the 1996 Ministry of Labor directive.

In 2010, North China Power Grid Company participated in a CDM Project for SF_6 recycling by adopting technology for online SF_6 leak detection and recycling to reduce emissions of SF_6 from electrical equipment.

Environmental controls were reinforced through GBT 28534-2012, HJ2025-2012, and DLT 1050/1553/662, which governed "The health and environmental impact on release of sulphur hexafluoride(SF_6)used in high-voltage switchgear and controlgear" and required closed-loop systems, 100% gas recovery, strict reuse conditions, and specialized equipment standards.

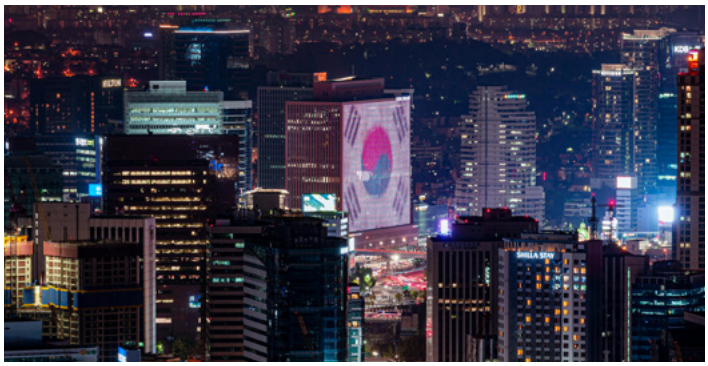
Institutionally, the State Grid Corporation played a leading role by incorporating SF_6 metrics into its operational governance, as early as 2005. This culminated in the 2017 "Measures for the Supervision and Administration of the Recovery, Treatment, and Recycling of SF_6 Gas", which formalized recovery targets (≥95%), purification benchmarks (≥98%), data accountability, and integration into provincial environmental performance assessments—enabling a reward and penalty mechanism.

At a State Council press conference in April 2021, China's Ministry of Ecology and Environment announced new actions to control non-CO_2 greenhouse gases—including SF_6—as well as to strengthen ozone-depleting substance (ODS) management. These steps build on President Xi Jinping's commitment to accept the Kigali Amendment and enhance regulation of super pollutants.

SOUTH KOREA

South Korea has incorporated SF_6 into its climate regulations as one of the targeted GHGs. The country's Framework Act on Carbon Neutrality and Green Growth (2021) explicitly defines SF_6 as a greenhouse gas alongside CO_2 and others. The nationwide Emissions Trading Scheme (ETS), Korea ETS, launched in 2015 covers direct emissions of six Kyoto gases, including SF_6.

South Korea has actively invested in research and development of alternatives to SF_6. In 2021, the Korea Electrotechnology Research Institute (KERI) developed an innovative SF_6-free insulating gas for power switchgear, marking a significant step toward reducing SF_6 use in the electricity sector. Additionally, several Clean Development Mechanism (CDM) projects in Korea have targeted SF_6 emissions across various industrial sectors. Of the six registered projects, four were dedicated to reducing emissions in electronics manufacturing, while the remaining two address the recovery and mitigation of SF_6 emissions from gas-insulated electrical equipment and power grids.



SF_6 COMPLIANCE CARBON INSTRUMENTS AND MARKETS

COMPLIANCE MARKETS

Compliance carbon markets are established through national, regional, or international regulations to drive emissions reductions. These markets set a price on carbon either by limiting emissions through tradable allowances or by directly applying a carbon tax on emitters, depending on the policy approach adopted by the country or governing body.

TAXES

DENMARK: In November 2024, Denmark adopted a national enhancement of the F-gas Regulation through the "Green Tripartite" agreement. This policy includes a planned rise in taxation on fluorinated gases, whether imported in bulk or embedded in products entering the Danish market. Starting from January 1, 2027, the tax will be raised to 750 DKK per ton of CO_2 equivalents.

ICELAND: To promote the adoption of climate-friendly cooling alternatives, Iceland introduced a tax in 2020 targeting fluorinated greenhouse gases such as HFCs, PFCs, SF_6, and blends containing these substances. This tax applies to importers and varies by gas type, reflecting their global warming potential. Over 50 substances are listed, with rates reaching up to ISK 10,000 (approximately EUR 67.75) per kilogram.

SINGAPORE: Singapore introduced a carbon tax in 2019 under the Carbon Pricing Act, initially set at SGD 5 per tonne of CO_2-equivalent. The rate increased to SGD 25 in 2024 and is planned to rise further—reaching up to SGD 80 by 2030. The tax applies to major industrial facilities emitting over 25,000 tCO_2e annually, covering gases including CO_2, CH_4, N_2O, HFCs, PFCs, and SF6.

NORWAY: A tax on Sulphur hexafluoride (SF6) "Avgift på SF6" was introduced in 2023 with a tax rate of NOK 952 /tCO2e.

SPAIN: Spain imposes a specific tax on fluorinated greenhouse gases, including sulfur hexafluoride (SF_6), as part of its broader climate strategy. This indirect tax (Greenhouse Gas Fluorinated Tax (IGFEI) targets manufacturers, importers, and acquirers of such gases—regardless of whether they are sold in containers or built into equipment. The tax is based on the gas's weight and its global warming potential (GWP), calculated using a coefficient of 0.015, capped at €100 per kilogram.

There are currently 36 Emission Trading Schemes (ETS) trading systems currently in force. While many ETS primarily focus on carbon dioxide (CO_2), several systems also regulate other greenhouse gases, including SF_6. The brief overview highlights regions with consideration for SF_6 inclusion.

EUROPEAN UNION EMISSIONS TRADING SYSTEM (EU ETS): Operating on a 'cap and trade' principle, EU ETS is a cornerstone of the European Union's policy to combat climate change and is the largest carbon market globally. Under the gases covered in the scope of ETS, SF_6 falls under the category of 'Non-CO_2' greenhouse gases.

The EU ETS operates supranationally in all EU Member States plus Iceland, Liechtenstein, and Norway and covers SF_6 in its scope. Since 2020, the EU ETS and the Swiss ETS have been linked. However, the main gases covered are CO2, N2O and PFCs. SF_6 and other F-gases (fluorinated greenhouse gases) are managed via specific regulations targeting F-gases, since 2007 under Regulation 842/2006.

SOUTH KOREA: as mentioned earlier in this report, South Korea's ETS had encompassed SF_6 emissions starting in 2015. This appeared as an effective hybrid carbon incentive mechanism, boosting the demand for credits otherwise used in Voluntary Carbon Market, to serve partially the demand of obligated companies within the ETS.

CHINA: China's national ETS currently focuses on CO_2 emissions. Nonetheless, Chongqing Pilot ETS (2014) have included SF_6, indicating a potential for broader inclusion in future national strategies.

SWITZERLAND: in principle, SF6 is covered in accordance with the CO2 Ordinance. However, in practice, only CO2, N2O, and PFCs require monitoring, as the share of the other gases is negligible.

NEW ZEALAND: New Zealand's ETS includes SF_6 and requires registration for entities importing or using HFCs, PFCs, or SF_6 in bulk, as outlined in the Climate Change (Stationary Energy and Industrial Processes) Regulations 2009. Operators of electrical equipment using SF_6 above a set threshold must also register. A levy applies to synthetic GHGs contained in goods. Exporters of HFCs and PFCs can earn NZUs under the Climate Change (Other Removal Activities) Regulations 2009.

JAPAN: The Cap-and-Trade Program of the Tokyo Metropolitan Government (TMG) and the Saitama Prefecture Target Setting Emissions Trading System both require monitoring and reporting of all seven GHGs, including SF_6.

AUSTRALIAN SAFEGUAR MECHANISM: under Australia's Safeguard Mechanism, facilities that emit GHGs above their assigned baseline are required to offset the excess emissions. This is done by surrendering either Safeguard Mechanism Credits (SMCs)—earned by facilities emitting below their baseline—or Australian Carbon Credit Units (ACCUs), which are generated through approved emissions reduction projects. SF_6 is one of the six GHGs covered under its scope.

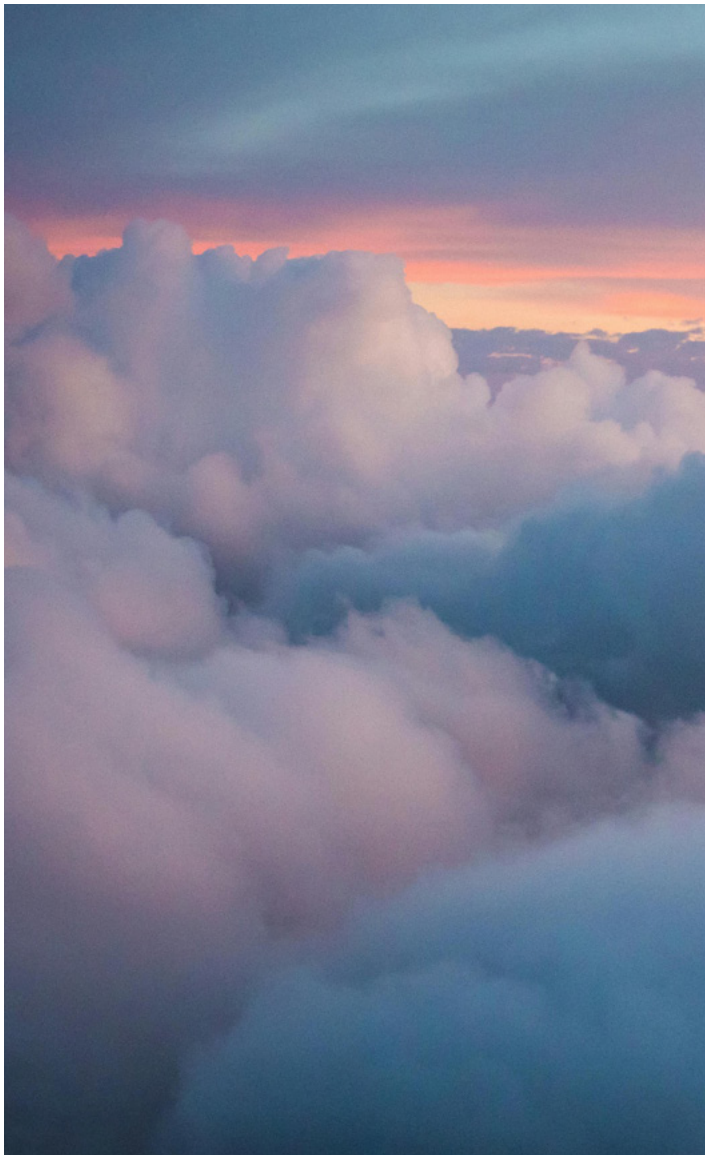
CANADA: Canada operates a diverse landscape of emissions trading and pricing systems across federal and provincial levels. The federal Output-Based Pricing System (OBPS) sets the national benchmark, complemented by regionally tailored programs. Notably, these systems include SF_6 within their scope of regulated substances, reflecting a comprehensive approach to managing high-impact synthetic greenhouse gases across the country.

USA: several state-level emissions trading programs incorporate SF_6 within their regulatory scope. The Washington Cap-and-Invest Program and California's Cap-and-Trade Program include SF_6 among the GHGs subject to monitoring or compliance obligations. Additionally, the RGGI primarily targets CO_2 but allows for offset projects in certain jurisdictions.

REBIRTH OF SF_6 IN CARBON MARKETS?

As we have seen, emissions trading schemes (ETS) mainly concentrate on CO_2, sometimes neglecting gases that have a significantly greater warming potential. Incorporating SF_6 into worldwide carbon markets or establishing an independent cap-and-trade framework for fluorinated gases would support a comprehensive strategy for climate change mitigation.

Including SF_6 in global carbon markets would aid in standardizing regulations across sectors avoiding emissions leakage, where businesses move to nations with lenient environmental regulations.



HOW AN SF_6 CARBON TRADING SYSTEM MIGHT OPERATE

A carbon marketplace for SF_6 could be organized in various approaches:

1. **Cap-and-Trade Scheme: Authorities or global organizations impose a limit on SF_6 emissions**

Utilities and industrial consumers would obtain or buy allowances. Firms that lessen SF_6 emissions might be able to sell their surplus allowances.

2. **Carbon Levy on SF_6 Utilization and Emissions**

Firms releasing SF_6 would incur a tax based on the volume emitted. The income produced may be reinvested in alternatives to SF_6 and improvements to infrastructure.

In some countries, taxation on the production and import of SF_6 serves as an incentive to transition toward SF_6-free equipment. The effectiveness of this approach, however, largely depends on the accessibility of viable alternatives and the implementation of SF_6 recycling systems to enable capture and reuse where substitution is not yet feasible.

This market, although has less coverage (2-4% of global GHGs), can be a harbinger for the design and development of similar markets for other super pollutants such as HFCs & even CH4. Ultimately, this market can cover 45% of all GHGs, and can be a very effective tool for climate action.

3. **Voluntary Carbon Market**

Project developers together with switchgear or grid operators can develop SF6 avoidance credits based on available standards and methodologies, and trade these credits to international buyers who are using these credits as part of their carbon compensation efforts or for Beyond Value Chain Mitigation (BVCM). This is essentially what has happened so far under the CDM.

WHY SF_6 CARBON PROJECTS SHOULD BE INCLUDED UNDER ARTICLE 6

Article 6 mechanisms under the Paris Agreement provide countries with a choice for voluntarily proposing their Nationally Determined Contributions (NDCs) which can include SF_6 among other Super Pollutants (F-gases and methane).

In most cases, countries do not include gases like SF_6, HFCs, PFCs & NF3 in their NDCs, specifying that statistical reporting has not yet been developed to estimate emissions.

This is slowly expected to change with the advent of the country-wise carbon markets which are being developed by many countries as of now.

India, for example, has developed its carbon credit scheme which intends to transition to a mandatory cap-and-trade system planned for the future. It has included fugitive emissions, including SF_6 in its planned methodologies under Phase 2[7].

Similar efforts to focus on SF_6 in the domestic carbon markets can see a flip in the recent future.

The need for SF_6 to be included under the domestic compliance carbon markets and subsequently in Article 6 mechanisms cannot be overstated, as this potent gas which can represent a significant portion of many countries' emission inventories.

1. **Unlocking International Finance for SF_6 Reduction**

The high cost of alternative technologies is a major obstacle to phasing out SF_6. However, by including SF_6 reduction in Article 6.4's carbon crediting mechanism, projects can generate revenue through carbon credit sales.

This financial incentive makes investments in, for example, SF_6-free equipment, more economically viable. An SF_6 carbon market is therefore crucial as a transitionary tool, similar to transition credits for phasing out coal-fired power plants.

[7] https://beeindia.gov.in/en/approved-sectors-in-offset-mechanism-under-ccts-by-central-government

For example:

A utility company executing a project to assess and monitor SF_6 emissions in their GIS's may unlock carbon finance for more technological adoption towards SF_6-free equipments in the future.

2. Encouraging Technology Transfer to Developing Countries

Developing nations often lack access to SF_6 alternatives due to the high upfront costs. Climate Finance instruments under Article 6 can help facilitate:

- Financial support for emerging markets to invest in SF_6-free grid technology.
- Knowledge-sharing partnerships between developed and developing nations.
- Incentives for multinational corporations to implement SF_6 reduction projects in lower-income countries.

Various countries have already initiated technology-driven projects under bi-lateral Article 6.2 agreements to issue and transfer ITMOs, or Internationally Transferred Mitigation Outcomes, a mechanism that allows countries to trade emission reductions across borders, helping them achieve their Nationally Determined Contributions (NDCs).

These can be waste-to-energy, electric buses, bioenergy, green hydrogen, or SF6-free equipment. ITMOs can be powerful instruments especially if the country does not have capabilities to implement such technologies domestically.

3. Enforcing Accountability Through Carbon Markets

SF_6 emissions are notoriously underreported due to weak regulations in many regions. Article 6 could strengthen monitoring and transparency by:

- Creating clear accounting rules for SF_6 emissions in global carbon markets.
- Encouraging countries to include SF_6 reduction in their national inventory and NDCs.
- Preventing double counting of emission reductions between nations.

4. Enhancing Private Sector Participation

Many companies are voluntarily offsetting emissions through carbon markets. SF_6 reduction projects under Article 6.4 could:

- Provide new high-quality carbon credits for businesses.
- Incentivize SF_6 "polluters" to reduce or offset their own SF_6 emissions. These can be utilities directly but also energy-intensive companies: heavy industrial site or mining operators, EV car manufacturers, data-greedy data and AI companies, semiconductor producers
- Improve the overall supply and integrity of global carbon markets.

5. Strengthening Global Climate Ambition and Cooperation

By integrating SF_6 mitigation into Article 6, more nations would have access to cost-effective emission reduction strategies. This would:

- Enable countries to meet their climate targets faster.
- Reduce the risk of carbon leakage, where industries relocate to regions with weaker regulations.
- Increase collaboration on phasing out high-GWP gases beyond CO_2, especially by bringing best practices from countries transitioning away from SF_6 now (e.g. EU countries, Switzerland, UK, California) - to those which have not started yet.
- Reducing the "delayed emission" factor by supporting an earlier adoption of SF6-free equipment, rather than continuing the installation of traditional SF_6 GIS.

HOW SF_6 CARBON PROJECTS CAN BE IMPLEMENTED UNDER ARTICLE 6

1. **Inclusion in National NDCs**
   - Countries should explicitly include SF_6 reduction targets in their Nationally Determined Contributions.
   - Technical Assistance program could be developed by supporting governments and development institutions, similar to the numerous Article 6 Capacity Building programs from organizations such as the World Bank, ADB, A6IP, or the SPAR6C led by the Global Green Growth Institute (GGGI)
   - This would create demand for SF_6-specific ITMOs under Article 6.2.
2. **Developing Standardized SF_6 Reduction Methodologies**
   - The Supervisory Body under Article 6.4 should approve SF_6 reduction methodologies for project eligibility.
   - This could include:
     - Leak detection and repair programs
     - Deployment of SF_6-free electrical infrastructure
     - Recycling and reclamation of SF_6 gas
     - Destruction of SF_6 from decommissioned facilities
     - Retrofilling & retrofitting activities
3. **Creating SF_6-Specific Carbon Credit Programs**
   - Similar to REDD+ (forestry credits), a specialized SF_6 mitigation credit program could be established.
   - Governments could certify projects that prevent or reduce SF_6 emissions.
4. **Integrating SF_6 Into Carbon Trading Schemes**
   - Existing markets like the Emissions Trading Systems (ETS) and CORSIA (for aviation emissions offsetting) could enhance activities for curbing SF_6 allowances in order to align itself with country-based taxation and broadly for meeting the EUETS targets.
   - Private-sector voluntary carbon markets could include SF_6 leakage reductions or phase-out projects as verified, high-quality offsets.

Bringing SF_6 carbon projects under Article 6 of the Paris Agreement would be a game-changer in tackling one of the world's most potent greenhouse gases. By leveraging international carbon markets, this approach would:

1. Attract investment for SF_6-free technologies.
2. Ensure financial support for developing nations.
3. Strengthen global monitoring and accountability.
4. Accelerate the transition toward low-GWP alternatives.

As climate change intensifies, policymakers must recognize that SF_6 regulation cannot be delayed any longer. By integrating SF_6 mitigation into Article 6 mechanisms, the world can take a crucial step toward a more comprehensive, effective, and equitable global climate strategy.

The time to act is now. SF_6 must not remain the "invisible" climate threat.