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Bulletin

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DATE: February 23, 2010

TO: Customers and Channel Partners

FROM: Strategic Marketing

SUBJECT: White Paper: *HFC's In Fire Protection Systems*

Tyco Fire Suppression and Building Products is pleased to provide you with a PDF copy of an article by George Dyer, founder of Greenland Enterprises, a consultancy specializing in leadership toward sustainable development.

HFC's in Fire Protection Systems: An Invisible and Unnecessary Climate Threat is an insightful and accurate description of the current state of the agents available for use in fire suppression systems. The analytic review is neither pro nor con toward any brand of agent, but entices the reader to gain a fuller appreciation of the environmental trade-offs involved in agent selection.

Last August, Tyco Fire Suppression & Building Products co-sponsored a webcast on *Fire Suppression and Climate Change*. The distribution of this new white paper is a second, and one of many future examples, of our renewed commitment to environmental responsibility in fire suppression. We take our environmental responsibility very seriously and hope that the information we pass on to you is both beneficial and eye opening.

Should you have any questions on this information, please contact your engineered systems sales manager.

KYOTO
Publishing

White Paper

Georges Dyer

HFCs in Fire Protection Systems

HFCs in Fire Protection Systems

An invisible and unnecessary climate threat

Georges Dyer, Greenland Enterprises, September 2009

Executive Summary

Hydrofluorocarbons (HFCs) are powerful greenhouse gases that contribute to global warming, and consequently to dangerous climate disruption, with a pound-for-pound impact thousands of times greater than carbon dioxide. Since the 1990s, they have been employed in a range of applications—air conditioning, refrigeration, aerosols, and fire suppression systems—as replacements for ozone-depleting substances. Safer alternatives can be developed for all of these applications, and in the case of fire suppression systems commercially competitive alternatives are already on the market.

In the American Clean Energy and Security Act of 2009, HFCs replacing ozone-depleting substances are set aside for special treatment under Section 619. The intent is to prevent unreasonable costs being passed through to consumers of air conditioners and refrigerators if producers and importers of HFCs are required to buy allocations in competition with the broader pool of greenhouse gases. HFCs for fire suppression systems are included in this group.

Even with their strong global warming impact, HFCs currently represent a small percentage of total greenhouse gas emissions, and the fire suppression industry represents only a small percentage of total HFCs. Still, the fire suppression industry has a responsibility to eliminate its contribution to this sustainability challenge, and it risks squelching innovation and passing on liabilities to customers if it does not take a proactive position in doing so. Given the magnitude and urgency of the climate challenge, we need to avoid any emissions we possibly can.

The Montreal Protocol, which phased out the production of ozone-depleting substances, provides an excellent model in international cooperation to avoid potential global catastrophe, and an excellent vehicle for doing the same in the case of HFCs. The clear and simple constraints of the Protocol provide an effective driver of innovation, and the industries that would be affected are familiar with its framework. In the case of the fire suppression industry, the existing alternatives will allow a relatively easy transition. In all industries, a more comprehensive approach to sustainable product design should be employed not only to drive innovation, but to avoid the continuation of the often costly cycle of solving the problems of today by creating the problems of tomorrow.

HFCs in Fire Protection Systems

An invisible and unnecessary climate threat

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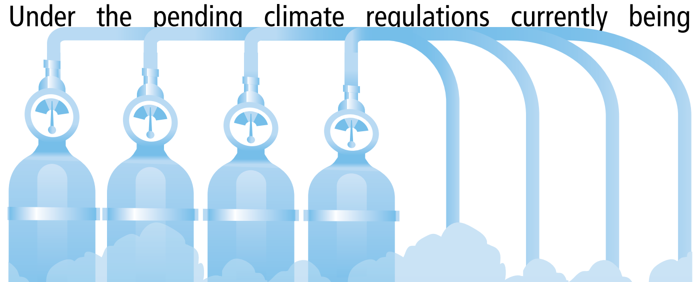
Invisible and Avoidable

If you're reading this in an office, look at the ceiling. Chances are you'll see a patchwork of sprinkler heads hanging over the room. Unless you work in the fire suppression business, you probably don't think much about them, or what they release. In most cases, they release water to extinguish the flames, and often cause significant water damage in the process. In spaces with sensitive electronic equipment or processes that can't stop for clean-up, an alternative is needed. Often chemical "clean agents" provide the answer, and often these agents are hydrofluorocarbons (HFCs)—powerful greenhouse gases. Thus, server farms and datacenters around the world—spaces most people never see—are equipped with protective systems most people rarely think about, full of substances most people have never heard of. Like so many sustainability challenges, this one is largely invisible.

HFCs are man-made compounds used in refrigeration, air conditioning, insulating foam, aerosols, medical devices, semiconductors, solvent cleaning, and fire suppression systems. In fire suppression systems, they are a replacement for halons, the ozone-depleting substances (ODS) commonly used before their production was regulated under the Montreal Protocol, which entered into force in 1989. Composed of hydrogen, fluorine, and carbon, HFCs do not contain bromine or chlorine, and as such do not destroy the ozone layer. Like halons, they are relatively inexpensive and suppress fire without damaging equipment (such as computers and electronics), or halting essential processes or services (such as emergency response/911 call centers), or causing immediate harm to people. HFCs are common in fixed-system, building-integrated applications like the sprinkler-head systems in offices and apartment buildings. While HFCs have certain characteristics that make them effective coolants and fire suppressors, they also absorb infrared radiation very effectively so that even small amounts can have a significant global warming impact.

There is little doubt that the economic performance of HFC systems is compelling. But the potential climate impacts are real, and the level of uncertainty around the ability to control HFC emissions from such systems is significant. Moreover, effective, commercially competitive alternatives exist. Consumed as we are with the dangerous rates of emissions from fossil fuels and deforestation, the HFCs in fire protection systems may seem like a footnote in the global struggle to avert climate disruption and disaster for humanity. But they are an avoidable footnote—a pollutant that we can eliminate with very little personal sacrifice in our daily lives, and a relatively low cost to industry.

Under the pending climate regulations currently being considered by Congress, the production and consumption of HFCs, often referred to as "super greenhouse gases," would be phased down. But those that are being used as ODS re-



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placements are set aside from the other greenhouse gases in a separate pool with its own system for allocating, auctioning, and phasing down the number of rights to consume them. Starting in 2012 and ending in 2032, HFC consumption will be reduced 85 percent below a baseline of the average consumption in 2004 – 2006.[1] The primary motivation for doing this is to subdue fears that including specific types of HFCs used in refrigeration and air-conditioning applications in the broader pool would be too costly, and these costs would be passed on to households. Although alternatives exist, some claim that they could not be made immediately available on the necessary scale and at affordable prices—a subject of ongoing current debate.

The HFCs used in fire protection systems—primarily HFC-227ea—are lumped into this same group as those for refrigeration and air conditioning, and set aside from the general pool, despite the fact that commercially viable alternatives are already competing in the market. Because these HFCs would be regulated as one broad group with an overall limit, and HFCs for fire suppression are a comparatively small percentage of that group, the industry anticipates that there will be access to sufficient credits even after the 85 percent reduction in supply, and that associated cost increases will be modest and unlikely to influence customer demand.[2] The alternatives to HFCs could virtually eliminate the need for their continued consumption in fire suppression immediately, but it's expected that including them in this special group will have minimal effect in reducing their production, consumption, and ultimately their release into the atmosphere.

On September 15, 2009, the U.S. State Department announced that, along with Canada and Mexico, it supported amending the Montreal Protocol to cover HFCs.[3] The Montreal Protocol is often cited as the most successful international environmental agreement. The industries affected by HFC regulations are largely the same as those that dealt with the ozone depletion threat and are familiar with the Montreal Protocol. Avoiding the potential confusion and delays of reducing the use of HFCs through climate legislation and international climate agreements by instead amending the Montreal Protocol to cover HFCs is the most direct and likely the most effective route to take.

For HFCs in fire suppression the Montreal Protocol option is a no-brainer. The alternatives exist at acceptable cost-premiums that will come down further over time. With regard to other HFC applications, like air conditioning and refrigeration, alternatives also exist, although in some cases their commercialization has been delayed due to industry inertia and a lack of clear incentives and price signals to drive these innovations to market.[4] But for all HFCs, the clear constraints provided by the Montreal Protocol will drive investment and innovation and lead to superior products and performance. This is particularly necessary as huge segments of the world's population (e.g. China and India) demand more of the air conditioners and refrigerators, cars and fire suppression systems that use HFCs. With their outsized global warming impact, failing to take advantage of the opportunity to leapfrog a massive distribution of these substances in the developing world would be a costly and potentially catastrophic mistake.

The Big Picture

Our global society faces an unprecedented challenge—and opportunity—of redesigning and recreating the systems we use to satisfy our needs. Simply put, our current systems—energy systems, industrial systems, transportation systems, building systems, agriculture systems, etc.—are not sustainable. They are designed in such a way that they are systematically undermining the social and ecological systems upon which our civilization depends. The complex process that is undermining our social and natural systems is like a disease with many interrelated symptoms, each of which is complex in its own right: climate change, terrorism, deforestation, poverty, topsoil loss, failed states, toxins, cancer epidemic, hyper-consumerism, depression, and on and on.

The root causes of these symptoms of the underlying 'unsustainability disease' can be articulated in four basic categories of activities that collectively undermine the social and ecological systems upon which we depend:

1. Systematically increasing concentrations of substances

* *These four mechanisms were originally identified and refined through a comprehensive consensus-building process involving hundreds of scientists from around the world coordinated by The Natural Step, and are commonly known as The Natural Step "System Conditions" or "Sustainability Principles."*

extracted from the **Earth's crust** (e.g. heavy metals, fossil fuels, etc.) in natural systems;

2. Systematically increasing concentrations of substances **produced by society** (e.g. CFCs, DDT, HFCs, etc.) in natural systems;
3. Systematically increasing degradation of natural systems by **physical means** (e.g. deforestation, overfishing, paving, etc.);
4. Systematically undermining people's **capacity to meet their needs** (e.g. exploitative labor, unfair trade agreements, abuses of power, etc.).[5] [*]

By stating these activities in the negative, they turn into four "principles for sustainability" that an individual, an organization, a community, or an entire industry can use and aspire to for "success" in terms of sustainability. In other words, only by not contributing to systematic degradation of natural systems and human communities can we create a sustainable society.

When an organization, such as a company in the fire suppression business, works to systematically eliminate its contributions—both direct and indirect, now and in the future—in all four of these aspects, it moves toward "sustainability." The collective impact of all organizations, groups, and individuals moving toward sustainability is the only way to shift our current unsustainable systems to a sustainable future. The good news is that we can generate unprecedented opportunities for innovation and creativity in the process. By developing more effective ways to satisfy our needs we will be able to lead more fulfilling lives without compromising the ability of future generations to do the same.

Emissions and Impact

There are six major greenhouse gases (GHGs) that are covered under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, including hydrofluorocarbons (HFCs) (see figure 1). To enable "apples-to-apples" comparison, these substances are measured in tons of carbon dioxide equivalent (CO_2e) units, based on their relative global warming potentials (GWP) over a 100-year time period. Carbon dioxide is the benchmark with a GWP of 1. Others are shown in Figure 1.

Figure 1

Substance	Lifetime (yrs)	Global Warming Potential (100–yr)
Carbon dioxide (CO_2)	Variable	1
Methane (CH_4)	12	25
Nitrous oxide (N_2O)	114	298
Perfluorocarbons (PFCs)	1,000 – 50,000	7,390 – 12,200
Hydrofluorocarbons (HFCs)	1.4 – 270	124 – 14,800
HFC-227ea	34.2	3,220
HFC-23	270	14,800
HFC-125	29	3,500
HFC-134a	14	1,430
HFC-236fa	240	9,910
Sulphur hexafluoride (SF_6)	3,200	22,800

Major greenhouse gases with corresponding global warming potential values for 100-year time horizon from the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007.

In other words, emitting one metric ton of HFC-227ea (the most common HFC used in fixed systems) has about the same contribution to global warming as emitting 3,220 metric tons of CO_2 into the atmosphere (considering a time-horizon of 100 years). However, in the case of HFC-227ea, which has a lifespan of 34.2 years, spreading out its impact over 100 years yields a deceptively low figure—its GWP over a 20-year time horizon is 5,310.[6]

When evaluating the potential climate impact of emissions of HFCs from fire suppression systems there are two important points to consider. First, HFCs represent a relatively small portion of total GHG emissions. While available data is far from perfect, most estimates put the current contribution at less than 3 percent. However, they are projected to grow considerably over the next 40 years as they continue to replace ozone-depleting substances like CFCs and HCFCs. A recent study suggests that by 2050 global HFC emissions could be from 9 percent to 19 percent of projected CO_2 emissions in business-as-usual scenarios; and could be as high as from 28 percent to 45 percent of projected CO_2 emissions in a scenario where atmospheric CO_2

is stabilized at 450 parts per million.[7] Second, although it is difficult to accurately measure emissions for HFCs from fire suppression systems, it is clear that they represent only a small fraction of total HFC emissions: less than 1 percent or 2 percent. So, estimated HFC emissions from fire suppression are on the order of less than 1 one-thousandth of 1 percent of current total GHG emissions.

A Bucket Full of Drops

Clean agents in fire suppression systems are only released into the atmosphere (i.e. emitted) in a few, often difficult to account for situations: (1) when a fire occurs and the system fulfills its purpose to suppress it; (2) when an accidental discharge occurs; (3) when there are leakages during the installation or transport of the agent; and/or (4) when a building is destroyed or changes use or ownership and the agent is released instead of being properly recycled or destroyed (through negligence, ignorance, or willful efforts to avoid costs).

Unlike most other GHG emissions, such as CO_2 from burning fossil fuels or industrial gases from manufacturing processes, these events that emit HFCs from fire suppression systems are relatively infrequent and hence emissions rates seem relatively low, for now. But given there are no clear systems of accountability for recapturing and destroying these HFCs at the end of their useful life, it is necessary to consider and account for not only the emissions, but also the entire installed base of HFCs in fire suppression systems. Some industry observers believe that it is safe to assume that capture and reuse or destruction of HFCs will occur as a result of normal market forces and industry culture,[8] but others contend that even with controls in place such as cost incentives and enforcement, there is a significant risk that a large percentage of the installed base will eventually be released into the atmosphere, citing anecdotal evidence from the case halons in Europe and Australia.[9]

It remains to be seen if a sufficiently robust system can be designed to control these emissions, but without such a system, and in observance of the precautionary principle, we must assume that a significant portion of the installed base will be emitted within a time frame relevant to the climate crisis (50 – 100 years). In 2005, the total installed base globally was estimated to be within the range of 26,360 – 43,321 metric tons of HFCs, which translates to an emission potential of 82 – 126 million metric tons of CO_2e[10]—the equivalent of adding 7,192,982 – 11,052,631 Hummers to the roads for a year.[11]

This installed base represents a sustainability liability for society as a whole given the potential social, economic, and environmental costs associated with it, but it also represents a financial liability for individual property owners. Last year, a high-profile case in Vancouver, British Columbia made this reality all too clear. A well-known Vancouver figure purchased a property with a vacant industrial building before learning that 3,810 kilograms of ozone-depleting Halon 1301 had been discharged via its fire suppression system days before while under the previous ownership. Because the building was vacant during the move, no one was there to abort the discharge during a false alarm. Still, the new owner was charged and could face $1.2 million in fines.[12]

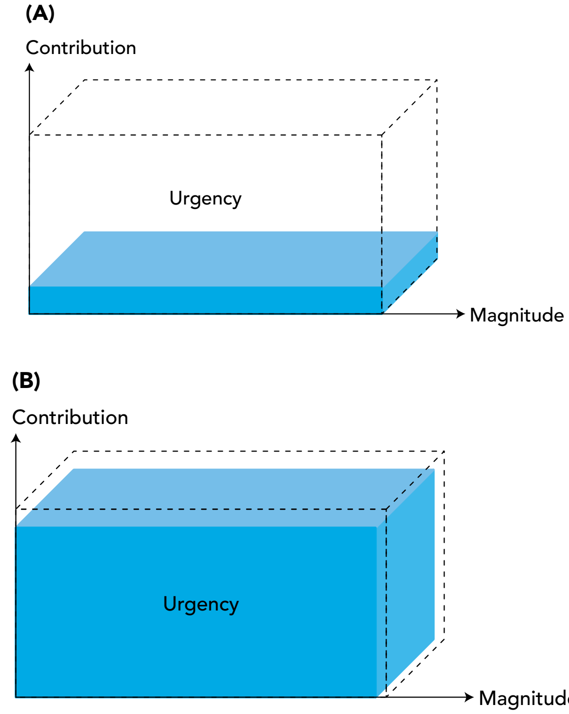
For policy makers deciding on the best way to limit the production and consumption of HFCs, this issue of the existing installed base, and how HFCs might ultimately be destroyed safely, is important. In a scenario where HFCs are phased down, but not out, as the current climate bill proposes, there is no clear path to ever dealing with the installed base, or even stopping its continued growth. As long as inexpensive HFCs can be produced without internalizing the true cost of their climate impact, it will be difficult for the market for recycling and repurposing HFCs from the installed base to compete. Phasing out HFCs all together under the Montreal Protocol is also not without risks. If existing systems are required to be replaced with safer alternatives, it could be difficult to enforce compliance and avoid intentional discharges given the lack of clear mechanisms for tracking and accounting for the installed base. If a secondary market of recycled HFCs is allowed to continue, there is a better chance most of the HFCs will stay in various systems longer, though no clear economic incentive for their destruction has been presented. It is possible that offset credits to be used in cap and trade systems could be generated from the destruction of HFCs, though for this to be effective, their production and consumption must first be phased out.

Without decisive action, the market for HFCs in fire suppression systems is expected to grow (and with it the installed base and eventual emissions or costly HFC destruction), with strong drivers like the information economy's continued generation of computer equipment, server farms, and data centers; the modernization of China and India's huge markets; and continued demand for halon replacements.[13] Since their introduction in the early 1990s, there have been an estimated 300,000 HFC-227ea systems installed in over sixty-five countries.[14] In 2010, the installed base is expected to grow to 198 – 225 MMTCDE.[15] Still, it is unlikely that HFCs from fire suppression will be a major source of GHG emissions globally when compared to emissions from fossil fuel, deforestation, and methane. Even accounting for the whole installed base, the HFCs in fire suppression systems may seem like a negligible consideration compared to overall emissions.

However, when the interconnectedness of the sustainability challenge is appreciated, contributions to unsustainability cannot be evaluated on a relative scale, where a violation of sustainability principles is allowed or ignored because it is "less bad" than the activity of others. This is akin to a doctor not stitching a patient's wounds because the patient has cancer: The cancer may be more serious, but eventually the patient could bleed to death if the wounds go untreated.

Violations of sustainability principles can and should be prioritized and addressed in comprehensive, strategic ways. However, this prioritization must be done from the perspective of each individual, group, or organization based on its unique contributions to unsustainability. In evaluating these contributions it is useful to employ a three-dimensional matrix, plotting the organization's contribution to a specific problem, the urgency of the problem, and the magnitude of the problem. GHG emissions represent an urgent problem of great magnitude, given the potential impacts of climate disruption. While HFCs from fire suppression may be relatively low on the "contribution" axis from the perspective of total

Figure 2

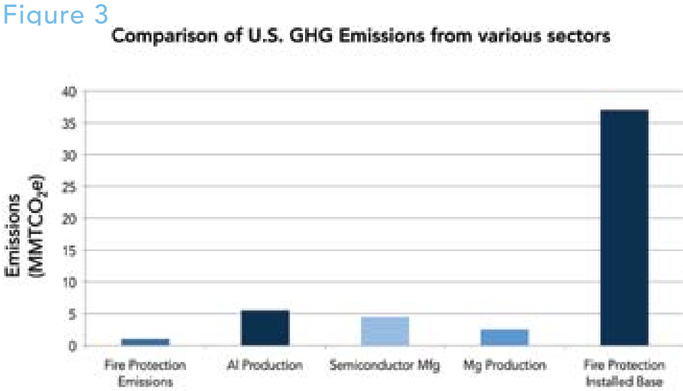


The contribution of HFCs from fire suppression systems to the urgent and severe problem of climate disruption (a) from the perspective of total GHG emissions and (b) from the perspective of companies in the fire suppression system business.[16]

GHG emissions, from the perspective of companies in the fire suppression business they are very large. Their contribution to the problem of "potential (or likely) HFC emissions from fire suppression systems" is 100 percent. Like any sustainability consideration from the perspective of an organization or an industry, this represents a great risk as well as a great opportunity.

HFC emissions from fire suppression may be on the order of less than 1 one-thousandth of 1 percent of total GHG emissions. Put another way, less than one out of every 100,000 units of CO_2e emitted comes from this source. But consider the contribution of your car's emissions compared to emissions from all the cars in the world. There are believed to be more than 700 million cars on the road. Your car is therefore responsible for about one in every 700 million units of CO_2e emitted from cars worldwide. It's a drop in the bucket. Still, we all take responsibility for our own auto emissions, and increasingly responsible citizens are proactively cutting back on driving

Figure 3



and seeking out alternatives. The bucket is full of drops.

Not All Emissions are Created Equal

When evaluating emissions from various sources it is necessary to consider not only the current and potential emissions rates but also the availability of alternatives and their costs.

In the case of HFCs in fire suppression systems, there are commercially viable and competitive alternatives, including inert gases, water mist, and fluoroketone. The latter is a clean agent, providing a suitable replacement in virtually any application. It is marginally more expensive (though still a small portion of an overall building budget)—typically on the order of a 10 percent premium, though some sources put it closer to 30 percent.[17] It is also currently produced by only one company in the industry and requires a bit more agent to do the same job—again, on the order of 10 percent to 13 percent more.[18] In some cases, but not all, this requires a little more floor space to house the system. However, it is not an ozone-depleting substance and it has a GWP on par with CO_2. Even without internalizing the true costs of the carbon-equivalent impacts of HFCs, it is already active and competitive in the marketplace. Its existence and proven viability in the marketplace erases any compelling case that HFCs in fire suppression should be subject to any special treatment or "essential use" exceptions under climate regulator schemes.

Building owners should also be aware of the potential risks associated with these substances as their impacts are better understood, and regulation catches up with the science. Fire suppression systems are not given much direct attention in the US Green Building Council's Leadership in Energy and Environmental Design (LEED) rating system. However, LEED does not allow for systems that contain ozone-depleting CFCs, HCFCs, or halons. LEED does allow HFC systems; however, buildings can apply for "innovation points" for using alternatives to HFCs, and thus reducing climate impact risks.

Today's Solutions, Tomorrow's Problems

It must be noted that though it's understood that fluoroketone is not an ozone-depleting substance and has a low GWP (of approximately 1), it is not necessarily "sustainable." At a certain quantity it too will represent a violation of Sustainability Principle 2. Indeed, despite thorough testing requirements, industry competitors continue to debate the potential of safety and environmental concerns from fluoroketone after certain reactions in certain circumstances.[‡] [19] [20] [21] While it is beyond the scope of this paper to fully evaluate this alternative, and what unforeseen impacts it might cause, we must not confuse incrementally better solutions with fully sustainable solutions.

The backdrop of the HFC issue provides a clear illustration of the importance of this way of thinking. CFCs were originally hailed as a dream compound that revolutionized the refrigeration industry, replacing toxic and explosive refrigerants like ammonia, chloromethane, and sulfur dioxide, before their role in the nightmare of ozone depletion was discovered. After the phase-out of CFC production began, HFCs were billed as a miracle substitute—until it became clear they were cursed with a huge global warming impact, and the potential to drive, accelerate, and amplify catastrophic climate disruption.

The extent to which the largely unregulated, untested, and little understood compounds produced by society may yield negative impacts—now or in the future, on their own or in combination with other natural or manmade compounds—is often unclear. However, what is clear is that we must shift our perspective on dealing with chemicals to be more responsible. We must reverse our assumption that all manmade compounds are safe until proven otherwise. We must also instill a

‡ *Under certain conditions, the fluoroketone FK-5-1-12 can chemically react with water to produce a toxic and corrosive acid (F-Propionic acid).*

sustainability perspective into all product and process design, so that "solutions" like CFCs, HCFCs, HFCs, and fluoroketone are viewed as stepping stones towards a truly sustainable society, and not a final solution, the continued use of which must be fought for against science-based regulation.

Conclusion

What the "truly sustainable" solutions are is impossible to

We must reverse our assumption that all manmade compounds are safe until proven otherwise.

say. They might be more advanced compounds that harmlessly break down in nature, and thus do not "systematically increase in concentration." Or more effective systems that can really ensure manmade compounds are kept in tight technical loops and are not allowed to leak into natural systems (even after discharge in the case of fire suppression). Or perhaps they are yet unimagined design solutions in buildings or equipment that sufficiently reduce or eliminate the threat of fire in the first place.

Whatever the case may be, a proactive approach to creating sustainable solutions opens up worlds of opportunities for innovation for all companies in the industry. By not sending the proper price signals, based on more perfect information from improved scientific information, we do a disservice to our businesses and our competitiveness. Any climate legislation should therefore, at the very least, price HFC-277ea and other HFCs used in fire suppression more aggressively than the version of the bill passed by the House in 2009. Simply amending the Montreal Protocol to cover HFCs is preferable, particularly given its proven effectiveness and the affected industries' familiarity with that regulatory framework.

The more time, expertise, and resources spent on research and development to drive innovation, instead of on efforts to fight or influence necessary, science-based regulations, the better off the individual companies, the industry, and all of society will be.

About the Author:

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For over ten years, Georges has been engaged in solutions-based, business-driven, and whole-system approaches to sustainable development. He is a founder of Greenland Enterprises, a consultancy specializing in strategic leadership towards sustainability for accelerating the role businesses and other organizations play in sustainable development. For two years Georges was the Head of Market Intelligence for the Institutional Equities Group at LaBranche Financial Services in New York, where he was an NASD Series 86/87 licensed analyst. Prior to Wall Street, he was engaged with private equity deals working with eco-efficiency start-up companies and on residential and commercial real estate projects. He has worked with design-build firms on four residential green building projects in Vermont and Colorado, and is certified in Permaculture design. Georges' master's thesis research focused on carbon reduction projects under the Kyoto Protocol and EU Emissions Trading Scheme, and he presented results at the 2006 Make Markets Work for Climate conference in Amsterdam.

Georges is also a Senior Fellow at Second Nature, and a Trustee of Stratleade Sustainability Education. He holds a Master of Strategic Leadership toward Sustainability from Blekinge Institute of Technology in Karlskrona, Sweden, and a B.A. in History and Environmental Studies from Dartmouth College. He is a member of SoL, The Society for Organizational Learning, participating actively in the SoL Sustainability Consortium's Carbon Commons working group.

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