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Running on Air

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An international agreement to phase out the most potent greenhouse gas is both warranted and feasible. *Full recommendations, page 4.*

Summary: Sulfur hexafluoride, SF_6, is the most potent greenhouse gas regulated under the 1997 Kyoto Protocol, but is nonetheless considered of minor importance as it represents only a tiny fraction of greenhouse gas emissions. However, atmospheric SF_6 concentrations are increasing at 15 times the rate of CO_2. This trend, combined with a lifetime for the gas of over three thousand years, warrants a closer look at the possibilities for SF_6 emissions reductions.

Because SF_6 production and consumption patterns are similar to those CFC market characteristics that made the Montreal Protocol so successful, SF_6 is the one greenhouse gas for which an effective and low cost control strategy could be quickly implemented through a similar agreement. There are very few SF_6 producers, and production is not a major profit center for any of them. Nor is there any large-scale refilling service industry. Furthermore, in each of the three main classes of applications for SF_6, the gas could be replaced, or its release minimized via a deposit-refund scheme, with no significant economic disruption.

There now exists no coordinated international effort to phase out low priority SF_6 uses, or to minimize its release. Instead, SF_6 is simply lumped together with other greenhouse gases. However, a separate agreement dealing solely with SF_6 phase-out bears more promise for limiting this gas's greenhouse effects. Such an agreement should take into account the lessons learned from the Montreal Protocol, and could be effectively structured as a side agreement to the Kyoto Protocol. ❖

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Background

SULFUR HEXAFLUORIDE (SF_6), along with carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs), is one of the six greenhouse gases regulated under the 1997 Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC). The possibilities for reducing SF_6 emissions are often overlooked because, to date, all the atmospheric SF_6 is estimated to have contributed only 0.1% of the total man-made global warming effect caused by CO2.[1] Due to this deceptively small contribution, SF6 is typically lumped together with other non-carbon greenhouse gases. However, some characteristics of SF_6 suggest that it should be treated separately.

Inertia is Forever

First, of the greenhouse gases, SF_6 is by far the most potent. On a per-kilogram basis, over a 100-year time horizon, when compared to CO_2, SF_6 has 24,900 times the ability to change the balance between incoming solar and outgoing infrared radiation. Over 500 years, this factor rises to 36,500 times.

Next, SF_6 concentrations are increasing at seven percent per year, 15 times the rate of CO_2. Prior to its use in industrial production in the mid-1950's, atmospheric concentrations of SF_6 from its one minor natural source were practically zero. By the end of 1996, an estimated 95,250 tons of SF_6 had been released into the atmosphere.

However, SF_6's most noteworthy physical characteristic is that it is extremely stable and inert. While this makes it desirable for insulating electrical equipment—as well as filling the tires of German taxicabs and the soles of American athletic shoes—it also results in an estimated lifetime in the upper atmosphere of over *three thousand* years. By comparison, carbon dioxide, the best-known greenhouse gas, survives there for only a century. The upper atmosphere life spans of HFCs, methane, and nitrous oxide are even shorter, lasting anywhere from a few hours to a few decades.

This spells compounded trouble, for the estimated 0.1% contribution of SF_6 to the total man-made global warming effect is not based on a lifetime of three millennia, but on a presumed upper atmospheric life of 100 years. Any SF_6 released today, however, in fact accumulates virtually indefinitely. It is not dissolved by the oceans or destroyed by microorganisms in soils and plants. No method of absorbing it from the atmosphere (like growing forests) is likely to be found. Seen in this light, our current releases of SF_6 will impact not only our children, but also generations in the very distant future.

The Montreal Model

The success of the Montreal Protocol in phasing out production of ozone depleting chlorofluorocarbons (CFCs) like Freon helped inspire the Kyoto Protocol to reduce greenhouse gas emissions. However, observers of both processes quickly saw that the two were quite different with respect to: (a) the number of producers, (b) the economic cost of control, and (c) agreement on the cause and nature of the problem. Production of CFCs was concentrated among a small number of companies largely in OECD countries, whereas greenhouse gas emissions of carbon dioxide, methane, and nitrous oxide are ubiquitous. There were good non-ozone depleting substitutes for CFCs (including the HFCs and PFCs now classified as greenhouse gases under the Kyoto Protocol) available at a low overall economic cost, whereas major reductions in greenhouse gas emissions are perceived by most as fairly expensive. Finally, there existed a scientific and policy consensus that ozone was being depleted by CFCs and that widespread adverse health impacts would ensue, whereas the scientific consensus on the nature of the climate change problem and, to an even larger degree, a policy consensus on what to do about it, are still evolving. While these differences are indeed quite pronounced when comparing CFCs to carbon dioxide or nitrous oxide, they quickly become similarities when CFCs are compared to SF_6.

Few Producers

There are six major manufacturers of SF_6 in OECD countries.[2] And although these six primary manufacturers share 90% of the 8,500 tons-per-year world market, SF_6 production is not of itself a major profit center for any of them. Moreover, in contrast to some of the more prominent CFCs like Freon, which *was* a major profit center for DuPont, no company holds patent rights on SF_6 production processes.

Apart from these six companies, the only other known producers are a small number of plants located in Russia and China that supply the remaining one-tenth of the world market. Finally, there is currently no large-scale SF_6 refilling service industry.

Few Consumers

Indeed, SF_6 has relatively few uses at all. In the three main classes of applications, as the next section will explain, SF_6 can either be replaced by available alternatives or emissions can be minimized via a deposit-refund scheme. No significant economic disruption will ensue.

The primary use of SF_6 is as an insulator of electrical equipment, accounting for 60% of global sales according to the latest estimates. Of this amount, half is released into the atmosphere during the production process because there is little incentive to capture and reuse the gas. The other half is 'banked' inside the manufactured equipment. Release of this banked SF_6 occurs when the equipment is repaired or when taken out of service and scrapped.

The second largest application of SF_6 is in the magnesium industry, where the gas is used by producers in industrialized countries to blanket molten magnesium. This practice is by no means universal. Chinese and Russian producers of magnesium, for instance, use SO_2 instead of SF_6 for this purpose.

Finally, another class of open SF6 applications utilizes the adiabatic properties of the gas, primarily for filling taxicab tires in Germany and the soles of some sport shoes in the United States. It is claimed that SF_6 makes the cab rides less bumpy and the shoes more bouncy. The gas is also used in some sound-insulating windows in Western Europe.

Effective Approaches

Recent estimates show that SF_6 emissions from open applications can be cut by 90%, primarily through the use of substitutes and by efforts to prevent what are now "costless" releases during the initial production process.[3] To begin with, for all electrical equipment applications, a deposit-refund or a pure refund scheme can be designed that will generate incentives for careful handling and minimum release of the gas. At the same time, releases of SF_6 already banked in electrical equipment such as power transmitters and accelerators can also be minimized through deposit-refund for new equipment or pure refund schemes for existing equipment.

In the magnesium industry, one possibility is to simply replace SF_6 with the alternative SO_2 technique throughout the sector. In some cases, however, this may involve relatively expensive plant retrofitting. The other option is to use SF_6, but to prevent its release into the atmosphere. A major producer in Norway, Norsk Hydro, has already shown the feasibility of decreasing SF_6 releases by a factor of 10 without significantly increasing production costs. The institution of a deposit-refund scheme for SF_6 would result in a largely one-time cost of doing business for most firms in the magnesium industry, as long as the SF_6 was not released into the atmosphere. The required deposit would provide incentives for producers to sharply curtail SF_6 use, or to catch it post-production rather than simply venting it into the atmosphere.

Finally, in all of the adiabatic applications, SF_6 can be phased out and replaced with already available substitutes without major sacrifices in product quality and price. In sum, the physical characteristics of SF_6 and the dynamics of the global market allow for a coordinated approach toward the gradual phase-out of the gas.

Separate Treatment

Currently, there exists no coordinated international effort to phase out low priority SF_6 uses and to minimize releases from all remaining applications. Instead, SF_6 is simply one of the gases that individual UNFCCC Annex I countries have pledged to reduce as part of their overall effort to control greenhouse gas emissions. While country-specific programs, such as the U.S. Environmental Protection Agency's SF6 Emissions Reduction Partnership for Electric Power Systems, have emerged in response, this is not the most expedient way of dealing with the issue. There is no reason why country-specific programs could not be expanded to a global scale

Recognizing that their use is a reaction to the CFC phase-out, the UNFCCC has recently asked parties to the Montreal Protocol to provide advice on ways of controlling HFCs and PFCs. Given its special characteristics, the UNFCCC has also asked for comments on whether SF_6 should be included in a future action plan. Eliminating SF_6 emissions would be a small but significant step in attempts to limit global climate change. A separate international agreement dealing solely with the phase-out of SF_6 is both warranted and feasible, and bears more promise for limiting the greenhouse effect of SF_6 than the Kyoto agreement's obligations based on a basket of radically different gases. Moreover, it is a step within reach that could take advantage of the negotiating and implementing experience accumulated via the Montreal Protocol. The recommended SF_6-related actions could be effectively structured as a side-agreement to the Kyoto Protocol, and would not necessitate re-negotiation of the Protocol itself. The side-agreement would simply further Kyoto objectives, by expediting the highly feasible phase-out of an extremely potent and long-lived greenhouse gas. While a country's reduction in SF_6 releases could still be counted toward its Kyoto obligations, coordinated action among the major international producers involving the further development of low cost substitutes and containment schemes is likely to be much more effective under a separate international agreement. ❖

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How to Phase Out Sulfur Hexaflouride (SF_6):

1. **Negotiate a Montreal Protocol-like agreement among all major producer and consumer countries.**
2. **Anchor it as a side agreement to the Kyoto Protocol.**
3. **Determine how to count SF_6 emissions reductions at the country level toward Kyoto obligations.**
4. **Replace SF_6 in many applications with available substitutes.**
5. **Institute deposit-refund schemes to make SF_6 release from remaining applications costly.**
6. **Monitor agreement implementation and punish violators severely.**

[1] Maiss, M.; Brenninkmeijer, C. A. M. *Atmospheric SF6: Trends, Sources, and Prospects*. Environmental Science and Technology 32, 20 (1998): 3077–3086.

[2] Asahi Glass Chemicals (Japan and United States), Air Products and Chemicals (United States and Canada), Allied Signal (United States and Canada), Ausimont (Italy), Kanto Denka Kogyo (Japan), and Solvay Fluor und Derivate (Germany).

[3] Brenninkmeijer, *Atmospheric SF_6*: 3085.

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