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Market experts see significant potential in crediting the reduction of sulphur hexafluoride (SF6) emissions linked to grid expansion in the power sector and the clean energy transition, with a German government-backed initiative also looking at the role of carbon finance in the relatively untapped field of mitigation.

Market experts see significant potential in crediting the reduction of sulphur hexafluoride (SF6) emissions linked to grid expansion in the power sector and the clean energy transition, with a German government-backed initiative also looking at the role of carbon finance in the relatively untapped field of mitigation.

SF6 emissions, one of the most potent greenhouse gases and part of the F-gases group, mainly originate from gas-insulated switchgear in the electricity infrastructure and they threaten to rise sharply in the course of grid expansion, especially in developing and emerging economies, as the world continues to electrify.

Electricity generation capacity globally is projected to quadruple to 32.1 TW in 2050 from 8.6 TW in 2021, and much of the rise in SF6 emissions is expected to come from Asian markets.

An international initiative supported by Germany is considering the technology and financing options for reducing SF6 emissions in light of this, with the aim “to create suitable regulation, monitoring, and incentive mechanisms, possibly based on carbon markets”, according to the government’s website (<https://www.international-climate-initiative.com/en/project/preparation-of-an-international-initiative-to-mitigate-sulphur-hexafluoride-emissions-in-the-power-sector-23-i-517-global-g-phase-out-sf6/>).

As per the Berlin-backed project, the development of the necessary quantitative and qualitative data and information basis has already started:

- Initial situation regarding SF6 in the electricity sector in various countries (existing infrastructure, local actors, current practices, national strategies (NDC, Leds), emission estimates and monitoring)
- Techno-economic feasibility of emission reductions
- Prioritisation of countries and regions
- Networking with key players in selected countries (especially responsible ministries and grid operators) and exploration of political interest in membership of the planned SF6 initiative started
- Networking with potential strategic partners of an SF6 initiative started (UN organisations, foundations, private sector, research/science)
- Initiated strategic dialogue with numerous development banks, which have a key role to play with regard to the short-term reduction of SF6 emissions and the medium-term phaseout of the technology

Results are expected in early 2025, though due to political uncertainty and new elections due early next year, the funding for any next steps of project could be under threat (<https://carbon-pulse.com/347927/>), as well as other climate initiatives.

CARBON FINANCE POTENTIAL

Some, including the German initiative, see the potential for carbon markets in helping to finance the abatement of these emissions linked to clean energy expansion.

“The grid expansion needed in developing countries for increasing the share of renewable electricity generation could come with a significant increase of SF6 emissions, the most potent greenhouse gas that exists,” said Axel Michaelowa, senior founding partner at consultancy Perspectives Climate Research, which is working alongside Germany in an advisory capacity on the project.

“International carbon markets could play an important role in accelerating replacement of SF6 in new electrical equipment,” he told Carbon Pulse.

Michaelowa also spoke at a side event during COP29 in Baku last month, alongside a German government representative, on the potential for carbon markets to mitigate SF6 emissions.

Some of this is linked to the fairly cheap abatement cost for some of the easier options, as presented during at the summit in the visualisation below. Clearly, many of the other options are still seen as more expensive than even some of the high-end carbon removal technologies, such as direct air capture (DAC).

content/uploads/2024/12/Screenshot-2024-12-10-110430.png)

(<https://carbon-pulse.com/wp->

In case of new installations, SF6-free alternatives offer abatement costs between €10-300 per avoided tonne of CO2e, though more research is needed to bring down this uncertainty, the side event heard.

Perspectives suggested a potential abatement pathway, including carbon markets under Article 6, as well as a large share from domestic financing.

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(<https://carbon-pulse.com/wp->

Mitigation outcomes could be both traded between countries and credited under Article 6, Michaelowa said, especially after the rules for these mechanisms were recently finalised (<https://carbon-pulse.com/346120/>) at the annual UN climate summit in Baku.

Demand for carbon credits could come from the implementation of Nationally Determined Contributions (NDCs) and the CORSIA international aviation offsetting scheme, as well as initiatives to provide results-based finance and the private sector, he told the side event.

There should also be a move to better explore project-based as well as policy-based crediting, but methodology development is still required.

Some work could be done from building on Kyoto Protocol-era Clean Development Mechanism (CDM) methodologies as starting point, and then revised to apply to the standards of Article 6.4 Paris Agreement Crediting Mechanism (PACM). Such a revision could be submitted under the Article 6.4 mechanism in early 2025, which is already due to see significant methodological work (<https://carbon-pulse.com/346792/>) next year.

Michaelowa suggested three main crediting pathways, speaking at COP29:

- Mandates: technology standards, performance standards, or quotas for low-GHG technologies
- Incentives: emissions trading, direct subsidies, tax credits or rebates
- Corrective legislation: removal of prohibitions or barriers

He underlined, however, that given the rather high costs of SF6 reductions to date, even current carbon allowance prices in compliance mechanisms would likely be insufficient to mobilise all activity types. The EU ETS, the largest such market, has benchmark prices currently trading at less than €70 per tonne.

VIEW FROM THE GROUND

In terms of how this could be put into practice on the ground, there are project developers already looking into the sector.

Lucas Zaehringer, co-founder and CEO at Planet2050, a Berlin-based startup working closely with carbon project developers, underlined the potential in terms of crediting scale.

“Worldwide, 80% of SF6 is in high-voltage, gas-insulated switchgears, which are critical electrical equipment for high-voltage transmission in our grids and large industrial sites,” he told Carbon Pulse.

“The total estimated stock of SF6 range from 100-200,000 tonnes globally, which represents a potential of 2.3-4.6 billion tonnes of CO2 equivalent.”

“This is as of 2020, but you need to add the fact that electricity generation will quadruple until 2050,” he added.

Not all the SF6 stock will be leaked, but the numbers give you an idea of the scale of the issue and that real potential for avoided emissions crediting exist, Zaehring continued.

He said he expected the first projects to emerge next year, but scale could take time.

“Some solutions exist today, especially regarding capacity building to reduce mishandling, leakage detection and reduction, sealing and repairs. For these we could see the first projects registered in 2025 already,” he said. “Retro-filling or retro-fitting based on SF6-free gas and equipment will still take a few years to be commercially viable, especially in the regions that would need it most.”

The role of both Article 6 and voluntary carbon markets could be huge, but there are quite a few hurdles ahead.

“One key barrier is that most countries do not have a clear GHG and NDC inventory for their SF6 emissions, but we see a changing trend with growing awareness and the pressure coming from the fact that SF6 is one of the mandatory GHG to report as part of NDCs,” he said.

“Flexibility will not be granted forever.”

OTHER FINANCE AVENUES

Other avenues that could be used to mitigate against the expected emissions growth include more traditional forms of international public climate finance in the form of grants or concessional loans, which could be provided for SF6 mitigation.

Experience with funding the phase-down of chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), as well as recently hydrofluorocarbons (HFCs), under **existing funds that fall under the Montreal Protocol** (<https://carbon-pulse.com/301737/>), could be used as a blueprint, Michaelowa suggested.

Given the strong role of a few industrialised countries as key global producers of switchgear, export credit agencies (ECAs) could also be key actors in providing climate finance for phasing out SF6, he added. Export credits could help lower the cost of SF6-free switchgear.

SF6 mitigation could also in theory be integrated into Just Energy Transition Partnerships (JETPs), **partnerships** (<https://carbon-pulse.com/282924/>) between rich nations and targeted developing countries, such as South Africa and Indonesia, that focus on coal phaseout and renewable expansion, Michaelowa told the side event. Public-private partnerships (PPPs) and blended finance could finally help lower the high upfront costs of new, SF6-free switchgear, he continued.

International public climate finance should also provide technical assistance and capacity building, both for the installation and maintenance of new, SF6-free switchgear as well as for creating conducive regulatory frameworks.

“Since public institutions such as government and development banks traditionally play an active role in supporting the financing of electrical grids in partner countries, it may sense that they look for more environmentally friendly solutions, especially when considering greenfield investments where SF6-free technology, when available, is 3-5 times more expensive than conventional alternative,” said Zaehring of Planet2050.

“This is where international climate finance can help, by covering the additional cost of CO2 abatement.”

EU REGULATION

There is already some fairly stringent regulation in force to deal with F-gases, such as SF6, **put in place by Brussels at the start of 2024** (<https://carbon-pulse.com/251692/>).

The policy aims to deal with F-gases, which **are still responsible for around 2%** (<https://www.eea.europa.eu/publications/fluorinated-greenhouse-gases-2021>) of the EU's greenhouse gas emissions, despite regulations dating back to 2006 that have helped to drive a shift towards cleaner alternatives amid persistent demand for the underlying products.

With new Green Deal goals placing a huge emphasis on electrification, notably to meet **highly ambitious renewable expansion goals** (<https://carbon-pulse.com/350217/>), as well as ramped up heat pump use, the new F-gas regulation seeks to deal with potential side-effects of this push towards cleaner forms of energy.

Heat pumps, for example, are considered key in the EU's electrification and decarbonisation plans, yet still rely upon F-gases in their manufacture.

More recent REPowerEU regulation, linked to moving away from Russian energy import reliance, seeks to double hydronic heat pump sales by 2027 at the latest, leading to 10 million new installations across the bloc.

At the heart of the concerns is that Brussels' plan for a rapid rollout of heat pumps and switchgear equipment – which control power systems such as smart meters – relies on technologies that have historically relied on F-gases to function.

The European Heat Pump Association (EHPA) has said that the required deployment of heat pumps under current EU climate plans may need to be double the expected rate.

The EU trade group expects about 20 mln heat pumps must be installed by 2026 and about 60 mln by 2030 to meet goals. Considering that some of these units will replace existing ones, this would lead to a stock of close to 70 mln units, providing heat to more than half of Europe's buildings.

In the regulation, approved by lawmakers earlier this year, Brussels legislated to phase out F-gases by 2050.

CONTEXT

SF6 has a global warming potential (GWP) 25,200 times greater than CO2 and has been described as a major unintended consequence of the green energy boom.

Globally, SF6 stock and emissions in Asia will be higher than in other regions of the world, certainly until 2050 – estimated by some to be as high as 80% of the global share.

In China and South Korea, SF6 intensity (SF6 inventory per GW installed generation capacity) is currently high, exceeding 45 tonnes per GW of power.

High SF6 intensity is also reported from Japan at 30 tonnes per GW.

Regulating the gases has not been easy.

The EU’s move has historically had side effects, including an emerging black market for trading F-gases, according to media reports. In 2018 alone, as much as 16.3 mln tonnes of CO2e of bulk HFCs were illegally placed on the market, according to the Environmental Investigation Agency (EIA), an international NGO.

The **1987 Montreal Protocol** (<https://www.unep.org/ozonaction/who-we-are/about-montreal-protocol>) established the global phase-down and out for substances that deplete the ozone layer that shields us from the sun’s harmful ultraviolet radiation.

The UN pact forced nations to downsize the HCFC and CFC output widely used in cooling and foam applications, but their replacement HFCs and other F-gases were later found to have a global warming potential (GWP) some 14,600 times stronger than CO2.

As well as the EU regulation, the G7 announced to end SF6 use in new installations in 2035. South Korea, China, and Japan also have some more informal policies.

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