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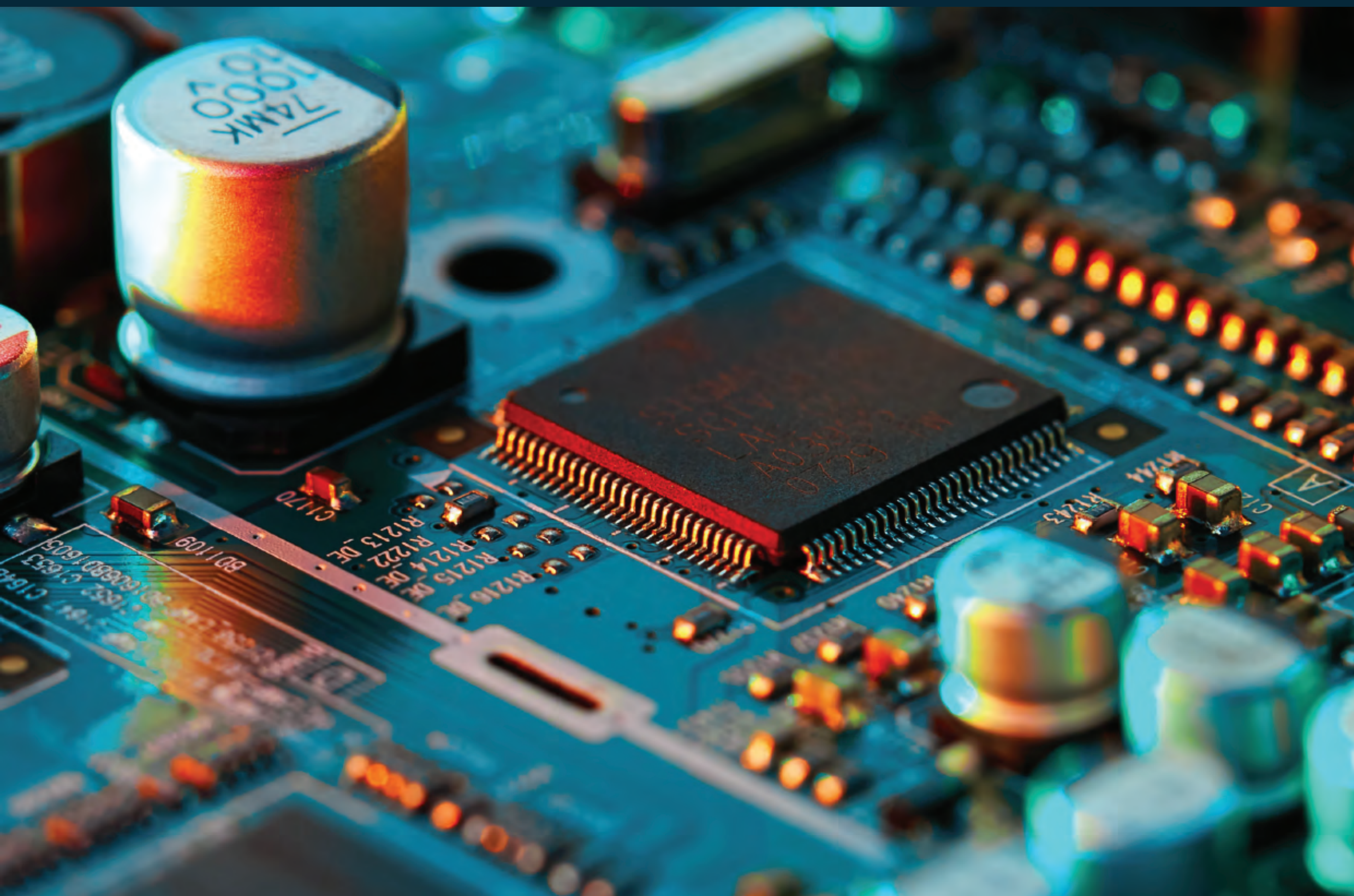
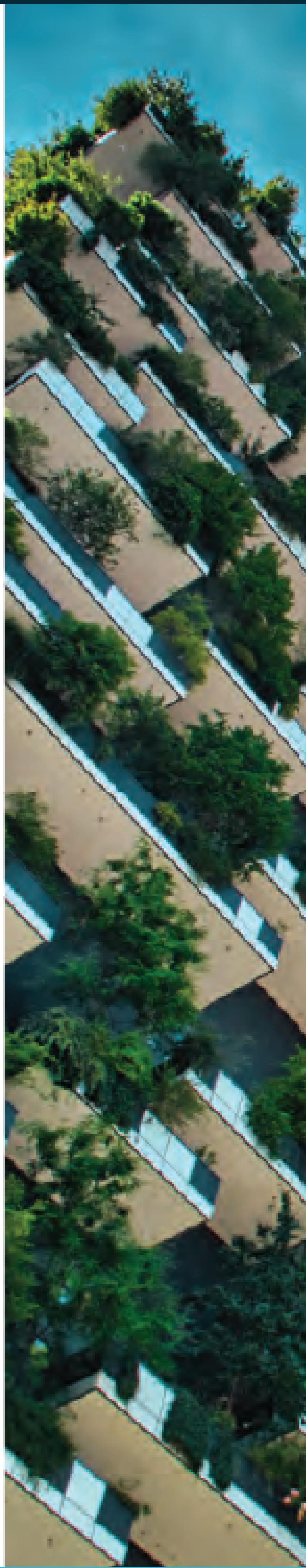
Understanding PFAS in Electronics

Risks, Legislation and Solutions for a PFAS-Free Future





Introduction

Per- and polyfluoroalkyl substances (PFAS), a group of synthetic chemicals, have been widely utilized in the electronics industry due to their dust, grease, water and heat-resistant properties, making them especially useful, both in the manufacturing of electronics and for specific electronics applications, such as in improving thermal stability or in providing electrical insulation. It is estimated that more than 10,000 PFAS chemicals exist, many of which are used in the electronics industry.

However, many PFAS chemicals are toxic to humans and the environment, in part because of their long-lasting properties. As a result, governments have started restricting or even banning their use. These chemicals are currently so widespread and have such unique properties that the electronics industry is struggling to both identify their use within their products and find viable replacements. For electronics manufacturers, suppliers and even consumers, the first step in tackling the PFAS dilemma is to fully understand the challenge we are facing. Let's start with human health and the risks involved with exposure to PFAS.

PFAS Human Exposure Dangers

PFAS exposure has been associated with a host of adverse health effects, such as liver damage, thyroid disease and an increased risk of certain cancers. Within the electronics industry, workers involved in manufacturing can face direct exposure to these chemicals. Numerous studies, including those conducted by the National Institute for Occupational Safety and Health (NIOSH), have painted a vivid picture of the harmful effects linked to PFAS exposure in electronics manufacturing environments. Furthermore, contamination from PFAS is widespread globally due to the improper disposal of electronics waste, further emphasizing the need for more robust management strategies. As a result, many of us have PFAS chemicals in our bodies. One commonly referenced study is already over twenty years old – in 1999, when the CDC's National Health and Nutrition Examination Survey (NHANES) found that of those Americans tested, 98% tested positive for PFAS chemicals in their bloodstreams.

Environmental Release of PFAS

In organic chemistry, the carbon-fluorine bonds found within PFAS chemicals rank among the strongest chemical bonds that exist. Thus, PFAS are also referred to as "forever chemicals," because they won't degrade naturally for hundreds or even thousands of years once synthesized. As a result, their half-life (the time it takes the chemical concentration to naturally decrease by 50% in a particular medium, such as water, soil or air) is difficult to assess. That's unwelcome news for the environment and all life, since PFAS will remain in the environment for centuries, having already found their way into crops, soil, water supplies, wildlife and wild plants.

The environmental persistence and bioaccumulation necessitate an urgent call to action to minimize risks to human health, wildlife and the natural environmental. To make matters more challenging, the electronics industry is facing escalating regulatory scrutiny worldwide, with the added threat of compliance response and in some cases, financial penalties for use of certain PFAS chemicals in products and processes. By continuing to integrate PFAS into electronics, businesses risk tarnishing their reputations and losing consumer trust, as the long-term dangers of PFAS increasingly come into public view and awareness. This is not to mention the anticipated regulatory response to comply with reporting, storage and disposal requirements, which will require the industry to act.

Areas for Reducing Risk Related to PFAS

So, what can the electronics industry do about PFAS risk? Companies need to tackle four immediate PFAS risks:

1. The first is direct exposure to PFAS in the production process, which poses a significant health risk to employees, inviting potential workforce health complications and legal liabilities related to occupational safety and health. Here are a few strategies to consider:

   · **Assessment:** First assess your company's use of PFAS both in the manufacturing process and in the materials used to produce your products. This requires accessing all data related to the processes and the materials used.

   · **Substitution:** Look for safer alternative materials to replace the use of PFAS in the production process. Several alternatives, such as hydrocarbon-based materials, have already been developed for many applications of PFAS. It's important that alternatives are fully vetted to ensure they don't pose similar or other health and environmental concerns. See the "Sustainable Alternatives to PFAS in Electronics" category later in this E-book.

   · **Containment:** Implement improved containment methods in the manufacturing processes to reduce potential PFAS releases. This can include enhanced engineering controls and closed-loop systems.

   · **Staff Training:** Ensure that all staff are well trained in the handling and disposal of materials containing PFAS. A well-informed workforce can significantly decrease the likelihood of accidental releases.

   · **Protective Equipment:** Provide adequate personal protective equipment (PPE) for employees who work directly with PFAS-containing materials to reduce their direct exposure.

   · **Waste Management:** Implement rigorous waste management practices, including proper disposal of PFAS-containing waste. If possible, explore opportunities for waste treatment technologies that can break down PFAS, such as plasma treatment, photolysis, Advanced Oxidation Processes (AOPs), biodegradation and electrochemical treatments.

• **Supply Chain Engagement:** Engage with suppliers to encourage them to reduce or eliminate their use of PFAS in products supplied for manufacturing processes. This can involve adopting procurement policies that favour suppliers who minimize or eliminate PFAS in their products and use of supply chain mapping software, such as CleanChain.

• **Monitoring & Reporting:** Regularly monitor PFAS use, emissions and worker exposure levels. Transparent reporting of these levels not only fosters trust with employees and the community but can also highlight areas where improvements can be made, hopefully leading to total elimination of PFAS from your supply chain and processes.

• **Innovation & Research:** Invest in research and development of non-PFAS materials for use in your products. Encouraging innovation in this area can lead to long-term solutions that are safer for both the environment and human health.

• **Policy Advocacy:** Support policies and regulations that aim to reduce PFAS use and exposure. Companies can play a significant role in shaping industry standards and regulations.

• **Partnerships:** Reach out to organizations and governmental agencies to gain access to information about PFAS legislation and to learn about the resources available to businesses to tackle the PFAS challenge in electronics.

In implementing these measures, it is essential to comply with local and national regulations that are already in place and to stay informed about ongoing research and evolving best practices for managing PFAS.

2. The second risk includes the environmental and human impacts posed by the release of PFAS into air, earth and water in the manufacturing process. Here is a brief overview of what that entails:

   - Processes using PFAS in electronics include such things as etching, coating and lubrication.

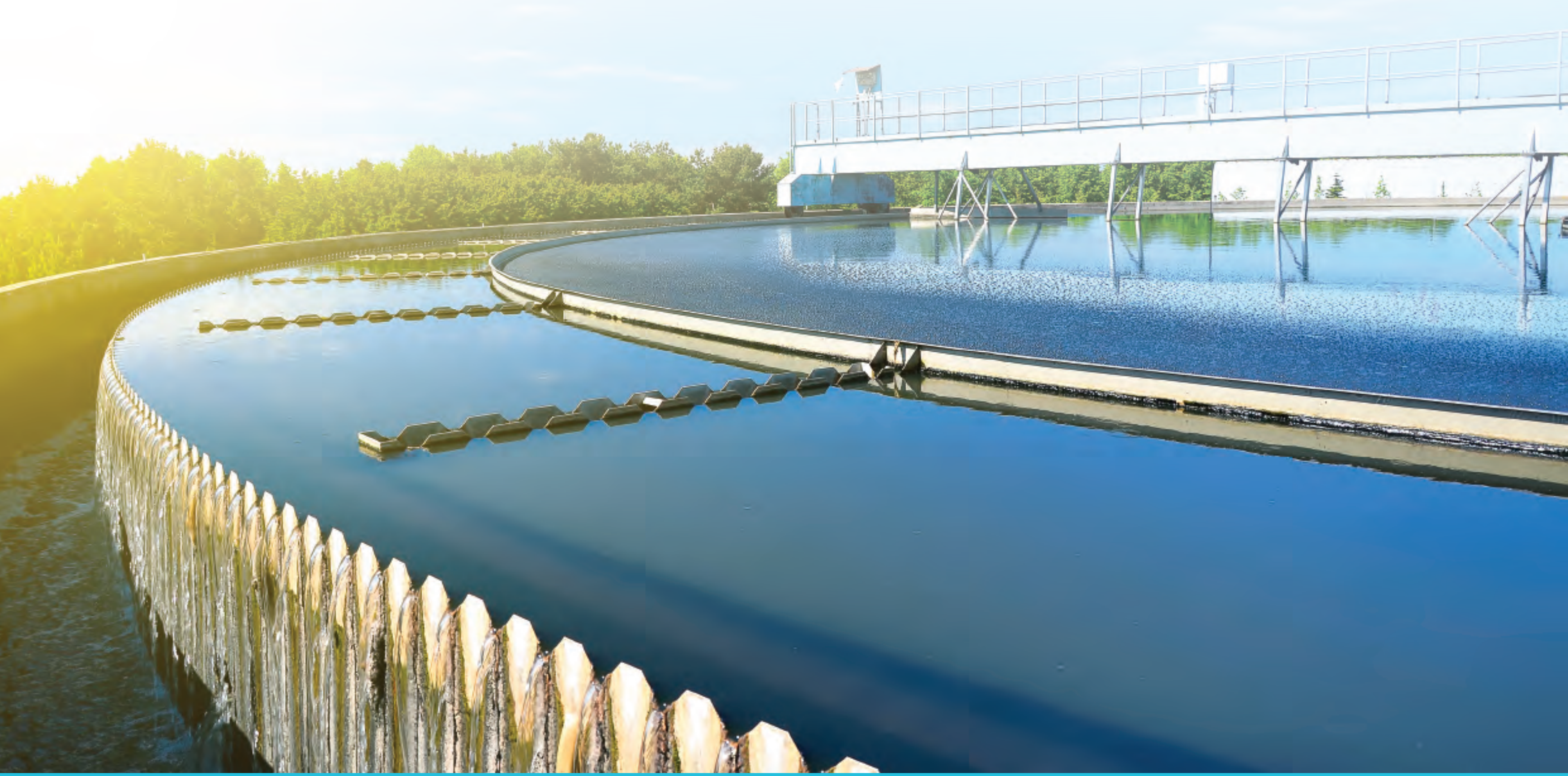
   - Improve process efficiency, such as improving equipment design, changing operating conditions or implementing more efficient manufacturing techniques, so that less or no PFAS chemicals are required, thereby reducing the potential for release.

   - Use pollution-control equipment to capture and treat PFAS emissions before they are released into the environment. This could involve scrubbers to remove particulates from air emissions, carbon filters to capture chemicals from water emissions and containment systems to prevent soil contamination.

   - Invest in technologies that ensure waste containing PFAS is properly disposed of through such things as incineration at high temperatures, oxidation or other treatment technologies.

3. Perhaps the most immediately obvious risk is the risk of human exposure to PFAS chemicals during the use phase of electronic products. As awareness of the risks associated with PFAS increases, consumers will want to know if your products contain PFAS—the sooner you minimize this risk, the better for your brand and your sales. Reducing the risk here means both trying to limit the amount of PFAS chemicals necessary in your products while also making sure the product is designed in such a manner that PFAS chemicals can never be emitted from the product and will never come in contact with humans or the environment.

4. The last risk relates to the difficulty of extracting PFAS from post-consumer electronic products, a risk that weaves its way into all the other the End-of-Life (EoL) challenges faced by the electronics industry. Solving this problem requires a thorough Lifecycle Assessment (LCA) of your products and probably also an end-to-end solution to track PFAS chemicals throughout the supply chain (see DataAssured for more information about chemical data tracking).



Emerging PFAS Global Legislation

When it comes to regulation, existing laws have primarily concentrated on PFAS production and direct environmental release and emissions. However, the regulatory landscape is changing. In the United States, for example, there's a growing push for stricter regulations on the use and disposal of PFAS across various industries, including electronics. Similarly, the European Union is mulling over a "One Substance, One Assessment" approach to streamline and enhance its management of chemicals like PFAS. Trends toward tighter PFAS regulation are also being observed in other regions of the world. Wherever the mandate exists for increased transparency around PFAS usage and improved disposal practices, it will lead to safer working environments, more limited human exposure to the chemicals and reduced environmental pollution.

Overall, PFAS tonnage in electronics amounts to anywhere between 1,000 and 10,000 tonnes annually, with 5-25% of these chemicals being released from products during the manufacturing and use phases. That's a serious quantity to consider, knowing that there are estimates that the volume of electronics sold will increase over the coming years, not decrease. To counter this trend, let's now review what we know about the current and upcoming regulations.

Europe

As part of the European Union's sustainability strategy, through the European Chemicals Agency's (ECHA) REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) framework, the EU has already restricted perfluorinated carboxylic acids (C9-14 PFCAs) along with PFOS and PFOA. These restrictions remain in place. In addition, the EU has made a new PFAS regulatory proposal, submitted on January 2023 by five EU member states (Denmark, Germany, the Netherlands, Norway and Sweden).

On March 22, 2023, the EU initiated a 6-month consultation period open to feedback from stakeholders while the PFAS committee evaluates this new restriction proposal before it is submitted to the European Commission in September 2023. This new regulation, when passed, will make the EU one of the strictest areas of the world with regard to PFAS regulatory compliance. Already, the EU considers LC-PFCAs, PFHxS, PFOA and PFOS as persistent organic pollutants (POP). But the EU is still deciding about restrictions related to PFHxS and PFHxA. Any foreign company importing products with these chemicals into the EU should carefully check the status of these restrictions or face potential legal repercussions, financial penalties or even loss of goods.

North America

In the United States, the Environmental Protection Agency (EPA) has proposed the classification of PFOA, PFOS and five other PFAS substances as "hazardous" under the Superfund law (CERCLA). Such a classification makes electronics manufacturers liable for post-release cleanup of these substances, significantly affecting design and manufacturing practices. The current administration has voiced a commitment to addressing PFAS effects in the environment. As such, the EPA has developed, as a key component of the administration's response, a comprehensive document, called the PFAS Strategic Roadmap, and a new interactive website: PFAS Analytic Tools.

But that was just at the federal level. More than a half-dozen states already have or are enacting PFAS regulations in 2023, with Maine having banned the use of PFAS in any product, including a sweeping requirement for all companies to report or make public the amount and purpose of PFAS use (see LD 1503). On July 1, a California law, AB 652, took effect, banning the sale and distribution of new children's products containing PFAS, including certain electronics. Companies are now required to use the least toxic alternative, which may vary according to product, but the law excludes electronic products and internal product components that will not have contact with the skin or mouth. You can find other upcoming California laws here.

Whether the reforms from additional states will immediately affect the electronics industry or begin to influence PFAS regulations with regard to electronics industry is still unclear. However, we will list them anyway, because they give you a sense of the momentum behind US state regulation.

Hawaii's new PFAS law, HB 1644, bans the manufacture, distribution and sale of some food packaging containing PFAS, include wrapping, liners, plates, food boats and PFAS boxes. The law also prohibits firefighting foams that contain PFAS. Such foams are used to extinguish gasoline, oil and jet fuel.

Similarly, under Rhode Island's SB 2298 law, public water utilities will regularly monitor use of six PFAS chemicals, particularly in drinking water. If PFAS levels exceed the established limit, entities are required to provide potable water to residents through other means until the levels reach an acceptable limit.

Vermont's S.20 law bans intentionally added PFAS from food packaging, residential rugs and carpets and ski wax. See additional information in the Vermont PFAS Roadmap.

Minnesota state agencies have collaborated to address (PFAS) contamination. Their approach, named the "PFAS Blueprint," strategizes short to long-term methods of preventing, managing and cleaning up PFAS, with a focus on research, health guidelines and water/food protection. Additionally, a stringent PFAS monitoring plan is in place, particularly focusing on waste management facilities, while landfills that use spray irrigation are being closely regulated to maintain PFAS levels below health-based values.

These regulations may already affect PFAS in electronics, depending on your company's activities, so it's best to check thoroughly through the current legislation in these states. It is widely expected other states will follow suit and that this regulatory trend will expand as the word gets out about PFAS-related health and environmental threats.

Concurrently, Canada's PFAS guidelines may influence broader environmental policies, calling for alterations in electronic component sourcing and manufacturing. For a breakdown of PFAS regulations in Canadian provinces, take a look at this article.

Australia, Asia, South America and Africa

Australia's PFAS regulation and the PFAS National Environmental Management Plan (NEMP), focusing on the phase-out of long-chain non-polymer PFASs and restrictions in firefighting foam, are starting to pose challenges to the electronics industry. See the Australian government's PFAS information portal for details. Also take a look at the forum for giving feedback at the National Environmental Management Plan on PFAS.

In Asia, the regulatory landscape varies across countries. In 2021, China announced its plan for managing new chemical pollutants. You may also want to check out China's chemical substance controls. Japan has implemented stringent PFAS regulations, categorizing PFOA and PFOS as a Class I Specified Chemical Substance, and South Korea is working toward greater regulation under the Persistent Organic Pollutions Control Act after extensive studies. Taiwanese companies account for roughly 50% of the world's semiconductor market, and the Toxic Chemical and Substance Bureau of Taiwan has banned or restricted PFAS chemicals, having classified them at various levels of toxicity.

Although Brazil has not updated its potability standards or provided new guiding values for soil and groundwater to include PFAS, CETESB aims to advance the country's regulatory framework for emerging contaminants and implement PFAS detection methods and monitoring in the State of São Paulo by 2023 (see LINK). The Biden and Lula administrations are working jointly on various PFAS regulatory initiatives.

As of yet, there has only been preliminary studies in certain African countries, in addition to countries, like South Africa, phasing out of products containing PFOS and PFOA. However, a larger issue for the electronics industry and African countries is on the post-consumer electronics waste side of the toxic chemical equation. For a comprehensive study on POP-related waste issues in African countries, including some information on electronics waste, see this study.

RiskFacts geographically identifies PFAS related activity within the United States, ranging from initial sampling of water supply or groundwater to sites that are being actively investigated for PFAS. RiskFacts' map has a layer to identify these locations within a search area, which does not mean that PFAS is actually present, but rather that some form of activity related to PFAS has occurred there. As US states track such sites, ADEC Innovations pulls from their databases to continually update the RiskFacts maps in relationship to PFAS.

PFAS used in the Electronics Manufacturing Process

Most electronics manufacturers using PFAS generate wastewater and then have some form of pretreatment of that wastewater before discharging to the POTW (publicly owned treatment works). In the US, the federal mandate requires "industrial users" report PFAS sampling of effluent. Therefore, running a RiskFacts report at industrial sites may be a good initial place to start to evaluate current or preexisting PFAS activity, at least in the United States where industry use of PFAS has been known to exist.

Supply Chain Mapping for PFAS

Supply chain mapping serves as a crucial tool in managing PFAS within the electronics industry. By identifying where PFAS are used in their production processes throughout the world, companies can take significant strides toward reducing their PFAS footprint. Apple, for example, has successfully identified and curbed PFAS use within its supply chain. The primary challenges in supply chain mapping for PFAS include the complexity of global supply chains and limited transparency from suppliers. Solutions might involve imposing stricter supplier requirements and leveraging technology to track and manage chemical usage. It may be that a comprehensive data collection system is the best place to start.

Harnessing Data for PFAS Management

Data analytics and reporting play a vital role in PFAS management. They provide companies the ability to quantify PFAS usage, pinpoint areas for reduction and monitor progress over time. Furthermore, transparent reporting allows consumers to make informed choices, acting as a catalyst for industry-wide change. Companies such as Dell have employed data analytics and transparent reporting to successfully reduce their environmental impact. As we look toward the future, PFAS management in the electronics industry will lean heavily on advanced analytics tools and put an increased emphasis on transparency.

PFAS Removal

The removal of PFAS from electronics is a complex issue that needs to address solids (treated components), liquids (coolants) and gases (emissions from manufacturing processes). Technologies such as adsorption, chemical oxidation and membrane filtration can help in removing PFAS. Successful initiatives like Samsung's, which implemented wastewater treatment processes to eliminate PFAS, offer hope. However, challenges, such as the high cost of treatment technologies and the need for solutions that are scalable across the industry, persist. Some studies on the handling and exposure of e-waste have been conducted, but more are necessary. One interested example involves a study that found wastewater bacteria itself may prove useful in the breakdown of PFAS chemicals.

Sustainable Alternatives to PFAS in Electronics

The search for eco-friendly, sustainable alternatives to PFAS has focused around a few chemically safe alternatives with similar properties to PFAS. Here are some alternatives of note.

Natural Oils/Waxes

Natural oils and waxes are considered promising replacements for PFAS in electronic applications due to their excellent insulating properties and natural resistance to water. For instance, beeswax is non-toxic, bio-degradable and can be used to encapsulate and protect electronic components, similar to how PFAS are used. Meanwhile, oils like linseed oil possess dielectric properties, making them also potential insulators in electronic devices. The challenge lies in the durability and heat resistance of these materials, but ongoing research is working on finding solutions to improve these characteristics.

Bio-Based Polymers

Bio-based polymers, derived from renewable resources, are being actively researched for their potential as PFAS substitutes. One example is polylactic acid (PLA), a biodegradable thermoplastic aliphatic polyester derived from renewable resources such as corn starch. PLA has been widely used in packaging, biomedical applications and the automotive industry. With the right modification, PLA can be an excellent alternative to PFAS in electronics due to its decent dielectric properties and lower environmental impact.

Glass-Reinforced Composites

Glass-reinforced composites, specifically glass-fiber-reinforced polymers (GFRP), have excellent insulating properties and mechanical strength, thus they can be used as an alternative to PFAS in certain electronic applications. The thermal stability, electrically insulative and non-flammable nature of GFRPs make them a viable and sustainable option. However, more research is needed to perfect the techniques for integrating them into electronic components and systems.

Silicone-Based Materials

Silicone-based materials are another promising alternative to PFAS. They possess a unique combination of properties including thermal stability, low toxicity, good electrical insulation, and excellent water repellence. Silicones are already widely used in a range of applications, from sealants and adhesives to insulation in electronics and with advances in manufacturing, the potential for replacing PFAS in more applications is growing.

Other Alternatives

Other chemically safe alternatives being explored include hydrocarbon-based materials and inorganic materials like ceramics. Hydrocarbons, such as polyethylene and polypropylene, are chemically stable, have excellent insulating properties and are more sustainable and less harmful than PFAS. Ceramics, on the other hand, have excellent thermal and electrical properties, making them suitable for various electronic applications.

The search for alternatives to PFAS in electronics is a challenging yet vital mission. It involves not only finding materials with similar properties but also ensuring they are sustainable, cost-effective and compatible with existing manufacturing processes. While none of the alternatives currently available can directly replace PFAS in all of their applications, the future looks promising as more research is dedicated to developing and refining these alternatives.

By replacing PFAS in electronics, we can create a healthier, more sustainable industry and planet. We're standing on the precipice of a greener electronics sector that respects both functionality and environmental responsibility. The challenge is complex, but the solutions are on the horizon, marking an exciting time for the industry and those who depend on it.

Ending Reliability on PFAS in Electronics

The rapidly evolving global PFAS regulatory landscape is fostering innovation within the electronics industry and prompting proactive regulatory engagement. Comprehending and adapting to this changing regulatory framework is crucial for the industry's long-term sustainability, environmental responsibility and societal acceptance.

The regulatory shifts already set in motion require the electronics industry to reassess their PFAS utilization and investigate feasible alternatives as soon as possible. Sincer PFAS chemicals are so versatile and useful in the electronics industry, breaking those carbon-fluorine bonds, metaphorically speaking, will prove highly challenging for everyone in the sector. Collective efforts, including industry coalitions and partnerships, may drive progress in PFAS management faster than if you try to go at it alone.

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With a commitment to sustainable development and impact sourcing and 40 years of group experience in professional services, enterprise technology solutions, workforce solutions and impact capital, the multi-national ADEC Innovations team provides fully-integrated solutions and delivers results across various areas, including education, health information and Environmental, Social and Governance (ESG) services and compliance.